CalWave – California Wave Energy Test Center

Department of Energy
DE-EE0006517-0005

Volume #1

Final Technical Report

And

Appendices #1-15

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DOE-CP-0006517

Final Report

Feasibility Study for the

California Wave Energy Test Center

Award Number: DE-EE0006517

Submitted to:
U.S. Department of Energy
Office of Energy Efficiency
and Renewable Energy
Golden Field Office
15103 Denver West Parkway
Golden, Colorado

U.S. DEPARTMENT OF ENERGY

Submitted by:
Cal Poly Corporation
Institute for Advanced Technology
and Public Policy
California Polytechnic University
San Luis Obispo, California

CALWAVE

CAL POLY
SAN LUIS OBISPO

July 2017

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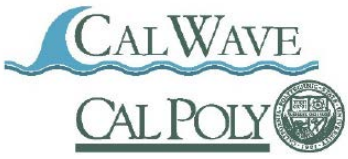

Cal Poly Corporation
Institute for Advanced Technology and Public Policy
California Polytechnic State University
San Luis Obispo, CA

July 2017

Principal Investigator:

Samuel N. Blakeslee, Institute for Advanced Technology and Public Policy, California Polytechnic State University (Cal Poly), San Luis Obispo

Project Manager:

William I. Toman, Protean Wave Energy Ltd.,

Principal Co-Authors:

Richard B. Williams, Leidos Maritime Solutions
Douglas M. Davy, CH2M
Anna West and Janet Thompson, Kearns & West, Inc.
Randy M. Connett, Omega Power Engineers, LLC
William I. Toman, Protean Wave Energy Ltd.

Contributing Authors:

Dale Dolan, Cal Poly, San Luis Obispo
Craig Baltimore, Cal Poly, San Luis Obispo
Paul Jacobson, Electric Power Research Institute
George Hagerman, Virginia Tech Advanced Research Institute
Chris Potter, California Natural Resources Agency
Brendan Dooher, Pacific Gas & Electric Company

Cost Share Partners:

California Natural Resources Agency
Pacific Gas and Electric Company
Protean Energy Ltd.

Contributing Partners:

Julie Thomas, Scripps Institution of Oceanography – UC San Diego
Stuart Herbert, UK Wave Hub Ltd.

Project Administrator:

Nicholas S. Osterbur, Institute for Advanced Technology and Public Policy, California Polytechnic State University (Cal Poly), San Luis Obispo

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Acronyms and Abbreviations

BIMEP	Marine Renewable Energy Test Center located in Bizkaia Spain
BLM	Bureau of Land Management
BOEM	Bureau of Ocean Energy Management
CDIP	Coastal Data Information Program
CDR	Conceptual Design Review
CFR	Code of Federal Regulations
CONOPS	Concept of Operations
CSLC	California State Lands Commission
DOD	Department of Defense
DOE	Department of Energy
DVT	Design Verification and Transfer
EA	Environmental Assessment
EIS	Environmental Impact Statement
EPC	Engineering, Procurement, and Construction Contractor
EPRI	Electric Power Research Institute
EMEC	European Marine Energy Center
EMF	Electromagnetic Field
FERC	Federal Energy Regulatory Commission
FDR	Final Design Review
HDD	Horizontal Directional Drilling
INCOSE	International Council on Systems Engineering
MEC	Marine Energy Convertor
MVA	Mega Volt Amp
NGO	Nongovernmental Agency
NNMREC	Northwest National Marine Energy Center
NOI	Notice of Intent (FERC Licensing Process)
NREL	National Renewable Energy Laboratory
OAG	Operational Advisory Group
OCS	Outer Continental Shelf

OPC	Ocean Protection Council
PAD	Pre-Application Document
PDMA	Product Development and Management Association
PDR	Preliminary Design Review
PG&E	Pacific Gas & Electric Company
PM	Project Manager
PMEC-SETS	Pacific Marine Energy Center - South Energy Test Site
PMI	Project Management Institute
RFP	Request for Proposal
SAG	Stakeholder Advisory Group
SOPO	Statement of Project Objectives
SOW	Scope of Work
SWBS	Systems Work Breakdown Structure
TRL	Technology Readiness Level
VAFB	Vandenberg Air Force Base
WBS	Work Breakdown Structure
WEC	Wave Energy Convertor
WECC	Western Electric Coordinating Council
WETS	Wave Energy Test Site

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Section C: EXECUTIVE SUMMARY - CalWave I & II

C.1 High-Level Project Description

The California National Wave Energy Test Center (CalWave) design will support full-scale, multi-unit array, grid-connected wave energy technology demonstrations and research in an area with market demand for wave energy, including the possibility of 25MW demand from the onshore host, Vandenberg Air Force Base (VAFB) plus other regional customers served by the incumbent utility, Pacific Gas and Electric Company. CalWave is designed with four (4) 10MW Test Berths in fully-energetic wave resource conditions with average annual power densities exceeding 30 kW/m, in water depths ranging from 70 to 120 meters but still close to shore. The Primary Site design, rated for 40MW, has been developed.

C.2 Outline of Objectives Accomplished

An initial one-year feasibility study of the cost, schedule, regulatory and stakeholder issues of establishing a national wave energy testing center in California was executed in 2014-15 (CalWave I). A second year was executed in 2016-17 (CalWave II), collectively the CalWave I and II Studies.

In CalWave Phase I Final Report, we progressed efficiently through program stages: Feasibility Study, Site Down-Selection, and Conceptual Design. During CalWave II, Engineering, Permitting and Stakeholder efforts continued that concluded with the Preliminary Design developed to adequate detail to produce the Draft Pre-Application Document (PAD), the Regulatory Roadmap, and the Stakeholder Engagement Plan for the Primary Site: the VAFB South Base Configuration Baseline.

C.3 Primary Site Selection

Site selection leveraged an extensive history of resource and site characterization by the core development team as documented in the CalWave Phase I Final Report. Prior studies and development include multiple studies on ocean energy by CalWave Partners: Electric Power Research Institute (EPRI), starting in 2004, and Pacific Gas and Electric Company's (PG&E's) WaveConnect Program in 2007. VAFB was added as a prospective site in 2009. In 2010, PG&E submitted a Draft Pilot License Application to the Federal Energy Regulatory Commission (FERC) for a wave energy test center site offshore of Humboldt Bay. These events were reported in December 2011.

In CalWave I, site selection was reevaluated at Humboldt Bay and Vandenberg Air Force Base (VAFB) and VAFB was selected as the primary site. Alternatives were further down-selected to a conceptual site at VAFB South Base with tests berths located off Point Arguello. During CalWave II, macro-siting was further developed, micro-siting progressed, and VAFB South Base was designated as the primary site. An alternative site in the VAFB area at offshore oil Platform Irene was also identified and evaluated.

C.4 Benchmarking Test Centers

The CalWave Team benchmarked existing test centers at the European Marine Energy Center (EMEC, Scotland, UK), Galway Bay (Ireland), and UK Wave Hub (Cornwall, UK) including prior visits during PG&E WaveConnect. During CalWave II, we monitored the progress of test centers worldwide including the Navy's Wave Energy Test Site (WETS) and the Northwest National Marine Energy Center (NNMREC). We partnered with the United Kingdom's Wave Hub. The Wave Hub Operations Director visited the Vandenberg AFB area during our Conceptual Design Review.

C.5 Key Findings in Conceptual Design Stage

The VAFB Site is well-suited for wave energy development. The Central California Region presents market opportunities for commercial marine renewable energy that are unmatched in the United

States, and perhaps the world. Our study included participation and benchmarking from the United Kingdom's Wave Hub Ltd., currently largest and most advanced wave energy test center in the world.

C.6 Systems Engineering and System Integration Goals and Objectives

The CalWave System Concept is centered on dedicated, "home run" cables to each of the test berths and other features that allow Wave Energy Convertor (WEC) Developers to field their mature pre-commercial system designs with a minimum of test facility-induced constraints. This approach incorporates significant lessons-learned from other wave energy test centers. The design goals and objectives enable precise measurement of performance from each test berth hosting individual WECs or arrays and are:

- Requirements-driven, modular design of an open-ocean, fully energetic test center.
- Grid-connected test berths with excellent wave resource in deep water.
- Design features such as mooring/anchoring flexibility, electrical system and power conditioning and test instrumentation options that remove barriers to entry for WEC developers.
- Integrate with host facility (VAFB) grid infrastructure (12kV and 70kV) and connecting utility.
- Integrate with host facility (VAFB) civil facilities and environmental guidelines.
- Integrate with local marine industry support with decades of experience at this site.
- Integrate input from stakeholders, agencies, and regulators in Draft Project Description.

C.6.2 Overview of System Concept and System Boundaries

The CalWave systems approach considered a "WEC-Referenced System" during Conceptual Design Stage Requirements Definition process to understand WEC Developer inputs. As we moved into Preliminary Design Stage and began planning for construction, we evolved to a "Grid-Referenced System", with system boundary defined as the "systems and sub-systems under the direct control of the CalWave Team". Boundary systems are defined as "systems or sub-systems that are a vital part of the design and are not under the direct control of the CalWave Team" and include: WEC systems, VAFB and PG&E electrical grids, and VAFB infrastructure.

C.7 Primary Project Site Overview: South Base Configuration Baseline

The CalWave South Base Configuration Baseline meets—and exceeds—the recent DOE minimum requirements, as described in the 2016 DE-FOA-0001419 Wave Energy Test Facility. CalWave will have four (4) grid-connected test berths, a 30-year design life, a 5th (spare) cable, and a 70kV export capability rated for 40MW. The design includes options for the NREL Grid Emulator. Each test berth will have a dedicated cable rated at 35kV/10MW. The 5th (spare) cable would have an identical rating and serve as a temporary replacement in case of a main berth cable failure. Key features of the site are:

- Wave resource studies-confirmed location as open-ocean, fully energetic, averaging an annual power density exceeding 30 kW/m, in water depths greater than 60 meters.
- Test berth definition allows flexibility in mooring/anchoring and shore cable interconnection to allow WEC technology developers to demonstrate their pre-commercial system designs.
- Grid-connected test berths with separate "home-run" cables ashore provide monitoring and instrumentation to ensure grid compliant power and power conditioning either on WEC or ashore.
- Shore-station infrastructure is adequate for 12kV and 70kV rated for 40MW at grid-connected host facility (VAFB) and connecting utility (PG&E).
- Energy storage in the form of batteries could be accommodated at VAFB at several locations.

C.8 Overview of Permitting and Regulatory Approach

The permitting effort developed a CalWave Regulatory Roadmap, in collaboration with the regulatory agencies and other stakeholders. A draft project description, for permitting purposes, was developed, circulated for review, and will be updated as the project progresses. The Draft FERC Pre-Application Document (Draft PAD) has been completed. This document incorporates the draft permitting project description, environmental baseline summary work that is the culmination of literature reviews, a matrix of potential permitting and licensing issues that was developed in consultation with regulatory agencies, and projections of future studies needed to resolve the issues during project permitting.

C.9 Overview of Stakeholder and Public Outreach Approach

The outreach and stakeholder engagement effort was developed in a manner consistent with PG&E WaveConnect, and executed during CalWave I and CalWave II. During CalWave II, the efforts included meetings of the CalWave Regulatory Agency Group and the CalWave Stakeholder Advisory Group (SAG) which was open to attendance from members of the public. Members of the Operational Advisory Group (OAG) participated in the October 2016 SAG meeting.

C.10 Discussion of Project Alternatives – Platform Irene Configuration

The concept of repurposing existing oil and gas infrastructure for renewable energy is technically feasible and attractive. The area off VAFB has four (4) offshore oil and gas platforms that can be repurposed into offshore substations. Platform Irene, 8 miles to the north, is an operating oil and gas rig that is grid-connected at the Surf Substation, owned by the platform operator and served by PG&E. VAFB owns land near Surf for a Shore Station. CalWave is in discussions with the platform owner to develop a cooperative use concept using the existing grid-connection of 25MW for four (4) Test Berths south of Platform Irene. Platform Irene also has pipelines to shore that may be able to be repurposed as subsea cable conduits or be used to transport desalinated water ashore produced by marine renewable energy.

C.11 Preliminary Cost and Schedule Overview

Cost estimating efforts focused on the Primary Site, and the Conceptual Design of the South Base Configuration Baseline, near Vandenberg Dock. Refinements were made as the Preliminary Design Stage was initiated. Cost comparisons were used to estimate the alternatives.

C.11.1 Primary Site – South Base (40MW)

The CalWave Team preliminary cost estimate is $82M with four (4) years from initiation of Phase 3 (Permitting) through Construction, Test and Certification.

C.11.2 Primary Site – South Base with Shore Station at Surf (40MW)

The CalWave Team preliminary cost estimate is $79M, with the same schedule.

C.11.3 Alternate Site – Platform Irene with Shore Station at Surf

The CalWave Team preliminary cost estimate is $75M. Scheduled to be determined.

C.12 Conclusions

Based on almost a decade of work by a dedicated core development team, and given the market demand and commercialization opportunities, it is reasonable to state that the CalWave site off VAFB has the potential to be one of the best wave energy sites in the United States.

The Central California Region presents market opportunities for commercial marine renewable energy that are attractive in size and value. As a result, the CalWave Test Center has the potential to be one of the most viable pathways to commercialization for marine renewable energy in the United States.

CalWave offers a versatile, reliable, and affordable test center that will remove barriers to entry for wave energy converter development, demonstration, and testing activities. The design allows a wide range of technology flexibility and minimizes risk, cost, and time-to-market. Further, based on

international benchmarking and review, the CalWave Primary and Alternative Site are well positioned to host one of the most capable and most flexible wave energy test centers in the world.

C.13 Recommendations

The CalWave Team recommends that U.S. DOE establish an integrated wave energy test architecture with early-stage to mid-stage Technology Readiness Levels (TRLs) at the National Marine Renewable Energy Center's PMEC-SETS facility in Oregon and the U.S. Navy's WETS Site in Hawaii and mature TRL testing and reliability demonstrations at CalWave where the market demand supports commercialization buildout opportunities.

SECTION D: PROJECT OVERVIEW AND SUMMARY - CalWave I and II

The California Wave Energy Test Center (CalWave) Feasibility Study sponsored by a U.S. Department of Energy (DOE) funding award (DE-EE0006517), is a program to identify and evaluate a primary offshore site along the California coast for a national wave energy testing facility appropriate for Technical Readiness Level 8-9 (TRL) Wave Energy Converters (WECs). Leveraging prior work by EPRI and PG&E's WaveConnect Program, the CalWave Team concentrated its efforts on two locations along the California coastline: (1) offshore of Humboldt Bay in the California North Coast area, and (2) offshore of Vandenberg Air Force Base (VAFB) in the Central Coast area (Figure 1-1). Throughout the CalWave Program, we employ techniques from Program and Project Management, Systems Engineering (requirements-driven design) and System Integration (spiral development) for successful project development.

D.1 Project Overview

The initial one-year feasibility study of cost, schedule, regulatory and stakeholder issues of establishing a national wave energy testing center in California was executed in 2014 and 2015 and called CalWave I. After a comprehensive siting area evaluation and down-selection process, the VAFB site was chosen for additional intensive study and the subsequent development of Conceptual Stage plans and designs. The VAFB South Base with associated test berths was designated as the "Notional Conceptual Baseline" to acknowledge a flexible combination of siting options that were identified at the end of CalWave I.

A second year of additional work was executed in 2016 and 2017 and was called CalWave II. The Notional Conceptual Baseline was confirmed as the most feasible configuration, and further developed through Conceptual Design Review with input from marine industry representatives, the VAFB host facility representative, and UK Wave Hub Ltd.

In addition to the Primary Site at VAFB South Base, the Alternate Site configuration associated with offshore oil Platform Irene was progressed using the concept of repurposing oil and gas infrastructure as offshore substations. Substantive discussions were held with the platform owners/operators and regulators.

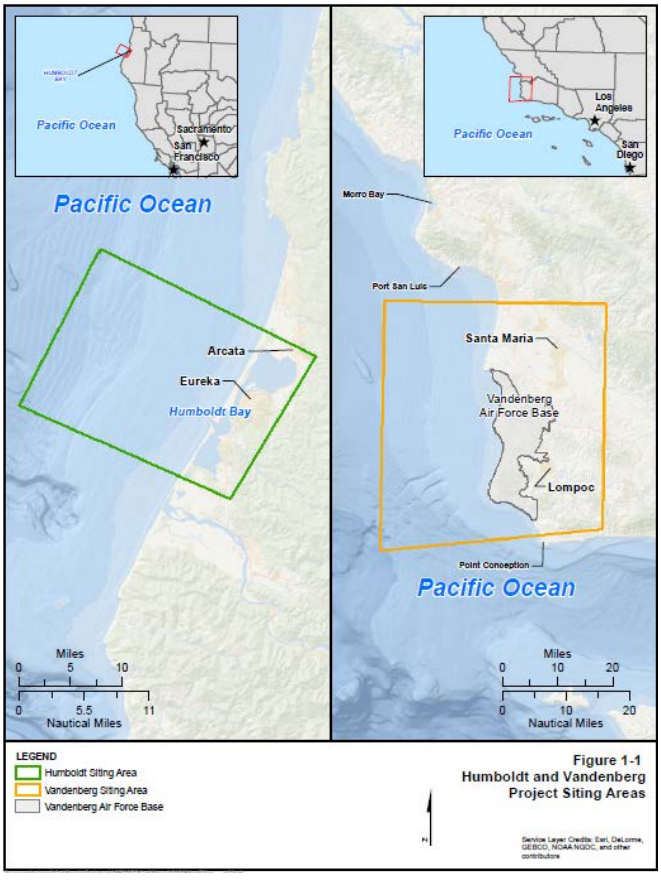

Figure D.1: CalWave Candidate Siting Areas

Development continued from Feasibility, to Conceptual, and into the Preliminary Design Stage with Engineering, Permitting and Stakeholder efforts developed to sufficient detail to produce the Draft Pre-Application Document, Regulatory Roadmap, and Stakeholder Engagement Plan for the Primary Site: the

VAFB South Base Configuration Baseline. Primary Site designs and cost estimates were leveraged and adapted to the Alternate Site: Platform Irene Configuration.

D.2 Project Objectives

The CalWave studies focused on the Statement of Project Objectives (SOPO):

- **Developing and using criteria to rank and finalize the choice for the candidate ocean test site (SOPO Task #1).** Comparison of the two candidate siting areas, Humboldt and VAFB.
- **Understanding the shore-side support infrastructure (SOPO Task #2).** Analysis of facilities, transportation infrastructure, harbor navigation, project operational resources and assets.
- **Exploring utility grid interconnection (SOPO Task #3).** Analysis of the capacities of specific substations and any required upgrades. Additionally, the task included determining the spare transmission capacity of existing submarine power cables and compiling anticipated costs for grid interconnection.
- **Identifying known environmental constraints and progress on permitting (SOPO Task #4)**. Literature reviews, desktop studies, and siting investigations to determine whether critical project development and environmental permitting issues or fatal flaws exist for prospective CalWave siting locations.
- **Public acceptance (SOPO Task #5).** Contact with key stakeholders and holding public and regulatory agency meetings to understand stakeholder issues that CalWave will encounter during development and permitting, including a summary of discussions with conclusions about expected public acceptance.
- **Top-Level Requirements and Device-Testing Criteria (SOPO Task #6)**. Develop top-level requirements and associated listing of specific test site design and a detailed analysis of the wave climate at each potential berth location for the CalWave project using a ten-year hindcast of wave conditions.
- **Develop Preliminary Design Drawings (SOPO Task #7).** Develop preliminary drawings for the baseline conceptual designs for the cables and shore station at the notional South Base location, including considerations for electrical, civil and ocean engineering as well as architecture.
- **Develop estimates of construction quantities and costs (SOPO Task #8).** Prepare general estimates of construction quantities and costs, based on inputs from conceptual design studies and preliminary bids from industry (such as offshore cable installers).
- **Develop operating, maintenance, and testing cost estimates (SOPO Task #9)**. Benchmark similar renewable energy testing centers to establish conceptual business and operational models for the test center and to develop preliminary estimates of operating, maintenance, and testing costs.
- **Develop Schedule for Site Development and Facility Construction (SOPO Task #10).** Develop a preliminary permitting, engineering design, procurement, and construction schedule for execution.
- **Develop Engineering Quantities, Cost and Schedule Estimates to Support Financing Plan, Select Preferred Location (SOPO Task #11).** Progress the design from the Conceptual Stage into the start of the Preliminary Stage. Incorporate inputs from additional meetings and initiate significant interactions with agencies/regulators/host facility to evolve both the design and operational aspects.
- **Develop Permitting Roadmap to Populate Draft Pre-Application Document PAD (SOPO Task #12).** Progress the literature review work and environmental baseline summaries to a “potential issues” matrix. Develop a draft Federal Energy Regulatory Commission Pre-Application Document (Draft PAD) with draft project description for review.
- **Develop List of Stakeholder Concerns and Develop Possible Solutions (SOPO Task #13).** Progress the outreach and stakeholder engagement effort of the CalWave Regulatory Agency and Stakeholder

Advisory Group. Develop the Operational Advisory Group. Maintain the project Fact Sheet and website with the most recent project information.

D.3 Programmatic Approach

CalWave program execution concept must balance Scope, Cost, and Schedule with Quality across Engineering, Permitting and Stakeholder elements.

The CalWave programmatic approach implements the technical, management, procurement, and administrative activities necessary for all phases of the CalWave program. In particular, the Triple Constraint Model of the Project Management Institute (PMI), that guides the balance between conflicting forces and also guides our Risk Management, Contingency Management, and Configuration Control methods.

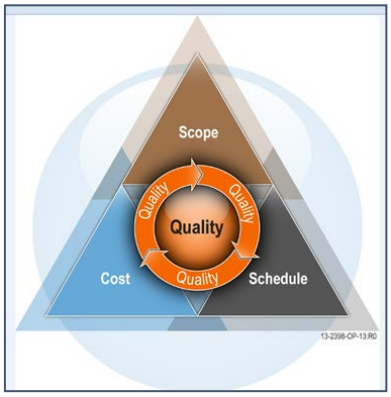

Figure D.3: Triple Constraint Model

The CalWave program envisions use of a Program Execution Plan (PEP) to employ industry best practices including: Program/project execution methods from the Project Management Institute (PMI), the stage gate methods of new product development from the Product Development and Management Association (PDMA) and the systems approach of the International Council on Systems Engineering (INCOSE).

D.4 Systems Approach

CalWave is envisioned as a permanent (25-30 year design life), fully energetic, open ocean test center that is designed for evaluation of WECs at mature TRLs (levels 7/8/9). The Conceptual Baseline Design is for a phased implementation to a fully-capable test center, rated at 25-30 MW, with an upgrade path to 50 MW.

A systems engineering approach to requirements-driven design is shown. Modular design practices and the use of proven components from related industries concepts were emphasized.

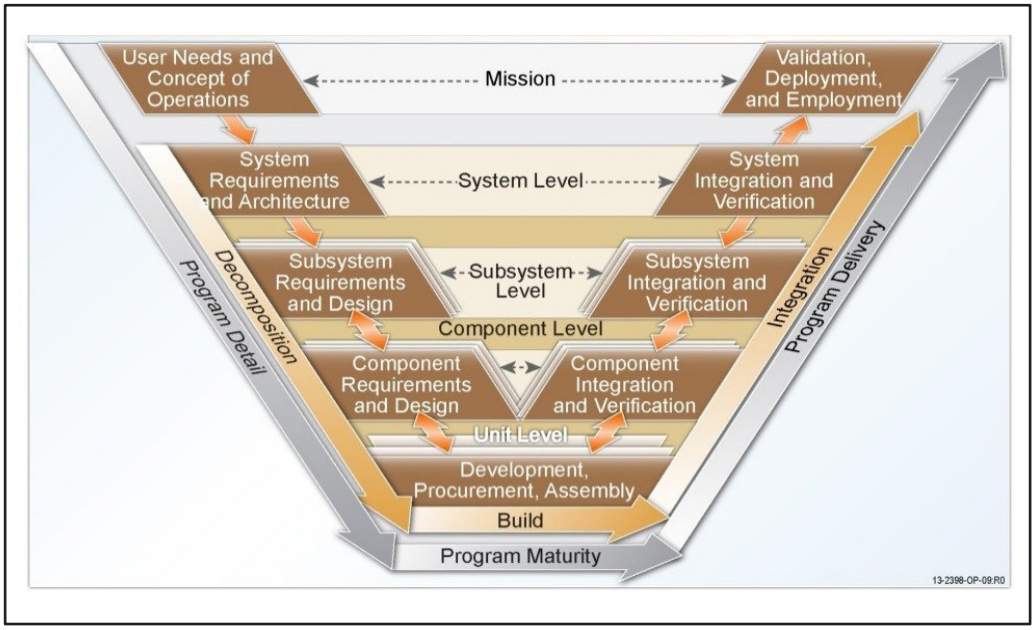

Figure D.4: Systems Engineering Approach

D.5 System Boundary

The system boundary defined, as including the Sea-Based Infrastructure and Shore-Based Infrastructure, is summarized below in the System Block Diagrams developed by Leidos, Inc**.** A more detailed discussion, including functional task areas, is in D.11 Engineering Element. Boundary systems were identified as: WEC/MEC System; VAFB-PG&E Electrical Grids; and VAFB Base Facilities.

D.6 System Block Diagram

There are two methods for describing CalWave, both emphasize the importance of interface definition and control, particularly at Designated Critical Interfaces as discussed more in Section D.11.

Grid-Referenced System Block Diagram: used during Preliminary, Final, and Detailed Design Stages. This method is "power purchaser-centered" and addresses the end goal of commercialization. It also acknowledges that the Grid is a mature Boundary System with which CalWave and WECs must comply. This method better represents the facility construction.

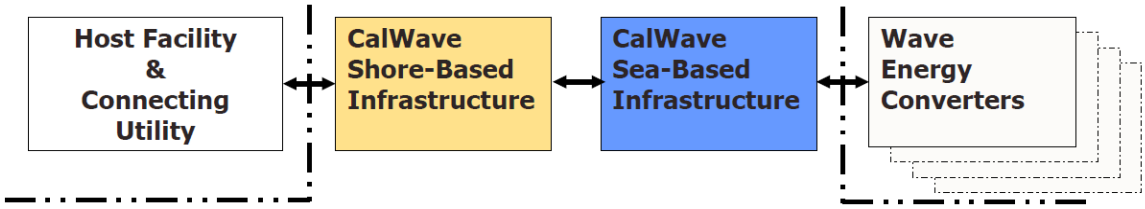

Figure D.6: Grid-Referenced System Block Diagram (Source: Leidos)

D.7 Design Approach

CalWave required a multi-disciplinary design approach that leveraged techniques from naval architecture and marine engineering for the sea-based infrastructure, terrestrial techniques for the shore-based infrastructure, techniques from New Product Development such as Stage Gate to anticipate the interfaces with the Wave Energy Converter (WEC) systems yet to be invented.

As discussed more in Section D.11, a spiral development model was adapted for CalWave to implement the cross-checks of major acquisition programs while maintaining a lean project management philosophy. Phasing and milestones were employed to prepare for the Conceptual Design Review (CDR) and will be employed through the major milestones Preliminary Design Review (PDR) and Final Design Review (FDR) yielding a Construction Design Baseline.

D.8 Site Down-Selection Process

The feasibility-stage project design envisioned a long-duration (25-30 year design life), fully energetic, open ocean facility, designed for evaluation of mature WECs at advanced TRLs. The Conceptual Baseline Design called for a phased implementation to a fully capable test center rated at 25-30 MW, with an upgrade path to 50 MW. The comparison criteria included WEC design flexibility, cable lay cost, manufacturing/shipbuilding and infrastructure support ports, variability of sea states and wave energy resource, mooring costs, accessibility for maintenance, cost for grid interconnect and existing infrastructure, regulatory and licensing processes and prospects, potential public acceptance, and long-term growth potential. The CalWave site selection process was conducted in two phases:

D.8.1 Down-selection Phase I: Humboldt or Multiple Options at VAFB

The formal multi-criteria review and down-selection process, assessed Humboldt and VAFB as documented in the Feasibility Study Final Report, (Appendix 11).

TABLE D-1
Site Selection Criteria, SOPO Task #1

No.	Site Selection Criterion
1	Wave energy resource for a test center, P_{min} 30 KW/m, months per year
2	Variability of sea states for a test center
3a	Flexibility to accommodate different WEC designs, compactness for a range of depths >75m
3b	Sea bottom terrain
4	Extreme event design environment
5	Operations port suitability/capability and affordability of ocean engineering equipment
6	Operations port proximity and ability to accomplish tasks in a day charter
7	Construction accessibility for both sea-based and shore-based infrastructure
8	Regional heavy manufacturing / marine supply chain capability
9	Regional industrial marine support operations capability
10	Certainty / length of regulatory and permitting pathway
11	Ease of interconnection for 30 MW
12	Power sales potential for 30 MW
13	Academic/research community proximity
14	Existing infrastructure for co-use, substation
15	Existing infrastructure for co-use, submarine cable
16	Stakeholder support
17	Site commercial buildout potential
18	Ease of interconnection for 300 MW
19	Proximity to shipbuilding facility for WEC fabrication

Siting area selection for the facility was driven by the test site criteria. Test site criteria development leveraged the significant efforts of the Oregon Wave Energy Trust (OWET) and the OWET Industry Advisory Council during the Territorial Sea Plan process employed by the State of Oregon to select wave energy test sites. The test site selection criteria were further refined by the CalWave Team during interviews with Marine Energy Converter (MEC) developers (focus on WECs), and benchmarking of existing wave energy test sites in the United Kingdom and evolving sites in the United States. Figure 1-1 shows the general siting areas considered in the north coast (Humboldt) and central coast (VAFB) regions.

During the siting evaluation process, the project team initially looked at five siting regions: (1) nearshore Humboldt, (2) offshore Humboldt, (3) nearshore VAFB, (4) offshore VAFB, and (5) Offshore VAFB using existing transmission from oil and gas Platform Irene. Initial analysis confirmed quickly that the nearshore sites (territorial waters) would be infeasible because of inadequate depth and relatively low available wave energy.

After identifying the candidate sites and developing the 19 scoring criteria, the project team members worked together to develop weighting scores for the criteria, recognizing that some should have more relative importance than others. In this process, each scoring participant (Cal Poly, Humboldt State University, Virginia Polytechnic Institute and State University, Leidos Maritime Solutions, Columbia Power, and CH2M) contributed a weighting score and these were averaged, with final weightings ranging from 2.0 for Criterion #4, "Extreme Event Design Environment" to 7.9 for Criterion #1 "Wave energy resource for a test center, P_{min} 30 KW/m, months per year".

The project team then developed scoring guidelines for each criterion. For example, for criterion #2, "Variability of Sea States for a Test Center," scoring focused on the number of days per year that significant wave height would be less than 1.5 m for more than 2 days in a row, with <20 scoring 0 to 2 points, 20 to 40 scoring 3-6 points, and >40 scoring 7-10 points.

Finally, the project team assigned responsibility to particular team members best qualified by their assigned roles on the project to analyze and score particular criteria and document the scoring process and findings for each criterion. The final evaluation of the candidate siting areas was determined by multiplying the site scores by the weightings for the criteria and adding up total scores by site. The result was then submitted to a review committee made up of project team members from the National Renewable Energy Laboratory, Sandia National Laboratory, and EPRI. The review committee provided comments on and endorsed the finding of the site evaluation exercise.

TABLE D-2
Siting Area Site Selection Scores

Site	Composite, Weighted Final [a]
Humboldt Area, Offshore Federal Waters, new cable from shore	5.4
VAFB Area, Offshore Federal Waters, existing cable from Platform Irene	7.7
VAFB area, Offshore Federal Waters, new cable from shore	6.8

[a] Composite of scores along 19 different criteria, each weighted by relative importance

- **Host Facility**—Vandenberg Air Force Base (VAFB) offers secure sites for a shore station and demand for test facility power. The goals of CalWave are consistent with the DOD's and VAFB's goals to develop more self-sufficient energy supplies, including renewables, and VAFB is a cooperative host and project partner. VAFB offers robust transportation and industrial facilities.
- **Shore Station**—the notional design is based on the "South Base" location near Vandenberg Dock. Vandenberg Dock was constructed for offloading rocket boosters and the Space Shuttle and is served by a well-constructed tow road to other parts of the base. Shore-station facilities would include electrical substations (12 kV and 70 kV), a switchgear building, gravel pad space to hold WEC-

developer power conditioning equipment, and operations buildings with offices for CalWave and WEC developer staff.

- **Co-Use of Existing Marine Infrastructure**— While it is conceptually feasible to co-use the existing offshore infrastructure at Platform Irene (platform, submarine power cable and shore substation), there are many engineering unknowns about platform system integration that need to be resolved via technical exchanges with the infrastructure owner. The study team has identified a potential $7 million cost savings to CalWave if we can have access to this infrastructure versus installing new cables.
- **Permitting Issues**—A critical issues analysis of environmental permitting issues in the VAFB area did not result in the identification of issues that could prevent project development or cause significant cost increases or schedule delays beyond what would be expected for a project of this nature.
- **Test Berth Sites**—Test berth sites are available within 3 to 7 nm from the Vandenberg Dock in the desired depth range of 70 to 110 m and in BOEM-defined lease blocks not currently leased for oil and gas development. The South Base location has the advantage of offering shore station facilities near good test berth locations, reducing the length and cost of the cable runs. The sites are located on sandy bottom and the prospective cable route can avoid rocky bottom near the shore using horizontal directional drilling (HDD). Note: test berth definition will be driven by BOEM Lease Block descriptions.
- **Wave Energy Resource**—the five prospective sites offer average annual energy flux ranging from 30.4 kW/m (South by Southeast) to 40.5 kW/m (South Central). The sites offer a wide variety of seasonal and year-to-year wave configurations that will be useful for testing under a variety of wave height and period conditions.
- **Shore Side Infrastructure**— the shore side infrastructure is highly developed for marine engineering and marine logistics services in support of the offshore oil industry. CalWave is located within a few nm of four offshore oil platforms, and a number of additional platforms are located farther east in the Santa Barbara Channel area. The platforms have been in operation for nearly 30 years and an oil services construction and operations industry has developed in the region. Capable shore side infrastructure is therefore readily available very near the project area. Infrastructure available includes port facilities at Port Hueneme (deep water), Santa Barbara, Port San Luis, and Morro Bay, all within a reasonable distance of the project site (i.e. 13 to 70 nm), and Vandenberg Dock at the project shore station site. Facilities include heavy lift floating (offshore rated) and dockside cranes, and a variety of work boats and other vessels, including large work vessels and cable lay vessels, remotely operated vehicles, and automated underwater vehicles.
- **Marine Operations Support—**In addition to port facilities and equipment, the offshore oil industry has fostered the development of an experienced marine operations workforce with first-hand experience supporting complex offshore industrial facilities in the project area. Local mariners have experienced a wide range of operational conditions in the area and understand marine industrial support operations.
- **Ocean Use—**Initial contacts with the local fishing communities of Morro Bay and Santa Barbara have indicated that commercial fishing concerns about a wave energy test site in the VAFB area are few and minor. The project site is not considered a productive fishing area, possibly because of the distance from port and associated transit costs, location near a restricted Vandenberg Launch Area; additionally, it is adjacent to a very large State Marine Reserve area where fishing is prohibited and to a federal Essential Fish Habitat Fishing Conservation Area where fishing for ground fish is prohibited.
- **Shoreside Land Use**—shore facilities to be located on VAFB do not conflict with land uses on the base. The base extends across 42 miles of shoreline up to the adjacent ridge tops. There are few residential,

resort, or recreational areas near the project site that could be a potential source of concerns regarding impacts to scenic viewsheds along this stretch of the coast. In addition, the WECs would be located relatively near oil platforms, compared with which they would not have a large visual profile seen from land.

D.8.2 Down-selection Phase II: VAFB Site Chosen

As a result of the siting study, the CalWave Team found that the VAFB site is better-suited for a test center. Additionally, VAFB had demand for the power output, the market conditions on the Central Coast could support wave energy commercialization, and the Central Coast industrial base was more capable. The subsequent phase of down-selection, which focused on VAFB, converged on the South Base and narrowed the test berth siting to the South and Southeast test berth locations near the Vandenberg Dock that use (VAFB) Substation "N".

D.9 Primary Site Top-Level Description

The CalWave Primary Site, referred to as the **"CalWave South Base Configuration Baseline"**, would be an open-ocean, fully-energetic, test center with four (4) test berths off the coast of VAFB on the South Base that leverages significant base infrastructure.

The test berth sites would be in BOEM lease blocks on the Outer Continental Shelf (OCS). Subsea cables would transit through Territorial waters to a shore landing near Vandenberg Dock.

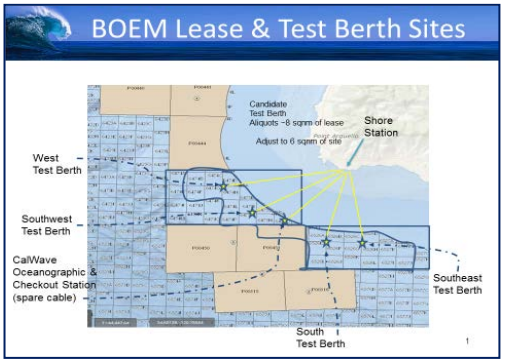

Figure D.9-1: BOEM Lease Blocks

D.9.1 Primary Site Concept

Test berth cables would be "home-run" (dedicated) cables from a dry-mate connector on the sea floor at the 50-fathom curve, approximately 3nm from Vandenberg Dock. WEC Developers would connect their WEC umbilical to the CalWave cable. Power from WEC(s) would come onto shore to verify grid-compliance and connect to the base electrical system. Power conditioning could be on the WEC device(s) or on-shore. The site is rated at 40MW.

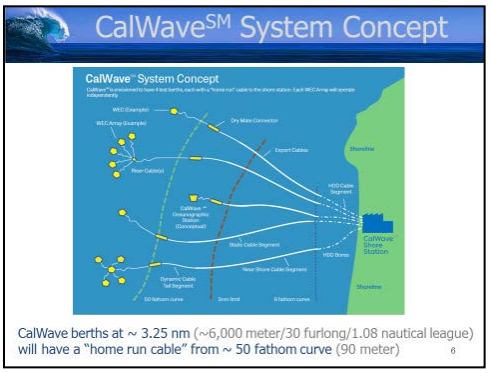

Figure D.9-2: System Concept

D.9.2 Basis of Design

The subsea cables would be surface lay, or buried from sea to the shore landing. Horizontal directional drilling would be used to provide conduits under the surf zone, thereby avoiding rock outcropping and kelp areas. The cables would transition from subsea specification to less-expensive terrestrial cabling at the "Upland" Site. Retention of excavation materials on-site, as suggested by the Host Facility, would save considerable tracking cost and carbon emissions. The Upland Site is well outside of the extreme event range for tsunamis.

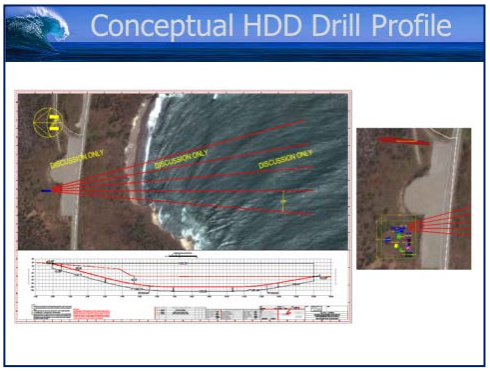

Figure D.9-3: HDD Profile

The CalWave Shore Station supports several functions: subsea cable shore landing and transition to terrestrial cabling; power conditioning area; a switchyard that provides test instrumentation and connection to the base 12kV distribution grid; a 70 kV substation and transmission line extension to Substation “N”, as well as parking and two office buildings. The Shore Station would be a CalWave controlled asset located near the Vandenberg Dock.

The Shore Station design and electrical, civil, and architectural engineering are described in more detail in Appendix 11.

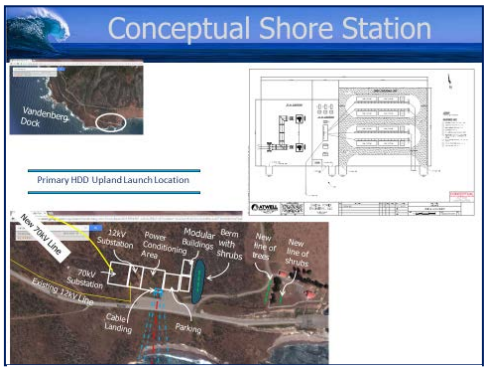

Figure D.9-4: Site Plan

D.10 Alternative Site Top-Level Description

The CalWave Alternative Site, referred to as the **"CalWave Platform Irene Configuration"**. Platform Irene is an operational oil and gas platform that is a candidate for repurposing to support offshore renewable energy.

Figure D.10-1: Platform Irene

Consistent with the Primary Site, the CalWave Platform Irene Configuration would be an open-ocean, fully-energetic, test center with four (4) test berths south of Platform Irene that would leverage the platform as an offshore switching station and/or substation.

D.10.1 Alternate Site Concept

Test berth cables would be "home-run" (dedicated) cables from a dry-mate connector on the sea floor at locations less than 1nm from Platform Irene. WEC Developers would connect their WEC umbilical to the CalWave cable. Power from WEC(s) would come onto Platform Irene to verify grid-compliance and connect to the platform electrical system and the shore cable to Surf Substation.

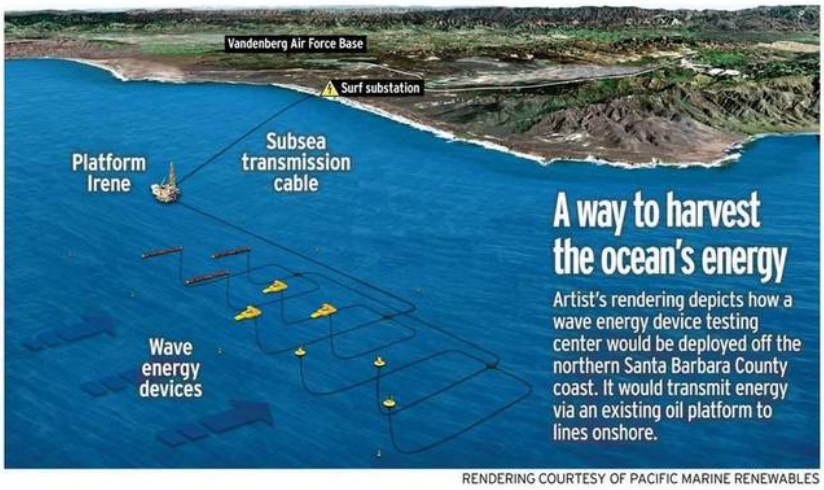

Figure D.10-2: System Concept

D.10.2 Basis of Design

The Alternative Site was addressed during the Feasibility Stage, so further development would continue in the Conceptual Stage. The basis of design for this key event (Final Report) is strongly influenced by the Primary Site Design and South Base Configuration Baseline.

This alternative is predicated on the availability of Platform Irene for repurposed use as an offshore substation or for co-use of an operational oil and gas platform, submarine power cable and shore substation. The repurposed scenario would mean fewer constraints for wave energy test center operations and would provide more operational flexibility. In the co-use scenario, much of the electrical system would be shared infrastructure that would necessarily be available to the wave energy test center at the discretion of the platform owner. Only the office buildings would be CalWave-controlled assets. This would impose significant space/volume/weight constraints and would be accommodated by a reduced compliment of test equipment and a stringent requirement for grid-compliant power from the WEC(s). However, if oil operations ceased and the oil drilling and handling equipment were removed, then there would be few constraints on placing wave test center equipment on Platform Irene's decks. Platform Irene's owner has announced that it is for sale as oil production rates have diminished in recent years. It is possible that Platform Irene could be cleared of oil production equipment and be fully available for wave test center uses in the near future.

The U.S. Bureau of Ocean Energy Management (BOEM) has indicated that repurposing Platform Irene to alternative energy uses is possible under the right conditions.

In the Platform Irene alternative, the CalWave Shore Station functions would be distributed between the Platform, Surf Substation, and the CalWave Shore Station to provide full functionality. For instance: the subsea umbilical cables of the test center would be connected to the Platform; the cables would be connected to switchgear and test instrumentation on the Platform; power generated could utilize the existing 25MW export cable ashore connecting to the Surf Substation; additional test instrumentation would be at the Surf Substation to ensure proper grid integration; the CalWave Shore Station near the Surf Substation would include office buildings and remote control functions. Connection to the PG&E transmission grid from the Surf Substation would allow “wheeling” of power to VAFB. VAFB has indicated that this arrangement would be acceptable to them.

Section D.11 - Task 11 ENGINEERING ELEMENT

Task 11 is intended to advance the engineering of CalWave to support submission of the Draft Pre-Application Document (Draft PAD) and per the SOPO: Develop Engineering Quantities, Cost and Schedule Estimates to Support Financing Plan. The Task 11 Statement of Work (SOW) states:

> *Leidos will provide system integration, systems engineering (SE&I), ocean engineering, and wave energy systems design expertise to California Polytechnic State University, San Luis Obispo (Cal Poly). The services are described as the Engineering Element for the California National Wave Energy Test Center (CalWave) Phase 2 US DOE in the Statement of Program Objectives (SOPO).*
>
> *For this Phase 2 effort, Leidos will provide the following services: 1) Engineering project management to California National Wave Energy Test Center (CalWave); 2) System Engineering and Integration(SE&I) services to CalWave; 3) Chief Engineer services to Cal Wave to coordinate design across engineering disciplines and organizations, and includes review of civil, electrical, construction engineering management and ocean engineering, under the systems engineering approach with the several major design considerations; 4) Support CalWave in benchmarking successful renewable energy test centers including coordinating a site visit by personnel from the United Kingdom (U.K.) Wave Hub; and 5) Investigate follow-on surveys and wave measurement instruments needed for CalWave, including core sampling requirements to support horizontal directional drill bore design and the requirements for a Cable Route Desktop Study that will be an input to planning.*

Engineering Summary: CalWave is envisioned as a permanent (25-30 year), fully energetic, open ocean test center designed for evaluation of WECs at mature TRLs (levels 7/8/9). The Conceptual Baseline Design is for a phased implementation to a fully-capable test center, rated at 25-40 MW, with an upgrade path to 50 MW.

The engineering tasks were managed to iteratively refine the concept from Feasibility Study into Conceptual Design Stage to and incorporate a range of alternatives:

- Two potential regional locations (Humboldt Bay and VAFB)
- Five test site alternatives
- Three potential cable landings with shore stations
- Potential co-use of an existing offshore oil platform

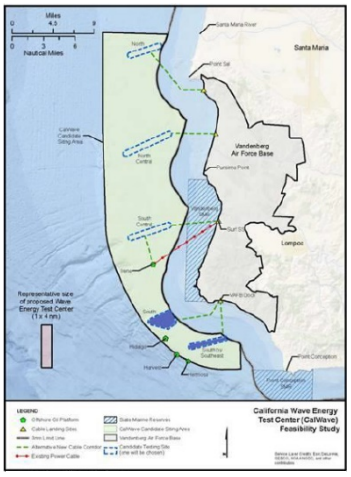

Figure D.11-1: Macro-Site

Work products listed in the SOW are incorporated in Appendix 11.

After the down-selection process to the VAFB location, further macro-siting narrowed the site selection to the VAFB South Base Site and refined the test berth sites to conform to BOEM lease blocks.

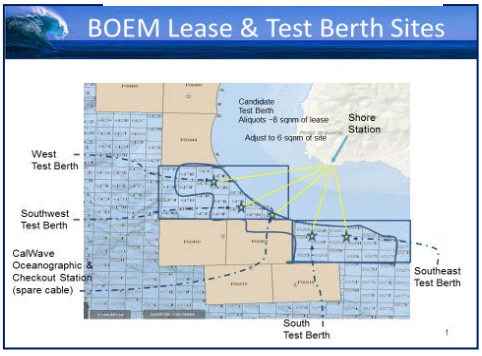

Figure D.11-2: BOEM Lease Blocks

The Conceptual Design was refined and vetted by WEC developers and test centers, and with the industry that would most-likely construct the site. Following Conceptual Design Review, emphasis was placed on a Draft Project Description adequate for the Draft Pre-Application Document (Draft PAD).

D.11.1 Engineering Project Management

The CalWave Chief Engineer of Leidos Maritime Solutions provided engineering input to the project management team and coordinated with the Cal Poly Principal Investigator, Project Manager, project management staff, and project team. Weekly project team conference calls continued; and, administrative tasks and reporting were accomplished. The Engineering Element collaborated closely with the Permitting Element and the Stakeholder Element.

D.11.2 Systems Engineering and Systems Integration

CalWave design is "requirements-driven". We determined user needs and top level requirements first and then carried these through the Feasibility Study, Conceptual Design, and into Preliminary Design Stages. We employed a system engineering approach that translates user needs into requirements; develops, analyzes, and selects from the best alternatives; and considers the total life-cycle of the design, including environmental, regulatory, outreach, and permitting.

D.11.2.1 Requirements Definition and Requirements Baseline

The CalWave requirements-driven design process drove requirements definition starting with user needs, and site selection criteria and translated those user needs into Top Level Requirements. The Top Level Requirements carried through the Feasibility Study, Conceptual and Preliminary Design Stages. The site selection criteria also informed the Top-Level Requirements, as reported in the Phase 1 Final Report and listed in Appendix 11 of this report implement CalWave as envisioned: a permanent (25-30 year), fully energetic, open ocean test center designed for evaluation of WECs at mature TRLs (levels 7/8/9), with four (4) test berths serviced by 10MW home run cables to a shore station rated at 25-40 MW, with an upgrade path to 50 MW. During Phase 1, the CalWave Shore Station was envisioned to include all shore-based infrastructure in the VAFB South Base Configuration (Primary Site).

During Phase 2, the only substantive change to the Top-Level Requirements was "decoupling" the physical location of the CalWave Shore Station subsea cable termination and electrical facilities from the Operations Center (two buildings) as needed for the Platform Configuration (Alternative Site). This refinement allows the option of placing the buildings near the Surf Substation in either configuration.

D.11.2.3 Functional Allocation

Requirements definition progressed from system level to capability level to functional allocation to feature level, as stated in the Executive Summary, expanded below, and covered in more detail in Appendix 11. Requirements analysis is ongoing as the design progresses into more detail. As alternatives are down-selected and degrees of freedom in design are reduced, the design can iteratively develop into preliminary and detailed design stages while minimizing rework.

Our systems approach is to acknowledge the multi-disciplinary engineering tasks involved including systems engineering and ocean engineering tasks as

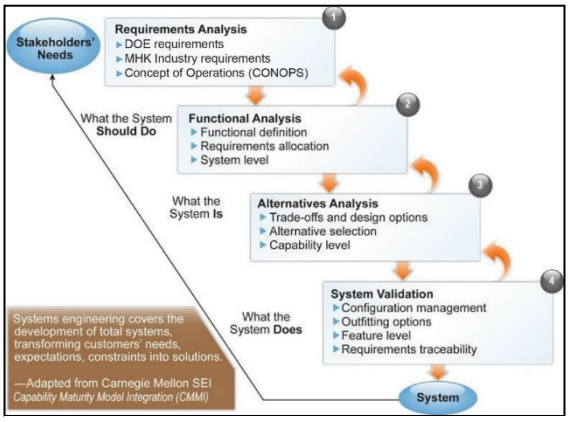

Figure D.11-3: Requirements Definition

well as civil/electrical/mechanical engineering and architecture. Each design iteration starts with requirements updates, maintains the requirements baseline, and ends with requirements tracking

D.11.2.4 Spiral Development

Since much of the design has been in the marine engineering domain, the spiral design process of naval architecture was used as a reference model for iterative design in the face of multiple uncertainties.

The system orientation of naval architecture was merged with the system engineering approach of "requirements-driven design".

Spiral development approach was employed to iterate the design from a high state of uncertainty toward a consensus design.

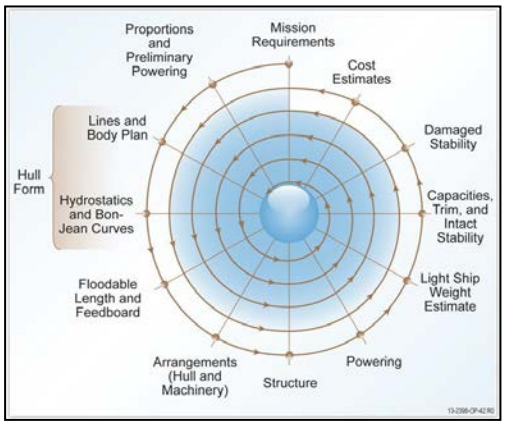

Figure D.11-4: Naval Architecture Model

The system approach workflow supports the systems engineering process and three major iterations with reviews: Conceptual Design Review (CDR); Preliminary Design Review (PDR); and, Final Design Review (FDR). In parallel, there are supporting processes that are more tightly coupled, such as:

- DOE Requirements
- Project Management
- Design Studies and Analyses
- Review and Oversight

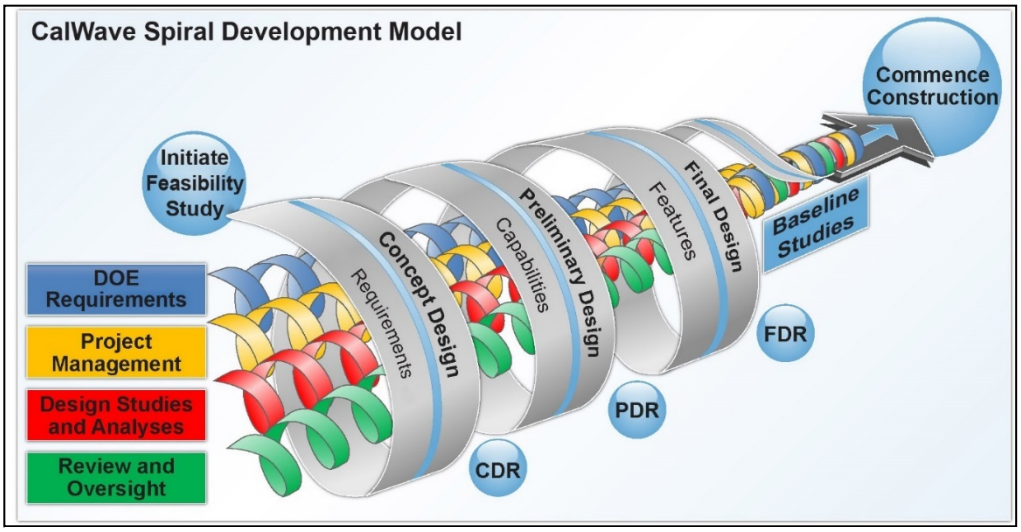

Figure D.11-5: CalWave Spiral Development Model

Phasing and milestones will leverage our existing spiral development process from Conceptual Design Review (CDR) through development of a Draft Preliminary Design adequate for the draft applications.

Systems engineering will continue to be used to ensure a requirements-driven design process. Requirements definition will progress from system level to capability level through functional allocation to feature level.

D.11.2.5 System Concept

The resulting system concept is shown.

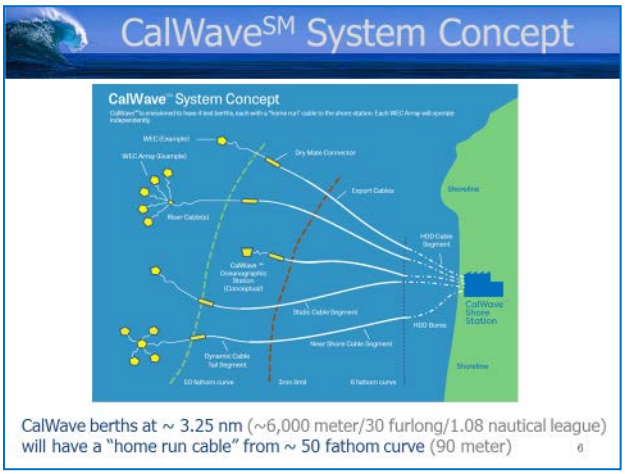

Figure D.11-6: CalWave System Concept

D.11.2.6 Interface Definition

The approach to interface definition is to use the system block diagram. A line between the blocks represents an interface. Once the interfaces are identified, the next considerations are: (1) the level of criticality, to either life or system function; and, (2) analysis of complexity, particularly where coordination is required across functional or organizational lines. This step determines the "critical interfaces" that have the highest level of controls. One of the benefits of this approach is use of as much detail as needed, and no more. This resulted in the following Preliminary Interface List:

Critical Interfaces

1. Subsea Connectors at CalWave System Boundary to WEC Subsea Connector
2. Subsea Cables to CalWave Transition Switchgear Grounding Scheme
3. 12kV Connection at CalWave System Boundary to VAFB Distribution Grid
4. 70kV Connection at CalWave System Boundary to VAFB Transmission Grid
5. WEC Onboard Monitoring and Telemetry to CalWave Control System

Controlled Interfaces

1. Subsea Cable Specification to HDD Bore Specification
2. Subsea Cable Connections to CalWave Switchgear and Instrumentation
3. CalWave Switchgear and Instrumentation to WEC Power Conditioning (inbound)
4. WEC Power Conditioning to CalWave Switchgear and Instrumentation (outbound)
5. WEC Mooring and Anchoring interface to sea floor
6. WEC interface to ocean environment
7. CalWave Shore Station to VAFB physical site (Air, Water, Ground)
8. CalWave Shore Station to VAFB environment and wildlife
9. CalWave Shore Station to VAFB cultural and historic resources

D.11.3 Design Engineering and Analysis

The Engineering Team refined the site selection that had narrowed the test berth siting to BOEM Lease Blocks that encompass the South and Southeast test berth locations near the Vandenberg Dock South Base Site. The shore station is intended to meet the minimum requirements expressed by DOE and the Host Facility. The Conceptual State design was vetted and approved during Critical Design Review.

Studies on the Subsea Cable Logistics by Center Marine, a Mooring and Anchoring Study by Glosten and Associates, naval architects, and an Extreme Events Analysis by Cal Poly are in Appendix 11.

The "Conceptual South Base Configuration Baseline", with all facilities near Vandenberg Dock, was finalized and carried into the Preliminary Design Stage as the "Preliminary South Base Configuration Baseline". The "Conceptual Platform Configuration" was considered and will require an expansion of the Surf Substation near the Surf Amtrak Station at the end of West Ocean Blvd.

D.11.3.1 Concept of Operations

A key engineering design consideration is "how will the end-users employ the system"? This question drove the Top Level Requirements development (SOPO Task #6) for developing test center operational criteria as well as the Siting Criteria. The outline of the Concept of Operations (CONOPS) in Phase I was derived from discussions with wave energy developers and experience operating surface ship engineering and submarine reactor plants.

D.11.3.2 System Work Breakdown Structure (SWBS):

The SWBS is a product-oriented frame of reference for naval architecture and marine engineering. It has been most useful during the design phases in highlighting the interfaces that must be carefully managed. See Appendix 11 for a top-level summary of the SWBS, based on the System Block Diagram.

D.11.3.3 Program Work Breakdown Structure (WBS): In contrast with the SWBS used in the design phases, the CalWave Program WBS activity-oriented and aligned with the anticipated Work Plan, structured with a hierarchy of performance period (approximately annual), tasks and subtasks. The Task Description Summary provides an additional level of definition. See Appendix 11 for WBS Summary.

D.11.3.4 Architectural/Civil Engineering

The Shore Station location is on the high ground above Vandenberg Dock as shown. The cables from test berths will come to the shore outboard of Vandenberg Dock.
Horizontal Directional Drilling (HDD) will be used for the cable landings as shown in the HDD Profile in Appendix 11. HDD will also help avoid rocky outcropping and kelp beds. An alternative cable landing near Vandenberg Dock is discussed in Appendix 11.

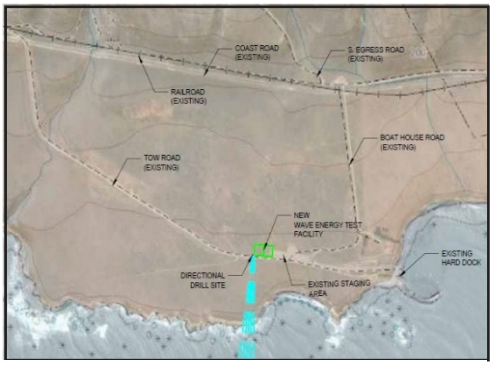

Figure D.11-7: Shore Station Site

A Cal Poly Survey Team performed a site investigation and executed a detailed topographic land survey of the conceptual onshore site location. This topographic information guided the civil, architectural, and shore-side infrastructure site layout aspects of the conceptual design. This topographic information was integrated into the conceptual project drawings.

Based on preliminary site assessment for site excavation, cut and fill quantities can be balanced on-site and HDD tailings can be used for a visual berm and retained on-site, further reducing cost.

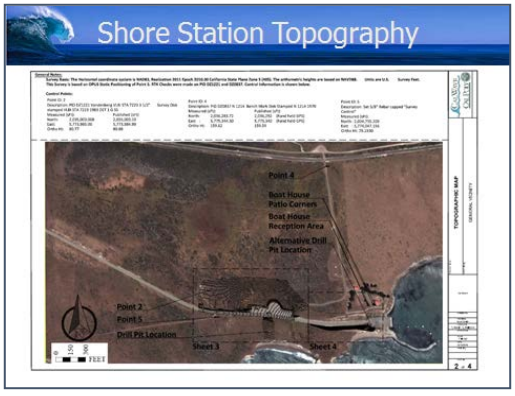

Figure D.11-8: Site Topography

This "Upland Site" (located on an approximately 100 ft x 200 ft

gravel pad) is planned as the site of two modular buildings and includes space for modular power conditioning equipment to be provided by the WEC developers. An adjacent 12 kV switchyard (located on an approximately 100 ft. x 100 ft. gravel pad) has been designed to connect with local distribution at 12 kV as well as a 70 kV Substation (located on an approximately 100 ft. x 100 ft. site on a gravel pad).

The CalWave Shore Station Operations Buildings will host key site personnel and WEC developer staff during test center operations with conference rooms, guest offices, and internet connectivity.

The top level architectural requirement could be satisfied with two standard construction job site trailers for the shore station buildings.

Figure D.11-9: CalWave Site Plan

Given the historical nature of the site, and the expected constraints to use of jobsite trailers at the location, the Cal Poly Architectural Engineering group has designed two affordable pre-manufactured, mobile, modular buildings as an alternative operations building that is architecturally consistent with the historical design of the remaining Coast Guard structure.

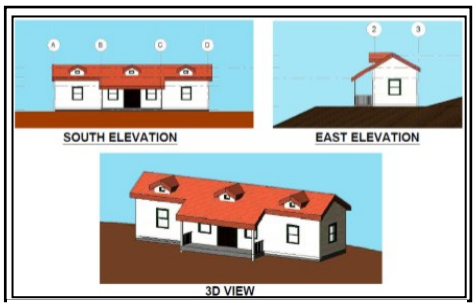

Figure D.11-10: CalWave Architecture

D.11.3.5 Electrical Engineering

The electrical design is modular in concept and uses readily available components from commercial and utility construction. The VAFB material list was also referenced for compliance to base regulations.

- Subsea cable rating and grounding scheme are key design factors
- The connection to the 12kV distribution grid will be underground to the existing pole line.
- The connection from the CalWave 70kV Substation will be above ground with a new pole line. Route and historic and wildlife resources review was conducted with favorable results.
- Single Line Diagrams and General Arrangements were evolved by picking up comments from project team and other stakeholders (including VAFB).
- Preliminary Design of 70 kV Transmission Line design was developed to the level of detail appropriate for the Draft PAD.

D.11.3.6 Grid interconnection impact study summary

Security approval was obtained from the Western Electric Coordinating Council (WECC) and the WECC database was released to Omega Power for preparation of the Transmission Impact Study. A summary was prepared which examined the impact of adding 50 MVA of WEC generators into the VAFB system. The primary focus of the task was to ensure that the installation would not require costly modifications to the PG&E transmission system to accommodate the installation. **This summary is not released for public disclosure as it constitutes proprietary/protected information.**

11.4 Benchmark Existing Test Centers overview

The CalWave Program has benefited from benchmarking activities that go back almost a decade and include two visits to EMEC, Galway Bay, and UK Wave Hub Ltd., and routine interaction with WETS, NNMREC, and Camp Rilea. Additional benchmarking was possible when UK WaveHub Ltd. joined the CalWave Team. CalWave's Electrical Engineer visited BIMEP in Spain and the CalWave Chief Engineer will visit BIMEP in March 2017.

D.11.5 Planning and Specifications – Surveys and Wave Measurements - overview

Existing geophysical, bathymetric and wave data were employed during the CalWave I and II Studies.

D.11.5.1 Wave energy resource assessment and findings summary

Data and models for the wave modeling effort were prepared by PG&E and Virginia Tech and extracted hindcast wave data for five Wavewatch III coastal grid points encompassing the CalWave candidate test berth sites, together with measured wave data from two validation stations operated by the Coastal Data Information Program (CDIP) at Scripps Institution of Oceanography.

D.11.5.2 Cable Route Desktop Study summary

The subsea cable route desktop study was completed. The survey team that conducted VAFB site visit included Fugro Pelagos, the cable logistics consultant, the HDD industry representative and CalWave's PM, Chief Engineer, Electrical Engineer and VAFB Host. The emphasis of future surveys will be to determine accurate bathymetry to support horizontal directional drill (HDD) bore profile design.

D.11.5.3 HDD Profile assessment, logistics, and determinations summary

An extensive industry survey was conducted by the CalWave Subsea Cable Route Design Team. As a result, the preferred Horizontal Directional Drilling (HDD) launch site was selected as well as an alternate launch site. See Appendix 11.

D.11.6 Construction estimate primary site - summary tables

Estimates are summarized below. See Appendix 11.

D.11.6.1 Primary Site – South Base (40MW)

The CalWave Team preliminary cost estimate is $82M with four (4) years from initiation of Phase 3 (Permitting) through Construction, Test and Certification.

D.11.6.2 Primary Site – South Base with Shore Station at Surf (40MW)

The CalWave Team preliminary cost estimate is $79M, with the same schedule.

D.11.6.3 Alternate Site – Platform Irene with Shore Station at Surf

The CalWave Team preliminary cost estimate is $75M. Schedule to be determined.

D.11.7 Follow on recommendations

We recommend that the CalWave Team continue to evolve the Preliminary Design from the Draft Pre-Application Document (Draft PAD) to Final Design Stage and into Construction, Test and Operation.

Survey work and core sampling, both ashore and offshore, will be critical path activities.

Discussions should commence with prospective Engineering, Procurement and Construction (EPC) contractors. A decision will be made if the work will be split into two categories: offshore and onshore.

The EPC RFP(s) will include a Value Engineering Review, a Final Design Review (FDR), and a Design Verification and Transfer (DVT).

D.11.8 Appendices

The following documents were developed during CalWave Phase II and are included as appendices:

- Attachment 11-1: Final Report – Task 11
- Attachment 11-2: Top- Level Requirements and Site Selection Criteria
- Attachment 11-3: Project Objectives, Alternatives and Top-Level Concept
- Attachment 11-4: System Block Diagrams and Interface Definition List
- Attachment 11-5: Cable Route Desktop Study Summary
- Attachment 11-5-1: Cable Route Desktop Study
- Attachment 11-6: Horizontal Directional Drill (HDD) Profiles
- Attachment 11-7: Civil/Architectural Engineering and Extreme Events Analysis Summary
- Attachment 11-7-1: Civil/Architectural Engineering Drawings
- Attachment 11-7-2: Extreme Events Analysis
- Attachment 11-8: Electrical Design and Interconnect Study Memo
- Attachment 11-8-1: Electrical Shore Facilities
- Attachment 11-8-2: Transmission Line Report Volume 1
- Attachment 11-8-3: System Impact Study Letter ***This file is protected/proprietary data and is not disclosed to the public**
- Attachment 11-9: Cable Logistics Lessons Learned Memo
- Attachment 11-9-1: Cable Logistics Lessons Learned Final Report
- Attachment 11-10: Mooring and Anchoring Study Memo
- Attachment 11-10-1: Mooring and Anchoring Study
- Attachment 11-11: Benchmarking: UK Wave Hub, Camp Rilea, BIMEP Memo
- Attachment 11-11-1: Marine Energy Insurance and Associated Risks for Test Sites Pres.
- Attachment 11-12: Risk Management Plan
- Attachment 11-13: Cost Estimating Summary
- Attachment 11-13-1: Comparison Table - Preliminary Cost Estimates
- Attachment 11-13-2: Basis of Estimate Cost Workbook – Rough Order of Magnitude (ROM)
- Attachment 11-13-3: Electrical Facilities Cost Estimate – Preliminary Design
- Attachment 11-13-4: Marine Operations Planning Estimate
- Attachment 11-14: 3rd Marine Hydrokinetic Instrumentation Workshop Report
- Attachment 11-15: OWET - Wave Energy Electrical Infrastructure Planning Presentation

Section D.12 - Task 12 PERMITTING ELEMENT

D.12.1 Introduction

SOPO Task 12 is intended to advance the environmental regulatory approval and permitting of CalWave. Subtasks are to evaluate environmental baseline information, review the applicability of existing marine life data, participate in stakeholder engagement activities, and prepare the regulatory roadmap for permitting the project. This document is the general report summarizing Task 12 activities for the grant. The SOPO text for the individual subtasks is presented in Section 2. Deliverables defined in the SOPO are included as separate reports that are attached to the Task 12 Summary Report (Appendix 12). They are:

- Appendix 12, Attachment 1: Federal Energy Regulatory Commission Draft Pre-Application Document (Subtasks 12.1 and 12.5)
- Appendix 12, Attachment 2: Biological Resources Data Evaluation Report (Subtask 12.2)
- Appendix 12, Attachment 3: Regulatory Roadmap (Subtask 12.4)

D.12.1 Permitting Element Overview

The following is the introduction SOPO Task 12, Permitting Element Description, verbatim, from the SOPO.

> *During Feasibility Study phase (FY2013-funded), the CalWave Project Team consulted with regulatory agencies, elected officials, and other stakeholders, held public meetings to accept general public input, and conducted literature reviews of available baseline data. This phase also involved the initial screening of candidate sites for ocean use conflicts and regulatory permitting issues.*
>
> *For the FY2015-funded phase, CalWave proposes to carry the Feasibility Study work forward to the development of environmental baseline summaries and a permitting roadmap suitable to populate the outline of a Draft Notice of Intent to File an Application for New License and Pre-Application Document (NOI/PAD) to the Federal Energy Regulatory Commission (FERC)*
>
> *Underpinning the work on the PAD is continued stakeholder involvement and public participation focused on specific candidate project sites (rather than a general siting area) that will lead to the development of permitting study plans and identification of key permitting issues.*
>
> *CalWave proposes the following subtasks during the FY2015-funded phase:*
>
> - *Literature review for key environmental disciplines and preparation of environmental baseline sections that will be included in a future PAD*
> - *Detailed evaluation of biological resources data sources identified during the Feasibility Study in terms of relevance for long-term licensing studies and monitoring plans*
> - *Additional consultation with regulatory agencies and their subject matter experts, Non- governmental Organizations (NGOs) and other stakeholders (*this is accomplished under SOPO Task 13*)*
> - *Identification of the permits and authorizations and regulatory agencies with permitting authority and a detailed permitting roadmap and schedule with analysis of*

- *the interactions between the various permits and authorizations*

Section 2 of the Summary Report summarizes project activities for the Task 12 SOPO subtasks in turn. These are:

- 12.1 Literature Review
- 12.2 Evaluation of Biological Resources Data
- 12.3 Consultation with Regulatory Agencies and Others
- 12.4 Regulatory Roadmap
- 12.5 Preparation of Environmental Baseline Summaries
- 12.6 Project Coordination

D.12.2 SOPO Subtask Summaries

The following subsections provide summaries of the CalWave SOPO Task 12 activities during the Period of Performance.

D.12.2.1 Literature Search

SOPO Subtask 12.1, Literature Search is as follows:

> *During the Feasibility Study phase, CalWave conducted detailed literature searches for (1) general environmental permitting documents in the project area such as EAs and EISs, and (2) marine biological resources in the project area. During FY2015-funded phase of work, we propose to conduct environmental baseline literature searches suitable for preparing preliminary draft environmental description sections of the PAD, for the key environmental disciplines that are required to be addressed in FERC application documents:*
>
> - *Geology and Soils*
> - *Water resources*
> - *Fish and Aquatic Resources*
> - *Wildlife and Botanical Resources*
> - *Wetlands, Riparian, and Littoral Habitats*
> - *Rare, Threatened, and Endangered Species*
> - *Recreation and Land Use*
> - *Aesthetic Resources*
> - *Cultural Resources*
> - *Socioeconomic Resources*
> - *Tribal Resources*

The activities of SOPO Subtask 12.1 were designed to gather available environmental baseline information suitable to prepare a FERC draft PAD. The purpose of the PAD, per 18 CFR 5.6, is to collect environmental baseline information suitable for the identification of key environmental regulatory permitting issues and the understanding of field and other studies that will be needed to address the issues identified during FERC licensing and through ancillary permitting processes. The PAD is then a basis for further discussions with FERC and other regulatory agencies regarding the preparation of Study Plans. Once the Study Plans are designed and approved by FERC and other agencies, they are implemented. After the studies are completed, the Applicant prepares environmental impact analyses, and designs mitigation measures, if studies identify impacts that might be significant and adverse. Thus,

the PAD does not include or focus on analysis of environmental effects.

SOPO Task 12.1 contemplates collecting environmental baseline data applicable to a PAD and preparing this information in the format of a Draft PAD so that, during the design and permitting of future phases of the project, this information could be quickly and easily modified to a PAD that could be submitted to the FERC to formally start the permitting process (after the Bureau of Ocean Energy Management [BOEM] lease application has been accepted). The SOPO mentions the FERC NOI because that document normally accompanies a PAD. The NOI is a notice of intent to start the FERC licensing process, however, and so it is premature to prepare the NOI in this early stage and it will be prepared during a future stage of the project. Preparation of the NOI is not a listed deliverable of Task 12.

The literature search conducted for Task 12.1 is summarized in the Draft PAD prepared in response to SOPO Task 12.1 and also SOPO Task 12.5 (Preparation of Environmental Summaries, see below). Task 12.1 involves the collection of the data and Task 12.5 involves the preparation of the Draft PAD. The Draft PAD is incorporated in this final report as Appendix 12, Attachment A.

D.12.2 Evaluation of Biological Resources Data

SOPO Subtask 12.1, Evaluation of Biological Resources Data is as follows:

> *Analysis of the potential effects on marine biological resources for licensing may require baseline studies, based on experience with previous MHK and off-shore wind project permitting. During the Feasibility Study phase, CalWave identified a large number of marine biological studies relevant to species that may inhabit the project area and also identified a number of repositories for data that has been periodically collected in the ocean and in the project area for a number of years. Because these data were collected for different purposes and over a long period of time, it will be necessary to evaluate them for applicability to CalWave environmental permitting.*
>
> *Existing data, if it can be interpreted in terms of its relevance to CalWave, could possibly provide a long-term perspective on the project area and potential project effects on marine fish and wildlife that could not be feasibly duplicated by data gathering efforts carried out specifically for the project. In addition, if the data can be found to be useful for CalWave permitting, this could save considerable time and effort in carrying out new studies specifically for CalWave. Evaluation of this data will also help in designing longer-term monitoring that will fit with previously recorded data, if long-term environmental monitoring is required during project operation.*

Permitting team staff collected information about long-term biological resources data sets from the project region that may be available and relevant to permitting and licensing CalWave and evaluated these data sets for relevance to the CalWave permitting process. The results of this analysis are presented in a separate deliverable, the Biological Resources Data Evaluation Report, included as Appendix 12, Attachment B.

D.12.2.3 Consultation with Regulatory Agencies and Others

SOPO Subtask 12.3, Consultation with Regulatory Agencies and Others is as follows:

> *The mechanics of regulatory agency, NGO, and public stakeholder consultation are discussed below. We will use the information gathered during consultations to identify key regulatory and permitting issues and consider preliminary study plan concepts. Preparing and the study plans in a subsequent phase and implementing work will result in collection of relevant data to address the regulatory and other issues identified during literature searches and consultations.*

Consultation with regulatory agencies took place in conjunction with the stakeholder engagement and public involvement program coordinated by Kearns & West under SOPO Task 13. These activities are described in much greater detail in the Task 13 report. See also the discussion under Subtask 12.6 Project Coordination.

Regulatory consultation activities included attendance and making presentations about the project and the proposed permitting plan at the following meetings:

- Agency Coordination Meeting – July 11, 2016 – Camarillo, CA
- Agency Coordination Meeting – October 20, 2016, Camarillo, CA
- Advisory Group Meeting – October 20, 2016, San Luis Obispo, CA
- Agency Coordination Meeting – December 8, 2016, Camarillo, CA

The permitting team also participated in specially scheduled coordination calls or meetings with the following regulatory agencies:

- BOEM Marine Renewable Energy Lease Group, Jean Thurston and Susan Zaleski, discussed Marine Renewable Energy Lease process.
- FERC Licensing Project Manager James Hastreiter, discussed FERC Licensing process
- California State Lands Commission, Jennifer Mattox, Science Policy Advisor and members of the CSLC Staff – discussed CSLC regulatory process
- U.S. Bureau of Land Management, David Ledig, California Coastal National Monument, discussed regulatory requirements of the BLM for the California Coastal National Monument

Permitting Team Staff also participated in a site visit to Vandenberg Air Force Base (VAFB) on June 14, 2016 to meet with VAFB Environmental Affairs Staff to discuss permitting issues at the Base and request copies of environmental review and analysis documents.

D.12.2.4 Regulatory Roadmap

SOPO Subtask 12.4, Regulatory Roadmap is as follows:

> *CalWave will identify the regulatory agencies with permitting authority and the permits and authorizations that will be needed before construction of the test center can begin. After consultation with regulatory agencies that has taken place during the Feasibility Study and that will continue through FY2015-funded work, CalWave will prepare a detailed permitting roadmap and schedule that identifies timing and key linkages between authorizations of different agencies and that considers subsequent pre-construction permitting phases.*

The CalWave permitting and stakeholder engagement staff worked with regulatory agencies and engaged regulatory agency staff at all-agency coordination meetings and in special meetings or conference calls with agency personnel (see discussion of Subtask 12.6, below). Information collected during these coordination activities included information about data requirements for permit applications, permit process and schedule, and linkages between allied permitting processes. The results of these efforts and other regulatory process research are consolidated and presented in the Regulatory Roadmap report, Appendix 12, Attachment C to this document.

D.12.2.5 Preparation of Environmental Baseline Summaries

SOPO Subtask 12.5, Preparation of Environmental Baseline Summaries is as follows:

> *The literature search, data evaluation, regulatory roadmap, stakeholder involvement program, and engineering design work will culminate in draft environmental baseline summaries, suitable for future inclusion in a PAD. By definition and per FERC and 18 CFR 5.6, the PAD contains "existing, relevant, and reasonably available information". Its purpose is to inform FERC and the public regarding key issues and related information needs for licensing the proposed facility. The PAD will be finalized and filed with FERC during a future phase of the project that begins the formal permitting process.*

Collection of environmental baseline data took place as part of Subtask 12.1 Literature Search. Under Subtask 12.5, the permitting team summarized the baseline data in a Draft PAD document. This document is included in this report as Appendix 12, Attachment C. The Draft PAD includes identification of key environmental regulatory permitting issues.

D.12.3 Project Coordination

SOPO Subtask 12.6, Project Coordination is as follows:

> *This task includes coordination with the project team, weekly project team conference calls and administrative expenses (review and approval of invoices, etc.), quarterly reports, and input to draft final report and final report. It also includes coordination with other wave energy test centers, including a site visit to previously established test centers, in particular the UK Wave Hub.*

Project Permitting Team staff participated in the stakeholder engagement and public involvement program coordinated by vendor Kearns & West under SOPO Task 13 and these activities are described in much greater detail in the Task 13 report.

Permitting Team Staff also participated in a site visit to VAFB on June 14, 2016 to meet with VAFB Environmental Affairs Staff to discuss permitting issues at the base and request copies of environmental review and analysis documents. The VAFB site visit also included meeting with the cable route desktop study and cable installation lessons learned subcontractors, a horizontal directional drill specialist, and the project team's Chief Engineering and lead Electrical Engineer.

The permitting team leader attended weekly conference calls for the duration of the project.

The permitting team leader also attended the following conferences focused on marine renewable energy:

- California Offshore Renewable Energy Conference, University of California, Davis, October 3, 2017
- Marine Renewable Energy Workshop for the California Energy Commission Integrated Energy Policy Report, May 25, 2016. Permitting lead Douglas Davy made a presentation on renewable energy permitting.

A site visit to the UK Wave Hub test center was not included in the final scope and budget for the program. However, CalWave sponsored officials from the UK Wave Hub on a site visit to the CalWave site and members of the permitting team interviewed Wave Hub Commercial Director Stuart Herbert, regarding the permitting and environmental regulatory issues surrounding Wave Hub.

Section D.13 - Task 13 STAKEHOLDER ELEMENT

A program of the complexity and visibility of CalWave requires the close integration of program management, engineering, permitting and stakeholder activities from the beginning and executed consistently throughout.

Deliverables defined in the SOPO are included as separate reports that are attached to the Task 13 Summary Report (Appendix 13). They are listed in Section D.13.8 below.

D.13.1 Stakeholder Element Overview

Outreach and engagement for this phase of CalWave was designed to support continued project development by informing stakeholders about key concepts related to project design, engineering, and permitting, and incorporating their feedback into these activities.

D.13.2 Goals for Outreach and Engagement

At the outset, the Project Team set the following goals for outreach and engagement:

- Transparent, robust, and clear information-sharing;
- Early, inclusive engagement and outreach with all affected/interested stakeholder groups;
- Meaningful response to inquiries; and
- Inclusion of stakeholder interests, where possible.

Above all, the engagement and outreach efforts aimed to incorporate information received from stakeholders and agencies early and throughout the process, ultimately leading to better project engineering and development as well as quality and efficient permitting and licensing.

D.13.3 Outreach and Engagement Approach

During CalWave Phase II, the project team conducted outreach and engagement with the following categories of stakeholders:

- Federal, state, and local permitting agencies
- Tribes (both federally- and non-federally-recognized)
- Local business interests
- Local coastal communities
- Fishing communities
- Recreation and environmental interests
- Navigation and marine interests
- Academic institutions
- Power industry
- Labor

D.13.4 Outreach and Engagement Activities

During CalWave Phase II, the Project Team placed emphasis on continued collaborative work with the regulatory agencies, convened a project Stakeholder Advisory Group comprised of representatives from all stakeholder categories, and engaged a group of experts to inform future project operations. Engagement focused on understanding and limiting potential impacts to existing ocean uses including navigation, shipping, fishing, recreation, and tourism

D.13.4.1 Regulatory Agency Group

The Project Team initiated engagement with the Regulatory Agency Group during the first phase of CalWave. During this second phase of effort, work with the Regulatory Agency Group was part informational in nature and part discussion and feedback-oriented.

Informational activities with the Regulatory Agency Group included: presentations about wave energy device types, including anchoring and mooring mechanisms; information about relevant existing studies in the project area; and scientific presentations about any potential impacts of electromagnetic fields (EMF) from subsea transmission cables to species in the area, potential impacts to marine mammals, and potential acoustic impacts from wave energy devices to species.

The Project Team sought feedback from regulatory agencies regarding siting parameters, issues that would need to be addressed during permitting, sources of available information for permitting, and information to be included in the FERC Draft PAD.

The Regulatory Agency Group met three times during this phase of the project, in July, October, and December 2016. The group was highly engaged, with nearly every relevant agency participating in each meeting either by webinar or phone. Meeting summaries are included in the appendices.

D.13.4.2 Stakeholder Advisory Group

In October 2016, the Project Team convened a Stakeholder Advisory Group comprised of a cross-section of interested stakeholders including fishing, environmental, recreation, local business, local policy leaders, tribes, and state and federal regulatory agencies, to provide input on siting, issue identification, and other topics of interest. This group held its first meeting in October 2016 to review its charter, learn about current project design, engineering, and permitting, and provide feedback on potential resource effects and information that will be needed for permitting. The meeting was open to the public and had more than 40 participants.

D.13.4.3 Operational Advisory Group

The CalWave Operational Advisory Group (OAG) is composed of local mariners and marine operators and those who employ marine services in the CalWave area. The purpose of the OAG is for CalWave to benefit from the decades of ocean engineering projects associated with oil and gas as well as experience and collaboration with fishermen. The OAG spans a range of geography and industry from Los Angeles/Long Beach Basin to Morro Bay. The OAG currently has 12 members, but will be expanded in the future to ensure access to the following skill sets and ranges:

- Shore side (ports, cranes, land transportation, rail);
- Water side (vessels, barges, landing craft, divers, ROVs); and
- Those in the middle (marine operations, marine constructors, HDD, cable installers, and geotechnical/bathymetric surveyors).

The Co-Chairs span the geographic catchment for marine services. The Co-Chairs attended the October 2016 Stakeholder Advisory Group meeting to provide marine operations input. In 2016, OAG members reviewed the project Conceptual Design and determined that it is both realistic and executable.

D.13.5 Outreach Materials

In order to support information-sharing to a broad array of interested stakeholders, the Project Team created and maintained the following outreach documents:

- Project website, with information about CalWave, the wave energy industry, and project milestones

- Fact sheet, with information about CalWave's purpose, development, and milestones, as well as public engagement opportunities;
- Email updates to stakeholders; and
- Ongoing development of a stakeholder contact database.

D.13.6 Key Issues Addressed During Phase II

The Regulatory Agency Group made significant progress during CalWave Phase II. The group reviewed and discussed existing information available and underway that is relevant for understanding potential land-based and marine resource impacts. Strong relationships have been established between the project team and the regulatory agencies given the almost two-year effort associated with CalWave, as well as the previous WaveConnect project in both Humboldt and Central Coast. Also, given the co-funding efforts by the State of California, including the State Lands Commission and the Natural Resources Agency (which includes the California Department of Fish and Wildlife, the Ocean Protection Council, and the California Coastal Commission) the groundwork has been laid to work closely through an efficient permitting process together with the state and federal agencies involved.

The 2016 Regulatory Agency Group meetings showed that the group is comfortable with using an "envelope" approach for permitting WEC devices and anchoring and mooring systems. The group will aim to permit WEC devices and anchoring and mooring systems that fall within a given set of parameters or boundaries; if a project developer wants to participate in CalWave, those project elements must fall within the "envelope" or be subjected to additional permitting activities. Future permitting activities will focus on defining that "envelope," including appropriate mitigation and adaptive management measures, where appropriate.

The meetings during this phase also clarified the information that the agencies think they will need to complete permitting activities. At these meetings, the permitting team shared a matrix listing possible environmental permitting issues by project "zone" (shore station, cable run, and test berths) with the regulatory agencies and asked them to comment on or add to the list from the perspective of their particular agency. The consolidated list of issues was discussed at the December meeting, with the goal of trying to define studies that could be conducted during a later permitting phase to address the issues. These matrices including the agencies' feedback are included in the appendices.

Lastly, agency personnel gave useful presentations on recent studies on the effects of electromagnetic field (EMF) emissions from subsea power cables (Ann Bull of the Bureau of Ocean Energy Management [BOEM]) and whale entanglement and acoustics issues (Greg Sanders of BOEM). The agencies generally concurred, after learning more about recent EMF studies, that EMF is not likely to be a major issue for permitting CalWave.

Initial work with the Stakeholder Advisory Group showed that the diverse membership is engaged, interested, and ready to discuss aspects of project design, engineering, permitting, and ultimately, avoidance, minimization, and mitigation measures. The October 2016 discussions focused on understanding parameters of the scope of the project (footprint of the devices, parameters of the cable lay), interaction between fishing gear and the project, project location relative to existing fishing grounds, decommissioning, and potential environmental studies. The participants were very involved in the discussions and requested additional meetings in early 2017.

D.13.7 Recommendations for Future Work

D.13.7.1 Topics for Outreach and Engagement

The first two phases of CalWave identified an array of topics that must be addressed in greater detail in future phases. These include:

- Potential impacts to military operations in the area
- Navigational safety review of activities in the area
- Siting of wave energy devices to minimize impacts to existing fishing operations
- Potential future mitigation for lost fishing gear
- Potential marine mammal and fisheries impacts of the project

Additionally, further discussion will be needed on the following regulatory items:

- Defining and clarifying the "envelope" for permitting
- Concurring on the list of studies needed for permitting, and subsequently for monitoring and adaptive management
- Defining the regulatory roadmap, including jurisdictions/responsibilities and corresponding timeframes

D.13.7.2 Approaches for Outreach and Engagement

Based on the information gathered during this phase, the Project Team recommends the following approaches for engagement and outreach for future phases of the project.

- Continued group meetings. The Regulatory Agency Group, Stakeholder Advisory Group, and Operational Advisory Group are comprised of highly engaged and interested participants. These groups will provide crucial information for continued project engineering and development, permitting, and serving a broader outreach/liaison function with additional stakeholders.
- Public meetings. At project milestones, host one or two public meetings in the project area to provide updates, solicit feedback on project siting and other characteristics, and share next steps. These meetings serve as an important bridge between Advisory Group members and citizens who are also interested in participating in project development.
- Small group and one-on-one meetings. Holding individual meetings with interested stakeholder groups, policy leaders, and others can be a highly effective way of listening to concerns, sharing information, and coming to agreement about preferred options for project development. Where possible, the project team should reach out to individual communities, most importantly the local fishing communities, local elected officials, and individual tribes (both federally-recognized and non-federally-recognized).

To achieve the goals listed above, we recommend placing a high priority on maintaining an up-to-date, clear project website and sending quarterly electronic updates to stakeholders. These activities will enable stakeholders to understand the public engagement and outreach process and timeline, and how to participate, if desired. To leverage these resources, we also recommend that each advisory group member and project team member/affiliate (as appropriate) reach out to his/her respective constituents to more directly share informational updates and seek feedback.

We recommend updating and continuing to use the following outreach materials:

- Fact Sheet. A fact sheet can be used to effectively brief stakeholders and legislators about the project, including major development milestones and unique aspects of the project

- PowerPoint Presentation. A single presentation can be used to explain the project highlights and development process to any group seeking a briefing on the project.
- Project Maps. These maps should contain not only the anticipated project location, but also overlays showing existing ocean uses and ranges of key species of concern.
- Stakeholder Database and Comments. As project development continues, develop and maintain a stakeholder database as well as gather a list of major stakeholder comments and concerns and publish a document that explains how each comment has been, or will be, addressed as the project is developed. This enables greater transparency and helps all stakeholders to see how concerns are being addressed.
- Frequently Asked Questions. These questions and answers will enable stakeholders to understand more about particular aspects of project development including how siting decisions are made, who is involved in the environmental review process, how the potential project would be laid out and operated, and others.

D.13.8 Appendices

The following documents were developed during CalWave Phase II and are included as appendices:

- 13-1 July 2016 Regulatory Agency Meeting Summary
- 13-2 July 2016 Regulatory Agency Meeting Presentation
- 13-3 October 2016 Stakeholder Advisory Group Meeting Summary
- 13-4 October 2016 Regulatory Agency Meeting Summary
- 13-5 December 2016 Regulatory Agency Meeting Summary
- 13-6 December 2016 Regulatory Agency Meeting Presentation
- 13-7 December 2016 Regulatory Agency Meeting Presentation from Greg Sanders
- 13-8 Stakeholder Advisory Group Members
- 13-9 Regulatory Agency Group Members
- 13-10 Matrix of Onshore Landing Topics of Interest
- 13-11 Matrix of Cable Route Topics of Interest
- 13-12 Matrix of WEC Test Berth Topics of Interest
- 13-13 CalWave Fact Sheet

Section E: CONCLUSIONS and RECOMMENDATIONS - CalWave I and II

E.1 Summary of Study Results and Objectives

The California National Wave Energy Test Center (CalWave) Studies progressed from Feasibility Stage, through Conceptual Stage and into Preliminary Design Stage with full integration of Program Management, Engineering, Permitting, and Stakeholder Elements. As articulated above, The CalWave site off VAFB has the potential to be one of the best wave energy sites in the United States.

The Central California Region presents significant market opportunities for marine renewable energy compared to other sites in the United States. The CalWave Test Center has the potential to provide the most viable path to commercialization for wave energy in the United States.

The resulting design concept, engineering implementation, permitting roadmap and stakeholder plan, as well as the Concept of Operations (CONOPS), cost and schedule estimates, provide an executable program that has been vetted with WEC Developers and marine industry and will result in the desired outcome of providing a world class test facility that will provide the capabilities and flexibility needed to greatly accelerate the commercialization timeline of wave energy technology.

E.2 Engineering Summary

The CalWave Engineering Element progressed efficiently through program stages: Feasibility Study; Geographic Site Down-Selection; Conceptual Design; Macro-Siting; Micro-Siting. Engineering, Permitting, and Stakeholder activities. Phase 1 progress was reported in the CalWave I Final Report.

The Engineering Element followed a Systems Engineering and System Integration Approach that was based on the guidelines: Requirements-Driven; Technology-Neutral; and, Vendor-Agnostic. These guidelines were necessary to design a test center that will become operational in 2020-2022, have a 30-year design life, and support Wave Energy Converters that have not yet been invented.

Given the complexity of the design task, and the marine domain, a Spiral Development Model was employed for iterative approach

A viable Primary Site was identified and developed to sufficient detail to produce the Draft Pre-Application Document (Draft PAD), Regulatory Roadmap, and Stakeholder Engagement Plan for the Primary Site: the South Base Configuration Baseline.

Additionally, a viable Alternate Site was identified and developed for comparative estimating.

E.3 Permitting Summary

The CalWave Permitting Element efforts progressed efficiently, and leveraged existing knowledge bases through literature reviews; issue identification; and interaction with stakeholders, agencies, and regulators; and resulted in the Draft Pre-Application Document (Draft PAD) and Regulatory Roadmap. The permitting element supported both the design and the stakeholder processes for the Primary Site: the South Base Configuration Baseline.

Permitting leveraged an extensive history of wave measurement and site characterization in prior studies and development include multiple studies on ocean energy by CalWave Partner Electric Power Research Institute (EPRI), starting in 2004, and by the core development team as documented in the Feasibility Study for the California Wave Energy Test Center (CalWave I). The CalWave Partner Pacific Gas and Electric Company (PG&E) WaveConnect Program started with two sites identified in a June 2004 study by the Electric Power Research Institute (EPRI) and evaluated sites off Fort Bragg in Mendocino County, CA and Eureka in Humboldt County, CA in 2007. After site visits, the Fort Bragg site and the associated Noyo Harbor were determined to be unsuitable for a test center. After an extensive search

for another site, VAFB was added in 2009. In 2010, PG&E submitted a Draft Pilot License Application to the Federal Energy Regulatory Commission (FERC) for the Humboldt site. These events were reported in the PG&E WaveConnect Final Report in December 2011.

In CalWave I, site selection criteria were reevaluated at Humboldt and VAFB. VAFB was selected as the primary site, then macro-siting alternatives were further down-selected to a notional conceptual site at VAFB South Base with Test Site off Pt Arguello.

During CalWave II, macro-siting was further developed and micro-siting was progressed and VAFB South Base was designated as the primary site. An alternative site in the VAFB area at Platform Irene was also identified and evaluated.

E.4 Stakeholder Summary

The outreach and stakeholder engagement effort was developed in a manner consistent with PG&E WaveConnect, and executed during CalWave I and CalWave II. The Project Team placed emphasis on continued collaborative work with the regulatory agencies, convened a Stakeholder Advisory Group comprised of representatives from all stakeholder categories, and engaged a group of experts to inform future project operations. The Regulatory Agency Group met three times during this phase of the project, in July, October, and December 2016. The group was highly engaged, with nearly every relevant agency participating in each meeting either by webinar or phone. During these three meetings, the agencies: reviewed and discussed existing information available and underway that is relevant for understanding potential land-based and marine resource impacts; confirmed the use of an “envelope” approach for permitting WEC devices and anchoring and mooring systems; and clarified the information that agencies think they will need to complete permitting activities.

The Stakeholder Advisory Group held its first meeting in October 2016 to review its charter, learn about current project design, engineering, and permitting, and provide feedback on potential resource effects and information that will be needed for permitting. Initial work with the Stakeholder Advisory Group showed that the diverse membership is engaged, interested, and ready to discuss aspects of project design, engineering, permitting, and ultimately, avoidance, minimization, and mitigation measures. The October 2016 discussions focused on understanding parameters of the scope of the project (footprint of the devices, parameters of the cable lay), interaction between fishing gear and the project, project location relative to existing fishing grounds, decommissioning, and potential environmental studies. The Project Team also created and maintained a project website and fact sheet and circulated email updates to stakeholders to ensure information-sharing to a broad array of interested stakeholders.

E.5 Primary Project Site Conclusion

The CalWave Primary Site (the VAFB South Base Site) will support full-scale, multi-unit array, grid-connected wave energy technology demonstrations and research in an area with market demand for wave energy, including 25MW demand from the onshore host, Vandenberg Air Force Base (VAFB). CalWave is designed with four (4) 10MW Test Berths in fully-energetic wave resource conditions with average annual power densities exceeding 30 kW/m, in water depths ranging from 70 to 120 meters, but still close to shore. The Primary Site design is rated at 40MW, with a path to 50MW, and has been developed into Preliminary Design Stage with adequate detail for a Draft PAD.

The VAFB South Base Configuration Baseline leverages a decade of work, supported by U.S. DOE funding, by a dedicated core development team. Based on the work performed by EPRI, the PG&E WaveConnect Team, and CalWave, it is reasonable to state that the CalWave site off VAFB has the potential to be one of the best wave energy site in the United States.

The CalWave System Concept is centered on “home run” cables and features that allow WEC Developers to field their mature pre-commercial system designs with a minimum of test facility-induced constraints. The dedicated cables enable precise measurement of performance and power quality from each test berth hosting individual devices or arrays. This design captures significant “lessons-learned” from European wave energy test centers and leverages input from the UK Wave Hub Ltd. resulting in the design of a world class WEC testing facility that has the potential to provide unparalleled capability and maximum flexibility to technology developers.

E.6 Alternate Project Site Conclusion

The CalWave Alternate Site (Platform Irene Site) will also support full-scale, multi-unit array, grid-connected wave energy technology demonstrations and research in an area with market demand for wave energy, including 25MW demand from the onshore host, Vandenberg Air Force Base (VAFB). The CalWave Alternate Site is also designed with four (4) 10MW Test Berths in fully-energetic wave resource conditions with average annual power densities exceeding 30 kW/m, in water depths greater than 60 meters and connected to an offshore platform. The Alternate Site design is based upon the Primary Site and has been developed through Feasibility Stage into Conceptual Design Stage. The Alternate Site is rated at 25MW, with a path to 50MW.

The trade-space between the two sites includes: projected cost saving in cabling and horizontal directional drilling at Platform Irene and the elimination of permitting for new cable landings in the 25MW configuration, versus higher engineering complexity, more complicated access requirements for boats and helicopters, and higher operating costs.

E.7 Cost, Schedule, and Economics Recap

The CalWave Primary Site, in the South Base Configuration Baseline, is estimated (Preliminary) at $82M with a schedule to become operational in 2021-22 with a design life of 30 years.

E.7.1 Cost Summary

The CalWave Primary Site, in the South Base Configuration Baseline, is estimated (Preliminary) to include approximately $60M in construction costs and $22M in Non-Construction Costs, for a total of $82M. These estimates include conceptual-level quotations from key vendors

The CalWave Primary Site, in the South Base Configuration Baseline, is estimated (Preliminary) to include approximately $40M in construction costs, associated with less subsea cabling and no horizontal directional drilling, and $35M in Non-Construction Costs to include platform engineering, increased marine operations, and access constraints, for a total of $75M.

E.7.2 Schedule Summary

The conceptual schedule is shown in Figure E.7-1.

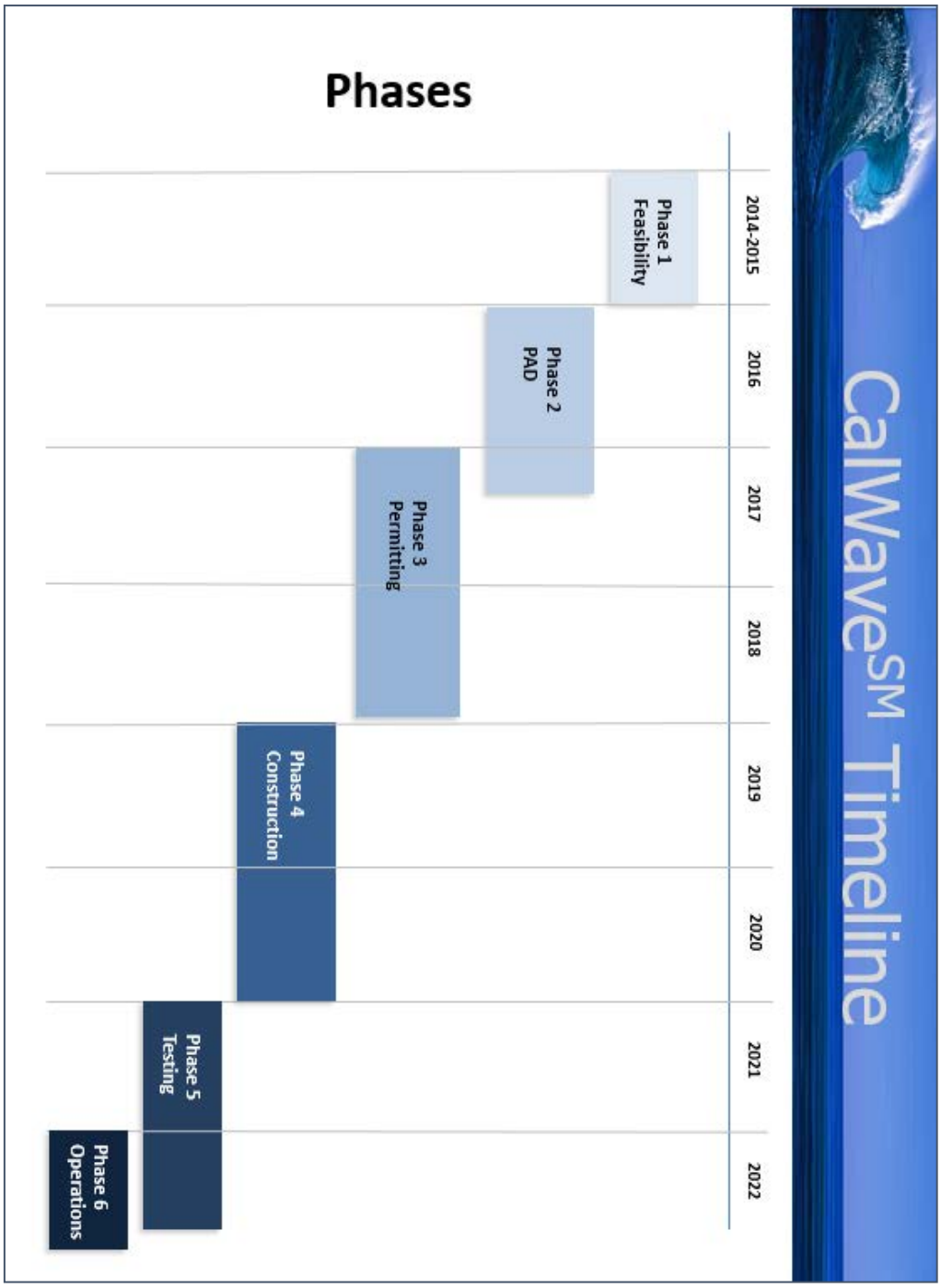

Figure E.7-1: Conceptual CalWave Acquisition Timeline

Figure E.7-2 shows the schedule in greater detail

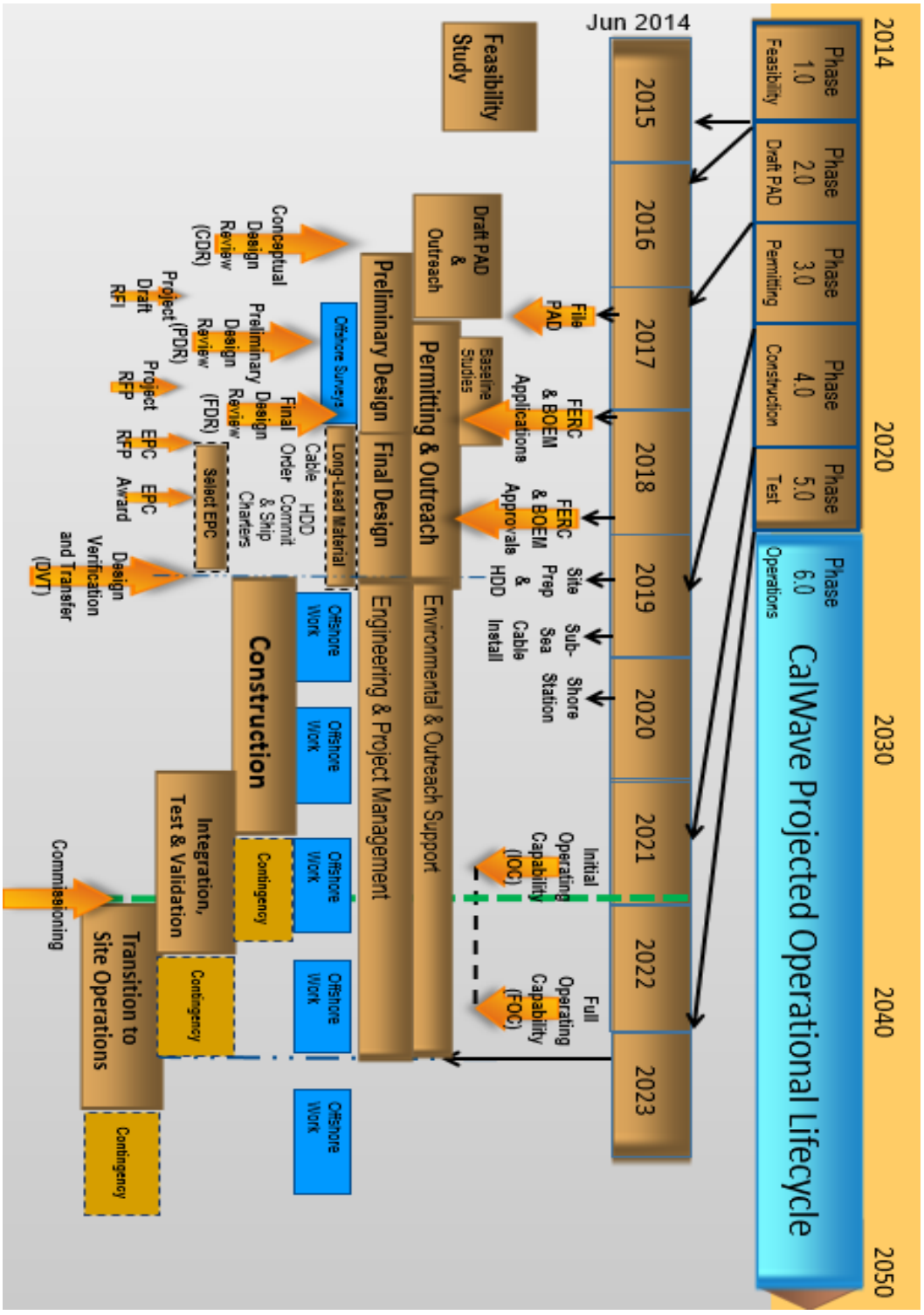

Figure E.7-2: Detailed Conceptual Timeline

The Work Plan is based on the CalWave Program Phases (Projects) proposed timeline, summarized here:

Table E-1 – CalWave Program Phases and Proposed Timeline					
SOPO	**Phase**	**WBS**	**Task Name**	**Start**	**Finish**
	Phase 0	0	WaveConnect (WaveConnect Completed)		
	Phase 1.0	1	Feasibility Study (CalWave I Completed)	5/7/14	10/7/15
	Phase 2.0	2	Draft PAD (CalWave II In Progress)	2/1/16	2/28/17
III	**Phase 3.0**	**3**	**Permitting (2017-2018)**	**3/1/17**	**12/31/18**
III-0		3	Contracts and PM	3/1/17	12/31/18
III-1		3.1	Engineering	3/1/17	12/31/18
III-2		3.2	Permitting/Environmental	3/1/17	7/31/18
III-3		3.3	Outreach	3/1/17	
III-4		3.4	In-Process Design Review	6/20/17	1/8/19
III-5		3.5	Initial Contracting Baseline	8/1/18	11/6/18
III-6		3.6	Change Management	9/7/17	12/17/18
III-7		3.7	Reporting	3/1/17	12/31/18
IV	**Phase 4.0**	**4**	**Construction (2019-2020)**	**10/1/18**	**12/31/20**
IV-0		4	Contracts and PM	10/1/18	12/31/20
IV-1		4.1	Engineering and Final Design	10/1/18	12/31/20
IV-2		4.2	Permitting/Environmental	10/1/18	12/31/20
IV-3		4.3	Outreach	10/1/18	12/31/20
IV-4		4.4	In-Process Design Review	3/18/19	9/4/19
IV-5		4.5	Configuration Management	10/1/18	12/31/20
IV-6		4.6	Change Management	10/1/18	12/31/20
IV-7		4.7	Reporting	10/1/18	12/31/20
V	**Phase 5.0**	**5**	**Test (2020-2021)**	**10/1/20**	**12/31/21**
V-0		5	Contracts and PM	10/1/20	12/31/21
V-1		5.1	Engineering	10/1/20	11/23/21
V-2		5.2	Permitting/Environmental	10/1/20	12/31/21
V-3		5.3	Outreach	10/1/20	12/31/21
V-4		5.4	Test Readiness Review	2/4/21	2/9/21
V-5		5.5	Configuration Management	10/1/20	12/31/21
V-6		5.6	Change Management	10/1/20	12/31/21
V-7		5.7	Reporting	10/1/20	12/31/21
VI	**Phase 6.0**	**6**	**Operations (2021-2022 plus 30 years)**	**10/1/21**	**12/30/22**
VI-0		6	Contracts and PM	10/1/21	12/30/22
VI-1		6.1	Engineering	10/1/21	10/13/22
VI-2		6.2	Permitting/Environmental	10/1/21	12/30/22
VI-3		6.3	Outreach	10/1/21	12/30/22
VI-4		6.4	Operational Readiness Review	2/4/22	2/9/22
VI-5		6.5	Configuration Management	10/1/21	12/30/22
VI-6		6.6	Change Management	10/1/21	12/30/22

E.8 Recommendations and Further Study Needs

We recommend that the CalWave Team continue to evolve the Preliminary Design from the Draft Pre-Application Document (Draft PAD) to Final Design Stage and into Construction, Test and Operation.

In the next phase of work, we will review responses from agencies and regulators and incorporate inputs, update the Preliminary Design, and submit a BOEM lease application and the Pre-Application Document (PAD) to FERC.

The responses and conditions associated with approval of the PAD will be incorporated into the design and we will conduct a Preliminary Design Review (PDR). After PDR actions are incorporated, we complete the Preliminary Design.

Survey work and core sampling, both ashore and offshore, will be critical path activities.

At that point, we proceed into the Final Design Stage to support selection of an Engineering, Procurement and Construction (EPC) contractor. The EPC RFP will include a Value Engineering Review, a Final Design Review (FDR), and a Design Verification and Transfer (DVT).

After Value Engineering inputs are considered and FDR actions are incorporated, we will complete the Final Design and then conduct the DVT. After the EPC completes DVT, they will commence the Detailed Engineering Stage at the level of specificity needed for construction drawings.

These steps are consistent with the Spiral Design Model and are needed in the marine construction domain for risk reduction.

Final Report

Feasibility Study for the

California Wave Energy Test Center (CalWave^{sm})

Award Number: DE-EE0006517

Submitted to:
U.S. Department of Energy
Office of Energy Efficiency
and Renewable Energy
Golden Field Office
15103 Denver West Parkway
Golden, Colorado

U.S. DEPARTMENT OF ENERGY

Submitted by:
Cal Poly Corporation
Institute for Advanced Technology
and Public Policy
California Polytechnic State University
San Luis Obispo, California

CALWAVE^{sm}

CAL POLY
SAN LUIS OBISPO

September 2015

Final Report

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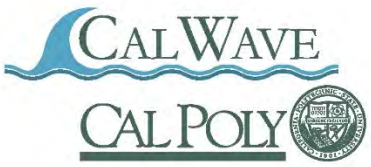

Cal Poly Corporation
Institute of Advanced Technology and Public Policy
California Polytechnic State University
San Luis Obispo, California

September 2015

Department of Energy Award Number: DE-EE0006517

Principal Investigator:

Sam N. Blakeslee, Institute for Advanced Technology and Public Policy, California Polytechnic State University (Cal Poly), San Luis Obispo

Project Manager:

William I. Toman, Institute for Advanced Technology and Public Policy, California Polytechnic State

Principal Co-Authors:

Richard B. Williams, Leidos Maritime Solutions
Douglas M. Davy, CH2M
Janet Thomson and Anna West, Kearns & West, Inc.
William I. Toman, Cal Poly, San Luis Obispo

Contributing Authors:

Dean Wendt, Cal Poly, San Luis Obispo
Dale Dolan, Cal Poly, San Luis Obispo
Craig Baltimore, Cal Poly, San Luis Obispo
Colin Sheppard, Humboldt State University
Andrew Harris, Humboldt State University
Randy Connett, Omega Power Engineers, LLC
George Hagerman, Virginia Polytechnic Institute and State University
W. Graham Lawson, Power Delivery Consultants, Inc.

Proposal Consultant:

Brendan Dooher

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Acronyms and Abbreviations

AACE	American Association of Cost Engineers
AC	Alternating Current
AFB	Air Force Base
AUV	Autonomous Undersea Vehicle
BA	Biological Assessment
BMP	best management practice
BOEM	Bureau of Ocean Energy Management
BTP	Berth Test Protocol
CalCOFI	California Cooperative Oceanographic Fisheries Investigations
Cal Poly	California Polytechnic State University, San Luis Obispo
CalWave^{sm}	California Wave Energy Test Center
CCC	California Coastal Commission
CDFW	California Department of Fish and Wildlife
CDP	Coastal Development Permit
CEQA	California Environmental Quality Act
CFR	Code of Federal Regulations
CONOPS	Concept of Operations
CSLC	California State Lands Commission
CWA	Clean Water Act
cyd	cubic yards
CZMA	Coastal Zone Management Act
DC	Direct Current
DOD	Department of Defense
DOE	Department Energy
EFH	Essential Fish Habitat
EA	Environmental Assessment
EIR	Environmental Impact Report
EIS	Environmental Impact Statement
EMEC	European Marine Energy Center
ESA	Endangered Species Act
EXWC	Expeditionary Warfare Center
FAD	Fish Attraction Device
FCMA	Fishery Conservation and Management Act
FERC	Federal Energy Regulatory Commission
FMECA	Failure Modes and Effects Criticality Analysis
FOC	Full Operating Capacity
FTE	Full-time Equivalent
HAPC	Habitat Area of Particular Concern
HDD	horizontal directional drill

ICPC	International Cable Protection Committee
ICSE	International Council on System Engineering
IOP	Initial Operating Capability
ISO	International Organization for Standardization
MCBH	Marine Corps Base Hawaii
MEC	Marine Energy Converter
METOC	meteorology and oceanography
MHK	marine hydrokinetic
MMPA	Marine Mammal Protection Act
MOU	Memorandum of Understanding
nm	nautical mile
NAVFAC	Naval Facilities Engineering Command
NEPA	National Environmental Policy Act
NHPA	National Historic Preservation Act
NMFS	National Marine Fisheries Service
NNMREC	Northwest National Marine Renewable Energy Center
NOAA	National Oceanic and Atmospheric Administration
NOAA-NMFS	National Oceanic and Atmospheric Administration-National Marine Fisheries Service
NMFS	National Marine Fisheries Service
NOI	Notice of Intent
NOI/PAD	Notice of Intent/Pre-Application Document
NREL	National Renewable Energy Laboratory
NWTC	National Wind Technology Center
OCS	Outer Continental Shelf
OEERE	Office of Energy Efficiency and Renewable Energy
OWET	Oregon Wave Energy Trust
PAD	Pre-Application Document
PG&E	Pacific Gas and Electric Company
PMP	Project Management Professional
PNNL	Pacific Northwest National Laboratory
ROM	Remotely Operated Vehicle
ROV	Remotely Operated Vehicle
RPL	Route Position List
RWQCB	Regional Water Quality Control Board
SOPO	Statement of Project Objectives
SWRCB	State Water Resources Control Board
TLR	Top-Level Requirements
TRL	Technology Readiness Level
TP	Test Protocol
USACE	United States Army Corps of Engineers
USC	United States Code
USFWS	United States Fish and Wildlife Service

USGS	United States Geological Survey
VAFB	Vandenberg Air Force Base
WEC	wave energy converter
WETS	Wave Energy Test Site
WQC	Water Quality Certification

Executive Summary

The California Wave Energy Test Center (CalWave[sm]) Feasibility Study, sponsored by the U.S. Department of Energy (DOE) through a grant (DE-EE0006517), evaluated offshore test sites along the California coast for establishment of a national wave energy testing facility appropriate for Technical Readiness Level 7-9 (TRL) Wave Energy Converters (WECs). TRL 7-9 refers to the testing of WEC devices under conditions that approach full-scale, grid-connected operation.

Led by the California Polytechnic State University at San Luis Obispo (Cal Poly) Institute of Advanced Technology and Public Policy (the Institute), the CalWave[sm] project team accomplished the project objectives to evaluate:

- Candidate test site areas, comparing a siting area in off Humboldt Bay in northern California and one off Vandenberg Air Force Base (AFB), Central California
- Availability of shore-side infrastructure to support the test center
- Availability and suitability of co-using existing offshore energy infrastructure
- Capacity of the local electrical grid system to accept test center power and on-shore power facilities
- Site area environmental permitting issues and agencies and available baseline data
- Potential for public and agency stakeholder acceptance of the project and siting area
- Top-Level Requirements and testing device design criteria
- Approach to preparing preliminary design drawings
- Potential costs of constructing the test center
- Potential costs of operating and maintaining the test center
- A schedule for project development and facility construction

Evaluation of the two candidate test site areas early during the Feasibility Study led to the conclusion that the Vandenberg site currently offers the best opportunity for developing the CalWave[sm] test center, because of its accessibility to shore-side support infrastructure and supply chain, among other factors.

The feasibility-stage project design envisions a long-duration (25-30 year design life), fully energetic, open-ocean facility, designed for evaluation of mature WECs at advanced TRLs. The Conceptual Baseline Design calls for a phased implementation to a fully-capable test center rated at 25-30 MW, with an upgrade path to 50 MW. The CalWave[sm] project design is “requirements-driven”, in that user needs and top level-requirements were determined first and then carried these through the Feasibility Study and conceptual design. The engineering tasks were managed to iteratively refine the concept and incorporate a range of alternatives:

- Two potential regional locations (Eureka/Humboldt Bay and Vandenberg/Central Coast)
- Five test site alternatives at Vandenberg
- Potential co-use of an existing offshore oil platform, its 25 MW capacity submarine power cable going ashore, and the associated shore substation with its existing interconnection with the incumbent utility
- Three potential new cable landings with shore stations at Vandenberg

The initial Conceptual Baseline Design for the Vandenberg siting area includes submarine power cables landing at Vandenberg AFB that connect to a Department of Defense (DoD) grid. CalWave[sm] will initially connect with the Vandenberg distribution local grid at 12 kV and 70 kV with the construction of a 5-mile-

long generator tie-line to an on-base substation that connects with the rest of the Vandenberg distribution system.

CalWave[sm] will provide shore station facilities, the cable runs to the test berths (one per berth, plus spare cable), and testing support services as needed. WEC developers will provide mooring and anchoring, umbilical, and power conditioning equipment that best suits their device.

Focusing on the notional Vandenberg South Base site, the Feasibility Study made the following key findings about the site and project area suitability:

- **Host Facility**—Vandenberg Air Force Base (AFB) has offered secure sites for a shore station and may be a purchaser of facility power. The goals of CalWave[sm] are consistent with the DOD's and VAFB's goals to develop more self-sufficient energy supplies, including renewables, and Vandenberg is a cooperative host and project partner. The base offers robust transportation and industrial facilities.
- **Shore Station**—The notional design is based on the "South Base" location near Vandenberg Dock. Vandenberg Dock was constructed for offloading rocket boosters and the Space Shuttle and is served by a well-constructed tow road to other parts of the base. Shore-station facilities would include electrical substations (12 kV and 70 kV), a switchgear building, compacted gravel pad space to hold WEC-Developer power conditioning equipment, and operations buildings that provide offices for CalWave[sm] and WEC developer staff.
- **Co-Use of Existing Marine Infrastructure**— While it is conceptually feasible to co-use the existing offshore infrastructure at Platform Irene (platform, submarine power cable and shore substation), there are many engineering unknowns about platform system integration that need to be resolved via technical exchanges with the infrastructure owner. The study team has identified a potential $10 million cost savings to CalWave[sm] if we can have access to this infrastructure versus installing exclusively new cables.
- **Test Berth Sites**—Test berth sites are available within 3 to 7 nm from the Vandenberg dock in the desired depth range of 70 to 110 m and in BOEM-defined lease blocks not currently leased for oil and gas purposes. The South Base location has the advantage of offering shore station facilities very near good test berth locations, reducing the length and cost of the cable runs. The sites are located on sandy bottom and the prospective cable route can avoid rocky bottom near the shore using horizontal directional drilling (HDD).
- **Wave Energy Resource**—The five prospective sites offer average annual energy flux ranging from 30.4 kW/m (South by Southeast) to 40.5 kW/m (South Central). The sites offer a wide variety of seasonal and year-to-year wave configurations that will be useful testing under a variety of wave height and period conditions.
- **Shore Side Infrastructure**— The shore side infrastructure is highly developed for marine engineering and marine logistics services in support of the offshore oil industry. CalWave[sm] is located within a few nm of four offshore oil platforms and a number of additional platforms are located further east in the Santa Barbara Channel area. The platforms have been in operation for nearly thirty years and an oil services construction and operations industry has developed in the region. Capable shore side infrastructure is therefore readily available very near the project area. Infrastructure available includes port facilities at deep water Port Hueneme, Santa Barbara, Port San Luis, and Morro Bay, all within a reasonable distance of the project site, and Vandenberg Dock, at the project shore station site. Facilities include heavy lift floating (offshore rated) and dockside cranes, and a variety of work boats

and other vessels, including large work vessels and cable lay vessels, remotely operated vehicles, and automated underwater vehicles.

- **Marine Operations Support—**In addition to port facilities and equipment, the offshore oil industry has fostered the development of an experienced marine operations workforce with first-hand experience supporting complex offshore industrial facilities in the project area. Local mariners have experienced a wide range of operational conditions in the area and understand marine industrial support operations.
- **Ocean Use—**Initial contacts with the local fishing communities of Morro Bay and Santa Barbara have indicated that commercial fishing concerns about a wave energy test site in the Vandenberg area are few. The project site is not considered a productive fishing area, possibly because of the distance from port and associated transit costs, location near a restricted Vandenberg Launch Area, and also because it is adjacent to a very large State Marine Reserve area where fishing is prohibited and also a federal Essential Fish Habitat Fishing Conservation Area where fishing for ground fish is prohibited.
- **Shoreside Land Use**—The shore facilities are located on Vandenberg AFB and will not conflict with land uses on the base. In addition, the base extends across 42 miles of shoreline including land from the shore up to the adjacent ridge tops. There are few residential, resort, or recreational areas near the project site that could be a potential source of complaints regarding impacts to scenic viewsheds along this scenic stretch of the coast. In addition, the WECs would be located relatively near oil platforms, compared with which they would not have a large visual profile seen from land.
- **Permitting Issues**—A critical issues analysis of environmental permitting issues in the Vandenberg area did not result in the identification of issues that could prevent project development or cause significant cost increases or schedule delays beyond what would be expected for a project of this nature. The project siting area appears to avoid some of the typical permitting pitfalls, such as large marine vessel traffic lanes, whale migration corridors, Essential Fish Habitat Areas of Particular Concern such as rocky seafloor, and critical habitats. Key permitting issues are likely to have more to do with the potential for noise and interference with bird and marine mammal movement posed by the WECs, WEC moorings, and support vessels. These are issues that have been addressed previously in marine energy project permitting and there are known regulatory pathways for resolving them. Though there are sensitive biological species along the shore near the shore station (snowy plover nesting, pinniped rookeries), these will be relatively easy to avoid using HDD under the shore and bluff area.

CalWave^{sm} team members have calculated a preliminary, conceptual cost of the facility, including permitting, stakeholder engagement, engineering, and construction, at between $72M and $83M at the Vandenberg Dock site. Operation is estimated to cost approximately $1.5M per year until the base is fully subscribed, after which operation would be self-supporting. Post-permit environmental monitoring (construction and first five years of operation) would cost an additional $4M to $9M.

Under a conceptual schedule developed for CalWave^{sm}, permitting could be completed and construction begin by Fall of 2018. Construction could be completed and testing begin by early 2021, with Initial Operating Capability by the end of 2021. The facility could be fully capable, with all four test berths occupied by the end of 2022.

It appears feasible to develop the CalWave^{sm} national wave energy test center at Vandenberg AFB according to the conceptual plans developed in this feasibility study. We recommend moving forward to the next phase of work, which would be the development of project design and environmental baseline information, supported by a public and agency outreach program, sufficient to submit the Notice of

Application/Pre-Application Document (NOI/PAD) to the Federal Energy Regulatory (FERC) Commission by Fall of 2016.

SECTION 1

Project Overview and Objectives

The California Wave Energy Test Center (CalWave[sm]) Feasibility Study, sponsored by a U.S. Department of Energy (DOE) funding award (DE-EE0006517), is a program to identify and evaluate a primary offshore site along the California coast for a national wave energy testing facility appropriate for Technical Readiness Level 8-9 (TRL) Wave Energy Converters (WECs). The CalWave[sm] project team concentrated its efforts on two locations along the California coastline: (1) offshore of Humboldt Bay in the California North Coast area, and (2) offshore of Vandenberg Air Force Base in the Central Coast area (Figure 1-1). After a comprehensive siting area evaluation process (SOPO Task #1), the Vandenberg siting area was chosen for additional intensive study and the development of conceptual plans and designs.

1.1 Objectives

The CalWave[sm] feasibility study focused on ten tasks, following the project work plan and Statement of Project Objectives (SOPO):

- **Developing and using criteria to rank and finalize the choice for the candidate ocean test site (SOPO Task #1).** With the goal of identifying Identify a national test facility site that meets the resource and support criteria for testing grid-connected, full-scale WEC devices, this task involved a comparison of the two candidate siting areas, Humboldt and Vandenberg Air Force Base. The comparison criteria included WEC design flexibility, cable lay cost, manufacturing/shipbuilding and infrastructure support ports, variability of sea states and wave energy resource, mooring costs, accessibility for maintenance, cost for grid interconnect and existing infrastructure, regulatory and licensing processes and prospects, potential public acceptance, and long-term growth potential.
- **Understanding the shore-side support infrastructure (SOPO Task #2).** This task included an analysis of dock facilities, transportation infrastructure, harbor navigation, project operational resources, contingency response operations assets, and ancillary facilities.
- **Exploring utility grid interconnection (SOPO Task #3).** This task included understanding the capacities of specific substations and any required upgrades. Additionally, the task included determining the spare transmission capacity of existing submarine power cables and compiling anticipated costs for grid interconnection.
- **Identifying known environmental constraints and progress on permitting (SOPO Task #4)**. This work included conducting desktop siting investigations to determine whether critical project development and environmental permitting issues or fatal flaws exist for prospective CalWave[sm] siting locations; analysis of available environmental baseline literature and data sources; and developing a preliminary permitting road map and plan, schedule, and budget for permitting CalWave[sm].
- **Public acceptance (SOPO Task #5).** This task included contact with key stakeholders and holding public and regulatory agency meetings to understand stakeholder issues that CalWave[sm] will encounter during development and permitting. This task included a summary of ongoing discussions including conclusions about expected public acceptance, and the level of outreach and engagement effort required as part of project development.
- **Top-Level Requirements and Device-Testing Criteria (SOPO Task #6)**. This task involved developing top-level requirements (TLRs) and associated listing of specific test site design criteria that will define expectations for each major element of the test facility, including the ocean test site, associated service port, and the shore-side ancillary facilities. This task also involved a detailed analysis of the wave

climate at each potential berth location for the CalWave[sm] project using a ten-year hindcast of wave conditions.

- **Develop Preliminary Design Drawings (SOPO Task #7).** During the feasibility study, CalWave[sm] developed preliminary drawings for the baseline conceptual designs for the cables and shore station at the notional South Base location, including considerations for electrical, civil and ocean engineering as well as architecture.
- **Develop estimates of construction quantities and costs (SOPO Task #8).** This task involved preparing general estimates of construction quantities and costs, based on inputs from conceptual design studies and preliminary bids from industry (such as offshore cable installers, etc.).
- **Develop operating, maintenance, and testing cost estimates (SOPO Task #9)**. The CalWave[sm] project team examined similar renewable energy testing centers such as National Renewable Energy Laboratory (NREL) facilities, the United Kingdom WaveHub facility, and the European Marine Energy Center (EMEC) to establish conceptual business and operational models for the test center and to develop preliminary estimates of operating, maintenance, and testing costs.
- **Develop Schedule for Site Development and Facility Construction (SOPO Task #10).** Based on the discussions with regulatory agencies and conceptual design considerations, the project team developed a preliminary permitting, engineering design, procurement, and construction schedule for project development.

The CalWave[sm] Feasibility Study has been conducted under a Department of Energy (DOE), National Renewable Energy Laboratory (NREL), Office of Energy Efficiency and Renewable Energy (OEERE) funding award (DE-EE0006517). The California Polytechnic State University (Cal Poly) Institute of Advanced Technology and Public Policy is the Prime Recipient of the DOE funding and the sponsoring organization for CalWave[sm]. Cal Poly conducted this Feasibility Study in a manner that effectively leveraged the outcomes of public funds used for the PG&E 2007-2011 WaveConnect Program. Cal Poly reconstituted the WaveConnect core project development team to capture their knowledge and expertise for CalWave[sm]. Additionally, CalWave[sm] added the expertise of registered professional electrical engineer to the Team, with distribution, transmission and substation design expertise. CalWave[sm] also engaged a submarine cable consultant.

This Feasibility Study report is the final deliverable for the CalWave[sm] feasibility study (FY2013 funded phase of work). Many organizations and persons contributed to this feasibility study, as listed in Appendix 1-1. The following sections present the results of the Feasibility Study and address the key project objectives.

1.2 Design Approach

CalWave[sm] is envisioned as a permanent (25-30 year design life), fully energetic, open ocean test center that is designed for evaluation of WECs at mature TRLs (levels 7/8/9). The Conceptual Baseline Design is for a phased implementation to a fully-capable test center, rated at 25-30 MW, with an upgrade path to 50 MW.

The engineering tasks were managed to iteratively refine the concept from Feasibility Study to Conceptual Design stage and incorporate a range of alternatives:

- Two potential regional locations (Eureka/Humboldt Bay and Vandenberg AFB/Central Coast)
- Five test site alternatives
- Potential co-use of an existing offshore oil platform, its 25 MW capacity submarine power cable going ashore, and the associated shore substation with its existing interconnection with the incumbent utility
- Three potential cable landings with shore stations

The initial phase CalWave[sm] development phase would be to install subsea cables to four berth locations in 70 to 110 meter depths with a spare cable to enhance reliability and redundancy and enable options to go deeper and/or shallower. The Shore Station provides space for WEC Developer-provided power conditioning equipment, a 12 kV substation with load banks and instrumentation to ensure grid-compliant power, and a 70 kV substation to allow higher outputs. For the Vandenberg siting area, an alternative design was considered that would use the existing oil and gas drilling Platform Irene submarine cable rated at 25 MW that connects to the Surf Substation. WEC umbilicals could be brought onboard the Platform. Space for power conditioning equipment would most likely be needed as the platform has mission-critical loads that would require stable, grid-compliant power.

The CalWave[sm] seafloor footprint would be constrained to an area of about four square nautical miles, as discussed during the initial outreach with fishermen, and to allow flexibility in the shape and size of test berths within the BOEM lease blocks. This eliminates the artificial constraints of "square berths" in order to enhance the anchoring and mooring design alternatives for WEC developers and maximize safety.

1.2.1 Systems Engineering Approach

The CalWave[sm] project design is "requirements-driven", in that we determined user needs and top level-requirements first and then carried these through the Feasibility Study conceptual design work. In addition, we employed a system engineering approach as defined by the International Council on Systems Engineering (INCOSE) that translates user needs into requirements; develops, analyzes, and selects from the best alternatives; and considers the total life-cycle of the design including environmental, regulatory, outreach, and permitting (Figure 1-2). As alternatives are down-selected and degrees of freedom in design are reduced, the design can iteratively develop into preliminary and detailed design stages while minimizing rework. The goal is to make progress towards final design for a fully-capable national wave energy test center design for a permanent (25-30 year design life), fully energetic, open-ocean facility, designed for evaluation of mature WECs at TRLs 7/8/9, defined as follows:

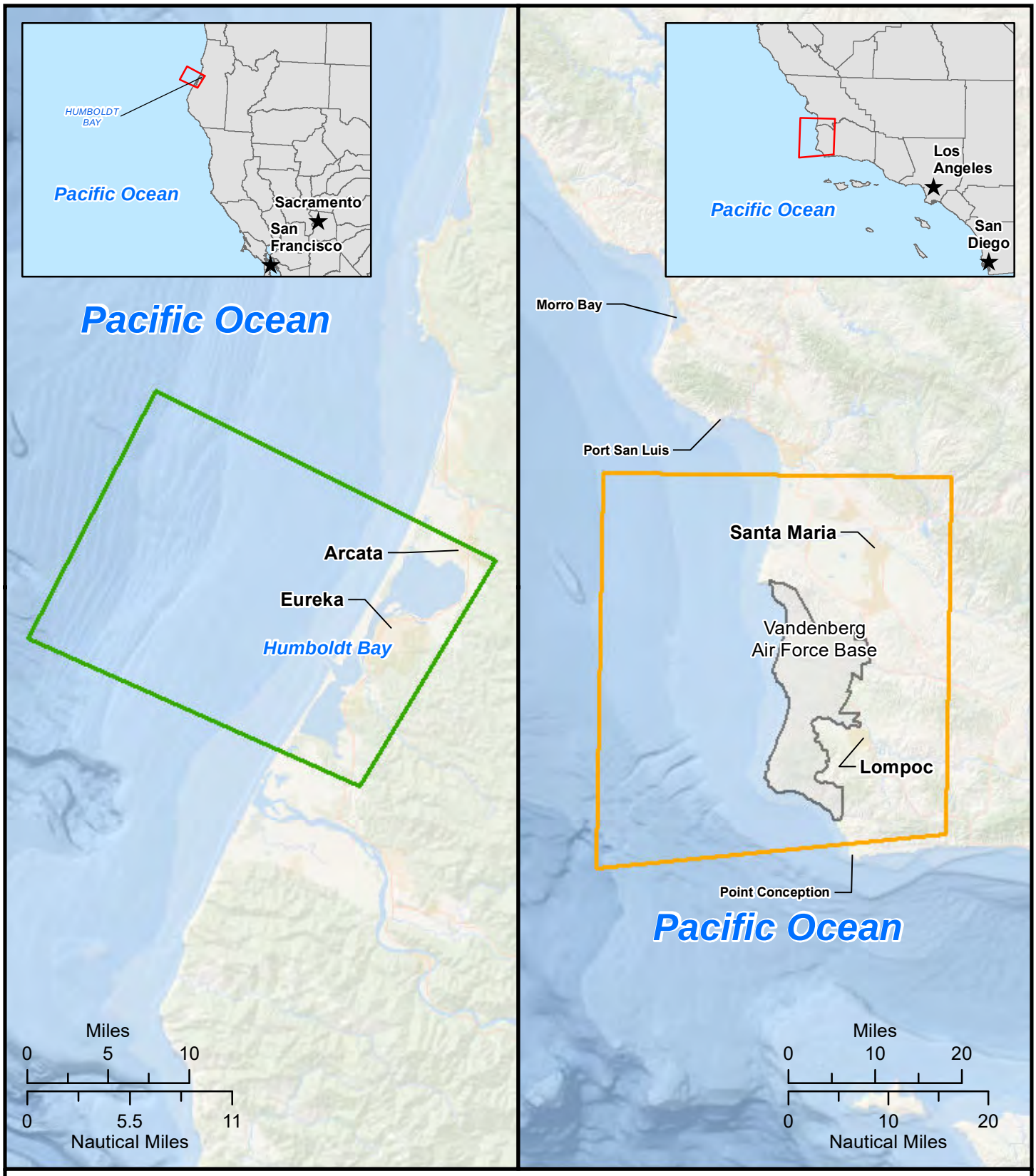
- TRL 7 – Full-scale prototype demonstrated in relevant environment (open ocean)
- TRL 8 – Actual system, tested, and qualified under expected conditions; final step of system development
- TRL 9 – Actual system operated under full range of operational conditions

Initial installations of subsea cables will extend to deep water test berths. Shallower, mid-depth, and deeper sites are available as alternatives for expansion. The primary focus on wave energy converters, with consideration given to possible future addition of floating wind, and wave-wind hybrid designs.

Our approach is to acknowledge the multi-disciplinary engineering tasks involved including systems engineering and ocean engineering tasks as well as civil/electrical/mechanical engineering and architecture. We reference naval architecture best practices that can accommodate large degrees of freedom in design and phased development. The "naval architecture spiral" that is often adapted for ocean engineering projects is shown in Figure 1-3. Figure 1-4 is a system block diagram for the CalWave[sm] project that reflects key systems and segments and key tasks.

The CalWave[sm] conceptual design incorporates user needs and TLRs as well as the findings from a preliminary Failure Modes and Effects Criticality Analysis (FMECA) that identified the requirement to accommodate a wide range of WECS out to the year 2050, with designs that are most likely not anticipated at present, and a range of potential failure modes.

One goal of the CalWave[sm] design was to incorporate features that ensure "graceful degradation" in the event of material failures in one Test Berth and enable continued operations of CalWave[sm]'s other Test



LEGEND

- Humboldt Siting Area
- Vandenberg Siting Area
- Vandenberg Air Force Base

Figure 1-1
Humboldt and Vandenberg Project Siting Areas

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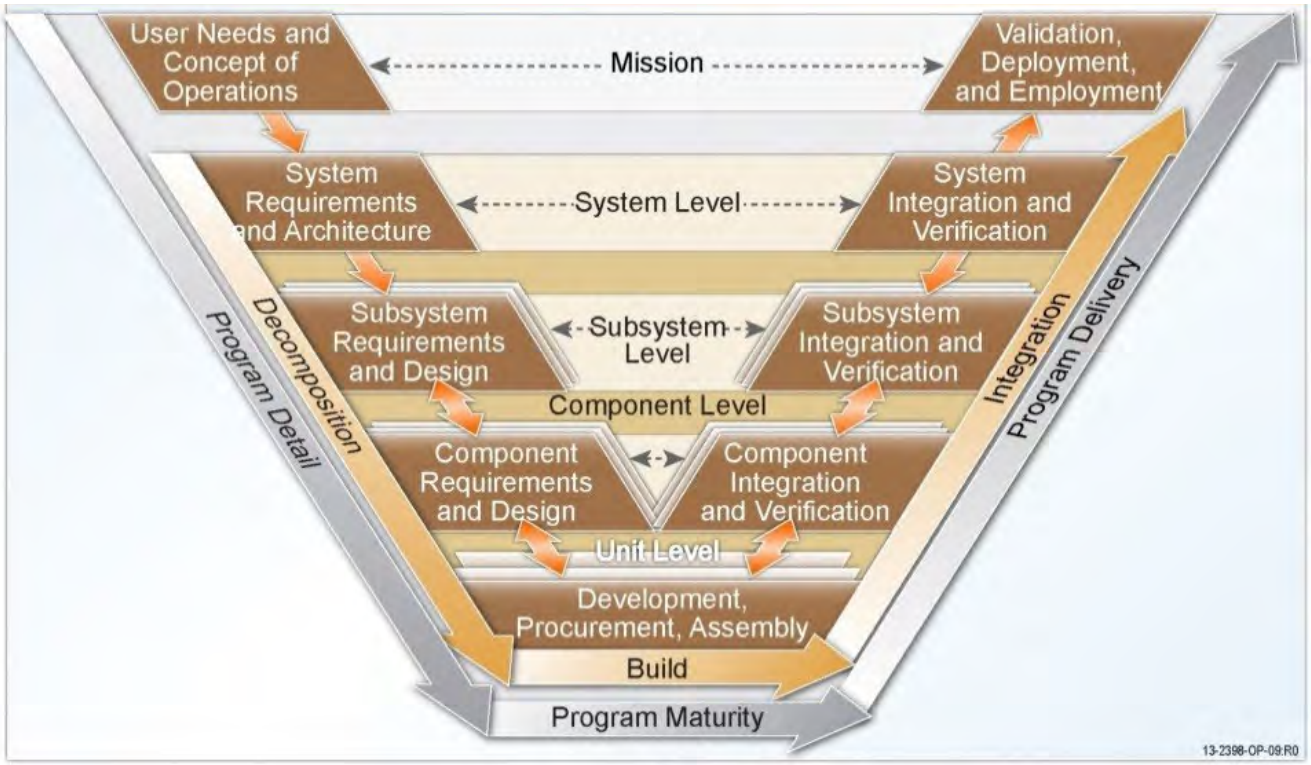
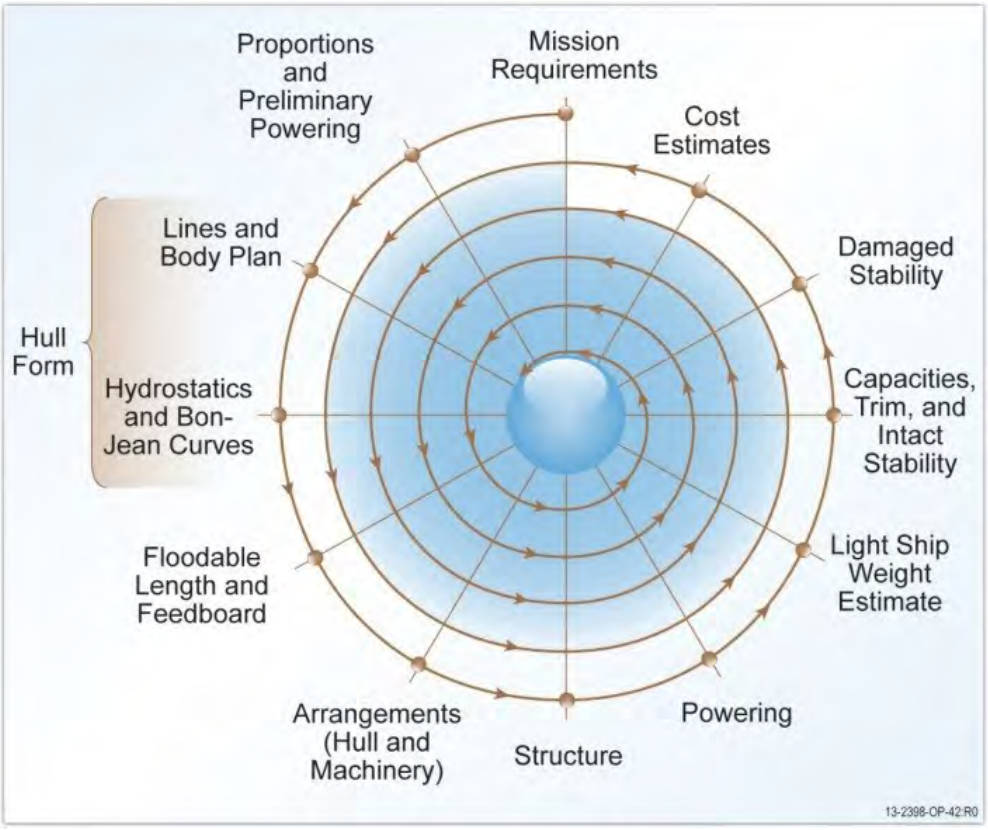


Source: Leidos Maritime Solutions

FIGURE 1-2
Systems Engineering Diagram
California Wave Energy Test Center



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Source: Leidos Maritime Solutions

FIGURE 1-3
Naval Architecture Design Spiral
California Wave Energy Test Center

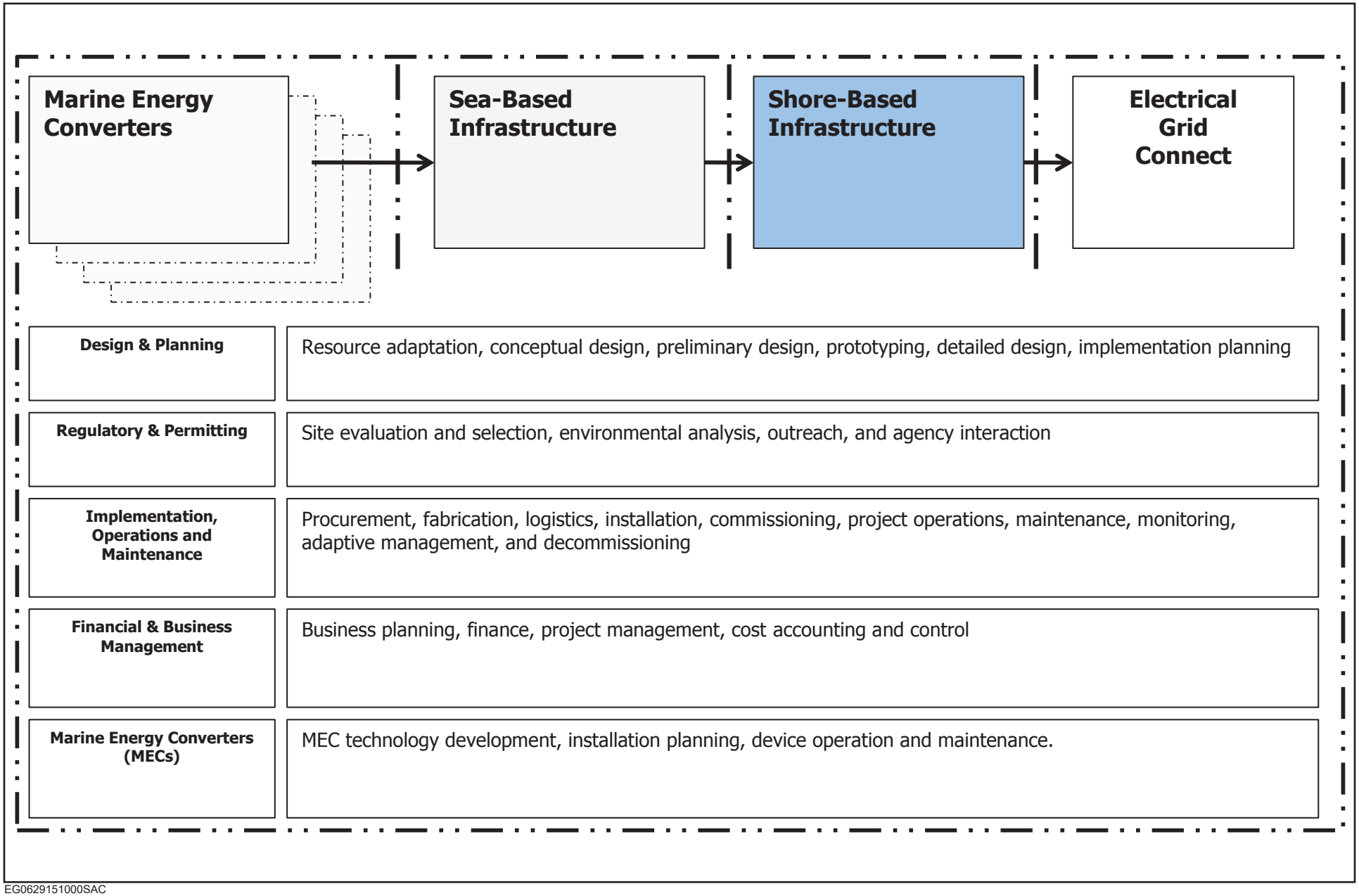

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FIGURE 1-4
CalWave System Block Diagram
California Wave Energy Test Center

Berths. In particular, a spare subsea cable, flexibility in the Shore Station design, and space for power conditioning, load banks, and a backup generator ashore were key design outcomes.

In FY2014, we worked to "future-proof" the key aspects of the CalWave^{sm} design that are dependent on specific design elements of current and future WECs. Design of these WEC-dependent aspects is intended to be iterative, providing flexibility to adapt to the range of WECs and WEC arrays that are projected to be ready to test when CalWave^{sm} opens and through the life cycle of the test site. CalWave^{sm} will be designed for WEC developers to provide key equipment that is optimized specifically for their device for most effective test performance, including the mooring and anchoring, umbilical, and power conditioning equipment.

The test berth area definition will allow flexibility in mooring and anchoring design that is WEC-specific and the WEC Developer will provide mooring and anchoring The cable termination at the sea end will use a standard interface and the WEC developer will provide an umbilical. The interface from shore-end to the power-conditioning area will allow WEC-specific power conditioning to meet grid interface standards and the WEC developer will provide the power-conditioning equipment.

1.3 Candidate Ocean Test Sites

The first major task (SOPO #1) was selection of the facility site. The design process commenced with review of the PG&E WaveConnect work on the feasibility study and conceptual design of at Humboldt Bay Site (Eureka), and the initial feasibility study at the Central Coast Site (Vandenberg) that was added for consideration in the PG&E WaveConnect project toward the end of the project.

1.3.1 Siting Area Selection Process

The siting area selection process compared Humboldt-Eureka and Central Coast-Vandenberg locations as possible siting areas for the facility. The requirements definition and site selection phases were iterated in parallel. The CalWave^{sm} Team developed a matrix comparison tool that employed 19 criteria to evaluate the Eureka and Vandenberg sites (Table 1-1). Site-Selection results documentation and the siting area comparison matrix are found in Appendix 1-2.

TABLE 1-1
Site Selection Criteria, SOPO Task #1

No.	Site Selection Criterion
1	Wave energy resource for a test center, P_{min} 30 KW/m, months per year
2	Variability of sea states for a test center
3a	Flexibility to accommodate different WEC designs, compactness for a range of depths >75m
3b	Sea bottom terrain
4	Extreme event design environment
5	Operations port suitability/capability and affordability of ocean engineering equipment
6	Operations port proximity and ability to accomplish tasks in a day charter
7	Construction accessibility for both sea-based and shore-based infrastructure
8	Regional heavy manufacturing / marine supply chain capability
9	Regional industrial marine support operations capability
10	Certainty / length of regulatory and permitting pathway
11	Ease of interconnection for 30 MW

TABLE 1-1
Site Selection Criteria, SOPO Task #1

No.	Site Selection Criterion
12	Power sales potential for 30 MW
13	Academic/research community proximity
14	Existing infrastructure for co-use, substation
15	Existing infrastructure for co-use, submarine cable
16	Stakeholder support
17	Site commercial buildout potential
18	Ease of interconnection for 300 MW
19	Proximity to shipbuilding facility for WEC fabrication

Siting area selection for the facility was driven by the test site criteria. Test site criteria development leveraged the significant efforts of the Oregon Wave Energy Trust (OWET) and the OWET Industry Advisory Council during the Territorial Sea Plan process employed by the State of Oregon to select wave energy test sites. The test site selection criteria were further refined by the CalWave^{sm} Team during interviews with Marine Energy Converter (MEC) developers (focus on WECs), and benchmarking of existing wave energy test sites in the United Kingdom and evolving sites in the United States. Figure 1-1 shows the general siting areas considered in the north coast (Humboldt) and central coast (Vandenberg) regions.

During the siting evaluation process, the project team initially looked at five siting regions: (1) nearshore Humboldt, (2) offshore Humboldt, (3) nearshore Vandenberg, (4) offshore Vandenberg, and (5) Offshore Vandenberg using existing transmission from oil and gas Platform Irene. Initial analysis confirmed quickly that the nearshore sites (territorial waters) would be infeasible because of inadequate depth and relatively low available wave energy.

After identifying the candidate sites and developing the 19 scoring criteria, the project team members worked together to develop weighting scores for the criteria, recognizing that some should have more relative importance than others. In this process, each scoring participant (Cal Poly, Humboldt State University, Virginia Polytechnic Institute and State University, Leidos Maritime Solutions, Columbia Power, and CH2M) contributed a weighting score and these were averaged, with final weightings ranging from 2.0 for Criterion #4, “Extreme Event Design Environment” to 7.9 for Criterion #1 “Wave energy resource for a test center, P_{min} 30 KW/m, months per year”.

The project team then developed scoring guidelines for each criterion. For example, for criterion #2, “Variability of Sea States for a Test Center,” scoring focused on the number of days per year that significant wave height would be less than 1.5 m for more than 2 days in a row, with <20 scoring 0 to 2 points, 20 to 40 scoring 3-6 points, and >40 scoring 7-10 points.

Finally, the project team assigning responsibility for analyzing and scoring particular criteria and documenting the scoring process and findings to particular team members best qualified by their assigned roles on the project to conduct the scoring for a particular criterion. The final evaluation of the candidate siting areas was determined by multiplying the site scores by the weightings for the criteria and adding up total scores by site. The result was then submitted to a review committee made up of project team members from the National Renewable Energy Laboratory and Sandia National Laboratory. The review committee provided comment on and endorsed the finding of the site evaluation exercise.

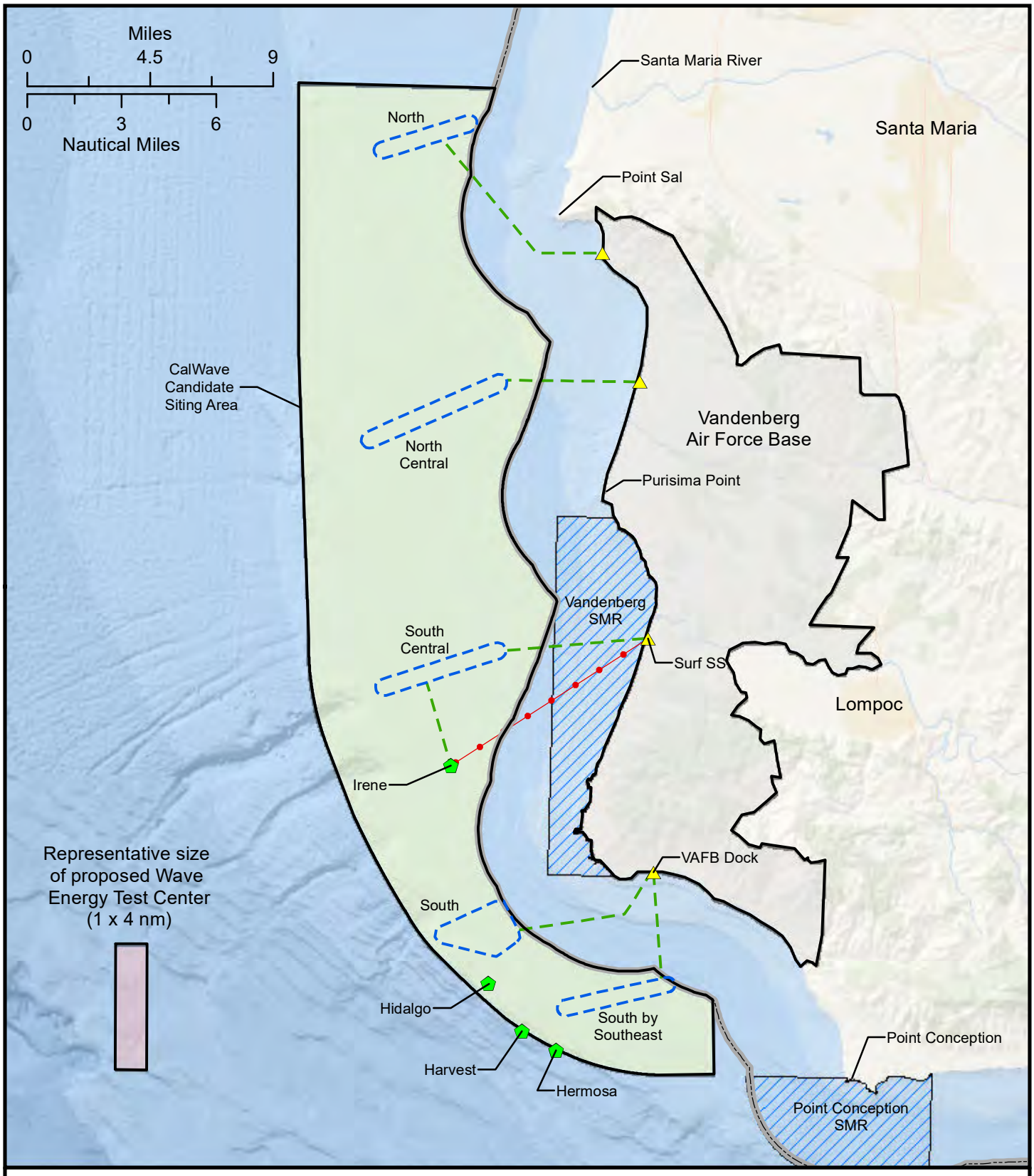

Figure 1-5
Vandenberg Candidate Siting Area
California Wave Energy Test Center

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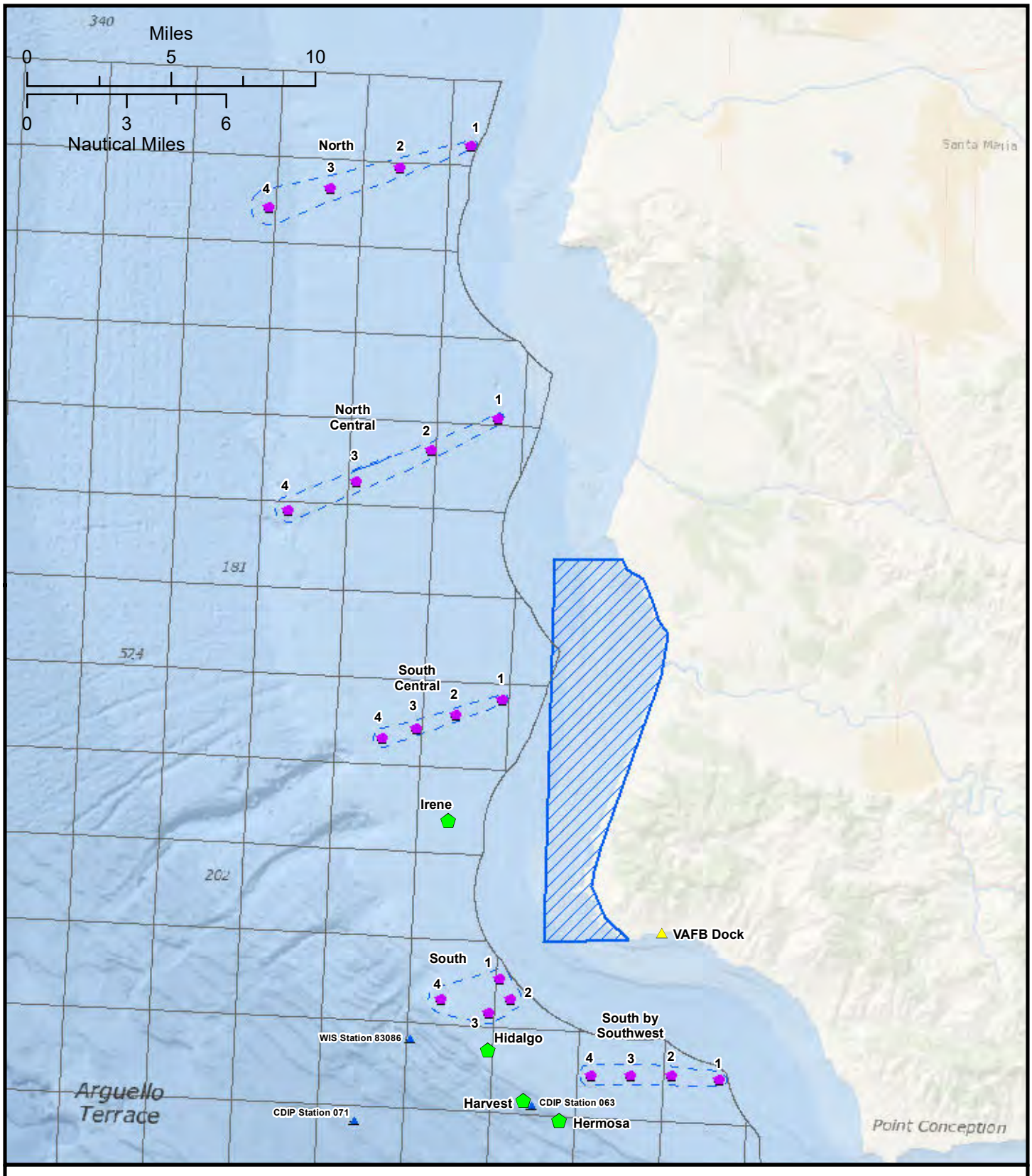

LEGEND

- Offshore Oil Platform
- Cable Landing Sites
- Berth Locations
- Wave Measurement Buoys
- Test Sites
- Vandenberg State Marine Reserve
- BOEM Lease Blocks

Figure 1-6
Vandenberg Prospective Test Sites
California Wave Energy Test Center

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The CalWave[sm] siting area selection process resulted in a determination that the Vandenberg siting area (Table 1-2, Figures 1-5, 1-6) would offer the best opportunity for development of a national wave energy test center in California, although the Humboldt area is clearly a suitable area for wave energy development also.

CalWave[sm] signed a Memorandum of Understanding (MOU) with VAFB towards cooperation in CalWave[sm] project development that has been helpful in the design effort and allowed access to VAFB staff and facilities.

TABLE 1-2
Siting Area Site Selection Scores

Site	Composite, Weighted Final Score[a]
Humboldt Area, Offshore Federal Waters, new cable from shore	5.4
Vandenberg Area, Offshore Federal Waters, existing cable from Platform Irene	7.7
Vandenberg area, Offshore Federal Waters, new cable from shore	6.8

[a] Composite of scores along 19 different criteria, each weighted by relative importance.

1.3.2 Candidate Sites in the Central California Siting Area and Siting Considerations

The CalWave[sm] candidate study area was delineated to refine project siting and enhance stakeholder collaboration. We considered several potential sites along the 42-mile Vandenberg coastline without pre-judging which of the locations within this larger general siting area would be best. The five candidate sites are located between the north and south extents of VAFB. This "macro-siting" approach has been useful for considering long-term development potential, and for interactions with stakeholder groups, agencies, and regulators; and successfully supported "micro-siting" to identify five possible test site alternatives locations as show in Figure 1-6. Initial screening was conducted to determine the engineering, environmental, public acceptance, and permitting factors applicable to the sites.

As a result of stakeholder and regulator inputs and additional examination of the logistical and environmental characteristics of the various sites, CalWave[sm]'s Conceptual Baseline Design determined the most advantageous facility location is in the South Base area near Vandenberg Dock. Accordingly, the South Base location was used for the notional shore station design. The notional shore station design for South Base could be readily adapted to Central Base and North Base alternatives.

The design drivers for the notional design at the South Base location have been its advantages in terms of the following, when compared with the North Base and Central Base locations:

- Siting for individual test berths in variable depth and wave energy conditions
- Availability of good alternative sites for the shore station
- Convenient access to the test berths and shore station site
- Proximity to marine logistical support

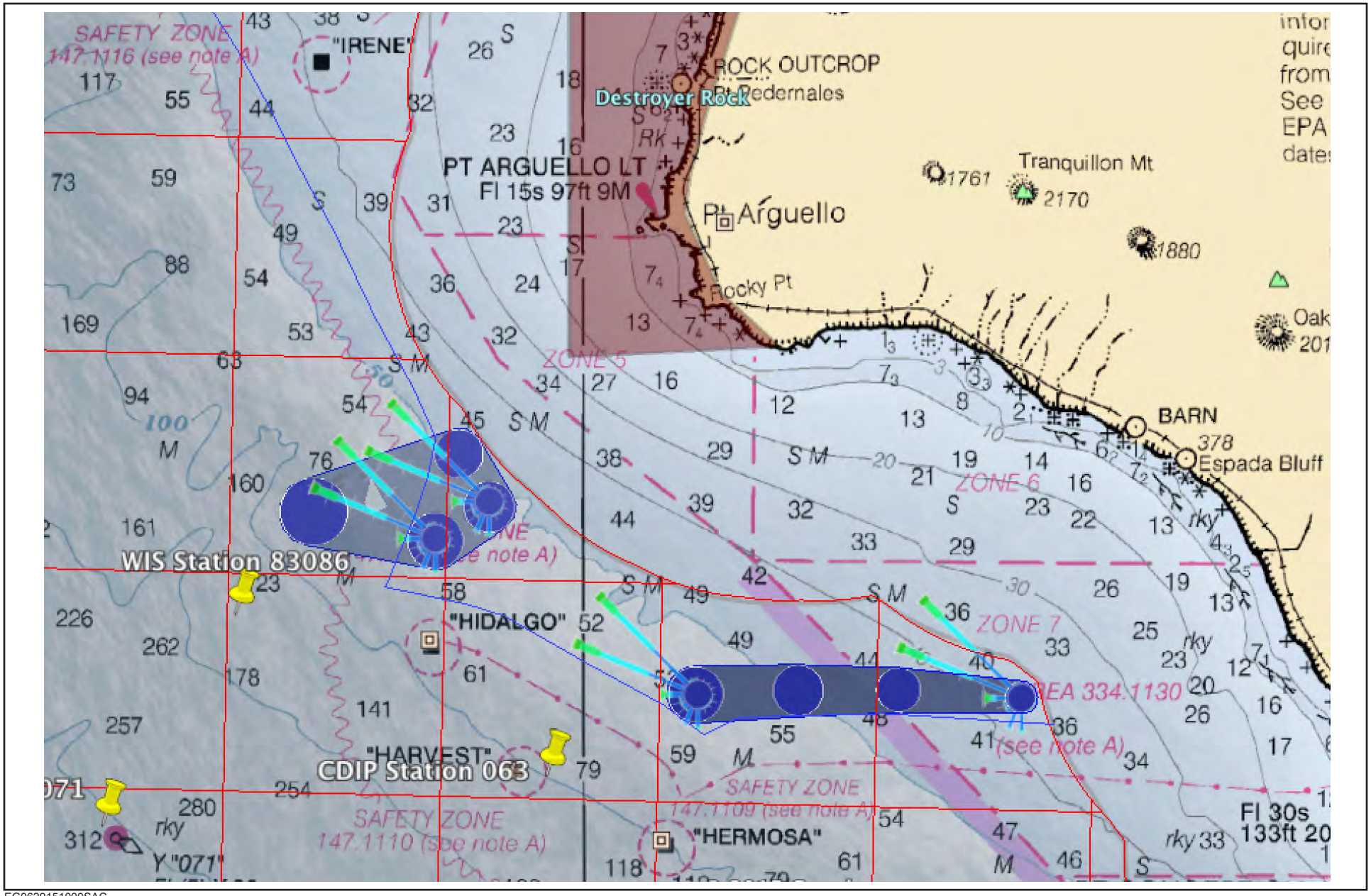
Marine logistical support is available to each of the prospective sites from both the south (Santa Barbara, Ventura, Port Hueneme, Los Angeles/Long Beach complex, and San Diego) and north (Port San Luis and Morro Bay); however, sea conditions are more favorable for vessels approaching from the south, which is

also where the marine engineering and industrial support facilities for the offshore oil and gas industry, which are directly applicable to CalWave[sm], are located.

A key consideration in both macro- and micro-siting was the wave energy resource. Macro-siting considered the Siting Area and identified five alternatives sites. Micro-siting analyzed the wave resource for each test berth at each site. Wave modeling by Humboldt State University, with collaboration and reviews by Scripps Institution of Oceanography and Virginia Polytechnic and State University, assisted with site selection. For additional discussion, please see Section 6.3 and Appendix 6-1.

Based on the proximity to marine logistic support and on-shore infrastructure, the shorter lengths of cable run (significantly affecting cost) and the characteristics of ocean depths and wave energy resource availability, two locations in particular in the South Base area appear promising: South Test Site Alternative and the South-by-Southeast alternative (Figure 1-7).

CalWave[sm] also conducted early and effective due diligence performed through the International Cable Protection Committee (ICPC) with the owner of the submarine cable that is located to the West of CalWave[sm] test berths (as shown on the NOAA charts that serve as the base map in Figure 1-7). The cable owner provided the detailed Route Position List (RPL) to the CalWave[sm] Team that is more accurate than the NOAA chart.



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Notes:
1) Depths in fathoms
2) Dark blue circles are test berth locations, some showing wave rose for that location
3) Red lines are BOEM lease block areas

FIGURE 1-7
South and South-by-Southeast Prospective Test Sites
California Wave Energy Test Center

SECTION 2

Shore-Side Support Infrastructure

The SOPO Objective #2 is to conduct a screening-level analysis of shore-side infrastructure available to the prospective test center site (docks, harbors, shore-side facilities, marine operations support personnel and facilities, etc.). The cooperative working relationship with Vandenberg AFB, among other factors, has allowed project conceptual design to progress beyond what might otherwise have been within reach of this Feasibility Study. Because of the availability and early identification of a shore-side dock, harbor, and shore-side facility site, CalWave[sm] staff has created conceptual design plans for the shore-side facility, which is discussed and illustrated below in Section 2.1. A discussion of off-site facilities follows.

2.1 Shore Station Facilities

CalWave[sm] design efforts have focused on a notional facility at the South Base location, near the South and South-by-Southeast test site alternatives off Vandenberg Dock. CalWave[sm] is designed with four berths in 70 to 110 meter depths, with options to go deeper and/or shallower.

A site for the CalWave[sm] shore station site is available on Vandenberg AFB with the cooperation and agreement of VAFB. The shore station site is located adjacent to Vandenberg Dock (see further discussion, below). The CalWave[sm] shore station will be designed to integrate with subsea cables that will land on VAFB and connect to the DOD grid on Vandenberg AFB that is supplied by PG&E. This location is free of the typical restrictions involved with more developed areas; hence, the South Base location is considered a "blank canvas".

As stated above, there will be five new subsea cables (four + spare) from the berths to VAFB, most-likely with horizontal directional drilled (HDD) shore landings and surface-lay cables to seaward. Two cable landings and four alternative HDD scenarios were considered as environmental/permitting alternatives and in the event of constraints on cable pull distance (Figures 2-1 and 2-2).

A shore station (located on an approximately 100 ft x 100 ft gravel pad) is planned as the site of two modular buildings and space for modular power conditioning equipment to be provided by the WEC developers. An adjacent 12 kV substation (located on an approximately 100 ft x 100 ft gravel pad) has been designed to connect with local distribution at 12 kV as well as a 70 kV Substation (located on an approximately 100 ft x 100 ft on a gravel pad) (Figures 2-3 and 2-4). Based on preliminary site assessment for site excavation, cut and fill quantities can be balanced on-site, further reducing cost.

The Vandenberg Dock area is located at the former US Coast Guard Surf Station, which may be available for office functions on a not-to-interfere basis. The CalWave[sm] operations buildings will host key site personnel and WEC developer staff during test center operations. The top level requirement specifies two standard construction job site trailers for the shore station building. Given the historical nature of the site, and the expected constraints to use of jobsite trailers at the location, the Cal Poly Architectural Engineering group has designed two affordable pre-manufactured, mobile, modular buildings as an alternative operations building (Figure 2-5 and 2-6) that are architecturally consistent with the historical design of the remaining Coast Guard structure.

2.2 Docks

The Vandenberg Dock in the South Base area is the primary docking support facility for CalWave[sm] (Figure 2-7) and is adjacent to the proposed shore station. The dock was designed by CalWave[sm] teammate Glosten

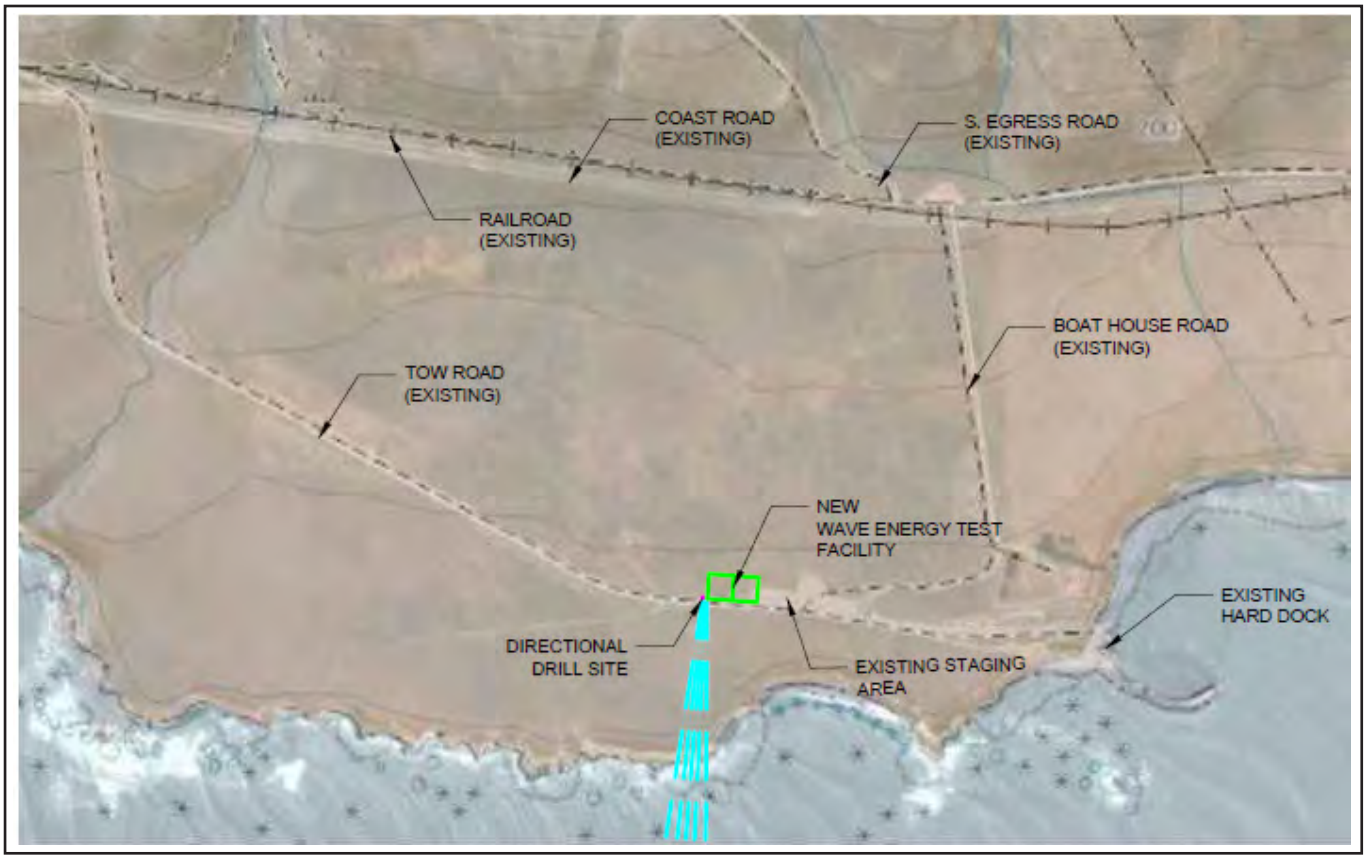

FIGURE 2-1
Vandenberg Dock Cable Landing and
Shore Site Facility Location
California Wave Energy Test Center

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FIGURE 2-2
Alternative Cable Landing and Route
California Wave Energy Test Center

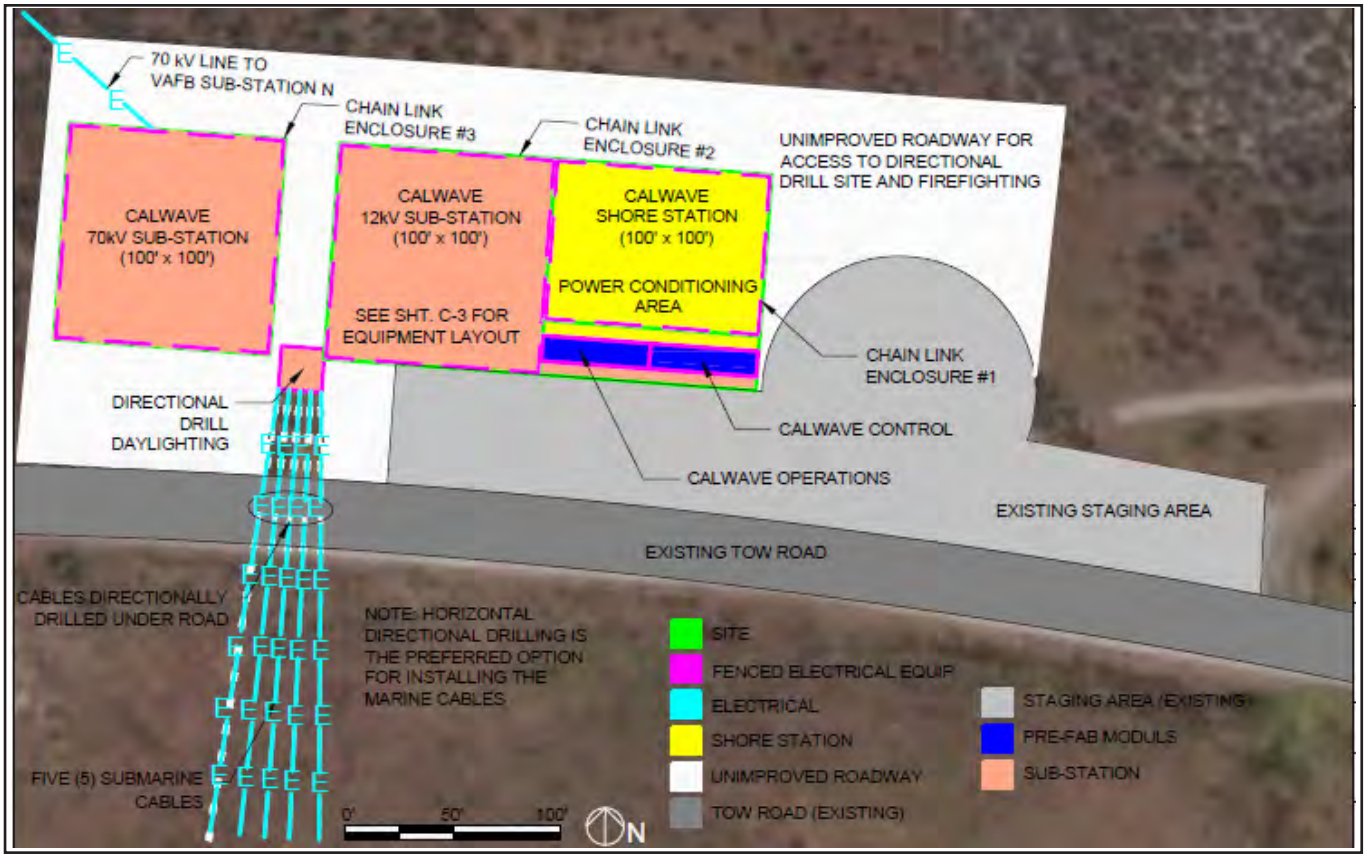

FIGURE 2-3
Shore Station Plan
California Wave Energy Test Center

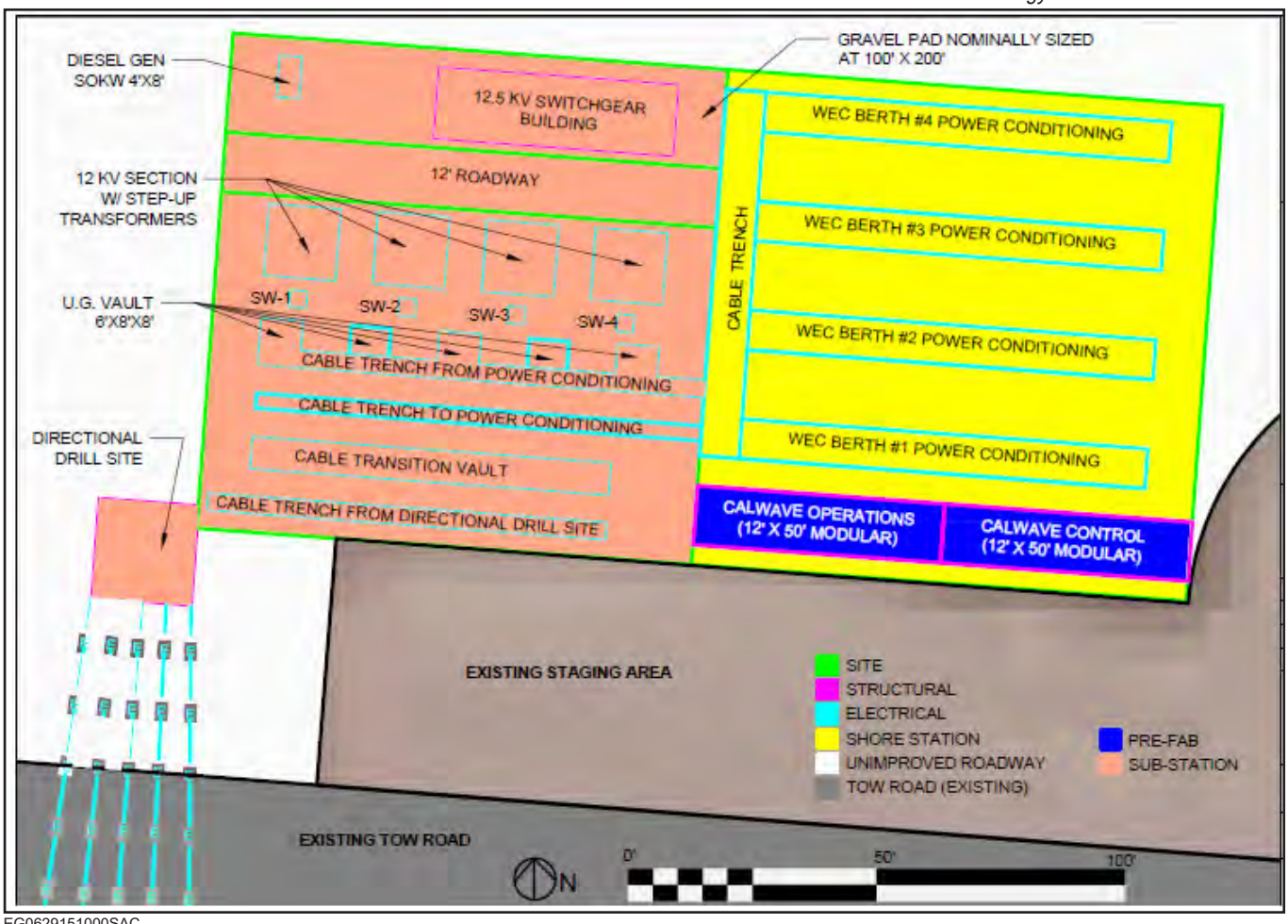

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FIGURE 2-4
Shore Station Plan Detail
California Wave Energy Test Center

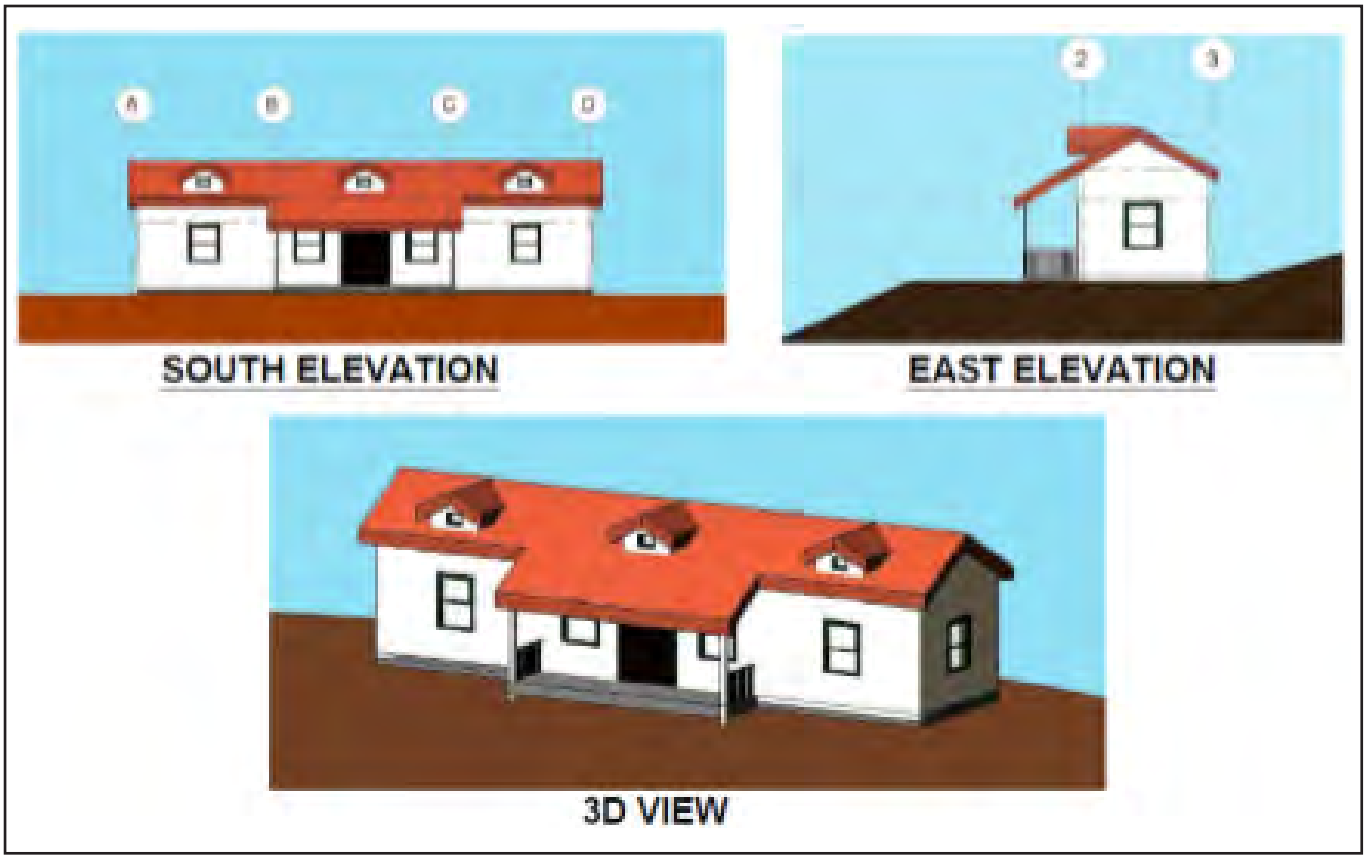

FIGURE 2-5
Architectural Rendering, Operations Building
California Wave Energy Test Center

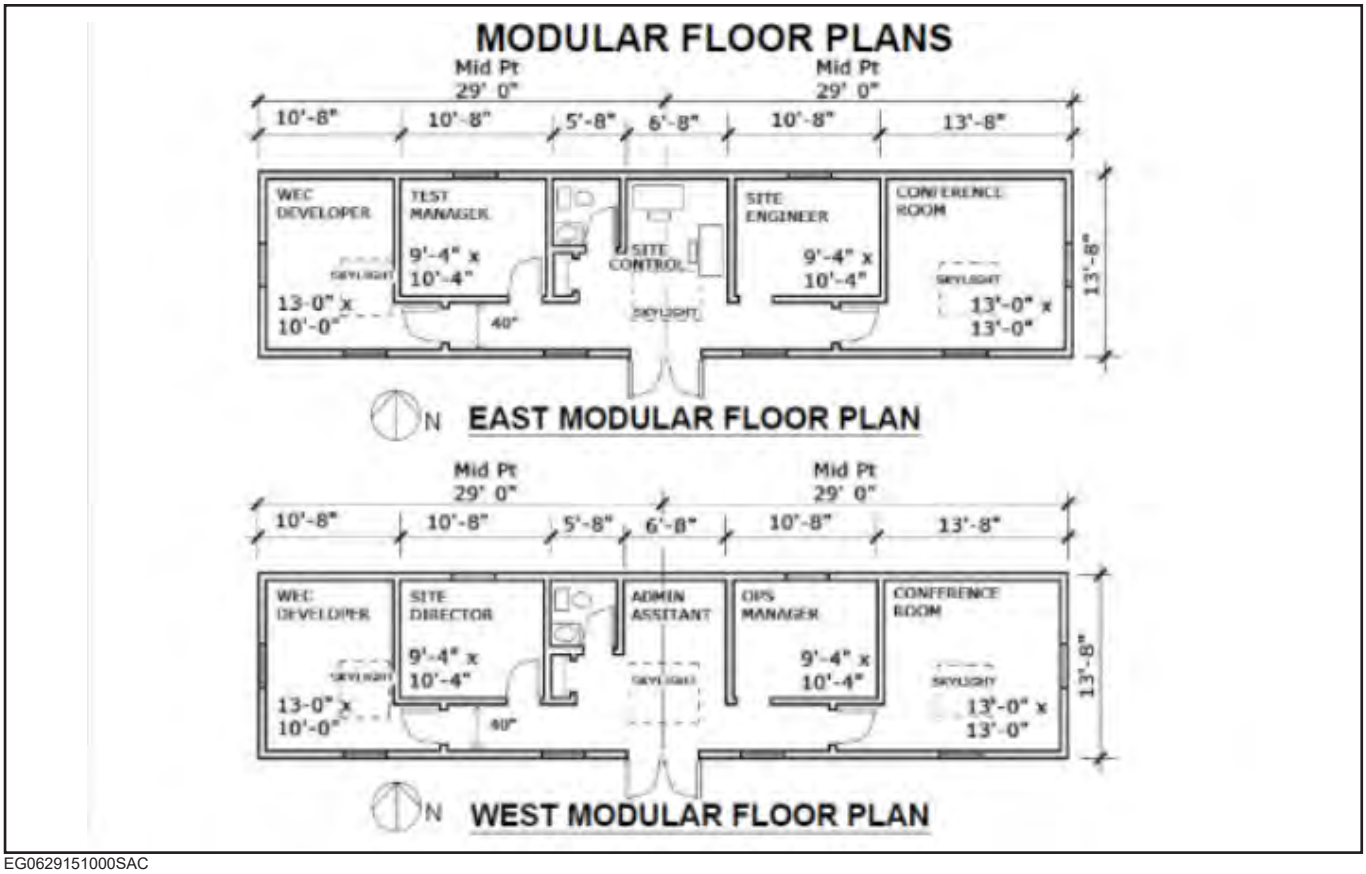

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FIGURE 2-6
Conceptual Plan, Operations Building
California Wave Energy Test Center

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Photo: Richard B. Williams

FIGURE 2-7
Vandenberg Dock
California Wave Energy Test Center

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Photo: Richard B. Williams

FIGURE 2-8
Port Hueneme, looking
east to the commercial area
California Wave Energy Test Center

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FIGURE 2-9
Aerial View of Port Hueneme
California Wave Energy Test Center

Associates and built to accommodate M/V Delta Mariner, a large transport vessel used to deliver rocket boosters to the Space Launch Complexes at Vandenberg. Additional, highly capable docks and piers are also available near the project site:

- Port Hueneme: The only deep water harbor between Los Angeles and the San Francisco Bay area and the U.S. Port of Entry for California's Central Coast region, located about 70 nm from Vandenberg Dock (Figures 2-8 and 2-9). This pier has the capability to host very large vessels and is home to large cranes and dockside storage facilities and a variety of marine operations services for the oil and gas industry. Vessel support to the oil platforms near Vandenberg is operated from Port Hueneme
  http://www.portofhueneme.org/
- Cal Poly Pier in Port San Luis (former Union Oil offloading pier), approximately 24 nm from Vandenberg Dock (Figure 2-10)
  http://www.marine.calpoly.edu/cal-poly-pier
- Port San Luis Boatyard, 24 nm from Vandenberg Dock (Figure 2-11)
  http://www.portsanluisboatyard.com/
- Ellwood Pier (personnel transfers, operated by Venoco for the for oil and gas industry) about 37 nm from Vandenberg Dock
- Santa Barbara Harbor, about 54 nm from Vandenberg Dock
  http://www.santabarbaraca.gov/gov/depts/waterfront/
- Casitas Pier in Carpentaria: (operated by Venoco for oil and gas industry), about 58 nm from Vandenberg Dock (Figure 2-12)
  http://www.carpinteria.ca.us/communitydev/oil-gas_carp-operations.shtml

2.4 Transportation Infrastructure

The transportation infrastructure in the vicinity of Lompoc and Vandenberg AFB is extensive and well-maintained. The Vandenberg AFB road network is maintained by DOD and is in excellent condition. The infrastructure is specifically designed for moving very large, heavy (and delicate) loads such as rockets and rocket payloads. Vandenberg Staff have experience routing and managing large and heavy loads. The South Base, in particular, has several alternative routes for entry and access to the Vandenberg Dock area, which is the entry point to the base for large loads transported by sea.

2.4.1 Cranes

In addition, the following crane resources are available near VAFB:

- Land cranes are locally available in Goleta for offload, rated 360 ton:
  Local Area: Santa Barbara/Goleta
  http://www.specialtycrane.net/pages/equipment/cranes.html
- Floater Crane can deploy to vicinity of CalWave^{sm} Site, rated 200 ton:
  Local Area: Morro Bay
  http://www.associatedpacific.com/about-us/waterfront-facilities/morro-bay/
  http://www.associatedpacific.com/featured-projects/offshore-projects/
- Floater Crane can deploy to vicinity of CalWave^{sm} Site, rated 300 ton:
  Local Area: Oxnard
  Region: Long Beach/San Diego

http://www.pacifictugboats.com/wp-content/images/CCC-300T-Specifications.pdf
http://www.pacifictugboats.com/ccc-300t-crane/

- Port San Luis Mobile Hoist, rated 60 tons (Figure 2-11)
  Local Area: Port San Luis
  http://www.portsanluisboatyard.com/

2.4.2 Truck Transport

The CalWave[sm] Team and Vandenberg Staff have reviewed the multiple routes into South Base from the surrounding county and state roads and found them to be suitable for wide loads and, with permits, super loads as defined by the California Transportation Department (Caltrans). The roads on Vandenberg are suitable for wide loads and super loads. The tow road to the Vandenberg Dock is wide and reinforced and was initially designed for transport of the Space Shuttle and large rocket boosters. The Vandenberg Dock is also suitable for crane offload using either locally-available land mobile cranes (up to 360 tons) or locally-available floater cranes (200 ton and 300 ton).

2.4.3 Rail Transport

The CalWave[sm] Team and Vandenberg Staff have examined the dedicated cargo rail spur available near Space Launch Complex 6 and Sub-Station N, approximately 6 miles from Vandenberg Dock. As stated above, cranes are locally-available for offload and the tow road is suitable for land transport of heavy loads from the rail spur to Vandenberg Dock.

2.4.3 Sea Transport

Several options are available for WEC and equipment delivery by sea to Vandenberg Dock or other nearby locations:

- Vandenberg Dock is suitable for barge delivery offload using either locally-available land mobile cranes (up to 360 tons) or locally-available floater cranes (200 ton and 300 ton)
- The M/V Delta Mariner can be contracted for moving large loads (Figure 2-14)
- The Cal Poly Pier in Port San Luis can accommodate a barge delivery and offload by land cranes or floater cranes.
- The Port San Luis straddle lift can launch a 60 ton load
- A barge delivery and floater crane offload could be staged in the protected waters of the Cojo Anchorage, east of Point Conception, an 8 to 12 nm tow from the test berths

2.5 Harbor Navigation

Port Hueneme is a deep water harbor with decades of marine logistics operations experience for the offshore oil and gas industry and for this reason it will be the most practical staging harbor for CalWave[sm]. The Port shares the harbor with the Naval Facilities Engineering Command (NAVFAC) Expeditionary Warfare Center (EXWC). The harbor welcomes deep draft vessels.

Other options include the following:

- Venoco, a platform operator, has offered use of their Carpentaria Pier, as well as the Elwood Pier for personnel transfers (Figure 2-12)
- Santa Barbara Harbor
- Port San Luis Harbor
- Morro Bay Harbor

Photo: Thomas Moylan, Cal Poly Marine Operations

FIGURE 2-10
Cal Poly-owned Pier at Port San Luis
California Wave Energy Test Center

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Photo: Port San Luis, used by permission

FIGURE 2-11
Sixty-ton lift crane at Port San Luis
California Wave Energy Test Center

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Photo: Richard B. Williams

FIGURE 2-12
Marine Operations Service Vessel and Crane at Venoco Carpinteria Pier
California Wave Energy Test Center

Photo: Richard B. Williams

FIGURE 2-13
Subsea Cable-Lay Bow Roller
California Wave Energy Test Center

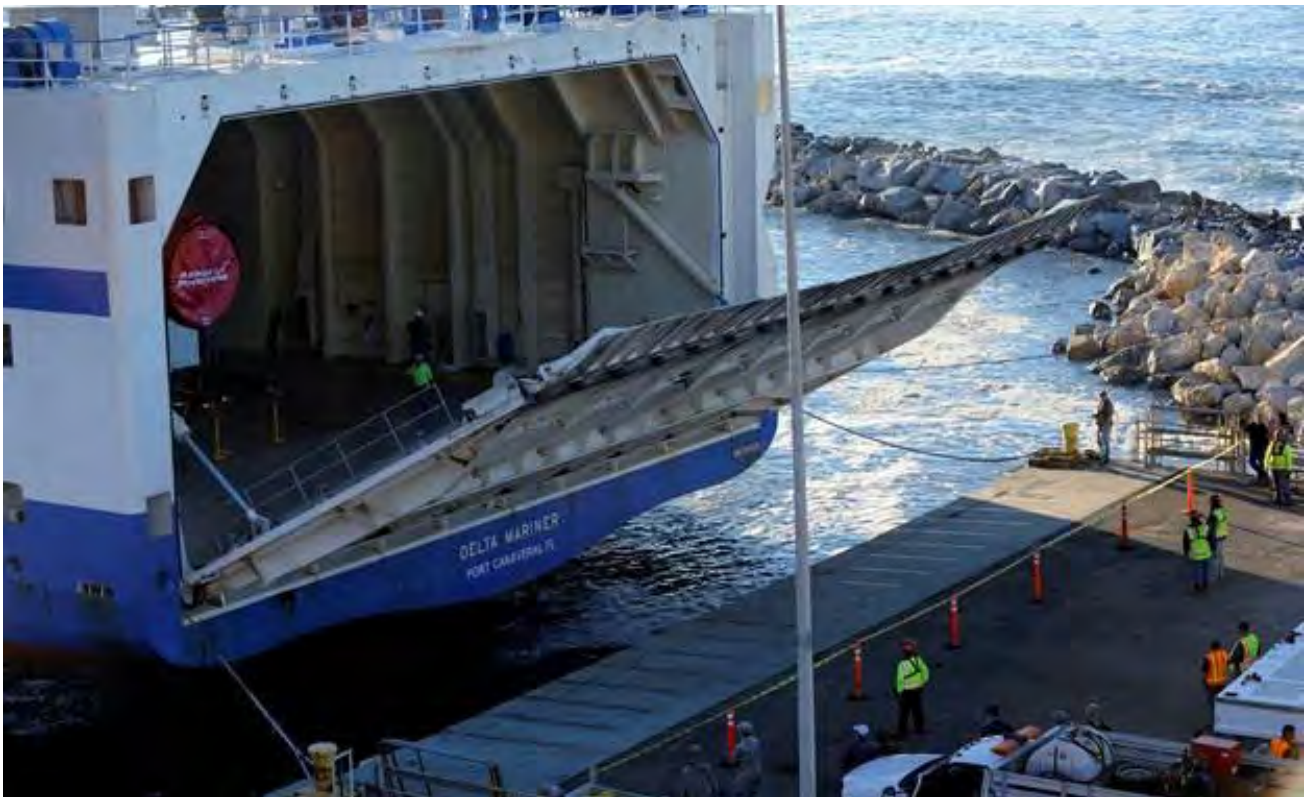

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Photo: Vandenberg Air Force Base

FIGURE 2-14
M/V Delta Mariner Preparing to
Offload at Vandenberg Dock
California Wave Energy Test Center

Vandenberg Dock can also be used for small boats, barges, floater cranes and large vessels such as the M/V Delta Mariner (Figure 2-13).

2.6 Development and Operation Support Resources

A key strength of the Vandenberg site is the local experience of the oil and gas platform industry that has been operating for decades in the near vicinity of the site. The availability to work with people experience in the subtleties of marine operations in this region, and who are experienced working with large offshore facilities will be a significant success factor for CalWave[sm]. In addition to the availability of seasoned offshore workers, the local availability of essential ocean engineering equipment will be a key asset. CalWave's Chief Engineer held meetings with three marine logistics companies that are interested in providing logistic support. Capable offshore support facilities available locally include the following:

- Crew transport vessels
- Horizontal directional drill (HDD)
- Subsea cable lay equipment and vessels

2.6.1 Hydrographic Survey Capabilities

A highly mature hydrographic survey industry and offshore services industry supports the oil and gas platforms in the vicinity. CalWave's Chief Engineer held meetings with the dominant local hydrographic survey contractor, and diving support contractor, and had telephone conversations with two competitors. Multi-beam, side-scan, sub-bottom profiling, and magnetometer survey capabilities are locally available. For example, Fugro Consultants has a full-capability location in Ventura (http://www.fugroconsultants.com/). Diver, Remotely Operated Vehicle (ROV), and Autonomous Undersea Vehicle (AUV) services are locally available. For example, Aqueos Subsea Solutions maintains a full-capability facility in Ventura (http://www.aqueossubsea.com/)

2.6.2 Submarine Cable Lay Capabilities

Submarine cable lay and pipeline operations are routine in oil and gas industry facilities near Santa Barbara and the Los Angeles/Long Beach Basin. Cable lay operations for the industry are planned in July 2015 in the Santa Barbara Channel that will provide excellent parametric cost estimating, lessons learned, and permits in the public domain that can be leveraged by CalWave[sm].

Submarine cable lay capabilities, both equipment and experienced personnel, are available locally; for example at L3 MariPro's facility in Goleta (Appendix 2-1 and Figure 2-14). These capabilities are relatively rare in many locations in the United States.

2.6.3 Contingency Response Operations Assets

Given the sensitivity toward readiness for contingencies in the oil and gas permitting and monitoring, a highly mature contingency response operations industry is locally available. Four locally available support vessels are shown in Appendix 2-2.

SECTION 3

Project Design: Utility Grid Interconnection

The Vandenberg Dock area is serviced by VAFB's existing 12 kV distribution grid with recently upgraded utility poles. CalWave^{sm} can integrate with the existing 12 kV distribution system for station power, as well as to provide wave energy generated power to the grid. A Grid Interconnect Study for thermal and dynamic loads is planned by PG&E during a subsequent project phase. Vandenberg AFB has a seasoned staff of engineers, technicians, operators and contractors that operate the grid for normal base operations and mission-critical launch operations.

In the next phase of the project, we also plan to finalize the design aspects that reached a higher level of maturity during the Feasibility Study phase: the CalWave^{sm} Shore Station, the CalWave^{sm} Substations (12kV and 70kV), and a planned five-mile-long generator tie-line to connect to the Vandenberg AFB 70 kV ring bus at Sub-Station 'N' (Figure 3-1). This future phase of work will continue to develop aspects of the design that are currently less mature: confirmation of the preferred test site alternative as a function of the stakeholder and permitting processes, specifics of the cable landings, and determination of whether horizontal directional drilling is required. Objectives of the study will be to:

- Evaluate the capacity of the existing 12 kV infrastructure
- Evaluate upgrades to the 12 kV infrastructure
- Determine when to implement the five-mile 70 kV extension to connect the CalWave^{sm} Shore Station to Vandenberg Substation 'N'

The existing Vandenberg AFB 70kV Substation 'N' is collocated with a 10 MW gas turbine backup generator. An additional substation bay with two breakers is proposed with associated buswork, steel structures, and relaying. Adequate space appears to be available to the adjacent to and within of the substation, assuming no major underground obstructions.

LEGEND

- Power Plant Substation
- Shore Facility
- VAFB Route

N

Figure 3-1
70 kV transmission upgrade route
to Vandenberg Substation 'N'
California Wave Energy Test Center

Service Layer Credits:

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SECTION 4

Environmental Permits and Authorizations

The key project objectives under SOPO Task 4 (Known Environmental Constraints and Progress on Permitting) are directed towards preparing a preliminary plan, timeline, and cost estimate for obtaining the permits and authorizations that will be needed for CalWave[sm] to begin construction. During this phase of work we concentrated on the following subtasks:

- Siting constraints analysis
- Marine biology literature search
- Infrastructure permitting documents literature search
- Permitting analysis and permit and authorization review
- Permitting schedule and cost

4.1 Siting Constraints Analysis

Proper siting of energy facilities involves constraints analyses of both existing infrastructure and environmental/permitting and public acceptance. Learning of siting critical issues or fatal flaws only later in the permitting process can be costly and avoidance of protected or otherwise sensitive resources can lead to permitting success and prevent public and agency controversy and permitting delays. Therefore, the first priority for the CalWave[sm] permitting task during the feasibility phase has been to conduct a high-level screening analysis to identify critical issues and potential fatal flaws to candidate sites. This work started during SOPO Task 1 (*Finalize Choice for Candidate Ocean Test Site*) for both the Vandenberg and Humboldt sites, and has continued for the Vandenberg siting area.

Critical issues analysis involves looking at project development and environmental permitting issues that have the largest potential to influence the cost and schedule of a project or issues that would be likely to prevent regulatory approval altogether or would render the project infeasible (fatal flaws). Key issues areas examined for the CalWave[sm] critical issues/fatal flaws analysis included the following:

- Potential for conflict with commercial fishing
- Threatened and endangered species and their critical habitats
- Potential for conflict with marine mammal migration (unlisted species)
- Fisheries resources, EFH, and Habitats of Particular Concern (HAPC)
- Potential conflict with ocean uses other than commercial fishing
- Visual resources assessment and potential conflict with shore-side land uses

Figure 4-1 shows the CalWave[sm] siting locations and also shows selected areas or resources that pose siting constraints that are referred to in the sections that follow.

4.1.1 Commercial Fishing

One of the most critical issues for a marine energy resources project is the potential for a project site to conflict with commercial fishing interests. This issue can arise from perceived exclusion from favored and economically viable fishing grounds and also from the potential for a wave energy project to pose an obstacle to movement or a hazard to fishing gear in the water column (net fouling on mooring lines) or on the seafloor (trawl gear fouling on transmission cables). These issues have been contentious for communications cable projects, MHK projects elsewhere (for example, PG&E Humboldt WaveConnect), and offshore wind projects on the eastern seaboard. The WaveConnect project, for example, was initially constrained to sites within the territorial sea and this siting area coincided with the most productive fishing

grounds in the region for crab, which is the most important fishery in that area. Fishers in the Humboldt area were concerned about loss of fishing grounds and also about crab pots drifting into WEC mooring cables. In completing SOPO Task 1 this was taken into consideration, and it became clear that the issue could be mostly avoided by siting the project farther off shore and outside of the most productive crabbing grounds.

For CalWave^{sm}, we took two approaches to assessing the potential for conflicts with commercial fishing to become a critical issue or a fatal flaw. One approach was to confer with the leaders of the commercial fishing community in Morro Bay, which is home port to the highest commercial fishing volume in the area. CalWave^{sm} project personnel showed key fishing representatives a map of the proposed general siting area and five candidate sites to ask them to provide their advice about the potential for conflict. This consultation was coordinated and facilitated by Dr. Dean Wendt, Marine Biologist, Director of the Center for Coastal Marine Sciences, and Dean of Research at Cal Poly. Dr. Wendt has conducted studies of Central Coast regional fisheries over a number of years and knows and is known to leading members of the commercial fishing community and has credibility among them.

Fishing community responses to Dr. Wendt can be summarized as follows:

- Key species in the CalWave^{sm} siting area are crab and spot prawn
- Very few fishers from Morro Bay access the siting area
- Fishers from Santa Barbara generally do not travel to this area

Members of the Morro Bay fishing community did not offer an explanation for why they seldom fish in the CalWave^{sm} project siting area, but one possible answer has to do with the distance to fishing grounds and corresponding time and fuel costs. For example, the distance from Morro Bay harbor to the northernmost prospective site is 25 nm and to the southernmost site is 57 nm. From Port San Luis, the distances are 13 and 43 nm, respectively. The distance to the southernmost site from Santa Barbara Harbor is 50 nm. An average speed for fishing vessels is about 10 knots (nm per hour). Conversations with Santa Barbara fishers that took place for the PG&E Central Coast WaveConnect project corroborate the statements of the Morro Bay fishers that fishers from Santa Barbara do not often travel to the Point Arguello area to fish.

Another possible factor in general avoidance of this area by fishers is the presence of the Point Conception Pacific Groundfish Essential Fish Habitat Conservation Area. This is a large area approximately 25 nm wide (parallel the shore) by 38 nm long (seaward), starting 4 nm from shore (See Figure 4-1). The CalWave^{sm} South and South by Southeast siting areas are located partly within this EFH conservation area. Within this area, using bottom trawl gear for fishing is prohibited except for demersal seine gear. However, anecdotal evidence indicates that the demersal seine equipment is not yet used, or available, in this part of California. Therefore, conflicts with commercial fishing for these sites can be expected to be fewer than elsewhere, because groundfishing is prohibited in the area.

A second approach was to examine fish landing information to assess which species are landed in project area ports (particularly Morro Bay and Port San Luis) and evaluate the habitat conditions (depth, substrate, distance from shore, etc.) for fishing these species to determine whether CalWave^{sm} would occupy important fish habitat. Table 4-1 (following page) shows the value of ex-vessel commercial fish landings for species with more than $25,000 per year for 2012 and 2013 (these are the latest years for which data is available for all of these species) and also the general bottom depths at which these species can occur.

Most of these commercial fishing species occur within the 75 to 110 m depth range where CalWave^{sm} will be sited. The sablefish, which was economically nearly twice as valuable as the second most important

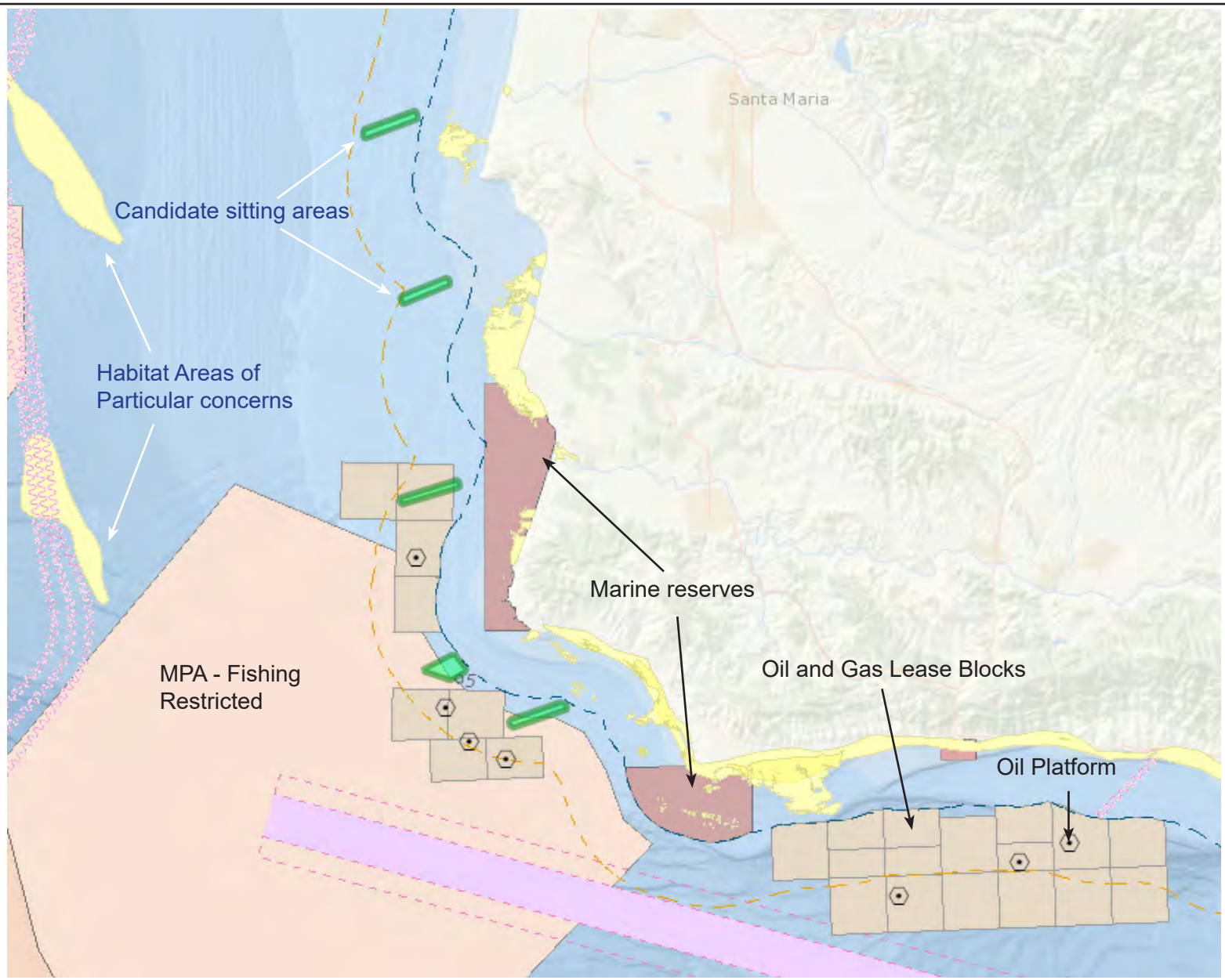

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FIGURE 4-1
CalWave Prospective Sites and
some Key Siting Constraints
California Wave Energy Test Center

TABLE 4-1
Ex-Vessel Commercial Fish Value, Morro Bay, 2012-2013

Year	2012	2013	2-yrTotal	Per year	Depths	70-110 m?
Sablefish	$1,861,677	$1,768,731	$3,630,408	$1,815,204	> 300 m	-
Market squid	$637,235	$1,356,477	$1,993,712	$996,856	to 500 m	+
Dungeness crab	$591,776	$1,148,995	$1,740,771	$870,386	< 75 m	-
Thornyheads	$575,943	$634,035	$1,209,978	$604,989	< 100 m, 500-1300 m	+
King salmon	$625,139	$337,708	$962,847	$481,424	30 to 80 m	+
Hagfishes	$295,393	$450,160	$745,553	$372,777	to 1700 m	+
Rockfish, all	$346,103	$318,056	$664,159	$332,080	to 3,000 m	+, hard bottom
Spot prawn	$304,877	$278,817	$583,694	$291,847	20 to 450	+
Dover/petrale sole	$313,122	$226,551	$539,673	$269,837	to 550 m	+
Swordfish	$214,509	$54,846	$269,355	$134,678	to 550 m	+
Albacore	$90,430	$42,180	$132,610	$66,305	250-300 m	+
Cabezon	$66,037	$65,149	$131,186	$65,593	to 85 m	+, hard bottom
California halibut	$30,861	$66,161	$97,022	$48,511	< 30 m	-

Source: California Department of Fish and Wildlife, http://www.dfg.ca.gov/marine/fishing.asp

species (market squid) over these two years, is one exception and mostly occurs in much deeper water. Per the Morro Bay fishers, Dungeness crab and spot prawn are the most important species in the CalWave^{sm} siting area. Dungeness crab occurs generally in water shallower than 75 meters, but are much more common in shallower water (less than 25 meters) than the CalWave^{sm} site and are taken using pots with lines and surface floats. Spot prawn are found in a wide range of depths but more typically found between 200 and 250 meters and are taken both by trap and trawl.

These data are preliminary and do not reflect all of the nuances of a very complex and important industry on the central California coast. During future phases of CalWave^{sm} project development, we propose to continue working closely with the commercial fishing community to identify potential conflicts and also to develop detailed information about the fishery leading to an economic impact analysis. Initial indications are, however, that conflict with commercial fishing is not a fatal flaw for siting CalWave^{sm} as proposed. Though conflicts with commercial fishing could occur, the potential for conflict does not appear to be significant for CalWave^{sm} in this location.

4.1.2 Threatened and Endangered Species and their Critical Habitats

Many energy development projects require the resolution of issues having to do with a project's potential effects on special-status species, particularly those officially listed under the Endangered Species Act (16 U.S.C. § 1531 et seq.) before construction can begin. Occasionally, such issues can pose a fatal flaw to a project site and, in many cases, the resolution of special-status species issues becomes critical in terms of permitting cost and schedule. If a project would remove or adversely affect critical habitat for listed species, the result can be significant delays and permitting and increases of construction and post-construction monitoring costs.

Special-status species include those designated as species of special concern, threatened, and endangered species (California and Federal lists), and species protected under the Marine Mammal Protection Act (administered by the National Oceanic and Atmospheric Administration National Marine Fisheries Service [NOAA-NMFS]). Although any special-status species is regulated and project effects on such species are carefully reviewed, the legal mandate behind protection of species that are actually listed as threatened or

endangered is much stronger as it is against the law to take (harm, harass, kill) even one individual of such a species without a permit to do so.

4.1.2.1 Marine Species

Table 4-2 (following pages) shows the special-status marine species that could occur in the project region. The table indicates whether the species is likely to occur in the project area (or would be rare or extremely rare) and whether there is critical habitat for that species (if critical habitat has been designated), for shallow waters and offshore waters.

Table 4-3 (follows Table 4-2) is a subset of Table 4-2 that shows species that are both (1) listed as threatened, endangered, or fully protected (California) **and** (2) likely to occur in the CalWave^{sm} project area. These are the species that will elicit the most regulatory concern. The following is a brief narrative discussion of the regulatory/permitting issues most likely to arise regarding the listed species found in Table 4-3.

Birds. The least tern and California pelican are California State fully protected, meaning that the CDFW would not issue a permit to take this species. Impacts to these species would be likely to occur mainly if shore facilities were to disrupt a nesting colony. (This also applies to the western snowy plover, which is federally listed as threatened and a California Species of Special Concern). Literature review for this phase of work indicates that the nearest least tern nesting colony is located at Point Purisima in Vandenberg Air Force Base (Robinette, D.P, R. Ball, J. Miller, and J. Howard 2013). This location is shoreward of the CalWave^{sm} siting area (closest to, but not directly shoreward of the North Central and South Central prospective sites) but not in a location that would be near CalWave^{sm} shore-side facilities if the North Central or South Central site were chosen. Vandenberg has 13.8 miles of beaches suitable for snowy plover nesting. It is unknown at this time whether snowy plovers nest near Vandenberg Dock and this issue should be addressed during field surveys for permitting. If snowy plovers are nesting near the Dock, it should be feasible to avoid them using standard measures and Best Management Practices.

With diving feeders such as least terns and Scripps' murrelets, there could be concern that diving birds could encounter lost fishing gear tangled in mooring cables. Studies indicate that least terns forage in the vicinity of Platform Irene. The potential for this impact to occur would be low and could be mitigated by cable maintenance procedures to clear lost fishing gear, if needed.

Fish. Listed fish species likely to be present are all anadromous salmonids. It is unlikely that CalWave^{sm} would cause concern over these species because CalWave^{sm} would not affect terrestrial stream habitat for salmonids (given reasonable measures during generator tie-line construction) and, in their marine phase, salmonids roam widely in the pelagic zone.

In previous cases of marine development, agencies have expressed concerns that MHK or similar devices could be fish attraction devices (FAD) where predators of salmonids would congregate, feeding on young salmon entering the ocean from the mouths of streams, for projects relatively near shore and near a stream outlet. The Santa Ynez and Santa Maria rivers and San Antonio Creek are the only large salmonid-bearing streams that enter the ocean near the CalWave^{sm} project site. The mouth of the Santa Inez River is about 5.5 nm from the eastern edge of the South Central site. The mouth of San Antonio Creek is about the same distance from the eastern edge of the North Central site and the mouth of the Santa Maria River is about the same distance from edge of the North site. The South and South by Southeast sites are 10 and 15 nm, respectively, from the mouth of Santa Inez River. Smaller streams enter the ocean from the Tranquillon Ridge near these sites. It is unknown without further consultation with NOAA-NMFS, whether these streams or those previously listed would pose a significant issue with regards to salmonids.

TABLE 4-2
Special-Status Species that Could Occur in Shallower or Deeper Waters off of Vandenberg AFB or be Affected by the CalWave[sm] Project

Species[a]	Status[b]	Critical Habitat[c]		Likely to Occur[d]	
		Inshore Waters	Offshore Waters	Inshore Waters	Offshore Waters
Marine Birds and Shorebirds					
Brant (*Branta bernicla*)	SSC	--	--	Y	N
Ashy storm-petrel (*Oceanodroma homochroa*)	SSC	--	--	Y	Y
Black-footed albatross (*Phoebastria nigripes*)	BCC	--	--	U	U
Black storm-petrel (*Oceanodroma melania*)	SSC	--	--	Y	Y
California least tern (*Sternula antillarum browni*)	E, E, CFP	--	--	Y	Y
Cassin's auklet (*Ptychoranphus aleuticus*)	SSC	--	--	Y	Y
California brown pelican (*Pelecanus occidentalis californicus*)	DE, CFP	--	--	Y	Y
Double-crested cormorant (*Phalacrocorax auritus*)	SSC	--	--	Y	Y
Hawaiian petrel (*Pterodroma sandwichensis*)	FE	--	--	U	U
Light-footed clapper rail (*Rallus longirostris levipez*)	E, E, CFP	--	--	Y	N
Marbled murrelet (*Brachyramphus marmoratus)*	FT, SE	N	N	U	U
Pink-footed shearwater (*Puffinus creatopus*)	BCC	--	--	Y	Y
Black-vented shearwater (*Puffinus opisthomelas*)	BCC	--	--	Y	Y
Short-tailed albatross (*Phoebastris albatrus*)	FE	--	--	U	U
Scripps' murrelet (*Synthliboramphus scrippsi)*	FC, ST	--	--	Y	Y
Tufted puffin (*Fratercula cirrhata*)	SSC	--	--	Y	Y
Western snowy plover (*Charadrius nivosus nivosus*)	FT, SSC	--	--	U	Y
Fish					
North American green sturgeon southern DPS (*Acipenser medirostris*)	FT	N	N	U	U
Central California Coast coho salmon ESU *(Oncorhynchus kisutch)*	FE, SE	N	N	Y	Y
Southern Oregon/Northern California Coast Coho salmon ESU *(O. kisutch)*	FT, ST	N	N	Y	Y
California Coast Chinook salmon ESU (*Oncorhynchus tshawytscha*)	FT	N	N	Y	Y

TABLE 4-2
Special-Status Species that Could Occur in Shallower or Deeper Waters off of Vandenberg AFB or be Affected by the CalWave[sm] Project

Species[a]	Status[b]	Critical Habitat[c]		Likely to Occur[d]	
		Inshore Waters	Offshore Waters	Inshore Waters	Offshore Waters
Sacramento River winter-run Chinook salmon ESU (*O. tshawytscha*)	FE, SE	N	N	Y	Y
Central Valley spring-run Chinook salmon ESU (*O. tshawytscha*)	FT, ST	N	N	N	N
Northern California steelhead DPS (*Oncorhynchus mykiss*)	FT	N	N	Y	Y
Central Valley steelhead DPS (*O. mykiss*)	FT	N	N	Y	Y
Central California Coast steelhead DPS (*O. mykiss*)	FT	N	N	Y	Y
South-Central California Coast steelhead DPS (*O. mykiss*)	FT	N	N	Y	Y
Southern California steelhead DPS (*O. mykiss*)	FE	N	N	Y	Y
Southern eulachon DPS (*Thaleichthys pacificus*)	FT	N	N	N	N
Tidewater goby (*Eucyclogobius newberryi*)	FE, SSC	N	N	U	U
Longfin smelt (*Spirinchus thaleichthys*)	FC, ST	--	--	N	N
Marine Mammals – Cetaceans					
Gray whale (*Eschrichtius robustus*)	DE, MMPA	--	--	Y	Y
Bryde's whale (*Balaenoptera edeni*)	MMPA	-	-	U	U
Humpback whale (*Megaptera novaeangliae*)	FE, MMPA	--	--	Y	Y
Blue whale (*Balaenoptera musculus*)	FE, MMPA	--	--	Y	Y
Killer whale – Eastern North Pacific Southern Resident (*Orcinus orca*)	FE, MMPA	N	N	U	U
Killer whale –Eastern North Pacific Transient (*Orcinus orca*)	MMPA	--	--	Y	Y
Minke whale (*Balaenoptera acutorostrata*)	MMPA	--	--	Y	Y
Fin whale (*Balaenoptera physalus*)	FE, MMPA	--	--	Y	Y
Sperm whale (*Physeter macrocephalus*)	FE, MMPA	--	--	U	Y
Sei whale (*Balaenoptera borealis*)	FE, MMPA	--	--	U	U
North Pacific right whale (*Eubalaena japonica*)	FE, MMPA	N	N	Y	Y
Harbor porpoise (*Phocoena phocoena*)	MMPA	--	--	Y	Y

TABLE 4-2

Special-Status Species that Could Occur in Shallower or Deeper Waters off of Vandenberg AFB or be Affected by the CalWave[sm] Project

Species[a]	Status[b]	Critical Habitat[c]		Likely to Occur[d]	
		Inshore Waters	Offshore Waters	Inshore Waters	Offshore Waters
Dall's porpoise (*Phocoenoides dalli*)	MMPA	--	--	Y	Y
Pacific white-sided dolphin (*Lagenorhynchus obliquidens*)	MMPA	--	--	Y	Y
Risso's dolphin (*Grampus griseus*)	MMPA	--	--	Y	Y
Northern right whale dolphin (*Lissodelphis borealis*)	MMPA	--	--	Y	Y
Common bottlenose dolphin (*Truncatus truncatus*)	MMPA	--	--	Y	Y
Striped dolphin (*Stenella coeruleoalba*)	MMPA	--	--	U	U
Short-beaked common dolphin (*Delphinus delphis*)	MMPA	--	--	Y	Y
Long-beaked common dolphin (*Delphinus capensis*)	MMPA	--	--	Y	Y
Short-finned pilot whale (*Globicephala macrorhynchus*)	MMPA	--	--	U	U
Baird's beaked whale (*Berardius bairdii*)	MMPA	--	--	Y	Y
Beaked whales (*Mesoplodon* spp.)	MMPA	--	--	U	Y
Cuvier's beaked whale (*Ziphius cavirostris*)	MMPA	--	--	Y	Y
Marine Mammals – Pinnipeds					
Harbor seal (*Phoca vitulina richardsi*)	MMPA	--	--	Y	Y
Steller sea lion Eastern DPS (*Eumetopias jubatus*)	DE, MMPA	--	--	Y	Y
California sea lion (*Zalophus californianus*)	MMPA	--	--	Y	Y
Guadalupe fur seal (*Arctocephalus townsendi*)	FT, ST, MMPA	--	--	U	U
Northern elephant seal (*Mirounga angustirostris*)	MMPA	--	--	Y	Y
Northern fur seal (*Callorhinus ursinus*)	MMPA	--	--	Y	Y
Mammals – Mustelids					
Southern Sea Otter (*Enhydra lutris nereis)*	FT	--	--	Y	U
Invertebrates					
Black abalone *(Haliotis cracherodii)*	FE	Y	Y	Y	N
White abalone (*Haliotis sorenseni)*	FE	--	--	N	N

TABLE 4-2

Special-Status Species that Could Occur in Shallower or Deeper Waters off of Vandenberg AFB or be Affected by the CalWave[sm] Project

Species[a]	Status[b]	Critical Habitat[c]		Likely to Occur[d]	
		Inshore Waters	Offshore Waters	Inshore Waters	Offshore Waters
Reptiles					
North Pacific Ocean Loggerhead turtle DPS (*Caretta caretta*)	FE	--	--	U	U
Green turtle (*Chelonia mydas*)	FT	N	N	U	U
Leatherback turtle (*Dermochelys coriacea*)	FE	Y	Y	U	U
Olive Ridley turtle (*Lepidochelys olivacea*)	FT	--	--	U	U

[a] DPS = Distinct Population Segment; ESU=Evolutionarily Significant Unit

[b] FC = Federal Candidate for listing; FE = Federally listed as endangered; FT = Federally listed as threatened; BCC = Bird of Conservation Concern; MMPA = Protected by the Marine Mammal Protection Act
SE = California state-listed as endangered; ST = California state-listed as threatened; CFP = California Fully Protected Species; SSC = State Species of Special Concern; DE = Delisted

[c] Y = critical habitat occurs in project area
N = critical habitat not in project area
-- = critical habitat not designated for species

[d] Y = likely to occur in CalWave[sm] project area
U = potentially within species' range but unlikely to occur in project area (e.g., rare in area and/or found generally farther offshore). Marine mammals in this category could be affected by noise and vibration from project activities.
N = outside of species' range

TABLE 4-3
Listed (Candidate, Threatened, or Endangered) Marine Species likely to Occur in CalWave[sm] Siting Area

Species name	Federal status	State Status	Comment/Potential Impact
Birds:			
California least tern (*Sternula antillarum browni)*	Endangered	Fully protected	Nests at Purisma Point, dive-feeder
California brown pelican (*Pelecanus occidentalis californicus*)	-	Fully protected	Colony nesting, skim feeder
Scripps' murrelet (*Synthliboramphus scrippsi*)	Candidate	Threatened	Nests on Channel Island, dive-feeder
Western snowy plover (*Charadrius nivosus nivosus*)	Threatened	Special Concern	Nests on VAFB beaches, shore feeder
Fish:			
Salmon (5 Evolutionarily Significant Units)	Endangered /threatened	Endangered /threatened	Impact unlikely in marine phase
Steelhead (5 Distinct Population Segments)	Endangered /threatened	-	Impact unlikely in marine phase
Marine Mammals			
Humpback whale (*Megaptera novaeangliae*)	Endangered	-	Present in project area, vessel strike hazard
Blue whale (*Balaenoptera musculus*)	Endangered	-	Active near Channel Islands, vessel strike hazard
Fin whale (*Balaenoptera physalus*)	Endangered	-	Present, vessel strike hazard
Sperm whale (*Physeter macrocephalus*)	Endangered	-	Present, vessel strike hazard
North Pacific right whale (*Eubalaena japonica*)	Endangered	-	Present, vessel strike hazard
Sei whale (*Balaenoptera borealis*)	Endangered	-	Present, vessel strike hazard
Other Mammals:			
Southern Sea Otter (*Enhydra lutris nereis*)	Threatened	-	Lives and feeds near shore in kelp forest
Invertebrates:			
Black abalone (*Haliotis cracherodii*)	Endangered/Critical Habitat (rocky shores)	-	Avoid by directional drilling cable run to shore
Reptiles:			
Leatherback turtle (*Dermochelys coriacea*)	Endangered/Critical Habitat (north of Pt. Arguello)	-	Possible entanglement hazard (fishing nets on mooring cables)

Marine Mammals (cetaceans). Several listed whale species are present in the project area and will likely be a cause of some level of regulatory agency concern. These include the humpback, blue, fin, sei, sperm, and northern right whale. A recent 15-year satellite tracking study of 170 tagged blue whales, for example (Irvine, et al. 2014), documents a "home range" area around the western Channel Islands and extending north past and including much of the CalWave[sm] siting area and a "Core Area" that is a smaller area and on the margins of which the southern portion of the CalWave[sm] siting area is located. For these large whale

species, one of the major management concerns has to do with vessel strikes, particularly with large vessels. It is likely that regulatory agencies will request detailed information on vessel traffic size and frequency needed to construct and operate CalWave[sm] and will propose measures to reduce vessel strike. It is possible that agencies will seek measures to control hazards to listed whales that may be expensive to implement until it can be shown that the risk from CalWave[sm] support vessels is small. It is also likely that regulatory agencies will request studies of potential effects of construction and service vessel noise on marine mammals and other species.

Sea Otter. The southern sea otter has been relatively rare in the project area, but has expanded its range south of Point Conception in recent years. Sea otters feed on the bottom and in kelp forests and so spend most of their time within 1 km of shore and in shallower water. Regulatory issues would have mostly to do with disturbance of feeding grounds during cable laying and horizontal directional drilling near shore.

Black Abalone. Critical habitat for the black abalone has been designated as consisting of rocky shore habitats in the Vandenberg project area. Impacts to this species should be relatively easy to avoid by horizontal directional drilling.

Leatherback turtle. Critical habitat for the leatherback turtle has been defined for a large ocean area, starting at an east-west line extending west from Point Arguello. The South and South by Southeast sites lie outside of this area and the North, North Central, and South Central sites lie within it. Although three of the candidate sites are within the critical habitat zone, it is not clear (without further consultation) that a project like CalWave[sm] would have the potential to affect critical habitat in a way detrimental to this species and their preferred jellyfish prey.

4.1.2.2 Listed Terrestrial Species

Terrestrial species are, initially at least, of less immediate regulatory concern because: (1) impacts and mitigation measures are relatively well known for most areas, and (2) the project footprint on land is small, consisting of the horizontal directional drilling pit, shore facilities (currently sited on a paved area), and generator tie-line consisting of upgrades to existing distribution line poles for a distance of approximately six miles (assuming the South or South by Southeast site). Potential impacts to listed terrestrial species should be relatively easy to avoid by moving facilities such as distribution line poles out of the way. Table 4-4 shows the terrestrial species that are either federal or state threatened or endangered and that are known to occur in the vicinity of the project's shore facilities (USGS quadrangles surrounding the Tranquillon Mountain Quadrangle, where Vandenberg Dock is located).

It is difficult at this point to say whether or to what extent these species would affect project permitting because without additional analysis and field work that is beyond the scope of this phase of study, we do not know whether habitat for these species is found immediately surrounding the paved area on which the shore station facilities will be located or along the route of the generator tie-line replacement poles. In addition, some species could constrain construction timing. For example, noisy construction activities may be limited during the nesting season for the southwest willow flycatcher within a certain distance of suitable nesting habitat in riparian willow groves among arroyos along the distribution line (if present). Many of these species will likely be ruled out based on detailed habitat analysis and determinations that the project would be unlikely to affect, or could avoid them.

TABLE 4-4
Threatened or Endangered Terrestrial Species from the Project Area*

Common Name	Scientific Name	Federal Status	State Status
Amphibians			
California tiger salamander	*Ambystoma californiense*	Threatened	Threatened
California red-legged frog	*Rana draytonii*	Threatened	None
Birds			
Bald eagle	*Haliaeetus leucocephalus*	Delisted	Endangered
Belding's savannah sparrow	*Passerculus sandwichensis beldingi*	None	Endangered
Tricolored blackbird	*Agelaius tricolor*	None	Endangered
Little willow flycatcher	*Empidonax traillii brewsteri*	None	Endangered
Southwestern willow flycatcher	*Empidonax traillii extimus*	Endangered	Endangered
Crustaceans			
Vernal pool fairy shrimp	*Branchinecta lynchi*	Threatened	None
Fish			
Unarmored threespine stickleback	*Gasterosteus aculeatus williamsoni*	Endangered	Endangered
tidewater goby	*Eucyclogobius newberryi*	Endangered	None
Invertebrates			
El Segundo blue butterfly	*Euphilotes battoides allyni*	Endangered	None
Plants			
Surf thistle	*Cirsium rhothophilum*	None	Threatened
La Graciosa thistle	*Cirsium scariosum var. loncholepis*	Endangered	Threatened
Gaviota tarplant	*Deinandra increscens ssp. villosa*	Endangered	Endangered
Beach layia	*Layia carnosa*	Endangered	Endangered
Lompoc yerba santa	*Eriodictyon capitatum*	Endangered	Rare
Beach spectaclepod	*Dithyrea maritima*	None	Threatened
Seaside bird's-beak	*Cordylanthus rigidus ssp. littoralis*	None	Endangered
Vandenberg monkeyflower	*Mimulus fremontii var. vandenbergensis*	Endangered	None

* California Natural Diversity Database list from 9 quadrangles surrounding and including Tranquillon Mountain USGS 7.5-minute quadrangle. Note: Because of its coastal position, there are only six quadrangles surrounding the Tranquillon Mountain Quadrangle.

Note: Species already listed as marine (salmonids, snowy plover, brown pelican, etc.) in Table 3-3 are not listed here also.

Source: California Department of Fish and Wildlife. https://map.dfg.ca.gov/bios/?tool=cnddbQuick, accessed June 11, 2015.

4.1.2.3 Special-Status Species Summary

Projects having adverse effects on listed species can suffer delays, high permitting costs, and high monitoring costs. While it is too early for making definitive statements about CalWave^{sm}'s most likely biological resources permitting obstacles without more detailed information and field surveys, it does not

appear that listed species issues will pose fatal flaws for the development of CalWave[sm] at the proposed site or sites.

Conflicts with terrestrial species habitats appear to be relatively easy to avoid even if the species and habitat are present. For marine species, analysis of project effects for MHK projects has in the past been hampered by lack of experience with the technology and corresponding uncertainty about the potential effects of the MHK devices. In addition, there is in general less information about ocean ecosystems than terrestrial ones, because it is more difficult and expensive to collect information in the ocean and there are fewer development projects to sponsor baseline surveys and impacts analyses. The presence of listed marine species such as leatherback turtle and the large cetaceans (blue, fin, humpback, sperm, and sei whales) in the project area and in particular of critical habitat for the leatherback turtle in portions of the siting area could be cause for regulatory concern. On the other hand, it is difficult to see how the deployment of MHK devices in the chosen location could cause significant impacts or obstacles to these species or pose issues that could not be resolved by implementing prudent measures to observe and avoid cetaceans. Nevertheless, it is possible that agencies such as NOAA-NMFS will want to see relatively expensive detailed studies or long-term monitoring to be assured that unexpected impacts are not going to occur, as has been the case with previous MHK projects in permitting review. It is also possible that there will be agency concern regarding Scripps' murrelets, simply because this species breeds on the Channel Islands and feeds by diving into the ocean. For marbled murrelets, the US Fish and Wildlife has, in other locations, expressed concerns about birds diving into derelict fishing gear that is attached to WEC mooring cables and also to birds being confused by WEC lighting and coming to harm by circling around the lights to exhaustion.

4.1.3 Potential for Conflict with Marine Mammal Migration (Unlisted Species)

The California gray whale was removed (delisted) from Endangered Species Act listing but is protected under the Marine Mammal Protection Act and regulated by NOAA-NMFS. Permitting the project will require consultation with NOAA-NMFS regarding this species and possibly a Letter of Authorization or Incidental Harassment Authorization from this agency recognizing that a certain level of injury to or death of gray whales may result from CalWave[sm] activities. Gray whales migrate between Baja California and Alaska annually and so the entire population of about 22,000 will pass the project area twice in a year. The migration generally takes place closer to shore than the CalWave[sm] facilities will be sited. The potential for vessel strikes will exist for service vessels traveling from the project site to shore. In addition, some regulatory agencies have in the past expressed concerns about whales becoming entangled in mooring cables (unlikely) or in derelict fishing gear attached to the cables. This is a regulatory issue that will need to be addressed during the CalWave[sm] permitting phase, but should not prevent successful permitting. It is possible that regulatory agencies will request that CalWave[sm] collect project-specific baseline data on this species such as whale counts during the migration, with distance from shore. This could be done using shore-based observation stations, or aircraft or marine vessel transects. Subsurface sonar buoys have also been used to collect whale vocalization data and then prepare population or presence estimates.

4.1.4 Fisheries Resources and Habitat areas of Particular Concern

One of the required permitting reviews for CalWave[sm] will be the NOAA-NMFS analysis of the project's potential to adversely affect fisheries and EFH. This analysis is required under the Magnuson-Stevens Fishery Conservation and Management Act (16 U.S.C. §§ 1801-1884). EFH can include specialized habitats that serve as nurseries for sea life, such as estuaries and kelp forests. In the project area, there are a number of EFH areas that are mapped as HAPC. These are considered high priority areas for conservation, management, or research because they are rare, sensitive, stressed by development, or important to ecosystem function. In the project area, HAPCs are designated that provide rocky seafloor habitats that are

productive for commercial fisheries. Figure 4-1 depicts those habitats in the CalWave[sm] siting area. As the figure shows, the CalWave[sm] prospective sites largely avoid rocky bottom EFH. Although there are EFH areas near Vandenberg Dock, it will be feasible to avoid these areas during submarine cable landing by using HDD.

4.1.5 Potential Conflict with Ocean Uses Other than Commercial Fishing

A previous section (4.1.1) addressed the potential for CalWave[sm] to conflict with commercial fishing. Other ocean uses in the project area include recreational fishing and tourism (sailing and whale-watching), shipping, and oil field service. An unusual local use has to do with safety and national security requirements of space launches that take place from Vandenberg Air Force Base.

Recreational Fishing, Sailing, and Whale Watching. Although additional detailed study is needed on this topic, the potential for CalWave[sm] to conflict with recreational fishing, sailing and commercial (charter) whale watching is limited by the distance of the project siting area to the nearest port from which these activities can be based. Recreational and charter boats are available at Morro Bay and Port San Luis but, as stated earlier, the distance from Morro Bay harbor to the northernmost prospective site is 25 nm and to the South by Southeast site is 57 nm. From Port San Luis, the distances are 13 and 43 nm, respectively. The distance to the South by Southeast site from Santa Barbara Harbor is 50 nm. When the gray whale migration is available for viewing all up and down the coast and within 1 or 2 nm of shore, there is no compelling reason for recreational or charter boats to sail as far as the project siting area.

Shipping. Figure 4-1 shows the designated major vessel shipping lane into and out of the Santa Barbara channel. It is located four to five nm south of the nearest CalWave[sm] prospective site (South by Southeast) and beyond the range of any expected vessel activity for CalWave[sm].

Oil Field Service. Several BOEM oil and gas lease blocks are located near some of the CalWave[sm] prospective sites and there are four offshore oil platforms in the general area (Irene, Hidalgo, Harvest, and Hermosa). The CalWave[sm] BOEM research lease blocks would be located entirely outside of the oil lease blocks and it is not likely that CalWave[sm] would interfere with oil production operations or service boats attending the platforms. In fact, CalWave[sm] will propose to make effective use of the oil field service industry for marine service to the test center, and may realize efficiencies by taking advantage of the experience of oil field service mariners and their vessels to help service CalWave[sm]. Some discussions with the industry have begun (see Section 2.0).

Missile Launch Safety and Security. Vandenberg Air Force Base has established safety and security zones along the shore within the territorial sea. For safety and security during missile launch windows, private vessel traffic is prohibited from entering the safety zones (although this is apparently not strictly enforced). Nevertheless, the presence of the base and its security zones prevents some mariners from using the area.

4.1.6 Potential Conflict with Shore-side Land Uses

Except for the northernmost portion of the siting area, the land shoreward of the CalWave[sm] siting area is owned by the U.S. Government, Vandenberg Air Force Base, including most land on adjacent hills up to the ridgetops. This greatly limits the potential for visual resources impacts, as there are very few private or recreational viewers in these areas in a position to see the WEC devices in the water. In addition, the viewers that are present in these areas are accustomed to seeing the much more massive oil platforms in their ocean viewshed.

At the northern end of the siting area, adjacent land consists of some recreational uses at Guadalupe Dunes and Point Sal. Users of these areas, if they could see the WECs from shore (not certain without further analysis), might have a concern. Further south, however, there is minor recreational use on Vandenberg

AFB (mostly surfing and beach use), but it exists through Vandenberg AFB hospitality and not due to private land ownership.

Just south of the Vandenberg southern boundary is Jalama Beach County Park, a popular beach recreation and surfing location. Jalama Beach is an isolated island of public access land, however, surrounded by Vandenberg on the north and private land to the south, access to which is strictly controlled all the way to Point Conception and beyond. Jalama Beach is 6.8 (statute) miles from Vandenberg Dock and about 4.8 nm from the South by Southeast prospective site. At this distance, the WECs might be visible to users of Jalama Beach, but would appear much less prominent than the oil platforms just beyond the project site. Simulation models of typical WECs in place could be developed to address this issue during the permitting phase.

Another issue of concern to surfers (for example, Surfrider Foundation) involves a wave farm affecting the incident wave energy and thereby reducing the magnitude of waves that reach the shore at favored surfing spots such as Jalama Beach. Because of the prevailing direction of the waves, this would likely be a topic of discussion for the South site. The distance from Jalama, however, and the seafloor-dominant effects could reduce any concerns to a minimal level. The swell direction through the South by Southeast site runs from northwest to southeast and so would bypass Jalama, which is almost due east of this site. Waves passing through CalWave^{sm} prospective sites further north would come ashore north of Point Arguello and not affect Jalama Beach. When the issue of potential effects on wave height at shore has been addressed previously by numerical modeling, it has been determined that, due to refraction and diffraction, wave energy is repaired (fills back in) in the wake of a wave farm within several miles (distance depending on the extent of the wave farm and devices used). A modeling study could address this issue during the permitting phase, if needed. This is unlikely to become a significant issue requiring mitigation or reconsideration of project siting.

4.2 Marine Biology Literature Search

One of the key goals of this feasibility study has been to make a preliminary assessment of the environmental data that are currently available and that could be used to help establish the environmental baseline for permitting CalWave^{sm}. The most consequential data for permitting have to do with marine biological resources. We anticipate that the most time consuming and difficult permitting issues will have to do with marine biological resources and that, in addition, gathering new data specifically to address these issues will be relatively expensive, due to the cost of collecting data in the marine space. For this reason, we concentrated our efforts in looking at marine biological studies in the scientific literature having to do with marine life in the project area and have compiled an annotated bibliography of 45 selected, relevant scientific studies for future reference (Appendix 4-1).

In general, this preliminary literature search shows that there is considerable information that will be very useful for CalWave^{sm} for baseline marine biological resources permitting analyses, particularly for marine birds and fish. Some of these scientific studies were sponsored by BOEM (previously Minerals Management Service). A number of the studies, particularly for marine fish, focus on the effects of the oil platforms, including the northern platforms near CalWave^{sm} as artificial reefs/fish attraction devices. Some of the studies summarize data collected systematically in this area and up and down the coast, by the California Cooperative Oceanographic Fisheries Investigations (CalCOFI) program, which is a collaboration between CDFW, the NOAA-NMFS Southwest Fisheries Science Center, and the Scripps Institution of Oceanography, University of California at San Diego. CalCOFI is a long-term oceanographic and marine biology sampling program with regular sampling locations along a series of transects running perpendicular to the coast and extending from San Diego to Point Reyes, with a sampling “core area” of 75 sampling stations between San

Diego and Port San Luis, which is just north of the CalWave^{sm} siting area. Data from this program is made available to researchers and reports are periodically published using this data.

In addition, regular studies from Vandenberg AFB are represented in this group of papers, including studies of least tern and snowy plover nesting areas and studies of pinniped rookeries on base.

4.3 Infrastructure Permitting Literature Search

Recent proposals by the oil and gas industry to modify the oil platforms and their infrastructure and other proposals for ocean use have required permits and the permitting documents (Environmental Assessments, Environmental Impact Statements, Incidental Harassment Authorization and Letter of Authorization applications documents, and Coastal Zone Management Act consistency determinations) are available for review. These documents contain a large amount of baseline and background information about their project areas, and some are located near the CalWave^{sm} proposed siting area. The documents also contain analyses of key regulatory permitting issues that have arisen in connection with these projects, some of which will be similar to issues expected to arise during CalWave^{sm} permitting. The following is a brief summary of some of the most relevant documents, with annotation:

- Initial Study/Mitigated Negative Declaration for ExxonMobil's Santa Ynez 4 Unit Offshore Power System Reliability-B Phase 2 Project. July 2014. Retrieval and replacement of out-of-surface subsea transmission cables from shore to Platforms Hondo, Harmony, and Heritage in the Santa Barbara Channel. Addresses key permitting issues having to do with laying submarine cables in this area, including potential effects of construction noise and construction vessel strike on marine mammals.
- Revisions to the Platform Hidalgo Development and Production Plan to Include Development of the Western Half NW/4 of Lease OCS-P 0450, Coastal Zone Consistency Analysis and Findings. October 2012. Proposal to drill two additional oil and gas wells from Platform Hidalgo.
- Environmental Impact Report for the Tranquillon Ridge Project. April 2008. Proposal to drill into State waters from Platform Irene to recover oil and gas.
- Environmental Assessment of Marine Geophysical Surveys by the R/V Marcus G. Langseth for the Central Coastal California Seismic Imaging Project. May 2012. Geophysical surveys for the PG&E Diablo Canyon Nuclear Power Plant with extensive discussions of the effects of seismic testing noise on marine life and measures that could be applied to mitigate the effects.
- Environmental Assessment and Incidental Harassment Authorization for Conductor Pipe Installation at the Harmony Oil Platform in the Santa Barbara Channel. Discusses construction noise abatement strategies in detail.
- Incidental Harassment Authorization Application for Rocky Intertidal monitoring by the Pacific Partnership for Interdisciplinary Studies of Coastal Oceans, University of California Santa Cruz. July 2014. Discusses effects of scientific study activities on pinnipeds along rocky shorelines.
- Programmatic Environmental Impact Statement for Research Activities of the NOAA Pacific Southwest Fisheries Sciences Center. April 2013. Describes effects of operating research vessels in terms of the take of marine mammals and listed marine species.
- Letter of Authorization (Marine Mammal Protection Act) Request for Target and Missile Launch Activities, U.S. Navy, San Nicholas Island. July 2013. Extensive discussion of noise impacts.
- Letter of Authorization (Marine Mammal Protection Act) Request for Launches, Aircraft and Helicopter Operations and Harbor Activities, U.S. Air Force, Vandenberg Air Force Base. July 2013. Extensive discussion of noise impacts.

These environmental documents contain useful baseline summaries and, more importantly, detailed analysis of key issues, particularly on the effects from noise of construction and other operations in the marine environment. CalWave[sm] can expect to encounter these same issues. It will be very helpful that the regulatory agencies have prior experience with key issues, such as how to assess the potential effects of noise on marine biota in the project area and measures available to mitigate these effects.

4.4 Permitting Analysis and Permit and Authorization Review

There are two major types of authorizations needed for CalWave[sm] to begin construction: land/seafloor use leases or agreements, and environmental/regulatory permits. Leases include the agreement with the U.S. Air Force for the use of facilities at Vandenberg Air Force Base, BOEM marine energy research lease of the project test site, the California State Lands Commission (CSLC) submerged lands lease for the portion of the subsea cable run that is located in state waters. Table 4-5 lists the major permits and authorizations, responsible agencies, and legal authorities.

4.4.1 Lease Agreements

Vandenberg Air Force Base Agreement. The project will require an agreement to lease the on-shore facilities site from Vandenberg AFB and to interconnect with the Vandenberg electrical grid. Onshore facilities include the subsurface cable run from the test site onshore to the shore facilities, HDD bore site, shore side facilities location, which is a large, paved area adjacent to the access road leading to Vandenberg Dock, and Vandenberg Dock. It is anticipated that CalWave[sm] will at some point upgrade the existing 12 kV distribution cables from Vandenberg Dock to Substation 'N', and add 70 kV cables capability on the existing poles for approximately six miles between the shore site and Substation 'N'.

CSLC Submerged Lands Lease (Cal. Pub. Res. Code § 6216[a])**.** Submerged lands below the mean high tide line within the California territorial sea (to 3 nm from shore) are owned by the State of California and managed by the CSLC. Use of these lands for submerged cable installation will require a Submerged Lands Lease, administered by the CSLC. In accordance with the California Environmental Quality Act (CEQA), CSLC must consider the effects of their actions in granting the lease on the environment. This environmental review, however, could be combined with the Federal review for the marine hydrokinetic power license for which FERC will be the lead agency, if both agencies agree with this approach. During initial agency consultations conducted for this feasibility phase of CalWave[sm] project development, these agencies have initially said that a combined CEQA/NEPA process may be feasible.

BOEM Research Lease (30 CFR 585.238)**.** BOEM is the federal agency with responsibility for issuing leases to entities wishing to develop energy projects on the Outer Continental Shelf (OCS). For oil and gas leases or commercial offshore energy (wind, MHK) leases, BOEM may define lease blocks (seafloor lease areas) and hold auctions allowing multiple parties to bid on the areas for energy resources development. Under the provisions of 30 Code of Federal Regulations (CFR) §585.238, BOEM may also issue leases to certain public entities for research purposes.

> The Director may issue OCS leases, ROW grants, and RUE grants to a Federal agency or a State for renewable energy research activities that support the future production, transportation, or transmission of renewable energy (30 CFR 585.238[a]).

Before issuing a Research Lease, BOEM must make a Determination of No Competitive Interest by advertising the proposed research lease. If there is no competitive interest in the lease area, BOEM may issue the Research Lease. For the CalWave[sm] project, it is likely that the Research Lease holding entity will be the State of California, either through Cal Poly or the California Resources Agency.

TABLE 4-5
Permits and Authorizations Required to Begin Construction

Agency	PermitorAuthorization	Purpose	Authority
1. FederalAgencies			
United States Air Force, Vandenberg Air Force Base	• Onshore lease agreement, utility sale agreement	• Project host, interconnection with VAFB grid	• On-shore facilities land owner
Bureau of Ocean Energy Management	• Offshore Research Lease	• Sole authority to lease areas in the Outer Continental Shelf (OCS) for Energy Development	• Federal Power Act, 30 Code of Federal Regulations (CFR) 585.238
Federal Energy Regulatory Commission	• Hydrokinetic Project License • National Environmental Policy Act (NEPA) review	• Responsible for siting and operation of grid-connected hydrokinetic power facilities. Lead NEPA agency.	• Federal Power Act, 18 CFR 5 • National Environmental Policy Act
U.S. Fish and Wildlife Service	• Incidental Take Authorization (terrestrial species)	• Protection and recovery of threatened and endangeredspecies • Protection of migratory birds	• FederalEndangeredSpeciesAct • Migratory Bird Treaty Act
National Marine Fisheries Service	• Incidental Take Authorization (marinespecies) • Marine Mammal Permit (non-listed marine mammals) • Essential Fish Habitat Analysis	• Protection and recovery of threatened and endangered species and marine mammals and Essential Fish Habitat	• FederalEndangeredSpeciesAct • Marine Mammal Protection Act • Magnuson-Stevens Fishery Conservation and Management Act
U.S. Army Corps of Engineers	• Section 10 RHA Permit • Section 404 CWA permit	• Responsible for use of navigable waterways • Protect water quality and wetlands	• Rivers and Harbors Act • Clean Water Act
U.S. Coast Guard	• Private Aids to Navigation	• Responsible for siting of navigation aids in coastal waters	• 33 CFR 66
2. State Agencies			
California Coastal Commission	• Coastal Zone Consistency Determination, Coastal Development Permit (submerged lands)	• Responsible for development in the Coastal Zone; ensures public access to the Coastal Zone	• California Coastal Act • CoastalZoneManagementAct
California State Lands Commission	• Submerged Lands Lease • California Environmental Quality Act Certification	• Leasing of state-owned submerged lands • Responsibledevelopmentof projects on state submerged lands	• Submerged Lands Act/California PublicResourcesCodeSection6702 • California Environmental Quality Act

TABLE 4-5
Permits and Authorizations Required to Begin Construction

Agency	Permit or Authorization	Purpose	Authority
California Department of Fish and Wildlife	• Incidental Take Authorization • Streambed Alteration Agreement (if stream crossing)	• Protection and recovery of threatened and endangered species	• California Endangered Species Act, Section 2081 • California Fish and Game Code, Section 1603
Central Coast Regional Water Quality Control Board	• Section 401 Water Quality Certification • Waste discharge requirements (if waters of the state) • General National Pollution Discharge Elimination System Permits for construction and operation	• Protect and manage water quality	• Federal Clean Water Act • Porter-Cologne Water Quality Control Act
California Office of Historic Preservation	• Section 106 compliance review	• Protect and manage historic properties and other cultural resources	• National Historic Preservation Act
3. Local Agencies			
Santa Barbara County	• Encroachment Permit/Coastal Development Permit will not be required as all project facilities will be on federal property	• Would apply only if on-shore facilities placed outside of VAFB (non-federal land)	• Santa Barbara County Code

BOEM and FERC signed a Memorandum of Understanding (MOU) on April 9, 2009 to establish their respective jurisdictions and roles in authorizing renewable energy development on the OCS. This document established the exclusive jurisdiction of BOEM to issue renewable energy leases on the OCS and FERC to issue licenses for renewable energy projects using MHK technologies (BOEM maintains jurisdiction to license offshore wind projects). In July of 2012, FERC and BOEM released a document titled "BOEM / FERC Guidelines on Regulation of Marine and Hydrokinetic Energy Projects on the OCS" outlining procedures for licensing MHK projects on the OCS. Most importantly, this document simplifies permitting for MHK projects by combining what would otherwise be the separate processes of BOEM and FERC into a single process.

In the standard BOEM renewable energy permitting process for offshore wind development, an applicant would prepare a series of activities plans (Site Assessment Plan [or Research Activities Plan], General Activities Plan, and Construction and Operation Plan) and BOEM's environmental review process would be based on environmental information gathered in conjunction with preparing these plans/project description documents. In the standard FERC licensing process, by contrast, an applicant prepares a Pre-Application Document that serves as a draft project description and also contains initial baseline environmental information about the project area. The applicant then consults with regulatory agencies to prepare environmental study plans and, once these are accepted, prepares a formal application document and environmental effects analyses. FERC then issues an Environmental Assessment or Environmental Impact Statement. Under the new BOEM/FERC agreement, licensing will follow the FERC process. BOEM will be a consulting/cooperating agency, but once the Determination of No Competitive Interest has been made, the FERC will be the lead agency for environmental review and permitting that will take place mainly under FERC licensing procedures.

4.4.2 Licenses, Permits, and Authorizations

To authorize the start of construction, CalWave^{sm} will require a number of separate permits from various agencies (Table 4-5). These are discussed briefly below.

4.4.2.1 FERC License (18 CFR 5)

If there were a "master" environmental permit for CalWave^{sm}, it would be the FERC license. It is through the FERC licensing process and through the FERC acting in the capacity as lead Federal agency for compliance with the National Environmental Policy Act (NEPA) that other agencies will have their most important opportunity to comment on the project and its potential effects on the environment. It is also through the FERC licensing authority that consultations with key sister agencies will take place, leading to authorizations under the Endangered Species Act, Marine Mammal Protection Act, Magnuson-Stevens Act, and National Historic Preservation Act that are separate from, but closely linked with, the FERC license.

FERC has three variations on its licensing processes (Integrated, Traditional, and Alternative) that vary in terms of the timing and means of working with agencies and stakeholder groups and it is premature to decide which path is best for CalWave^{sm}. Nevertheless, a characteristic of all three processes is early consultation with regulatory agencies and development of study plans before implementing the plans and entering the environmental analysis phase.

Using the Alternative process as an example, the applicant would form a stakeholder working group to discuss key permitting issues and provide input to study plan development. The applicant then submits a Pre-Application Document and draft study plans. FERC begins the scoping process and, after agreement on the Study Plans, carries out the studies. The applicant can then file the formal application document along with a draft NEPA Environmental Assessment. The Traditional and Integrated processes differ in the organization and timing of stakeholder involvement and study plan submittal. One advantage of the

Alternative Process is that it allows the Applicant to prepare the draft NEPA EA. If the project requires an EIS, the Applicant can participate in selecting a third-party contractor to prepare the document. Under these circumstances, the Applicant may have better control of the permitting schedule during this phase of work.

The following is a brief discussion of consultations that FERC is required to make with sister agencies as part of the licensing process.

Endangered Species Act (16 USC § 1531 et seq.)—FERC is required to consult with the US Fish and Wildlife Service (terrestrial species and marine birds) and NOAA-NMFS (marine species) regarding whether the project may adversely affect species listed in the Federal Endangered Species Act or their critical habitat. This may take the form of an informal consultation, if agencies can agree that adverse effects are not likely, or more formal consultation, requiring these agencies to issue a Biological Opinion (BO) regarding the effects of the project on listed species and possibly an Incidental Take Permit that specifies the amount or level of take that will be allowed for the activity permitted, and the mitigation measures that would be required. The BO is partly based on the applicant's/FERC's analysis of project effects and proposed measures to avoid or mitigate them provided in a Biological Assessment (BA) document. FERC will also consult with the US Fish and Wildlife Service (USFWS) under the Migratory Bird Treaty Act regarding the project's potential effects on migratory birds.

Marine Mammal Protection Act (16 USC § 31)—Marine mammals not listed under the Endangered Species Act are protected from harm and harassment under the Marine Mammal Protection Act. The FERC is required to consult with NOAA-NMFS regarding the potential effects of the project on marine mammals. NOAA-NMFS will issue an Incidental Harassment Authorization or Letter of Authorization, similar to a take permit, that allows a clearly defined level or amount of harassment or take per annum.

Magnuson-Stevens Fishery Conservation and Management Act (16 USC §§ 1801-1884)—The FERC is also required to consult with NOAA-NMFS regarding a project's possible effects on the viability of commercial fisheries. NOAA-NMFS has designated certain areas as EFH and carefully reviews proposed actions that would affect EFH in a way that could damage the productivity of commercial fisheries. In the project area, the defined EFH mostly has to do with rocky seafloor bottom and CalWave^{sm} is unlikely to affect this.

National Historic Preservation Act (16 USC § 470 et seq.)—Under Section 106 of the National Historic Preservation Act, federal agencies must consider the effects of their actions on historic properties (those meeting the criteria for listing in the National Register of Historic Places). FERC would issue this request to the California Office of Historic Preservation, along with a copy of CalWave's report of surveys of archaeological and historic properties that could be affected by the project. Historic properties could include shipwrecks along the submarine cable lay or in mooring areas.

4.4.2.2 U.S. Army Corps of Engineers Section 10 and 404 Permits

Under Section 10 the Rivers and Harbors Act (330 USC §§ 407) the U.S. Army Corps of Engineers (USACE) has the authority to permit development in navigable Waters of the United States and under Section 404 Clean Water Act (30 USC §§ 1251-1387), the USACE has the authority to regulate dredge and fill (construction activities) in Waters of the United States. The agencies would require a detailed project description and analyses of the potential impacts on navigation and on water quality. These permits are at times issued in tandem. USACE would rely on FERC to be the lead NEPA agency for the overall analysis of environmental impacts associated with the project.

4.4.2.3 California Water Resources Control Board Section 401 Water Quality Certification

Under the Clean Water Act, the USACE's issuance of a Section 404 permit automatically requires a Water Quality Certification (WQC) under Section 401 of this law. Responsibility for implementing Section 401 has been delegated in California to the State Water Resources Control Board and Regional Water Quality Control Boards. The WQC will dictate conditions for the preservation/control of water quality associated with construction and operation of the project.

4.4.2.4 California Coastal Commission CZMA Consistency Determination

The FERC requires a determination that the project is consistent with the federal Coastal Zone Management Act (16 USC §§ 1451–1464). In California, this determination is made by the California Coastal Commission (CCC), which also issues Coastal Development Permits (CDP) in its retained jurisdiction, which includes submerged lands of the territorial sea. On private land in the Coastal Zone (roughly, 1,000 feet from the shoreline), Coastal Development Permits are issued by the local jurisdiction, if an approved Local Coastal Plan is in place. CalWave^{sm} would not require a Coastal Development Permit for shore facilities because they are on federal land. To obtain the CDP, CalWave^{sm} will submit a Coastal Resources Assessment and CDP application. The CCC will rely on the CSLC for CEQA review of its permitting action.

4.4.2.5 California Department of Fish and Wildlife CESA Consultation, Section 1602 Permit

Consultation with the CDFW regarding the project's potential effects on species listed under the California Endangered Species Act will take place through the CEQA process which may take place through the CSLC or as a combined state/federal process coordinated through the FERC license. The CDFW has particular concern over species that are state-listed but not federal listed, such as the California brown pelican and Scripps' murrelets, but will require an Incidental Take Permit application under Section 2081 of the California Fish and Game Code if take of listed species is likely.

CalWave^{sm} may also need a Lake and Streambed Alteration Agreement (Section 1602 of the California Fish and Game Code) if it will involve construction within the bed and bank of a stream or lake. It is possible that this would be required for the generator tie-line pole upgrade between the shore site and substation. Final routing and pole placement will determine whether this is needed.

4.4.2.6 U.S. Coast Guard

CalWave^{sm} has begun coordinating procedures for the U.S. Coast Guard's review and comment on private aids to navigation, in this case, WEC lighting and marking, per Coast Guard regulations at 33 CFR 66.

4.4.2.7 Santa Barbara County

All of the components of the CalWave^{sm} project are on federally owned and managed land or in submerged lands. For this reason, the project will not require a County Coastal Development Permit.

4.5 Permitting Schedule

The time that it will take to secure permits and authorizations needed for CalWave^{sm} to begin construction will depend on a number of factors, including whether there are changes to the project design or siting during permitting, the level of controversy over the project among the public and agencies, and the kinds of studies that agencies require in order to resolve environmental permitting issues. Table 4-6 is a hypothetical scheduling scenario that assumes that there is a relatively mature project description to begin permitting at the initial stages depicted on the bar chart. The table shows the permitting being conducted in three phases: (1) Pre-application, (2) Application Review, and (3) Final Permits.

4.5.1 Pre-application Phase

Pre-application activities include BOEM's Determination of No Competitive Interest. This is a pre-requisite for issuance of a BOEM Research Lease. Competitive interest in the project siting area is considered unlikely. At this point in project development, CalWave[sm] will have finalized selection of a preferred/proposed project site and will request a research lease for a single 2.5 x 2.5 nm lease block or a smaller subset thereof. CalWave[sm] will submit a Notice of Intent (NOI) to file an application and a Pre-Application Document (PAD) to FERC. The NOI/PAD will contain a detailed description of the project site location, a description of the project design, and general information about the environmental baseline that will allow agencies, stakeholders, and interested parties to understand the scope of the project. FERC will then hold scoping meetings and prepare scoping documents that identify key regulatory and public interest issues. In consultation with FERC and the regulatory agencies and the collaborative working group established through the stakeholder involvement program, CalWave[sm] will prepare draft study plans for review. These study plans will identify data that will need to be collected to address the key regulatory issues. Preparation of study plans is CalWave[sm]'s opportunity to focus the study effort on substantive issues and of regulatory agencies to request data they feel is necessary to address key issues.

Finally, CalWave[sm] will implement the study plans and begin collecting the data that will be necessary to permit the project. After this phase of initial encounter with FERC, the public, and regulatory agencies, issues may arise that lead to minor changes to the project design.

4.5.2 Application Phase

CalWave[sm] can begin preparing the FERC license application based on the initial project design and the results of scoping studies and discussions with regulatory agencies, and the public. The actual time it will take to complete this phase of the schedule is undetermined at this early stage because it is not clear whether the study plans will require data from more than one season or even more than one year. If long-term studies will not be needed to resolve environmental resources issues (for example, potential effects on listed species or marine mammals), then less time may be needed for field studies and the schedule might possibly be shortened.

CalWave[sm] will prepare the final license application and file the document with FERC. The license application will contain a detailed project description suitable for permitting, environmental baseline analyses of the key environmental resources disciplines of interest to FERC, and analysis of CalWave[sm]'s potential effects on environmental resources. Under the Alternative Licensing Process, CalWave[sm] could also submit a preliminary draft NEPA EA document at or shortly after this time which, after acceptance by FERC, would serve as FERC's NEPA compliance document if an EIS is not necessary. In the latter case, the EIS would be prepared by a third-party, paid for by CalWave[sm], instead of by FERC staff.

It is possible that the NEPA document, with minor changes, could also serve as a CEQA compliance document and it will be a goal of the next phase of CalWave planning and development to gain a more definitive agreement between state (CSLC) and federal (FERC) agencies that this is feasible for them.

During this phase also, CalWave[sm] will prepare the following application documents and submit them to the applicable regulatory agencies:

- Clean Water Act Section 404/Rivers and Harbors Act Section 10 Permit – USACE
- Submerged Lands Lease – CSLC
- Coastal Development Permit and CZMA Consistency Determination – CCC
- Clean Water Act Section 401 Water Quality Certification – SWRCB/RWQCB

TABLE 4-6

CalWave[sm] Hypothetical Permitting Process Schedule

Party	Task/Event	Year 1												Year 2												Year 3											
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
Pre-Application:																																					
BOEM	Det. of No Competitive Int.																																				
CalWave	NOI and Pre-Application Doc.			◆																																	
FERC	NEPA Scoping Meetings																																				
CalWave	Draft Study Plans							◆																													
Agencies	Study Plan Review																																				
CalWave	Final Study Plans										◆																										
CalWave	Conduct Field Studies																																				
Application Review:																																					
CalWave	FERC License Application																					◆																
FERC	ESA, MMPA, FCMA, NHPA																																				
CalWave	Apps. to USACE, CSLC, CCC																							◆													
Agencies	Information Requests to FERC																																				
CalWave	Responses to Info Requests																																				
CW/FERC	Draft NEPA/CEQA doc																												◆								
Agencies	ESA, MMPA, MSFCMA, NHPA																															◆					
FERC	Final NEPA/CEQA doc																															◆					
Final Permits:																																					
BOEM	Final Lease Agreement																																◆				
USACE	Issue 404/10 Permit																																	◆			
CSLC	Issue Submerged Lands Permit																																	◆			
CCC	CZMA Determination/CDP																																	◆			
SWRCB	Issue 401 WQC																																		◆		
FERC	Final Licensing Order																																		◆		
◆	Major milestone																																				

After acceptance of the application and CalWave[sm]'s Biological Assessment as complete, FERC will initiate the required consultations with sister agencies (NOAA-NMFS, USFWS, California Office of Historic Preservation), work with the applicant or third-party consultant to finalize the NEPA document and then issue the document to the public and agencies for comment. After receiving comments, FERC, with CalWave[sm]'s help and that of the third-party consultant, will respond to the public and agency comments and issue the final NEPA document. After consultations with sister-agencies are completed, FERC will issue the final NEPA document and its own findings.

4.5.3 Permit and Lease Issuance

Once the final NEPA/CEQA document is certified BOEM can issue the Research Lease, contingent on obtaining all authorizations needed from other agencies. Once the federal and state agencies have issued the ancillary permits and their comments to FERC with proposed licensing conditions for resources under their responsibility, FERC can issue the final licensing order and CalWave[sm] can enter the construction phase.

4.6 Cost Estimate

The cost of licensing and permitting CalWave[sm] has the following essential components:

- Gather baseline data/literature search
- Gather site-specific field data
- Prepare and file application documents
- Respond to information requests and comments on the license and permit applications
- Prepare construction monitoring and compliance plans
- Monitor construction
- Monitor post construction

Costs in each of these phases will also include costs of coordination with the CalWave[sm] project development team and of participating in the public involvement and stakeholder engagement program (meetings with regulatory agencies, etc.).

At this stage of development (feasibility study), costs of two components in particular are especially difficult to predict. These are the site-specific data gathering and the post-construction monitoring components. Costs of site-specific data gathering will depend to a large extent on the outcomes of the (1) literature search that will establish what site-specific data or good proxy data is already available and (2) the outcome of negotiations with regulatory agencies regarding which issues will require site-specific data gathering and the extent of data needed to address regulatory issues. Costs of post-construction monitoring will depend largely on the level of uncertainty that remains regarding potential project effects after construction.

4.6.1 PNNL Permitting Cost Studies

The DOE Pacific Northwest National Laboratory (PNNL) has conducted several studies to estimate the potential contribution of licensing and permitting to the development of MHK power projects. These studies established several reference models (tidal, ocean current, point absorber, oscillating water column, nearshore flap, etc.) and prepared generic estimates of potential licensing costs for each reference model. Copping and Geerlofs, 2011; Copping, Geerlofs, and Hanna, 2013, 2014).

The PNNL studies assumed that the following biological field data collection efforts would be needed to license an MHK wave farm (point absorber, oscillating water column), among other studies needed:

- **Marine Mammals—**Large vessel for gray whale surveys in spring and winter; small vessel surveys for resident gray and humpback whales in summer and fall; acoustic monitoring with autonomous recorders for other species
- **Fish and Invertebrates**—Grab sampling to assess benthic invertebrates, trawling to assess demersal fish and benthic invertebrates
- **Birds**—Small boat surveys and line transects, some of which can be done in conjunction with marine mammal surveys
- **Sea turtles**—Surveys done in conjunction with marine mammal and seabird boat surveys or by aircraft.

These studies are recommended to continue for a year (marine mammals, sea turtles) or more (fish and invertebrates) for sites where baseline data is not available, and for CalWave^{sm} would commence later in Year 1 (see schedule, above) after study plans are approved.

The PNNL studies developed low and high cost range estimates for three scenarios: (1) pilot project, <5 M for 5 years, (2) small-scale commercial (10 to 50 devices), and (3) large-scale commercial (> 50 devices). The scenario that best fits CalWave is the small-scale commercial model. Differences are that CalWave^{sm} may host fewer than 50 devices. It will operated for more than 5 years, but possibly less than the 30-year presumed lifetime of a large commercial wave farm (assume 25 to 30 years). Table 4-7 reproduces the PNNL cost estimates (adjusted for inflation), for Reference Model #3, point absorber buoy with a reaction plate, anchored to the seafloor, assuming northern California location, and Reference Model #6, Oscillating Water Column devices sited in 50 m of water in Northern California. Copping and Geerlofs note that these costs estimates do not include possible costs of mitigation, which would be specific to a particular project and which, for some projects, could be substantial.

TABLE 4-7
PNNL Permitting Cost Estimates, Reference Models #3, Point Absorber and #6, Oscillating Water Column

Reference Model	RM#3, Point Absorber		RM#6, Oscillating Water Column	
Project Phase	**Low Estimate***	**High Estimate***	**Low Estimate**	**High Estimate**
Siting & Scoping	$341,794	$538,585	$330,000	$530,000
Pre-Installation Studies	$2,055,944	$3,847,774	$1,753,000	$3,452,000
NEPA & Process	$937,345	$1,786,652	$1,100,000	$2,300,000
Subtotal - Permitting	$3,335,083	$6,173,010	$3,183,000	$6,282,000
Post-Installation Monitoring	$7,493,579	$18,068,484	$9,355,000	$19,800,000
Grand Total	$10,828,662	$24,241,495	$12,538,000	$26,082,000

Source: Copping and Geerlofs, 2011; Copping, Geerlofs, and Hanna, 2014
* These costs have been adjusted upward from those provided by Copping and Geerlofs by 3.5 percent to account for price inflation between 2011 and 2013.

The PNNL reference models indicate that, not surprisingly, the largest costs will be for pre-installation data gathering and post-installation monitoring. PNNL estimates costs to permit an oscillating water column as higher than point absorber, partly due to the size and deck area required for an oscillating water column. This leads to more potential conflicts with marine mammals and sea birds.

These costs are relatively high compared with energy facilities on land, but this is partly due to the high cost of collecting data in the ocean and also the scale of the facilities. Costs for large-scale solar farms requiring large amounts of land have reached, and exceeded, these levels routinely for initial permitting.

The post-construction monitoring cost estimates seem particularly high, although less so when placed in the context of a 30-year project life. The standard approach for environmental permitting is that applicants and regulatory agencies, working together, should be able to predict or foresee what impacts to public resources will be significant and adverse, and prepare plans or mitigation measures to avoid or compensate for adverse impacts before construction takes place. In reality, however, some impacts of MHK projects implemented in the marine environment are still uncertain and agencies are likely to require post-construction monitoring to determine whether or not unforeseen impacts are taking place. Copping and Geerlofs put it this way:

> Until sufficient data exist to anticipate interactions of MHK devices with marine animals and habitats, extensive monitoring is likely to be required during the initial years of deployment at the commercial scale, resulting in front-loading of costs in the first five years (2011:3.13)

Once the MHK industry is well established, it is expected that post-construction monitoring will be required only for a few particularly intractable issues for which additional information needs to be gathered to resolve issues.

4.6.2 CalWave^{sm} Permitting Cost Estimate

The PNNL reference model cost estimates are very helpful in estimating MHK project permitting costs and were intended as reference models for developing site-specific cost estimates for proposed facilities. Each location will have special data-collection needs that will drive permitting costs at that location.

The cost estimate included here in Table 4-8 for CalWave^{sm} is based on the PNNL cost models and also assumes the following:

- It will take approximately three years to permit the project
- One year of field studies (or less) will be sufficient to gather baseline data needed to permit the project
- These permitting costs do not include bathymetry and wave resource assessment, turbulence, and other oceanographic site characterization tasks
- CalWave^{sm} will host up to 15 WECs and will operate for 25 to 30 years
- Post-construction monitoring can be significantly reduced after 5 years
- These permitting costs do not include the costs of stakeholder participation and public involvement (those are estimated separately – see Section 5.0)
- This cost estimate is preliminary and Rough Order-of-Magnitude (ROM) estimate only and is based on current information (feasibility study).

TABLE 4-8

CalWave^{sm} Permitting Preliminary Cost Estimate*

Task	Low	High	Notes
Gather Baseline Data	$70,000	$100,000	Lit. search for environ. disciplines
Field Studies:			
Marine Mammals	$300,000	$800,000	Vessel, airplane, or sonar-buoy
Fish and Invertebrates	$200,000	$750,000	Trapping, netting, trawling
Seabirds	$50,000	$100,000	Combine with MM survey
Habitat mapping (from bathymetry)	$20,000	$30,000	Assumes bathymetry available
Terrestrial Biology	$40,000	$80,000	Survey shore site, gen-tie line
Cultural Resources	$35,000	$60,000	Survey shore site, gen-tie line, assume historic shipwrecks avoided
Commercial Fishing Assessment	$35,000	$120,000	LOE depends on fisher concern

TABLE 4-8

CalWave[sm] Permitting Preliminary Cost Estimate*

Task	Low	High	Notes
Other (Visual Resources, Recreation, etc.)	$25,000	$50,000	Prepare visual simulations
Water Quality/Hydrodynamic modeling	$100,000	$200,000	Deploy conductivity, temperature, depth instrument, combine with other surveys
Noise modeling	$20,000	$50,000	Estimates of project noise levels
Air emissions modeling	$30,000	$50,000	Model construction and operation emissions for NEPA/CEQA analysis
Sediment trans/shoreline wave modeling	$30,000	$50,000	Model effects of wave energy removal on sediment, recreational surfing
Ship navigation transponder	$5,000	$10,000	Deploy AIS transponder to record ship tracks (if not available from VAFB)
Subtotal field studies	$890,000	$2,350,000	
Applications (FERC, USACE, CSLC, CCC, etc.)	$250,000	$300,000	Applicant-prepared documents
NEPA/CEQA document	$100,000	$650,000	If EIS/EIR, consultant-prepared (high)
Information Request Responses	$150,000	$250,000	Applicant and 3rd party consultant
Subtotal Application/licensing process	$500,000	$1,200,000	
Total Permitting Costs	**$1,390,000**	**$3,550,000**	**Cost to authorize construction**
Post-Licensing Compliance Plans	$60,000	$80,000	Plans required by permit for construction compliance
Construction Monitoring	$150,000	$350,000	Whale monitors, etc. for construction
Post-Construction Monitoring	$3,463,333	$8,710,000	Most in first five years, 20-year project
Total Post-permitting costs	**$3,673,333**	**$9,140,000**	
Grand Total, permitting and operation	**$5,063,333**	**$12,690,000**	

*Estimates based roughly on PNNL reference models for a site with no previous pilot project to establish baseline data

4.6.3 References Cited

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Irvine LM, Mate BR, Winsor MH, Palacios DM, Bograd SJ, et al. (2014) Spatial and Temporal Occurrence of Blue Whales off the U.S. West Coast, with Implications for Management. *PLoS ONE* 9(7): e102959. doi:10.1371/journal.pone.0102959.

Robinette, D.P, R. Ball, J. Miller, and J. Howard. 2013. Monitoring and Management of the Endangered California Least Tern and the Threatened Western Snowy Plover at Vandenberg Air Force Base, 2013. Unpublished Report, Point Blue Conservation Science, Petaluma, CA.

SECTION 5

Stakeholder Participation and Public Involvement

For CalWave[sm] SOPO Task #5 (Public Acceptance by Coastal Community and Other Ocean Users) Project Team members conducted a six-month stakeholder engagement process with the local coastal communities and ocean users. Additionally, the Project Team worked with state and federal permitting agencies to begin to coordinate permitting requirements and information needs for CalWave[sm].

5.1 Outreach Activities

The Project Team implemented a three-stage public engagement approach:

- Conducted interviews with 11 project stakeholders representing a variety of interests
- Held a public meeting to present information about the project and accept comments and questions (See Appendix 5-1 for a meeting summary)
- Held a meeting with the key regulatory agencies to present the project and accept comments and questions (See Appendix 5-1 for a meeting summary. Appendix 5-2 contains copies of the posters used for both meetings).

In addition, the Project Team conducted meetings with the fishing community in Morro Bay and had individual conversations with public elected officials and several additional several stakeholders, including the Northern Chumash Tribal Council and Sierra Club (which is seeking a National Marine Sanctuary in the area).

5.1.1 Response from Interviews and Public Meetings

The public outreach program determined that, while stakeholders raised interests and concerns related to the project's potential impact to existing ocean uses and biological and cultural resources, they largely support the concept of CalWave[sm], but would want to know specifics as they become known. Stakeholders indicated appreciation for the early outreach and the project team's attempt to identify potential project sites that interfere with ocean uses and known resources as little as possible. The following concerns and interests were raised during the interviews and public meetings:

- Biological resources
  - Potential impacts from electromagnetic fields and acoustic noise
  - Potential impacts to marine mammals, migrating species, seabirds, and local fish populations
  - Potential impacts to Marine Protected Areas and the Channel Islands National Marine Sanctuary
- Transmission
  - Potential impacts from transmission infrastructure, both onshore and offshore; recommend use of existing infrastructure if it results in the least environmental impact
  - Potential impacts from development of additional transmission infrastructure from Vandenberg AFB to elsewhere in Santa Barbara County (to deliver power beyond the base)
- Fisheries and Fishing
  - Potential impacts to fisheries and to both recreational and commercial fishing communities (Morro Bay, Santa Barbara, and Port San Luis)
- Tribal/Cultural Resources
  - Potential impacts to submerged cultural sites from transmission cables coming onshore

- Public Engagement and Outreach
  - Standard, large-format evening meetings will be useful in addition to smaller, face-to-face meetings with key groups (e.g., fishing community)
  - Present information directly to tribal elders councils and engage tribes individually throughout the process; engage with federally-recognized and non-federally-recognized tribes
  - Ensure that stakeholder feedback is used in the feasibility study and publicly acknowledged
  - Spread information through the Channel Islands National Marine Sanctuary Advisory Council and other local organizations such as the Santa Barbara Harbor Commission
  - Recommend using a similar engagement approach that was used for the proposed Pacific Gas & Electric Company WaveConnect project, which was very effective

These interests and potential impacts are being considered during appropriate phases of project development.

5.1.2 Response from Regulatory Agency Meetings

The regulatory agencies supported continued coordination to ensure a smooth permitting process. They reviewed likely marine and terrestrial species of concern to be reviewed in the environmental review phase, and expressed interest in providing information to support siting decisions among the five candidate options. The regulatory agencies discussed the potential advantages of using the FERC Alternative Licensing Process and having a joint NEPA and CEQA document prepared by FERC as the lead federal agency for NEPA and the CSLC as the lead CEQA agency should the project continue to future phases.

5.1.3 Summary of Early Engagement Feedback

The Project Team's early outreach resulted in largely positive feedback from the environmental and recreational communities and the fishing community (based on the potential project locations identified to date). Business and tribal leaders indicated an interest in and willingness to further discuss the project, and the regulatory agencies expressed interest in coordinating closely on the project. Furthermore, both the Northern Chumash Tribal Council and Sierra Club see offshore renewable energy as compatible with their proposal to create a broad-scale National Marine Sanctuary in the region. This feedback indicates a likelihood of project feasibility for CalWave^{sm}.

5.2 Recommendations for Future Engagement

Based on the information the Project Team gathered during this preliminary engagement phase, the Project Team recommends the following approaches for public engagement and outreach for future phases of the project.

5.2.1 Goals for Outreach and Engagement

The Project Team has set the following goals for future outreach and engagement:

- Transparent, robust, and clear information-sharing
- Early, inclusive engagement and outreach with all affected/interested stakeholder groups
- Meaningful response to inquiries
- Inclusion of stakeholder interests, where feasible

Above all, the engagement and outreach efforts should incorporate information received from stakeholders and agencies early and throughout the process, ultimately leading to better project siting, quality and efficient permitting and licensing with appropriate protection, mitigation, and enhancement measures,

strong adaptive management and monitoring plans, and sound development and construction plans and management decisions.

5.2.2 Audiences for Outreach and Engagement

In order to develop a successful project, we recommend conducting outreach to, seeking feedback from, and discussing the proposed project with the following categories of stakeholders:

- Federal, state, and local permitting agencies
- Tribes (both federally- and non-federally-recognized)
- Local business interests
- Local coastal communities
- Fishing communities
- Recreation interests
- Environmental organizations
- Navigation and marine interests
- Academic institutions
- Power development and utility industry
- Labor

5.2.3 Engagement Methods

To achieve the outreach and engagement goals outlined above, we recommend placing a high priority on two activities in particular: 1) collaborative work with the regulatory agencies, and 2) convening a project advisory group comprised of representatives from each stakeholder category. In both cases, the engagement should focus on understanding and avoiding/minimizing/mitigating biological and cultural resource impacts; limiting impacts to existing ocean uses including navigation, shipping, fishing, recreation, and tourism; and developing appropriate protection, mitigation, and enhancement measures.

5.2.3.1 Regulatory Agency Group

We recommend that CalWave[sm] convene a group of regulatory agency representatives at least three times over the course of 12 months, ideally at the BOEM Pacific Offices in Camarillo, which is the most convenient location for most state and federal resource agencies. This group would provide initial input on siting and issue/information identification, existing available information, identification of potential studies to be conducted in future phases, and information to be included in the FERC Pre-application Document (PAD). The regulatory agency group would also work to develop a coordinated regulatory process, or roadmap, for permitting the project, including each agency's permitting process and a suggested timeframe to achieve well- coordinated and efficient licensing and permitting.

5.2.3.2 Stakeholder Advisory Group

We recommend that CalWave[sm] establish an Advisory Group for this project, comprised of a cross-section of interested stakeholders such as fishing, environmental, recreation, local business, local policy leaders, and state and federal regulatory agencies, to provide input on siting, issue identification, and other topics of interest. The state and federal regulatory agencies will also be invited to participate in the Regulatory Agency Group. The Advisory Group would be convened at least once during the next (FY 2015-funded) phase of the project and would meet in a central location for stakeholders (likely in Lompoc). This Advisory Group would then be convened in future phases in the project development process, as needed, to solicit feedback in a collaborative manner from a wide variety of local perspectives. This collaborative forum would enable a variety of stakeholders to hear and understand others' perspectives and jointly propose solutions and ideas that can work for multiple interests. Advisory Group members could serve as liaisons

with their constituents/members and others in the local community sharing information about the proposed project.

5.2.3.3 Marine Industry Advisory Group

We recommend that CalWave[sm] establish a Marine Industry Advisory Group to promote the safety of CalWave[sm] marine operations through communications, mutual cooperation, and understanding of lessons from industry counterparts with decades of experience in the vicinity of VAFB. Initial feedback from industry members is positive.

5.2.3.4 Additional Stakeholder Engagement Activities

As the budget allows, we recommend that the following activities be included in the engagement process for the next phase of CalWave development:

- **Public meetings.** At project milestones, host one or two public meetings in the project area to provide updates, solicit feedback on project siting and other characteristics, and share next steps. These meetings serve as an important bridge between Advisory Group members and citizens who are also interested in participating in project development.
- **Small group and one-on-one meetings.** Holding individual meetings with interested stakeholder groups, policy leaders, and others can be a highly effective way of listening to concerns, sharing information, and coming to agreement about preferred options for project development. Where possible, the project team should reach out to individual communities, most importantly the local fishing communities, local elected officials, and individual tribes (both federally-recognized and non-federally-recognized).

5.2.4 Outreach Methods

To achieve the goals listed above, we recommend placing a high priority on maintaining an up-to-date, clear project website and sending quarterly electronic updates to stakeholders. These activities will enable stakeholders to understand the public engagement and outreach process and timeline, and how to participate, if desired. To leverage these resources, we also recommend that each advisory group member and project team member/affiliate (as appropriate) reach out to his/her respective constituents to more directly share informational updates and seek feedback.

We recommend development the following as additional outreach supporting materials:

- **Fact Sheet**. A fact sheet can be used to effectively brief stakeholders and legislators about the project, including major development milestones and unique aspects of the project.
- **PowerPoint Presentation**. A single presentation can be used to explain the project highlights and development process to any group seeking a briefing on the project.
- **Detailed Project Maps**. These maps should contain not only the anticipated project location, but also overlays showing existing ocean uses and ranges of key species of concern.
- **Stakeholder Database and Comments**. As project development continues, create and maintain a stakeholder database and a list of major stakeholder comments and concerns and publish a document that explains how each comment has been, or will be, addressed as the project is developed. This enables greater transparency and helps all stakeholders to see how concerns are being addressed.
- **Frequently Asked Questions**. These questions and answers will enable stakeholders to understand more about particular aspects of project development including how siting decisions are made, who is involved in the environmental review process, how the potential project would be laid out and operated, and others.

5.3 Budget Estimate

The cost of conducting stakeholder engagement and outreach to support a successful CalWave[sm] project going forward through the additional phases of study plan preparation and permitting has the following components:

- **Regulatory Group Meetings**: We recommend two meetings prior to the issuance of the NOI/PAD and six meetings during the development of studies (year one), eight meetings to develop protection, mitigation, and enhancement measures (year two), four meetings during the draft NEPA document phase, and two meetings after the final license order is issued (year three) (Total: 22 meetings).
- **Advisory Group Meetings**: We recommend one meeting prior to the issuance of the NOI/PAD and four meetings during studies development (year one); four meetings to develop protection, mitigation, and enhancement measures (year 2); two meetings during the draft NEPA document phase; and one meeting after the final license order is issued (year 3) (Total: 12 meetings).
- **Public Meetings**: We recommend one meeting prior to the issuance of the NOI/PAD and one meeting during studies development (year one), one meeting during the draft NEPA document phase (year two), and one meeting after the final license order (year three). Each meeting will be held in three locations near the project (Total: 12 meetings, four times at three locations).
- **Materials and Website Support:** This task would include ongoing development and updates of website text and graphics, stakeholder database development and updates, email updates to stakeholders, fact sheets, maps, and other documents, as appropriate.
- **Project Team Coordination:** Regular conference calls with the entire project team to ensure that all potential issues and concerned are appropriately discussed and addressed through the public engagement and outreach program.

TABLE 5-1
Stakeholder Engagement and Outreach Budget Estimates

Public Engagement Tasks	Year 1	Year 2	Year 3	Total
Regulatory Group Meetings	$240,000	$ 240,000	$180,000	$660,000
Advisory Group Meetings	$160,000	$160,000	$120,000	$440,000
Public Meetings	$90,000	$45,000	$45,000	$180,000
Materials & Website Support	$50,000	$50,000	$50,000	$150,000
Project Team Coordination	$36,000	$36,000	$36,000	$108,000
Grand Total	$576,000	$531,000	$431,000	$1,538,000

SECTION 6

Top Level Requirements Site Testing Criteria

As stated in Section 1.0, the CalWave[sm] engineering design approach is requirements driven, in that we used a system engineering approach to determine User Needs and translated those User Needs into Top Level Requirements. The Top Level Requirements carried through the Feasibility Study design effort.

The site selection criteria formed the basis of the Vandenberg site selection.

6.1 Engineering and Operational Criteria

A key engineering design consideration is "how will the end-users employ the system"? This question drives the Top Level Requirements development (SOPO Task #6) for developing test center operational criteria. The outline of the Concept of Operations (CONOPS) below was derived from discussions with wave energy developers and reference to experience operating surface ship engineering and submarine reactor plants.

The CalWave[sm] Shore Station design is envisioned to enable the following operational modes to support device testing.

- **Secured**
  No station power, no staff on site
  Indications remoted to Cal Poly
  - This would be an abnormal condition
- **Standby**
  Station power, no staff on site, condition monitoring
  Indications remoted to Cal Poly
  - Monitoring condition of shore-based infrastructure
  - Monitoring condition of sea-based infrastructure
  - Monitoring condition of any installed WECs
- **Ready**
  Station power, with staff on-site, condition monitoring
  Shore station is controlling, with indications remoted to Cal Poly
  - Monitoring condition of shore-based infrastructure
  - Monitoring condition of sea-based infrastructure
  - Monitoring condition of any installed WECs
- **Testing**
  Station power, with staff on-site, performance monitoring
  Shore station is controlling, with indications remoted to Cal Poly
  - Monitoring performance of shore-based infrastructure
  - Monitoring performance of sea-based infrastructure
  - Monitoring performance of any installed WECs
  - Monitoring grid interface
  - Coordinating with VAFB and PG&E
  - Generating to load bank
  - Installing or removing WECs
  - Conducting maintenance, refresh, or upgrades

- **Operating: Non-Grid Connected**
  Station power, with staff on-site, performance monitoring
  Shore station is controlling, with indications remoted to Cal Poly
  - Monitoring performance of shore-based infrastructure
  - Monitoring performance of sea-based infrastructure
  - Monitoring performance of any installed WEC
  - Monitoring grid interface
  - Coordinating with VAFB and PG&E
  - Generating to Load Bank

- **Operating: Grid Connected**
  Station power, with staff on-site, performance monitoring
  Shore station is controlling, with indications remoted to Cal Poly
  - Monitoring performance of shore-based infrastructure
  - Monitoring performance of sea-based infrastructure
  - Monitoring performance of any installed WECs
  - Monitoring grid interface
  - Coordinating with VAFB and PG&E

CalWave[sm] Shore Station equipment will support the following operational modes.

- **Berth Tagged-out For Safety:**
  - All power secured, all breakers open and racked-out
  - Submarine cable circuits grounded to prevent induced voltage problems

- **Berth Shutdown:**
  - Main power secured, with breakers open
  - Auxiliary circuits secured with breakers open
  - Fiber channels in-use for wave measurement and meteorology and oceanography (METOC)

- **Berth Monitoring:**
  - Fiber data channels in-use for wave measurement, METOC, and WEC monitoring
  - Auxiliary Circuit #1 powering berth condition monitoring
  - Auxiliary Circuit #1 powering WEC instrumentation and WEC condition monitoring

- **Berth Ready:**
  - Fiber data channels in-use for wave measurement, METOC, and WEC monitoring
  - Auxiliary Circuit #1 powering berth condition monitoring
  - Auxiliary Circuit #1 powering WEC instrumentation and WEC condition monitoring
  - Auxiliary Circuit #2, powering WEC system and breaker controls and performance

- **Berth Startup:**
  - Fiber data channels in-use for wave measurement, METOC, and WEC monitoring
  - Auxiliary Circuit #1 powering berth condition monitoring
  - Auxiliary Circuit #1 powering WEC instrumentation and condition monitoring
  - Auxiliary Circuit #2, powering WEC system and breaker controls and performance
  - Main Power Circuit powering berth, WEC and Power Conditioning

- **Berth Testing:**
  - Fiber data channels in-use for wave measurement, METOC, and WEC monitoring
  - Auxiliary Circuit #1 powering berth condition monitoring

  - Auxiliary Circuit #1 powering WEC instrumentation and condition monitoring
  - Auxiliary Circuit #2, powering WEC system and breaker controls and performance
  - Main Power Circuit powering berth, WEC and Power Conditioning
  - Main Power Circuit generating into Load Bank

- **Berth Operating – Non-Grid Connected:**
  - Fiber data channels in-use for wave measurement, METOC, and WEC monitoring
  - Auxiliary Circuit #1 powering berth condition monitoring
  - Auxiliary Circuit #1 powering WEC instrumentation and condition monitoring
  - Auxiliary Circuit #2, powering WEC system and breaker controls and performance
  - Main Power Circuit powering berth, WEC and Power Conditioning
  - Main Power Circuit generating into Load Bank: grid emulation

- **Berth Operating –Grid Connected:**
  - Fiber data channels in-use for wave measurement, METOC, and WEC monitoring.
  - Auxiliary Circuit #1 powering berth condition monitoring
  - Auxiliary Circuit #1 powering WEC instrumentation and condition monitoring
  - Auxiliary Circuit #2, powering WEC system and breaker controls and performance
  - Main Power Circuit powering berth, WEC and Power Conditioning
  - Main Power Circuit generating into CalWave^{sm} Sub-Station

- **Berth Fault Detect**

- **Berth Emergency Shutdown**

The Concept of Operations drives the CalWave^{sm} operational, maintenance, and testing costs addressed in Section 9.0. Further refinement of the CONOPS is planned for development during the next project design phase.

6.2 Environmental and Other Criteria

Humboldt State University Schatz Energy Center conducted an analysis of the wave climate in the candidate siting area by looking at each of the five Vandenberg test site alternatives. This “macro-siting” approach involved running a ten-year hindcast of wave conditions using the *Simulating WAves Nearshore* (SWAN) model. The modeling approach was based on similar work performed by Sandia National Laboratories for other regions of interest for wave power development (Dallman et al. 2014). Appendix 6-1 provides the full wave climate report.

The wave hindcast covered an approximately 1800 square-mile region encompassing the five test site alternatives. The temporal range spanned from August 1994 through July 2004, as these dates have fairly complete input data available for the geographic region. The boundary conditions were extracted from a 30-year WaveWatch III hindcast reanalysis performed by NOAA in 2011. Spectral model outputs were generated for the five potential CalWave berth sites in addition to the existing Scripps Buoy (CDIP 071) within the model domain. The modeling generated six wave metrics of interest: omnidirectional wave power, significant wave height, energy period, spectral width, direction of maximally resolved power, and the directionality coefficient. The SWAN model was validated by comparing outputs to observed wave characteristics at CDIP Buoy 071. The wave roses, charts, and diagrams in the report provide a detailed picture of project area wave climate. Table 6-1 summarizes the annual average wave climate characteristics at each of the five test site alternatives, compared with the CCIP Buoy 071, which is located approximately 5 nm west of the South by Southeast site and 4 nm southwest of the South site.

TABLE 6-1

Annual Average Wave Characteristics at CDIP Buoy 071 and the Five Prospective Sites

Site	Peak Power Direction, degrees	Directionality Coefficient	Spectral Width	Hm0 (m)	Te (seconds)	Energy Flux (kW/m)
CDIP Buoy 071	292	0.982	0.232	2.56	11	43.3
North	287	0.982	0.237	2.23	11	36.2
North Central	289	0.983	0.236	2.33	11	39.2
South Central	289	0.983	0.237	2.36	11	40.5
South	289	0.982	0.236	2.39	10.9	39.1
South by Southeast	283	0.983	0.251	2.08	10.7	30.4

Hm0 - Significant wave height, meters

Energy flux - kilowatts per meter of wave front

Peak power direction - North azimuth compass direction of peak power swell

Te - Wave period (seconds)

The wave climate report demonstrates that a wide range of wave regime testing conditions are available at the prospective sites. All of them average more than 30 kW/m energy flux (minimum requirement for the DOE) and most of them are very energetic, averaging near to or more than 40 kW/m.

An analysis of potential test berth locations ("micro-siting") will follow for the selected test site alternatives. The South Test Suite and the South-by-Southeast test site are the most attractive and are associated with the notional "South Base" shore station.

Reference Cited

Dallman, A.R., Neary, V.S., Stephenson, M. (2014) Investigation of Spatial Variation of Sea States Offshore of Humboldt Bay, CA Using a Hindcast Model, SAND2014-18207. Sandia National Laboratories, Albuquerque, NM, 2014.

SECTION 7

Preliminary Design Drawings

Per SOPO Task #7, preliminary drawings are attached as:

- Appendix 7-1 - Electrical
- Appendix 7-2 - Civil
- Appendix 7-3 - Architectural

The following is a discussion of the Basis of Design.

7.1 Basis of Design

The Basis of Design was derived from the Top-Level Requirements, as reflected below, and a Conceptual Baseline Design was developed using the South Base location for the notional Shore Station near Vandenberg Dock:

- Five submarine cables (four primary and one spare) rated at ~25kV and ~10MW, with insulation rated for 34.5kV, with wide range of input voltages inbound from the offshore end. The cables will accept AC up to 25kV, 10 MW, or DC. Home run cable for each berth to allow total isolation between different WECs.
- A submarine power cable transition vault to transition to terrestrial cable with wide range of input voltages inbound from the offshore end. Directional drilled to transition vault.
- Cable trenches from each of the four primary subsea cable transitions to the four power conditioning "pads" with wide range of input voltages inbound from the offshore end. Each WEC developer was budgeted two (2) 40 ft ISO container footprints for power conditioning.
- Cable trenches from the four power conditioning "pads" with grid-compliant power inbound to the 12kVAC substation. WEC developer must present grid compliant power to the substation
- Switchgear and instrumentation to support. Load Bank to allow demonstration of stable operation prior to paralleling to grid. Distribution bus for 12 kVAC near VAFB Dock. Standby diesel generator.
- Step up transformers from 12 kVAC to 70 kVAC. 70 kVAC Bus for outbound to 70KV Ring. 50 kW(+/-). 70 kVAC line extension to Vandenberg AFB Substation 'N'.

Conceptual requirements justification is as follows:

- Four test berths of 5 to 10 MW each, with spare cable, and options for future shallow/mid water berth and future deeper water berth
- 30 MW will supply the typical base load of host Vandenberg AFB, with net metering for community
- 50 MW would supply the typical base load of host Vandenberg AFB and provide additional generation for the local community as "community-scale distributed generation site"

Conceptual requirements justification is as follows:

- Four test berths of 5 to 10 MW each, with spare cable, and options for future shallow/mid water berth and future deeper water berth
- 30 MW will supply the typical base load of host Vandenberg AFB, with net metering for community
- 50 MW would provide net metering for local community as "community-scale distributed generation site"

Benchmarking was employed as a frame of reference:

- Description of WaveHub rated at 20 MW (derated) with design of 30 MW
  http://www.wavehub.co.uk/wp-content/uploads/2012/01/Marine-Energy-Park-prospectus.pdf

http://www.power-technology.com/projects/cornwallwaveenergyhu/

- Description of the European Marine Energy Center (EMEC) rated at 11 MW
  http://hydropower.inel.gov/hydrokinetic_wave/pdfs/day3/2_emec_overview.pdf
- Description of Kanehoe Bay Wave Energy Test Site (WETS) rated at 2.25 MW
  http://hinmrec.hnei.hawaii.edu/wp-content/uploads/2009/12/Wave-Energy-Test-Site-at-Kaneohe-Bay.pdf
- Scoping document for proposed Pacific Marine Energy Center rated at 20 MW
  http://www.pmec.us/wp-content/uploads/2014/07/scoping_mtg_070914_slides.pdf

As stated in Section 1, we worked diligently to "future-proof" the key aspects of the CalWave^{sm} design that are dependent on specific design elements of current and future WECs by ensuring that design elements that are best optimized for particular WECs are the responsibility of the WEC developer (mooring, cable termination at the sea- end, power conditioning). Further, we considered the risks of overloading the 12 kV distribution system and designed for 70 kV. Also, we developed the "notional Shore Station" on the South Base to enable progress.

As discussed in more detail in Section 8.0 (construction cost estimates) the design was progressed to enable a feasibility-stage estimate for identify rough order-of-magnitude costs consistent with an AACE Class 4 (30 to + 50%) estimate. To prepare such an estimate, a conceptual design scope was prepared to implement the Top-Level Requirements as basis for the estimate for quantities.

The preliminary design of the CalWave^{sm} Shore Station and the adjacent CalWave^{sm} Substation (vicinity of Vandenberg Dock) was based on a phased implementation of the test facility

Draft Subsea Cable Requirements: Validated as reasonable per industry

The (3) conductor MV export cable, with two auxiliary circuits, and fiber data path. The 3 conductor requirements: cable that can be rated for ~10MW for a ~5nm run at ~25kV.

- WEC developers may connect as a single WEC or as a WEC array (~5 WECs)
- WEC developers will provide umbilicals to connect the WEC/WEC array to the CalWave-provided export power cable connectors
- WEC developers will provide shore-based, modular power conditioning equipment to connect the shore end of the CalWave-provided export power cable.
- WEC developers will provide grid-compliant power (voltage, frequency and power quality) from the power conditioning equipment to connect the CalWave^{sm} Substation.

Berths Requirements:

- All berths would use dry mate connectors designed for 34.5kV, rated at ~25kV ~10MW
- Spare cable de-energized with a capped dry-mate connector
- Feature: Two berths would be wet-mate capable using an adaptor cable.
  - Wet-mate adaptor cost by WEC developer
  - Conductor size and insulation constraints will limit voltage and amperage - presently ~11kV, with a resulting rating of ~ 4MW
- Auxiliary circuits:
  - Auxiliary Circuit #1: Condition monitoring (berth and WEC) - ~5nm run, rated at 440v and 20 amps powering berth for instrumentation and telemetry
  - Auxiliary Circuit #2: Performance monitoring - ~5nm run, rated at 440v and 50 amps powering berth for:
    - Grid Reference

    - WEC system controls
    - Breaker controls
- Fiber data channels: Fiber channels for WEC/WEC array, a bottom-mounted ADCP, and wave measurement buoy and or meteorological and oceanographic (METOC) equipment.

7.2 Design Drivers

Among the most important of the CalWave[sm] specific engineering design drivers are:

- WECs to be tested (not under CalWave[sm] design control)
    - WEC system components
    - Anchoring and mooring
    - Umbilical(s)
    - Umbilical connector
    - WEC power conditioning
    - WEC telemetry and controls
- Submarine (subsea) power cables
- The Vandenberg AFB grid interconnection
- The PG&E grid interconnection

The critical interfaces include:

- WEC umbilical to the sea-end of the CalWave[sm] subsea cables
- Shore end of the subsea cable to shore (terrestrial) cables
- Shore cables to the WEC developer's Power Conditioning
- WEC Power Conditioning to the CalWave[sm] 12kV Substation
- CalWave[sm] 12kV Substation to the VAFB 12 kV Distribution Grid
- CalWave[sm] 12kV Substation to the CalWave[sm] 70kV Substation
- CalWave[sm] 70kV Substation to the VAFB 70 kV Ring

Key "boundary system" considerations include:

- WECs to be tested (not under CalWave[sm] design control)
    - WEC system components
    - Anchoring and mooring
    - umbilical(s)
    - Umbilical connector
    - WEC power conditioning
    - WEC telemetry and controls
- Submarine (subsea) power cables
- The Vandenberg AFB grid interconnection (not under CalWave[sm] design control)
- The PG&E grid interconnection(not under CalWave[sm] design control)

7.3 Substation Design

Layout will be consistent with industry best practices for access, safety and boundaries and security. In the event that transformers employ fluids, impermeable isolation barriers to the environment will be used, consistent with industry best practices and applicable regulations.

Input voltages from WEC power conditioning modules will meet grid integration standards approved by VAFB and PG&E. Orientation to allow maneuvering of incoming/outgoing substation modules on existing paved staging area will be considered.

Phase 1: Design for step-up of most-probable input voltages for four Test Berths and allow plan for adaptation and expansion.

- Possible input voltages include 600 v, 6kV, 12kV, and 24kV
- Probable input voltages: 12kV; 24kV
- Probable output voltages included VAFB distribution voltage ~12kV) and PG&E distribution voltage (~70kV).
- Ensure isolation and instrumentation of each test berth.
- Ensure breaker isolation that considers station lower (low voltage from shore to Test Berth) and induced voltages in submarine cables.

Phase 2: Expansion to include grid connection to Shallow Bert and Mid-Depth Berth

Phase 3: Expansion to include grid connection to Shakedown Berth

Phase 4: Expansion to include deeper West Test Berth

7.4 Shore Station Design

Optimize layout to enable placement and removal of WEC shore modules with readily available truck and tractor rig, thus avoiding the need to mobilize cranes and/or specialized ISO container fork lifts.

- Maintain access for fire trucks on two sides of each module.
- Underground cabling inside the boundaries of the Shore Station, thereby eliminating risk of electrocution during fire-fighting response.

Phase 1: Optimize orientation to allow maneuvering of ten (10) incoming/outgoing modules for four test berths on existing paved staging area.

- Footprint for two (2) CalWave^{sm} test center modules with adjacent parking.
- Footprint for two modules for each of four (4) Test Berths.
- Integration with up to five (5) directionally-drilled bores for submarine power cable shore landing in vicinity of VAFB Dock.

Phase 2: Expansion to include grid connection to shallow berth and mid-depth berth.

Integration with approximately three (3) directionally-drilled bores for submarine power cable shore landing in east of Vandenberg Dock.

Phase 3: Expansion to include grid connection to Shakedown Berth

Integration with directionally-drilled bore from Phase 2 for submarine power cable shore landing in east of Vandenberg Dock.

Phase 4: Expansion to include deeper West Test Berth.

Integration with directionally-drilled bore from Phase 1 for submarine power cable shore landing in vicinity of Vandenberg Dock.

7.5 Preliminary Design Drawings

The following are notes on the drawings:

Electrical Single Line Drawings (Appendix 7-1) - The single line drawings determined overall quantities. Spacing was analyzed to determine the rough site layout.

Site Drawings (Appendix 7-2) - The civil design was driven by the electrical design and quantities, and site-specifics. The notional Shore Station site placement is shown on the Cover Sheet (G-1) and Site Map (C-1). The site is relative flat and easily accessed as shown in the topographic detail.

Architectural Drawings (Appendix 7-3) - The architectural design was driven by Shore Station requirements. The Vandenberg Dock area is located at the former US Coast Guard Surf Station, which is a potential location for office functions on a not-to-interfere basis. The CalWave^{sm} Shore Station will host key personnel and WEC developer staffs during test center operations. The top level requirement is two job site trailers.

Given the historical nature of the site, and the expected constraints to use of jobsite trailers at the location, the Cal Poly Architectural Engineering group has designed two affordable pre-manufactured, mobile, modular buildings as an alternative.

SECTION 8

Estimates of Construction Costs

The estimates that follow are ROM estimates suitable for the Feasibility Study phase of the project, per the following standards of estimate:

- American Association of Cost Engineers (AACE) Class 4 (Study or Feasibility) Estimate
- DOE-AACE Class 4 (Concept Study or Feasibility) Estimate
- DOD Class F – Feasibility Design ("Ball Park") Estimate

We have prepared conceptual estimates that compare the Conceptual Baseline Design with reduced cost scenarios, with different shore station location alternatives, and with the use of oil and gas Platform Irene.

8.1 Conceptual Baseline Design

CalWave^{sm} construction quantity and cost estimates are attached as Appendix 8-1 for the Conceptual Baseline Design at the notional South Base Shore Station. Table 8-1 compares alternatives at the notional South Base Shore Station.

8.2 Shore Station Alternatives

We are designing a facility to accept WECs and perhaps floating wind and wave-wind hybrid devices, through the year 2050, so flexibility is a key factor. The South Base is a readily accessible "blank canvas" when compared to Central Base and North Base. The Conceptual Baseline provides redundancy and reliability, maximizes the gains for the expensive fixed costs of HDD and marine mobilization/demobilization, and provides the upgrade path to 50 MW. Table 8-2 compares the Conceptual Baseline (South Base) with two alternative base locations. Longer cable lengths, longer sea transits, more remote sites, and the need to integrate with launch operations increases the estimated costs at the central and northern alternative sites, compared to the South Base site.

8.3 Oil and Gas Platform Irene Alternative

We also explored the possible use of oil and gas Platform Irene as an offshore substation. Table 8-3 compares estimated costs of using Platform Irene, compared with the notional South Base Shore Station. Advantages of Platform Irene include the use of the existing 25 MW cable and Surf Substation so that there would be a potential savings of approximately $10 million due to fewer submarine power cables needed and their associated costs of horizontal directional drilling cost. Stakeholder feedback was that minimizing seafloor excavation by utilizing the existing cable is a desirable outcome. The disadvantages of Platform Irene include somewhat more expensive marine operations and the need to integrate with mission-critical power on the operational oil and gas platform, limitation initially to 25 MW or less (additional new cables would need to be installed later to facilitate the upgrade path to 50 MW), and integration with ongoing platform operations. If Platform Irene were to be repurposed, however, it would pose a favorable alternative as a possible offshore sub-station.

TABLE 8-1
Construction Cost, CalWave[sm] South Base Shore Station, Feasibility Study Estimates

Baseline Scenario Alternative	Minimum Baseline	Reduced Baseline	Conceptual Baseline[1]
Assumptions/Specifications	• 4 HDD Bores • Cables (25 miles) • Shore Station • 12 kV Substation • 20 MW • Upgrade path to 40MW	• 5 HDD Bores • Cables (29 miles) • Spare Bore & Cable • Shore Station • 12 kV Substation • 25 MW • upgrade path to 40MW, 50MW	• 5 HDD Bores • Cables (29 miles) • Spare Bore & Cable • Shore Station • 12 kV Substation • 70 kV Substation • 30 MW • upgrade path to 40MW, 50MW
Site Civil & Foundations, no escalation	$0.2M	$0.2M	$0.2M
Site Architectural/Security, no escalation	$0.25M	$0.25M	$0.25M
Networks/Control/Telemetry, no escalation	$0.1M	$0.1M	$0.1M
Shore Electrical Facilities, escalated to 2018	$6M	$7M	$14M
Horizontal Directional Drill, no escalation	$2.5M	$2.8M	$2.8M
Subsea Cabling, no escalation	$11M	$12M	$12M
Marine and Cable Operations, no escalation	$20M	$22M	$22M
Sub-Total	$40.1M	$44.4M	$51.4M
Contractor and CalWave[sm] Fees, est 26%	$10.4M	$11.6M	$13.4M
TOTAL (ROM)	**$51M**	**$56M**	**$65M**

[1] Note that the spare bore and cable features add $6M and 70 kV features add $9M to the overall cost estimate, to enable the upgrade path to 50MW.

TABLE 8-2
Cost Comparison, North, Central, South Base Scenarios, Feasibility Study Estimates

Base Location Scenario	South Base, Conceptual Baseline	Central Base	North Base
Assumptions/Specifications	• 5 HDD Bores • Cables (29 miles) • Spare Bore & Cable • Shore Station • 12 kV Substation • 70 kV Substation • 30 MW • upgrade path to 40MW or 50MW	• 5 HDD Bores • Cables (36 miles) • Spare Bore & Cable • Shore Station • 12 kV Substation • 70 kV Substation • 30 MW • upgrade path to 40MW or 50MW	• 5 HDD Bores • Cables (47 miles) • Spare Bore & Cable • Shore Station • 12 kV Substation • 70 kV Substation • 30 MW • upgrade path to 40MW or 50MW
Site Civil & Foundations, no escalation	$0.2M	$0.5M	$0.6M
Site Architectural/Security, no escalation	$0.25M	$0.25M	$0.25M
Networks/Control/Telemetry, no escalation	$0.1M	$0.15M	$0.15M
Shore Electrical Facilities, escalated to 2018	$14M	$15M	$15M
Horizontal Directional Drill, no escalation	$2.8M	$10.5M	$11.5M
Subsea Cabling, no escalation	$12M	$14M	$19.2M
Marine and Cable Operations, no escalation	$22M	$22M	$22M
Sub-Total	$51.4M	$62.8M	$68.7M
Contractor and CalWave Fees, est 26%	$13.4M	$16.3M	$17.9M
TOTAL (ROM)	**$65M**	**$79M**	**$87M**

TABLE 8-3
Cost Estimates Comparing South Base Scenarios with Platform Irene Alternative, Feasibility Study Estimate

Scenario/Alternative	Platform Irene-Minimum Scenario	South Base – Minimum Scenario	Conceptual Baseline: South Base
Assumptions/Specifications	• Cables (14 miles) • Off-shore Station • Platform-dependent • 25 MW	• 4 HDD Bores • Cables (25 miles) • Shore Station • 12 kV Substation • 20 MW • upgrade path to 40MW, 50 MW	• 5 HDD Bores • Cables (29 miles) • Spare Bore & Cable • Shore Station • 12 kV Substation • 70 kV Substation • 30 MW • upgrade path to 40MW, 50MW
Site Civil & Foundations, no escalation	$0.8M	$0.2M	$0.2M
Site Architectural/Security, no escalation	$0.5M	$0.25M	$0.25M
Networks/Control/Telemetry, no escalation	$0.4M	$0.1M	$0.1M
Shore Electrical Facilities, escalated to 2018	$4M	$7M	$14M
Horizontal Directional Drill, no escalation	$0M	$2.8M	$2.8M
Subsea Cabling, no escalation	$9.6M	$12M	$12M
Marine and Cable Operations, no escalation	$23M	$22M	$22M
Sub-Total	$39M	$44.4M	$51.4M
Contractor and CalWave Fees, est 26%	$11M	$11.6M	$13.4M
TOTAL (ROM)	**$50M**	**$56M**	**$65M**

SECTION 9

Operating, Maintenance, and Testing Costs

CalWave[sm] operational, maintenance, and testing costs will be dominated by labor costs for the first four to five years until reaching capacity with all test berths operating. Labor costs over the second five years will be reduced, by comparison, while monitoring and maintenance costs will rise, then stabilize over the long-term.

The CalWave[sm] Operational Model will have three major priorities:

- Ensure safe operations
- Implement effective procedures for efficient operation
- Ensure regulatory compliance

CalWave[sm] staffing will be determined from the operational, technical, and safety requirements, and supported by the fees collected from client WEC developers. The total staffing level that can be supported depends on the mix of personnel and percentage of time devoted to CalWave[sm] per employee.

The primary driver of CalWave[sm]'s operational success, however, will be the caliber of people chosen to staff the facility. Early staffing with the best-qualified people and positive retention will be the enablers of test center success.

A key factor in designing cost-effective operations, maintenance, and testing budgets is to ensure that all Operational Procedures (OPs), Test Procedures (TPs), and Berth Test Protocols (BTPs) are completed and validated during construction and commissioning.

- Installation of a WEC(s) in one berth to achieve Initial Operating Capability (IOC) during Commissioning.
- All Berths tested during Commissioning.
- Full Operating Capability (FOC) will be achieved when WECs are installed in all berths.

Another key factor will be the enterprise model and business organization to ensure that legal, risk management, contracts and procurement functions are staffed to support the CalWave[sm] Test Center as an operational site.

9.1 Operational Objectives and Assumptions

The CalWave[sm] enterprise model, business model, and operational model are under development. Further benchmarking of existing marine energy test centers business models is planned in the next phase of work.

Multiple anticipated revenue streams (test berth fees, State and Federal grants, research contracts and Power Purchase Agreements, to name a few) will be allocated to a range of accounts to enable activity-based costing, and include capital projects, financing, contracts, procurement, operations, maintenance, and operations and overhead (legal, insurance, quality control, administration).

A possibility of an enterprise model is based upon one proposed by the Federal Highway Administration (2014) for a toll road that is project financed, built, and operated for a long duration (Figure 9-1). This is analogous to a wave testing center in that they both have capital intensive infrastructures, ongoing operating costs, and customers who have to help pay for the services (highway access and WEC testing, respectively) of the facility.

Paraphrasing from the Federal Highway Administration (2014) toll road example (with WEC example substitutions in brackets):

In the case of a greenfield [WEC testing] project, a public agency transfers all or part of the responsibility for project development, construction, and operation to a private sector entity. Greenfield projects generally present higher risks to both parties than do brownfield projects because of the greater uncertainty surrounding [WEC testing] traffic forecasts, permitting, and construction. Given the complex role that revenue risk plays in a P3 (public-private partnership) deal, this particular risk is generally separated from other risks when considering whether to have a toll concession or an availability payment concession.

FIGURE 9-1
Public-private partnership structure under a design-build-finance-operate-maintain concession.

Solid lines = cash flows into project
Dotted lines = cash flows out of project
SPV = Special Purpose Vehicle
Source: Federal Highway Administration, 2014

Excessive [WEC tester] traffic risk can deter private sector entities or reduce their ability to secure financing. For greenfield projects, [WEC tester] traffic volume is more difficult to accurately forecast than for already existing brownfield projects. Public agencies may therefore modify the P3 structure for greenfield or hybrid projects to offer guaranteed payments to the private sector partner. A *shadow toll-based concession* allows the public agency to compensate the private sector entity based in part on a "shadow toll" or fee paid by the public agency for each vehicle that uses the facility. Such payments generally have a fixed component that guarantees partial revenue, even if [WEC tester] traffic volume were to be below projections.

With an availability payment-based concession, the public agency retains the traffic risk by making payments directly to the private sector partner based on the availability of the facility rather than on the number of vehicles. Payments are contingent on achievement of pre-agreed performance standards; however, the private entity is exposed to long-term appropriations risk.

One of the ways to lower the lifecycle cost of the wave test center is to incorporate non-recourse long-term debt into the financing structure, as it is cheaper money than that of other project partners' equity investments. As an example, because a wave energy test center would have uncertain revenues from test energy power sales over 25 to 30 years, the total project cash flows each year (Figure 9-2), need to have contractual revenues from sufficiently high quality credit providers and offtakers, to provide the financial

risk profile of the project that is acceptable to long-term debt providers. In this hypothetical example shown in Figure 9-2, certain tax features are included which may not apply to CalWave[sm] cash flows.

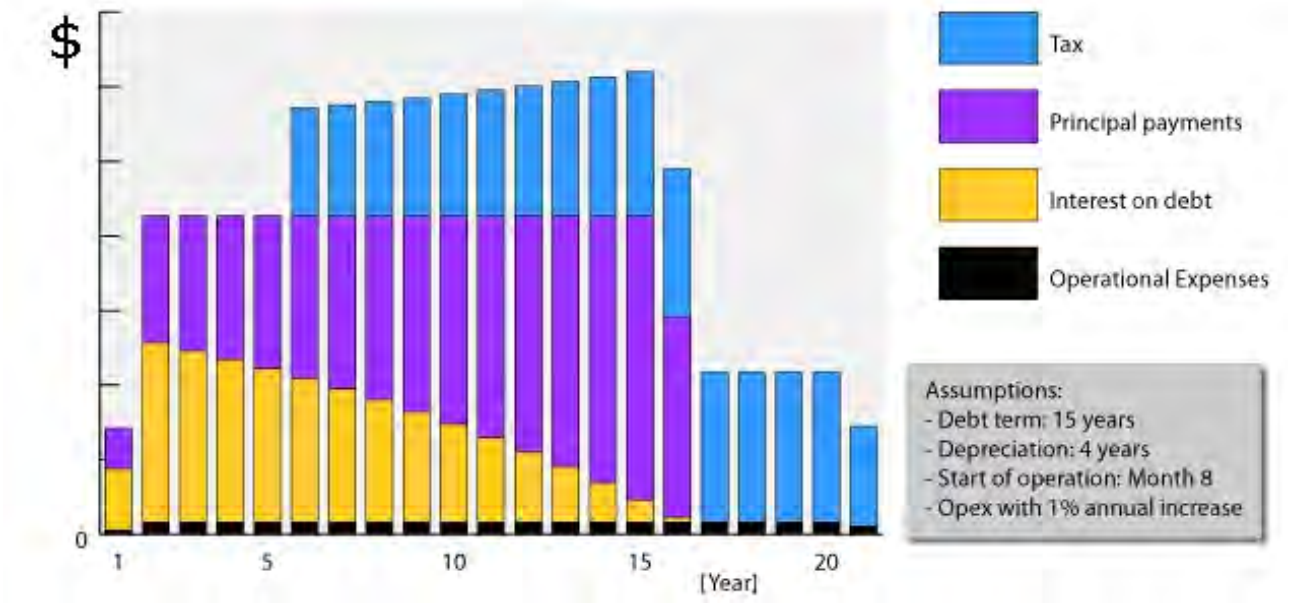

FIGURE 9-2
Example of Wave Test Center Operational Cash Flows.

Opex = Operating Expenses

Source: Renewable Energy Projects - Operating Model; Green Rhino Energy Ltd., 2013

Ideally, a sustainable business model has a revenue stream of magnitude, duration and trajectory to match each project cost or series of costs. This would include the cost of any debt service or return on equity of project investors in a non-recourse financed project.

9.1.1 Assumptions

- Subject to benchmarking in the next phase of project development, fees per berth of between $250K and $500K fee were considered and $400K/year was used. This Berth Fee would be for a one-year deployment of the WEC. A schedule of included services will be developed.
- CalWave[sm] will also have a fee-for-service schedule for labor to support WEC installation, monitoring, and reporting.
- CalWave[sm] will have a fee-for-service schedule for marine service contractors for supporting WEC installation, monitoring, and reporting.
- Site personnel will monitor and report compliance with environmental permit requirements as required by the permits.
- Assisting the WEC developer to obtain their technology-specific permit or permit amendment will not be a function of site personnel.
- Each site is suitable for one WEC or a WEC Array of a number to be determined.
- Operations and Maintenance begins with the completion of WEC installation, testing, and completion of a shakedown run.

9.1.2 Additional Considerations

Personnel continuity is vital and so startup funding must be a priority. If funding is inadequate to cover CalWave[sm] start-up costs, some staffing may initially be programmed as part-time, if the site is operating a

single berth. As the number of berths in use and WECs increases, these personnel would become full time or additional personnel would be added in part-time capacity.

If there are fewer than four berths in use, some additional financial support will be necessary.

9.1.3 Installation, Operations and Maintenance Schedule.

A notional CalWave[sm] and WEC schedule would start with a single berth and develop a trajectory towards full implementation. Commissioning of the CalWave[sm] facility will precede Berth #1 setup. The concept of operations is: 1) setup, 2) WEC installation and testing, followed by 3) a period of WEC operation prior to 4) removal and replacement. The CalWave[sm] berths will all be similar so that a learning curve benefit for successive installations will be realized. Parallel installations could be accomplished but would need a careful assessment in advance of resource availability support installation and potential hazards posed.

9.2 Staffing

9.2.1 Staffing FTE

The proposed staffing matrix to support the proposed project schedule is outlined in Table 9-1 (following page). The number of Full Time Equivalent (FTE) personnel varies during construction and commissioning but averages approximately ten (10) FTE. A reduction in staffing is anticipated as operations become more efficient with experience and use. The minimum needed to operate the facility initially would be six staff. This minimal operational staffing would not be sufficient during installations and removals. A Project Developer and Business Manager are essential. An Administrative Assistant is a cost-effective person to provide continuity and may transition to a part-time basis. Initially, the electrical and environmental compliance duties will be part of CalWave[sm] costs. At some point, these positions could be provided on a fee-for-service basis. The position descriptions are found in the next section.

9.2.1 Staff Position Descriptions

Proposed Staff position descriptions are as follows.

Site Director

- The Site Director will be fully accountable for all CalWave[sm] assigned personnel, and be involved in the commissioning, installation and test of the first and second berths. The Site Director will be a certified Project Management Professional (PMP), with ocean engineering and ship operations experience.
- The following positions will be direct reports to the Site Director: Operations Manager, Safety and Quality Manager, Site Engineer, and Project Developer.
- Occupancy of three or four berths will warrant the full-time attention of the Director, with some reduction during the operational period. As the facility comes on line and gains experience with initial commissioning of the first and second berths, the Director's involvement will be slightly less and the Director will pursue full subscription of the facility.
- Removal and replacement starts the cycle over again. The success of the WEC will determine if the reduction in labor cost is real. The removal and replacement period may also require attention to CalWave[sm] maintenance and adaptive monitoring activities.
- If the installation extends beyond the first year, there may be maintenance actions and retests with the WEC to coordinate with CalWave[sm] activities. (This also implies a pro-rated charge for the extension.)
- During backshift and weekends and holidays, the CalWave[sm] Site Director trades off on-call responsibilities weekly with the Operations Manager, Test Manager and Site Engineer. As the number of WECs increase, the on call duties are further shared with the electrical technician and the environmental technician as these personnel become full time.

TABLE 9-1
Proposed CalWave[sm] Staffing, FTE

Operational Scenario	Site Director	Ops Manager	Safety & Quality	Test Manager	Site Engineer	Electrical Tech	Enviro Tech	Project Devel	Business Manager	Admin Assistant	FTE Total
Installation	1	1	1	1	1	1	1	1	1	1	10
Testing (All Berths)	1	1	1	1	1	1	1	1	1	1	10
Commissioning	1	1	1	1	1	1	1	1	1	1	10
Berth #1 Setup	1	1	1	1	1	1	1	1	1	1	10
WEC #1 Installation and Testing	1	1	1	1	1	1	1	0.25	1	1	9.25
WEC #1 Operation	0.75	0.75	1	0.5	0.75	0.25	1	0.25	1	1	7.25
WEC #1 Removal	1	1	1	0.5	1	0.5	1	0.25	1	0.5	7.75
WEC #1 Replacement	1	1	1	0.5	1	0.5	1	0.5	1	0.5	8
Initial Operating Capability	1	1	1	0.5	1	0.5	0.5	1	1	1	8.5
Berth #2 Setup	1	1	1	1	1	1	1	1	1	1	10
WEC #2 Installation and Testing	1	1	1	1	1	1	1	0.25	1	1	9.25
WEC #2 Operation	0.75	0.75	1	0.5	0.75	0.25	1	0.25	1	1	7.25
WEC #2 Removal	1	1	1	0.5	1	0.5	1	0.25	1	0.5	7.75
WEC #2 Replacement	1	1	1	0.5	1	0.5	1	0.5	1	0.5	8
Berth #3 Setup	1	1	0.75	0.5	1	1	1	0.5	1	0.5	8.25
WEC #3 Installation and Testing	1	1	1	1	1	1	1	0.25	0.5	0.5	8.25
WEC#3 Operation	0.75	0.75	0.75	0.5	0.5	0.75	0.75	0.25	0.5	0.5	6
WEC #3 Removal	1	0.75	0.75	0.5	1	0.5	0.5	0.25	0.5	0.5	6.25
WEC #2 Replacement	1	1	0.75	0.5	1	0.5	0.5	0.5	0.5	0.5	6.75
Berth #4 Setup	1	1	1	0.5	1	1	1	0.5	1	0.5	8.5
WEC #4 Installation and Testing	1	0.75	0.75	1	1	1	1	0.25	0.5	0.5	7.75
WEC #4 Operation	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.25	0.5	0.5	6.5
WEC #4 Removal	1	1	0.75	0.5	1	0.5	1	0.25	1	0.5	7.5
WEC #4 Replacement	1	1	0.75	0.5	1	0.5	1	0.5	1	0.5	7.75
Final Operating Capability	1	1	0.5	0.5	1	0.5	0.5	0.5	0.5	0.5	6.5

- The CalWave[sm] Site Director will also need to be available for visitors since it is likely that prospective clients and others will want to see the operations while safeguarding developer data.

- Once operational expectations are refined, there may be an opportunity to reduce staffing but the initial experimental nature of the operation warrants additional attention. Ramping up from too few resources would be too difficult.

Operations Manager

- The CalWave[sm] Operations Manager will supervise the Site when the Director is not present. The Operations Manager will have the authority to approve operational plans, and will refer situations where consensus was not reached to the Site Director. The Operations Manager should have marine operations experience in the project area.
- The following positions are direct reports to the Operations Manager: Business Manager, Administrative Assistant, and Environmental Technician.
- The Operations Manager will focus on operational procedures, adaptive monitoring, regulatory compliance and scheduling.
- The Operations Manager will schedule and coordinate with CalWave[sm] activities, including submitting the on-call schedule for the Site Director's approval.
- During backshift and weekends and holidays, the Operations Manager will trades off on-call responsibilities weekly with the Site Director, Test Manager and Site Engineer. As the number of WECs increases, the on call duties are further shared with the electrical technician and the environmental technician as these personnel become full time.

Safety and Quality Assurance Manager

- The CalWave[sm] Safety and Quality Assurance Manager will focus on occupational safety and health, marine operations safety, quality assurance and quality control, risk management, hazardous material procedures, and regulatory and standards compliance. The Safety and Quality Assurance Manager will hold the appropriate professional credentials to meet federal and State of California requirements for a health and safety professional.
- The Safety and Quality Assurance Manager will be the primary point of contact for regulators and inspectors, will have the authority to approve monitoring plans and activities, and will refer situations where consensus was not reached to the Site Director.
- During backshift and weekends and holidays, the Safety and Quality Assurance Manager will trade off on-call responsibilities weekly with the Site Director, Operations Manager and Site Engineer. As the number of WECs increases, the on-call duties will be further shared with the electrical technician and the environmental technician as these personnel become full time.

Test Manager

- The Test Manager will focus on test procedures, berth condition monitoring, and WEC operational monitoring. The Test Manager shall have experience and the appropriate professional credentials similar to DOD technical and operational test and evaluation (TECHEVAL/OPEVAL) and /or utility test and commissioning.
- The Test Manager will focus on test procedures, berth condition monitoring, and WEC operational monitoring.
- The Test Manager will be the primary point of contact for WEC Developers and WEC Testing, will have the authority to approve test plans and activities, and will refer to the Site Director situations where consensus was not reached.
- During backshift and weekends and holidays, the Test Manager will trades off on-call responsibilities weekly with the Site Director, Operations Manager and Site Engineer. As the number of WECs increase,

the on call duties are further shared with the electrical technician and the environmental technician as these personnel become full time.

Site Engineer

- The Site Engineer will supervise the Site when the Site Director, Operations Manager, and Test Manager are not present.
- The Site Engineer will focus on CalWave[sm] Berth operations and WEC installation and removal and replacement reduction during steady state operating periods, giving particular attention to the first WEC installation. The Site Engineer shall be a registered professional engineer with ocean engineering experience.
- The following positions are direct reports to the Site Engineer: Electrical Technician and Assistant Engineer.
- The Site Engineer will supervise the Electrical Technician and Assistant Engineer (when assigned), and be fully involved during CalWave[sm] Berth operations and WEC installation and removal and replacement reduction during steady state operating periods, with more attention to the first WEC.
- The Site Engineer will maintain a log of operations for other CalWave[sm] staff to review and report for incorporation.
- The removal and replacement periods are also CalWave maintenance periods.
- The Site Engineer will also task the part time junior engineer (when assigned) in learning CalWave[sm] operations and maintenance, help with WEC developer activities.
- During backshift and weekends and holidays, the Site Engineer will trade off on-call responsibilities weekly with the Site Director, Operations Manager and Test Manager. As the number of WECs increase, the on call duties are further shared with the electrical technician and the environmental technician as these personnel become full time.

Electrical Technician

- The Electrical Technician performs any required technical monitoring. These duties will increases as the number of WEC increase. These duties may be combined with the Site Engineer for the first WEC. The Electrical Technician will hold the appropriate professional credentials similar to Marine Technician qualifications on the research vessels.
- Principal duties are to review CalWave and WEC health indications regularly and to track trends.
- The summary of the previous operational period needs to be collected and reviewed, particularly off-nominal and alarm conditions and follow up on corrective action.
- The Electrical Technician will cross-qualify to assist the Operations Manager, Test Manager, or Site Engineer and share in the on-call duties as determined by the CalWave[sm] Site Director.

Environmental Technician

- The Environmental Technician performs any required environmental monitoring and oversees WEC developer monitoring. The duties are for each Berth. For the first two WEC, the Berths may be adjacent. The Environmental Technician shall hold the appropriate professional credentials to satisfy federal and State of California requirements.
- The level of activity increases as additional Berths are filled.
- The Environmental Technician will cross-qualify to assist the Operations Manager, Test Manager, or Site Engineer and share in the on-call duties as determined by the CalWave[sm] Site Director.
- The WEC related activities will increase and the Environmental Technician will likely have to assist the CalWave[sm] Site Director with visitors and regulators.

- The Environmental Technician will provide oversight of the WEC developer environmental monitoring and reporting.

Project Developer

- There are a large number of project development-related tasks that an experienced project developer can best address. Close coordination with the Site Director, Business Manager, and contracts personnel will be required to complete the WEC Developer leases and the insurance and financial dealings.
- Interface with the marine renewable energy community will be required.
- Some visitors will be interested in the business elements that the Project Developer will be best suited to address.
- The Project Developer may assist the Safety and Quality Assurance Manager and Environmental Technician with defining WEC and CalWave^{sm} responsibilities with regulators.
- On-call duties are not expected to be shared by the Business Manager (see below) but, as the Site develops, the Project Developer may be able to assist in that role.
- The CalWave^{sm} Site Director and Operations Manager may be able to provide backup support for the Project Developer.

Business Manager

- There are a large number of business related tasks that require the level of detail that only an experience business manager can address. Close coordination with contracts personnel will be required to complete the WEC Developer leases and the insurance and financial dealings
- Interface with the Cal Poly community outreach will also be required
- Some visitors will be interested in the business elements that the Business Manager will be best suited to address.
- The business manager may assist the Environmental Technician with defining WEC and CalWave^{sm} responsibilities with regulators.
- On-call duties are not expected to be shared by the Business Manager but as the Site develops, the Business Manager may be able to assist in that role for at least initial notification.
- The CalWave^{sm} Operations Manager may be able to provide some back up for the Business Manager.

Administrative Assistant

- The Administrative Assistant is a key person for continuity between Site Staff and WEC Developers.
- The focus of duties will be administrative, scheduling, documentation, records keeping, and reception.

Assistant Engineer

- There is provision for ¼ time for a junior engineer to be learning operations and maintenance. This is above and beyond minimum staffing requirements.
- When proficiency is determined by the CalWave^{sm} Site Engineer and Operations Manager to be adequate, and after approval of the Site Director, the Assistant Engineer may fill in as backup for the Test Manager or Electrical Engineer or for on-call duties.

9.3 Operational and Maintenance Costs

The following are some additional cost considerations for operation and maintenance.

Direct and Indirect Labor: The CalWave^{sm} budget will be labor-dominant at first. Staffing will be determined from the operational, technical, and safety requirements, and supported by the fees collected from client WEC developers. The total staffing level that can be supported depends on the mix of personnel and

percentage of time devoted to CalWave[sm] per employee. For this analysis, a range of $700,000 to $900,000 was considered and $800,000 was used.

Included Services: Direct support for monitoring and adaptive management and the associated costs (vehicles, boats, training, operations, etc.) from off-site engineering should be anticipated as personnel become more familiar with equipment and operations. Deficiencies will be identified that need to be technically adjudicated. The goal is to appropriately allocate facility costs (fixed) separately from WEC-related (variable) costs and assign WEC costs to the Developers. For this analysis, a range of $100,000 to $200,000 was considered and $150,000 was used.

Shore Station Operating Costs: Overhead rates would include cost of heating, air conditionings, and lighting. For this analysis, a range of $25,000 to $75,000 was considered and $55,000 was used.

Spares and Repair Pool: Replacement of spares consumed from original outfitting and emergent repairs will require replacement. Some level of spares will be provided in the initial outfitting once the preliminary design is settled and the final design establishes the cost of components and initial spares. For this analysis, a range of $10,000 to $20,000 was considered and $15,000 was used.

Off-Site Engineering Support: Initially, some support from off-site engineering should be anticipated as personnel become more familiar with equipment and operations. Deficiencies will be identified that need to be technically adjudicated. Configuration changes may be identified that need to be evaluated and if approved, implemented. WEC interfaces may need to be updated as the characteristics of follow on WEC design are identified. Installation, initial testing, and removal operations are the activities most likely needing technical support for first time evolutions. The goal is to allocate most offsite-engineering to the capital project and ensure the facility is working properly at Commissioning and Initial Operating Capability. For this analysis, a range of $100,000 to $300,000 was considered and $200,000 was used.

Consulting and Sub-contracted Expertise: Over the long-term, CalWave[sm] will require the services of specialists to review WEC Developer plans for anchoring, mooring, submarine cable umbilicals, and power conditioning. Contracting for services will be more cost-effective than employment. For this analysis, a range of $100,000 to $300,000 was considered and $200,000 was used.

Contingency: Given the Feasibility Stage, a budget for contingencies is included. For this analysis, a range of $100,000 to $200,000 was considered and $150,000 was used.

Summary of Operations and Maintenance and Test Costs: At the Feasibility Stage and, based on initial benchmarking, the annual operating and maintenance budget analysis considered is shown in Table 9-2.

TABLE 9-2
Projected Expenses Until EOC

Cost Category	Expense
Direct and Indirect Labor	$750,000
Included Services	$150,000
Shore Station Facility Costs	$50,000
Spares and Repair Pool	$15,000
Off-Site Engineering Support	$200,000
Consulting and Sub-contracted Expertise	$200,000

TABLE 9-2
Projected Expenses Until EOC

Cost Category	Expense
Contingency	$150,000
Total	$1,515,000

For this analysis, the annual operating and maintenance budget is $1.5M. For the first several years, external funding from grant programs will be required. Once fully-subscribed, CalWave[sm] is intended to be self-sustaining (Table 9-3).

TABLE 9-3
Projected Expenses and Test Berth Fees (Assuming $1.5M/year at Feasibility Stage)

Cost Category	1 WEC	2 WECs	3 WECs	4 WECs
Expense	$1,500,000	$1,500,000	$1,500,000	$1,500,000
Test Berth Fees	$400,000	$800,000	$1,200,000	$1,600,000
Difference	($1,100,000)	($700,000)	($300,000)	$100,000

9.4 Conclusions

Examination of the FTE and fee tables leads to the following conclusions:

- Early staffing during construction and commissioning is key to ensuring the facility is well-tested and controlling operational phase budgets.
- Full staffing will be needed early. There is wide range of staffing assumptions that could be applied as the number of WECs increase, depending on the building and installation rate. Full staffing starts at 10 FTE, and can be reduced as operational experience increases and learning curve effects can be evaluated. There will be some variability in staffing needs as the number of WECs increases and each developer/device goes from installation and testing to operations and maintenance, and finally to removal.
- An Administrative Assistant is a key person and a cost-effective manner to ensure continuity.
- An Assistant Engineer may be included as a grant-funded position and to partly to afford a training opportunity.
- Contracting staff, as well as project control and administrative assistance will be required.
- The Operations and Maintenance costs are composed of variable personnel costs and fixed costs of off-site engineering support, facility support costs, and a small amount to replace spare parts consumed from the original outfitting CalWave[sm] Berths.
- The rates are a key determining factor for what staffing can be supported by fees, revenue, and external grant support.
- Several positions will need to be subsidized by external funding in the first few years.

9.5 References Cited

Federal Highway Administration. 2014. Risk Assessment for Public-Private Partnerships: A Primer. Innovative Program Delivery, P3 Toolkit. January 2014. http://www.fhwa.dot.gov/ipd/p3/toolkit/publications/primers/risk_assessment/ch_2.aspx.

Green Rhino Energy Ltd. 2013. Renewable Energy Projects - Operating Model. http://www.greenrhinoenergy.com/finance/renewable/business_model.php.

SECTION 10

Site Development and Construction Schedule

As discussed in the Project Plan under SOPO Task #10, the construction schedule depends on first completing preliminary design and obtaining the necessary permits and authorizations to begin construction. Figure 10-1 is a preliminary and conceptual timeline that incorporates permitting, engineering design, procurement, construction, and commissioning. A more detailed schedule for permitting alone is found in Section 4.0. Highlights of the schedule by year, assuming that a subsequent phase of work would begin in October of 2015, are found in Table 10-1.

TABLE 10-1

CalWave^{sm} development, permitting, and construction project schedule highlights

Year/Milestone	Project Team Segment
2015	
• Complete Feasibility Study and file Final Report with DOE	Project Team
• Begin work on the NOI/PAD	Project Team
2016	
• File application for BOEM Section 238 Research Lease	Project Development
• BOEM issues Determination of No Competitive Interest	BOEM
• Complete Preliminary Engineering Design and Project Description sufficient for NOI/PAD	Engineering
• Conceptual Design Review	Engineering
• Prepare and File NOI/PAD	Project Team
• Begin offshore surveys (bathymetry, etc.)	Engineering
• Prepare draft environmental study plans	Environmental
• Consult with public and agency stakeholders regarding the study plans	Public Affairs
• Begin environmental baseline surveys	Environmental
• Preliminary Design Review	Engineering
• Request for Information from WEC developers	Project Development
• Conduct public meetings to build project support	Public Affairs
• FERC NEPA Scoping Meetings	FERC
2017	
• Complete environmental baseline surveys	Environmental
• Complete offshore surveys	Engineering
• Prepare and file FERC license application	Project Team
• Continue outreach with agencies through NEPA and permitting process	Public Affairs
• Final Design review	Engineering
2018	
• FERC and BOEM approval	FERC and BOEM
• Order long lead-time materiel	Procurement
• Arrange HDD and commit ship charters	Procurement
• Select EPC Contractor	Project Development

TABLE 10-1

CalWave[sm] development, permitting, and construction project schedule highlights

Year/Milestone	Project Team Segment
• Final Design review	Engineering
2019	
• Site preparation and HDD of offshore cable	Construction
• Install subsea cable (primary)	Construction
• Begin construction	
2020	
• Begin construction of Shore Station	Construction
• Install subsea cable (alternate)	Construction
• Complete construction	Construction
2021	
• Integration, Test and Validation	Testing
• Installation of first WEC achieves initial operating capacity	Testing, Operation
• Begin transition from testing to site operations	Operation, Testing
2022	
• Achieve full operating capacity with all berths occupied	Operation
• Complete transition from testing to site operations	Operation

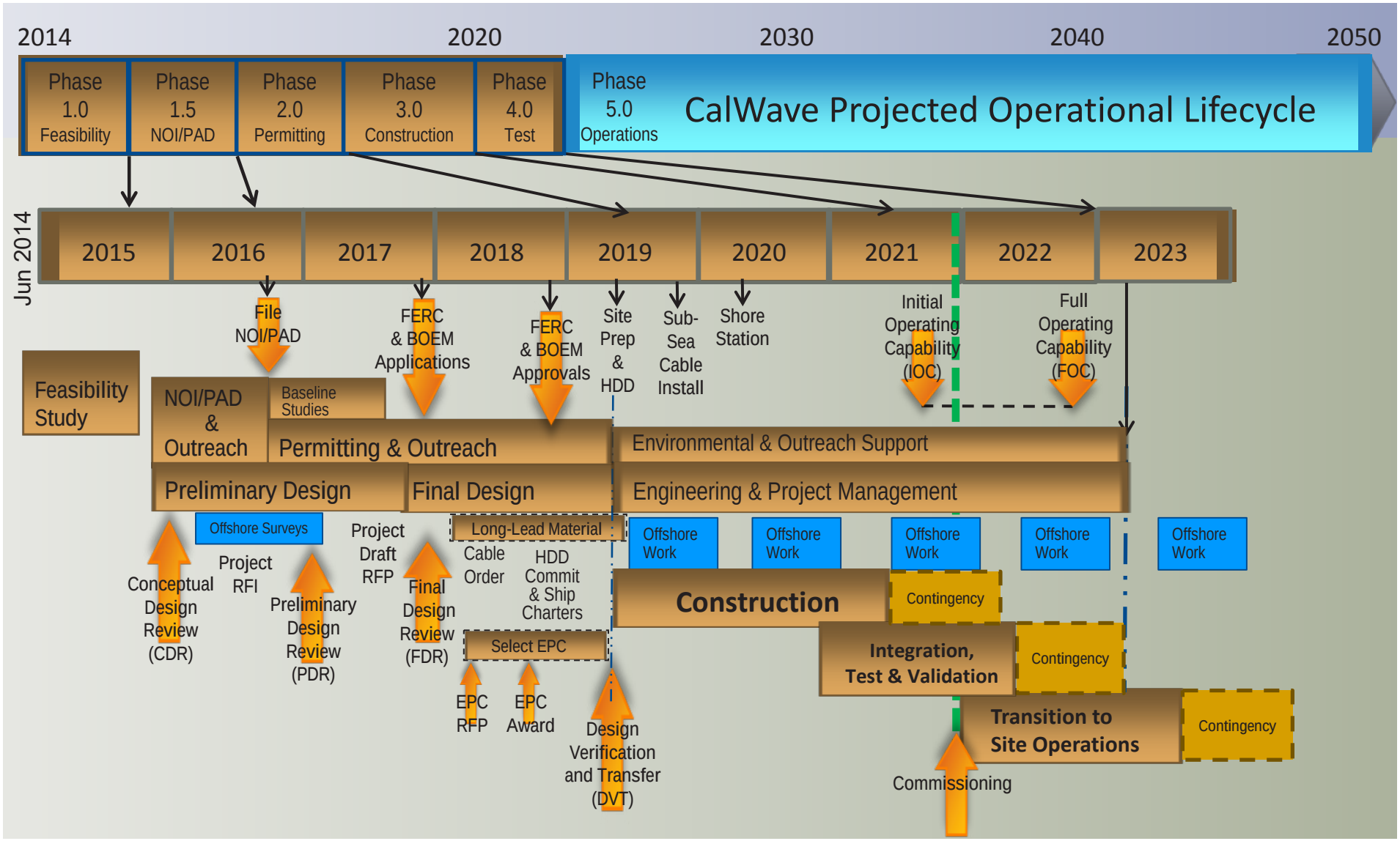

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FIGURE 10-1
Conceptual Timeline
California Wave Energy Test Center

SECTION 11

Conclusions and Recommendations

The work completed to date studied the feasibility of siting a national wave energy test facility in California. The conclusion is that it is feasible, and favorable, to develop the facility in cooperation with Vandenberg AFB on federal lands in the Central California Coast near Point Arguello. CalWave[sm] is envisioned as a long-duration (25 to 30 year design life), fully energetic, open ocean test center that is designed for evaluation of WECs at advanced TRLs. The Conceptual Baseline Design is for a phased implementation to a fully-capable test center, rated at 25-30 MW, with an upgrade path to 50 MW.

During a subsequent phase of work, the project team will further develop the enterprise, business, and operational models for CalWave[sm]. The enterprise model will likely involve a public/private, non-profit entity. The applicant for leases and permitting will be either Cal Poly or the State of California. The business model will include the structures of funding, debt, and revenue streams. The operational model will focus on the day-to-day operational details of the test center and will have three major priorities: (1) ensure safe operations, (2) implement effective procedures for efficient operation, and (3) ensure regulatory compliance.

The following discussions progress addressing each of the 10 SOPO tasks, followed by recommendations for further activities to develop CalWave[sm] at the Vandenberg site.

11.1 Summary of Study Results and Objectives

The following are some highlights of the characteristics of the Vandenberg CalWave[sm] site:

Host Organization and Shore Station Site—The cooperation of the U.S. Air Force and Vandenberg AFB is very significant for CalWave[sm] because Vandenberg will provide a secure location for shore-side facilities, a capable dock at the shore station, a variety of industrial support possibilities, and a potential customer for the power produced. Vandenberg Dock was constructed for offloading large rocket boosters and the Space Shuttle, and its access roads are engineered for large and heavy equipment.

Interconnection—It is feasible to interconnect with the Vandenberg 12 kV and/or 70 kV on-base electrical system. Although a full system interconnection study has not been done (recommended for the next phase of the project), the Vandenberg system appears to have the capacity to accept CalWave[sm]'s power output. Initially, the interconnection could be a direct connection to the Vandenberg 12 kV system at Vandenberg Dock. Eventually, and with the construction of 5 miles of upgraded transmission line, CalWave[sm] could connect directly with the Vandenberg system at 70 kV.

Co-Use of Existing Marine Infrastructure— While it is conceptually feasible to co-use the existing offshore infrastructure at Platform Irene (platform, submarine power cable and shore substation), there are many engineering unknowns about platform system integration that need to be resolved via technical exchanges with the infrastructure owner. The study team has identified a potential $10 million cost savings to CalWave[sm] if we can have access to this infrastructure vis. installing exclusively new cables.

Test Berth Site Characteristics— CalWave[sm] test berths could be sited in 70 to 150 meters of water within 3 to 7 nm of the Vandenberg Dock shore station, with direct and relatively short cable runs that would minimize cable costs. Furthermore, the cable routes avoid rocky seafloor bottom, and with it cable maintenance and permitting problems and costs. A narrow strip of rocky bottom adjacent to the shore can be avoided by HDD.

The test berths avoid existing oil and gas lease blocks and berths could be sited in BOEM designated lease blocks in a 4 square nm configuration or other configuration subject to BOEM approval. The test sites are exposed to open ocean swells with productive wave energy resource, yet can be reached routinely from marine operations service vessels from the more protected Santa Barbara Channel.

Wave energy resource—Wave climate studies and hindcasting show that all five of the prospective test sites have average annual wave energy flux greater than 30 kW/m. A wide range of wave period and significant height conditions are available at the sites for WEC device testing under a broad array of conditions.

Shore Side Operational Support—The Vandenberg site is located within a few nautical miles of four offshore oil platforms (Platforms Irene, Hidalgo, Harvest, and Hermosa) that have been in place for nearly 30 years and there are a number of additional oil platforms further east in the Santa Barbara Channel area. Consequently, there is a highly developed and experienced marine construction, operations, and logistics service industry based in the Santa Barbara/Ventura/Port Hueneme area near the CalWave^{sm} site that can provide cranes, cable lay and maintenance services, and construction vessels and operations work boats that is near at hand. CalWave^{sm} will have access to marine construction and operation services without having to mobilize and demobilize them from long distance, resulting in significant economies of construction and operation.

Port Facilities—Port Hueneme, a capable deep water port with available shore side storage and work areas, is about 70 nm from the CalWave^{sm} site. Ports at Santa Barbara, Port San Luis, and Morro Bay are also relatively near to CalWave^{sm}. Cal Poly owns a robust dock in Port San Luis that was formerly an oil tanker offloading dock. These dock facilities have or are capable of hosting cranes that can lift large machinery such as WECs. Vandenberg Dock, adjacent to the CalWave proposed Shore Station site, is designed to hosting a large mobile or barge-mounted cranes and other equipment, as well.

Lack of Public Controversy—In meetings with stakeholder and regulatory agency groups, the CalWave^{sm} project did not encounter any significant opposition to the project concept or proposed locations. Most notable in this regard is the apparent lack of significant opposition from commercial fishing interests. In many offshore energy projects, the potential for the project to conflict with commercial fishing has been one of the most important siting and permitting obstacles to overcome. In the case of CalWave^{sm}, commercial fishers have indicated that there is little fishing activity in the project siting area. This may be partly because it is relatively distant from the regional major fishing ports of Morro Bay and Santa Barbara. As the project is located offshore of Vandenberg AFB, which owns 42 miles of shoreline and adjacent land up to the top of the ridgeline, there is little or no opportunity for conflicts having to do with scenic views of the ocean from coastal residences or recreational facilities and, in any case, a wave energy farm would have a low profile and be relatively invisible, particularly when compared with the existing oil platforms.

Although the Santa Barbara area in particular is known for active environmental advocacy organizations that oppose many activities of the oil and gas industry, initial discussions with these groups have not indicated opposition to CalWave^{sm}. There has long been a concept of support for renewable energy among some of these groups.

Permitting Obstacles—Permitting MHK offshore of California will be relatively time-consuming and expensive due to the higher cost of collecting environmental data in the marine environment, compared with locations on shore. Nevertheless, initial screening does not indicate that extremely difficult or unsurmountable permitting obstacles exist. The South Base project and southern test berth sites avoid major commercial and recreational fishing areas, commercial vessel traffic lanes, Essential Fish Habitat/Habitat Areas of Particular Concern (in this case, hard or rocky seafloor), and critical habitat for

listed marine species. Sensitive species and habitats exist along shore (plover nesting areas, pinniped rookeries) but these are avoided by HDD under the surf and rocky bluff zone to the shore station.

The major permitting issues are likely to have to do with the WECs and service vessels and the noise they may produce as obstacles to the movement of species such as cetaceans, diving birds, and marine mammals like the southern sea otter and these issues have been debated and discussed repeatedly and there are known permitting pathways to resolve them.

Data Collection for Permitting—Proximity of the oil and gas industry may offer significant cost and schedule reductions for permitting because, over the past 30 years, BOEM and oil companies and other agencies (CalCOFI) have been collecting marine biological baseline data to address issues having to do with permitting oil and gas operations in the Santa Barbara channel area. It is likely that CalWave will be required to collect marine biological baseline data on some scale for permitting. Available data that has been collected over a long period of time, however, will help to reduce the uncertainty among regulatory agency personnel in evaluating potential project effects for permitting.

11.2 Cost and Schedule Summary

Project development cost estimates have been presented in individual sections for engineering and construction (Section 8), permitting (Section 4) and stakeholder engagement/public involvement (Section 5) and an overall scheduling summary is found in Section 10. Table 11-1 consolidates those by element.

11.3 Recommendations

The CalWave^{sm} Vandenberg AFB site is clearly a promising location for the development of a fully energetic national wave energy test facility appropriate for TRL 7, 8, and 9 WECs. We recommend pursuing continued project development, engineering design, permitting, and public/stakeholder acceptance development of this site. The next phase of work would involve the following key tasks:

- Continue to work with WEC developers to determine their requirements for a wave energy test center. Conduct interviews and benchmarking meetings to determine short- and long-term needs in a test center, from the point of view of the customer.
- Continue to work with other test centers (UK WaveHub, EMEC, etc.) to share information on lessons learned and the fine points of test center management and operations.
- Refine the business model and cost and schedule estimates to be proposed for CalWave^{sm}.
- Continue relations with Platform Irene's owner to progress to agreements for CalWave^{sm}-to-platform integration feasibility studies, construction and operations activities and potential sale of a portion of CalWave^{sm}'s generation to power platform operations.
- Progress the conceptual design towards a preliminary engineering design of sufficient maturity for inclusion in FERC NOI/PAD document. Per FERC, the NOI/PAD should have a sufficient level of detail that will allow agencies, stakeholders, and interested parties to understand the scope of the project and to comment on the proposal. Key milestones at this level of detail would include:
  - Gap Analysis: determine sufficient design granularity for NOI/PAD submission
  - Conduct Grid Integration Engineering Analysis
  - Confirm WEC-dependent aspects of CalWave^{sm} Design

TABLE 11-1
Summary of ROM Estimated CalWave Costs through Construction (Costs in $1,000s)

Alternative	Platform Irene Alternative	South Base Conceptual Baseline	Cost Difference (PI minus South Base)
Permitting[a]:			
Field Studies	$2,350	$2,350	$0
Obtain Permits	$1,200	$1,200	$0
Compliance Plans and Monitor Construction	$450	$450	$0
Subtotal Permitting	$4,000	$4,000	$0
Stakeholder Engagement/Public Involvement:	$1,600	$1,600	$0
Engineering:			
Preliminary Engineering (for planning, permitting, surveys)	$2,000	$1,400	$600
Final Engineering Design including RFPs and bid review	$4,000	$3,100	$900
EPC Design and Construction Management Fees	$9,000	$6,500	$2,500
System Integration, Test, and Validation	$1,400	$1,000	$400
Subtotal Engineering	$16,400	$12,000	$4,400
Construction:			
Shore Station (Civil, Electrical, Network, Architecture)	$6,000	$14,600	-8,600
Horizontal Directional Drill	$0	$3,000	-3,000
Subsea Cabling	$10,000	$12,000	-2,000
Marine and Cable Construction	$23,000	$22,000	1,000
Fees	$11,000	$13,400	-2,400
Subtotal Construction	$50,000	$65,000	-$15,000
Total	**$72,000**	**$82,600**	**-$10,600**

[a] This estimate is the higher range of estimates provided in Table 4-8. Section 4.6.

- Finalize location-based design aspects, in collaboration with stakeholder and permitting processes:
  - Confirm Test Berth locations
  - Cable Design and Logistics Planning
  - Cable Routes
    - Accomplish Cable Route Desktop Study
    - In-water Survey Plan and Cost Estimate
  - Cable Landings
    - Confirm HDD
    - Confirm Surface Lay to seaward
    - HDD Bore Design
  - Confirm CalWave Shore Station location
    - WEC Power Conditioning Requirements
    - Land Survey

    - CalWave Sub-stations (12kV and 70kV)
    - 70kV line extension
  - More-detailed Cost Estimating
  - Draft CalWave Project Industry RFI
  - Engineering Plan for Permitting and Detailed Design
- Pursue a robust stakeholder engagement and public involvement program that will:
  - Build support for the project among the public and state and local government officials
  - Progress to detailed discussions with regulatory permitting agencies regarding information requirements and data needs for the permit applications that will eventually be needed.
  - Identify key stakeholders and engage them regarding any issues of major concern and work on developing solutions to these issues.
  - Document the stakeholder engagement and public involvement program in detail to support the subsequent permitting phase of work
- Develop the NOI/PAD document and submit the document to FERC, officially starting the permitting process. To support the NOI/PAD, conduct the following:
  - Collect and summarize environmental baseline data in the FERC licensing disciplines and prepare the FERC NOI/PAD, presenting this baseline information
  - For key disciplines such as marine biology, collect and summarize existing field data on oceanography and marine life. Present the data to the regulatory agencies and begin discussions on the sufficiency of existing data to address what may be key issues regarding environmental effects. The goal of this discussion will be to focus the FERC study plans on collecting data sufficient to address these key issues and to obtain agency buy-off on the scope of the studies described in the study plans.
  - Prepare preliminary draft environmental Study Plans. These will be finalized and formally submitted for agency approval during the phase of permitting that follows submittal of the NOI/PAD.

After the NOI/PAD is submitted to FERC and the Section 238 Research Lease application is submitted to BOEM, the project team should seek funding for final permitting, construction, and operation of the facility as long as the project remains feasible as expected, as a third phase of work. During this future phase, final design for permitting would occur, and CalWave^{sm} would gain approval of and implement the study plans leading to the filing of the FERC license application and applications for the environmental permits outside of the FERC's authority. During this permitting phase, the CalWave^{sm} engineering team would finalize detail design for construction, plan for essential equipment and construction services procurement.

Feasibility Study for the

California Wave Energy Test Center (CalWave[sm])

Award Number: DE-EE0006517

Submitted to:
U.S. Department of Energy
Office of Energy Efficiency
and Renewable Energy
Golden Field Office
15103 Denver West Parkway
Golden, Colorado

U.S. DEPARTMENT OF ENERGY

Submitted by:
Cal Poly Corporation
Institute for Advanced Technology
and Public Policy
California Polytechnic State University
San Luis Obispo, California

CALWAVE[sm]

CAL POLY
SAN LUIS OBISPO

September 2015

List of Appendixes

1-1 CalWave Study Participants
1-2 Regional Site Selection Matrix

2-1 Cable Lay Resources (L3 Mari-Pro)
2-2 Support Vessels

4-1 Annotated Bibliography, Regional Marine Biology Scientific Literature
4-2 References Consulted, Regional Marine Biology and Regulatory Permitting Cases

5-1 Public Meeting Summary
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7-1 Electrical Engineering Drawings
7-2 Civil Engineering Drawings
7-3 Architectural Drawings

8-1 Basis of Cost Estimate

Appendix 1-1
Participants in the CalWave Feasibility Study

APPENDIX 1-1

Participants in the CalWave Feasibility Study

TABLE A-1/1

CalWave Feasibility Study Participants

Organization	Participants	Roles
I. Sponsors		
United States Department of Energy		
Office of Energy Efficiency and Renewable Energy	James Ahlgrimm	Project Manager
	Pam Brodie	Contracting Officer
	Yvette Petersen	Grant Manager
	Tim Ramsey	Project Officer
IIa. Public Recipients		
California Polytechnic University at San Luis Obispo (Cal Poly) – Prime Recipient		
Institute for Advanced Technology and Public Policy	Sam Blakeslee, Founding Director	Principal Investigator
	William I. Toman	CalWave℠ Project Manager
	Christine Roberts	Contract Administrator
College of Science and Mathematics	Dean Wendt, Dean	Commercial Fishing liaison, Marine Biology
College of Engineering	Dale Dolan	Electrical Engineering
	Craig Baltimore	Architectural Design
Humboldt State University, Arcata, California		
Humboldt State University, Schatz Energy Research Center	Arne Jacobsen, Director	Wave energy resource
	Colin Sheppard	Wave energy resource modeling
	Andrew Harris	Wave energy resource modeling
National Renewable Energy Laboratory		
	Frederick Driscoll	Engineering, Offshore Wind and Power
	Arielle Cardinal	Engineering, Offshore Wind and Power
Sandia National Laboratories		
	Jesse Roberts	Oceanography, wave energy
	Richard Jepsen	Water resources engineering

TABLE A-1/1

CalWave Feasibility Study Participants

Organization	Participants	Roles
Virginia Polytechnic Institute and State University		
	George Hagerman	Wave energy resource modeling
University of California at San Diego, Scripps Institution of Oceanography, Coastal Data Information Program		
	Julie Thomas, Executive Director	Oceanography, wave energy resource, marine life data
University of California at Davis, California Wind Energy Collaborative		
	C.P. Case Van Dam	Renewable Energy Engineering
Electric Power Research Institute		
	Paul Jacobsen	Marine Renewable Energy
IIb. Private Recipients		
Columbia Power Technologies		
	Reenst Leeseman, CEO	WEC operation and logistics
	Brad Lamb, COO	WEC operation and logistics
	Kenneth Rhinefrank, VP Research	WEC operation and logistics
Glosten Associates		
	Jay Edgar, President	Renewable energy engineering and logistics
III. Cooperating Agencies		
Vandenberg Air Force Base		
30th Civil Engineering Squadron	Ken Domako	DOD Liaison
	Bradley King	Utility infrastructure
State of California		
Office of the Lieutenant Governor	Kevin Schmidt	State government liaison
IV. Vendors		
Leidos Maritime Solutions		
	Richard Williams	CalWave Chief Engineer
	Rich Chwaszczewski	Operational Model
	Jennifer Snyder	Operational Model
	David Goodwin	Project Administration
	David Tietje	Wave Modeling
	Thomas Proios	Electrical Engineering

TABLE A-1/1

CalWave Feasibility Study Participants

Organization	Participants	Roles
Omega Power		
	Randy Connett	Electrical Engineering Design
CH2M		
	Douglas Davy	CalWave℠ Permitting Lead, General Report Editor
	Marc Driscoll	Marine energy resources permitting
	David Rasmussen	Marine biology
Kearns & West		
	Anna West	CalWave℠ Stakeholder Engagement Lead
	Janet Thompson	Stakeholder Engagement Coordinator
	Kelsey Rugani	Stakeholder Engagement
HT Harvey and Associates		
	Sharon Kramer	Marine Biology
Independent Consultants		
	William Lyte	Ports and International Relations
	Brendan Dooher	Chief Consulting Scientist

Appendix 1-2
Regional Site Selection Report

CAL POLY
SAN LUIS OBISPO
Institute for Advanced Technology & Public Policy
Cal Poly State University
Tel 805-756-1694

October 14, 2014

Dear CalWave Team,

The CalWave project is a U.S. DOE co-funded yearlong study to identify and evaluate a primary offshore test site along California's coast that may be suitable for the establishment of a full-scale, high Technology Readiness Level (TRL)[1] national wave energy test center. CalWave proposed to evaluate two locations along the California coastline;

1) Due west of Humboldt Bay in Humboldt County, California, and

2) About 20 miles northwest of Point Conception, offshore of Vandenberg Air Force Base in Northern Santa Barbara County, California.

Both of these sites had been previously considered as prospective wave energy pilot and demonstration locations by Pacific Gas and Electric Company (PG&E) in their DOE co-funded WaveConnect program[2].

A siting prioritization subcommittee was created to evaluate the relative merits of two proposed California sites in hosting a national wave energy test center. The charter of the subcommittee was to recommend the single best proposed site to focus efforts by the California Wave Energy Test Center (CalWave) project study team in evaluating the placement of a future national wave energy test center.

This subcommittee is made up of CalWave team members from Sandia National Laboratory, National Renewable Energy Laboratory and the Electric Power Research Institute. Dr. Rich Jepson of Sandia chaired the subcommittee.

After a thorough review of the report by the subcommittee[3], and after reviewing the comments of the CalWave team as a whole regarding this report, I have decided to accept the guidance of the siting subcommittee, that, **"the review finds that the method of using weighted scoring was beneficial and the overall outcome has come to a reasonable conclusion that, although the Humboldt site has many attractive qualities, the Vandenberg site is more suitable for a WEC test center."**

The remaining CalWave activities under a U.S. Department of Energy (DOE) co-funded study will therefore be focused on the Vandenberg site as primary, while the Humboldt site will serve as an alternative.

As Principal Investigator for the CalWave study, I'd like to thank the subcommittee and the entire CalWave team in pulling together the information used in this side-by-side site comparison.

Sincerely,

Honorable Sam Blakeslee, Ph.D.
Founding Director, IATPP

[1] Technology Readiness Level (TRL); Technology Readiness Assessment Guide, R Sanchez, US DOE, g413.3-4a, 2011
[2] PG&E WaveConnect Program, Pacific Gas and Electric Company, 2011
[3] Final CalWave Subcommittee Report, Sandia National Laboratories, October 9, 2014

APPENDIX 1-2B

CalWave Site Evaluation Matrix

10/17/2014 **(Revised)**

Weighted Requirements Evaluation

Bolded Numbers are Inputs

UnBolded Numbers are Calculated Values

Step 1: Assign site reqt weighting factors (Rose Cells)

- Site requirements' weighting can be any value, but column total must sum to 100.

Step 2: Assign site scenario score for each site reqt (Blue Cells)

- Site senario scores range is 0 to 10

Step 3: Review resultant weighted average score (Green Cells)

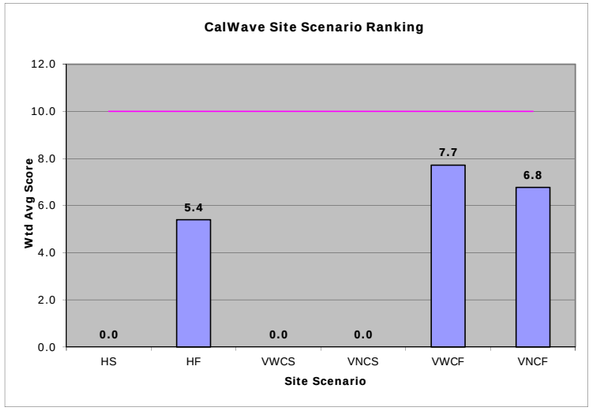
- Also presented graphically on subsequent page

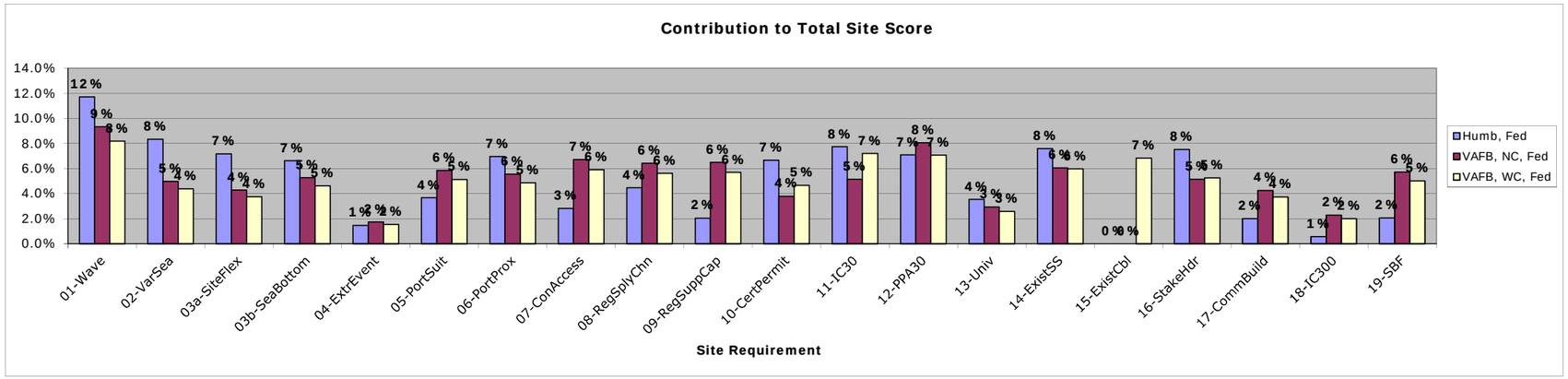
Orig Index	Site Requirements	Site Reqt Lbl	Reqt Lead	Scoring Guidelines: 0 to 2	Scoring Guidelines: 3 to 6	Scoring Guidelines: 7 to 10	[If HSU Switch = 1, then use HSU WF, else use Team Avg WF] HSU Switch 0 Team Weighting Factors (0 to 10)	Site Senarios: HF Humb Federal Nom	Site Senarios: VWCF VAFB w/ P,C&SS Federal Nom	VNCF VAFB No P,C&SS Federal Nom	Link to Scoring Rationale
1	Wave energy resource for a test center, Pmin 30 KW/m, months per year	01-Wave	VT	Wave energy flux 10 to 100 kW/m < 5,000 hrs/yr	Wave energy flux 10 to 100 kW/m 5,000 to 7,000 hrs/yr	Wave energy flux 10 to 100 kW/m > 7,000 hrs/yr	7.9	**8**	**8**	**8**	SR1&2
2	Variability of sea states for a test center	02-VarSea	VT	Hs < 1.5 m for two or more days in a row < 20 times/year	Hs < 1.5 m for two or more days in a row 20 to 40 times/year	Hs < 1.5 m for two or more days in a row > 40 times/year	5.6	**8**	**6**	**6**	SR1&2
3a	3a - Flexibility to accommodate different WEC designs, compactness for a range of depths >75m	03a-SiteFlex	HSU	4 x 1,000 m diameter circular bays facing incident waves would fit within > 5 sq nm or cannot be fit at all	4 x 1,000 m diameter circular bays can be fit facing incident waves within 5 sq nm	4 x 1,000 m diameter circular bays can be fit facing incident waves within 2.5 sq nm	4.8	**8**	**6**	**6**	SR3a,3b,12&13
3b	3b - Sea bottom terrain	03b-SeaBottom	HSU	Significant sloping, rocky, broken sea bottom	Modest sloping (depth gradient 15-30 m/km), mostly sandy sea bottom	Flat, sandy sea bottom (depth gradient < 15 m/km)	3.6	**10**	**10**	**10**	SR3a,3b,12&13
4	Extreme event design environment	04-ExtrEvent	VT	offshore 100-yr Hs > 10m; high onshore potential for ground shaking & tsunami inundation	offshore 100-yr Hs 8 to 10m; high onshore potential for ground shaking & tsunami inundation	offshore 100-yr Hs < 8m; low onshore potential for ground shaking & tsunami inundation	2.0	**4**	**6**	**6**	SR4
5	Operations port suitability/capability and affordability of ocean engineering eqpmt	05-PortSuit	Leidos	Piers exposed to incident weather and surge. Need to mob offload equipment (high capacity land cranes and floater cranes)from outside of region. Need to mob equipment (high capacity land cranes, floater cranes, and tugs) for transfer to ocean site outside of region. Expensive mob, day rates and demob due to no other entities using assets: Lack of large pier cranes. Lack of large land cranes. Lack of floater cranes. Lack of ocean-going tugs. Lack of crew boats and support vessels.	Piers protected from incident weather and surge. Availability of offload equipment in geographic region. Availability of equipment (high capacity land cranes, floater cranes, and tugs) for transfer to ocean site in geographic region. Less-expensive mobilization, day rates and demobilization due to few entities using assets: Large pier cranes in region. Large land cranes in region. Floater cranes in region. Ocean-going tugs in region. Crew boats and support vessels in region.	Piers protected from incident weather and surge. Multiple piers. Reinforced piers. Installed pier cranes. Availability of offload equipment in local area. Availability of equipment (high capacity land cranes, floater cranes, and tugs) for transfer to ocean site in local area.Affordable mob, day rates and demob, with multiple entities using assets, due to: Large pier cranes in local area. Large land cranes in local area. Floater cranes in local area. Ocean-going tugs in local area. Crew boats and support vessels in local area.	6.6	**3**	**6**	**6**	SR5,6,7,9&19
6	Operations port proximity and ability to accomplish tasks in a day charter	06-PortProx	Leidos	Requires 16 hr or overnight tug and tow charter to transit, conduct 4 hrs on-site services, and return. Requires 16 hr or overnight tug charter to transit, conduct 4 hr on-site services, and return. Requires 16 hr or overnight monitoring boat charter to transit, conduct 4 hr on-site services, and return. Requires 16 hr or overnight crew boat charter to transit, conduct 4 hr on-site services, and return.	Requires 12 hr tug and tow charter to transit, conduct 4 hrs on-site services, and return. Requires 12 hr tug charter to transit, conduct 4 hr on-site services, and return. Requires 12 hr monitoring boat charter to transit, conduct 4 hrs on-site services, and return. Requires 12 hr crew boat charter to transit, conduct 4 hr on site services, and return.	Ability to use 8 hr tug and tow charter to transit, conduct 4 hrs on-site services, and return. Ability to use 8 hr tug charter to transit, conduct 4 hrs on-site services, and return. Ability to use 8 hr monitoring boat charter to transit, conduct 4 hrs on-site services, and return. Ability to use 8 hr crew boat charter to transit, conduct 4 hrs on-site services, and return.	5.4	**7**	**7**	**7**	SR5,6,7,9&19
7	Construction accessibility for both sea-based and shore-based infrastructure	07-ConAccess	Leidos	Shore site inaccessible by large trucks and cranes. At-sea site close to restricted navigation area.Launch site constraints require large cranes or floater cranes that are not available in region.	Shore site accessible by large trucks and cranes with reinforcement. At-sea site stands off from restricted navigation area. Launch site able to use large cranes or floater cranes that are available in region.	Shore site routinely used by large trucks and cranes with reinforcement. At-sea site clear of restricted navigation area. Launch site routinely used by large cranes or floater cranes that are available in local area	5.1	**3**	**9**	**9**	SR5,6,7,9&19
8	Regional heavy manufacturing / marine supply chain capability	08-RegSplyChn	W Lyte	light manufacturing	medium manfacturing	heavy marine manufacturing	4.8	**5**	**9**	**9**	SR8
9	Regional industrial marine support operations capability	09-RegSuppCap	Leidos	Lack of heavy marine fabrication capability in region. Lack of marine hardware vendor. Lack of diesel/marine electrical/marine refrigeration service vendors.	Heavy marine fabrication capability in region. Marine hardware vendor in region. Diesel/marine electrical/marine refrigeration service vendors in region.	Heavy marine fabrication capability in local area. Marine hardware vendor in local area. Diesel/marine electrical/marine refrigeration service vendors in local area.	5.5	**2**	**8**	**8**	SR5,6,7,9&19
10	Certainty / length of regulatory and permitting pathway	10-CertPermit	CH2M/K&W	poorly understood, potentially as lengthly as WaveConnect	somewhat understood, potentially faster than WaveConnect	fairly well understood, potentially faster than WaveConnect	5.1	**7**	**7**	**5**	SR10&16
11	Ease of interconnection for 30 MW	11-IC30	W Lyte	substantial upgrading	moderate upgrading	little upgrading	7.0	**6**	**8**	**5**	SR11&14
12	Power sales potential for 30 MW	12-PPA30	HSU	**No Interest Identified:** No particular entity has been identified who may be interested in purchasing power from a wave energy test facility.	**Tentative Interest Identified:** One or more entities have been identified and have expressed some interest in the idea of purchasing power.	**Strong Interest Demonstrated:** One or more entities have expressed strong interest in purchasing power and have formally documented their interest.	5.5	**7**	**10**	**10**	SR3a,3b,12&13
13	Academic/research community proximity	13-Univ	HSU	Few to no discipline areas present on campus, with few to no faculty engaged in research relevant to marine energy.	Gaps in some discipline areas, or gaps in disciplines where faculty are engaged in research relevant to marine energy.	All discipline areas present on campus, with a faculty research community with capacity to engage in work related to marine energy in all areas.	2.2	**9**	**9**	**9**	SR3a,3b,12&13
14	Existing infrastructure for co-use, substation	14-ExistSS	W Lyte	no SS nearby	PG&E SS nearby	contracted private SS co-use	5.1	**8**	**9**	**8**	SR11&14
15	Existing infrastructure for co-use, submarine cable	15-ExistCbl	Cal Poly	no cable nearby	cable nearby, needs upgrading	cable nearby, no upgrading	5.9	**0**	**9**	**0**	SR15
16	Stakeholder support	16-StakeHdr	CH2M/K&W	substantial overlap with comm fishing	moderate overlap	little overlap	5.8	**7**	**7**	**6**	SR10&16
17	Site commercial buildout potential	17-CommBuild	Cal Poly	no commercial interest	nearby FERC/BOEM process underway	FERC lic issued	3.6	**3**	**8**	**8**	SR17
18	Ease of interconnection for 300 MW	18-IC300	W Lyte	substantial upgrading	moderate upgrading	little upgrading	3.1	**1**	**5**	**5**	SR18
19	Proximity to shipbuilding facility for WEC fabrication	19-SBF	Leidos	Need to transport WECs from distant shipyards by land or sea. Constraints in land transport routes. Need to mobilize sea transport from outside of region.	Availability of shipyard facility in geographic region. Ability to move large loads on land transport routes. Availability of sea transport in geographic region.	Availability of shipyard facility in local area Routine movement of large loads on land transport routes. Availability of short-sea transport in local area.	5.5	**2**	**7**	**7**	SR5,6,7,9&19
						Weighting Factor Sum (must = 100):	**100.0**	**5.4**	**7.7**	**6.8**	**Wtg Avg :Score**

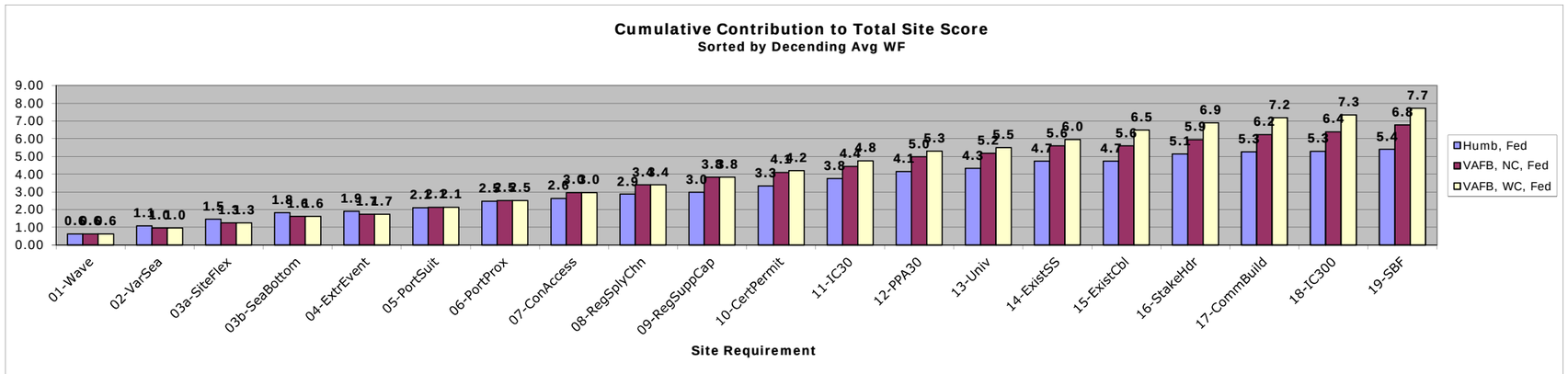
APPENDIX 1-2B

CalWave Site Evaluation Matrix

Weighted Requirements Evaluation







Appendix 2-1
Cable Lay Resources (L3 MariPro)

MariPro

Marine Services

2015

L-3 MariPro History – Since 1961

MariPro

- L-3 MariPro Corporate History
  - Located in Goleta, California
  - Founded in 1961
  - ~100 Employees
  - High employee retention rate, average tenure 14 Years
- 5 Decades of Operation
  - 70+ Programs
  - 313 cable strings
  - 8,675 km of cable
  - water depths up to 5,000 meters
  - 158 Shore Cable
  - Landings at 84 Worldwide Locations
  - Systems operational for 3 decades in 5,000 meters of water
- Loyal customers with repeat business

Since 2011 L-3 MariPro has Installed Over 1356 km of Power & Fiber-Optic Cable Without a Single Incident. We have a "Zero" TRIR for 2 Years Running!

L-3 MariPro Capabilities

- **Fully integrated capabilities**
  - **Turnkey system solution provider**
    - **Design**
    - **Fabrication**
    - **Manufacturing & Test**
    - **Marine Installation**
    - **Operations & Maintenance**
- **Considerations of at sea installation inherent to our design process**
- **Proven ability to provide 20+ year life marine systems**
- **AS 9100:2009 certified for all processes**
- **California, Oregon and Alaska General Engineering "A" State Contractor Licenses**
- **World wide operations**

Certificate of Registration

nqa global assurance

This is to certify that the Quality Management System of:

L-3 Communications MariPro, Inc.
1522 Cook Place
Goleta, CA 93117

applicable to:

Design, Fabrication, Integration, Installation, Testing and Servicing of Undersea Range and Ocean Systems

has been assessed and approved by
National Quality Assurance, U.S.A., against the provisions of:

ISO 9001:2008 and AS 9100:2009

Certificate Number: 14632
EAC Code: 19
First Issued: February 6, 2013
Valid Until: February 6, 2016

For and on behalf of
NQA, USA, 4 Post Office Square,
Acton, MA 01720

ANAB ACCREDITED

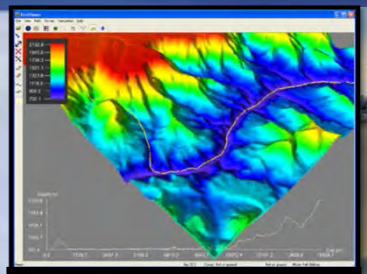
Page 1 of 1

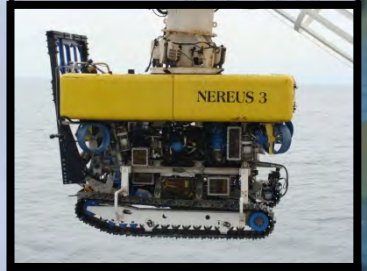
This approval is subject to the company maintaining its system to the required standard, which will be monitored by NQA, USA, an accredited organization under the Aerospace Registrar Management Program.

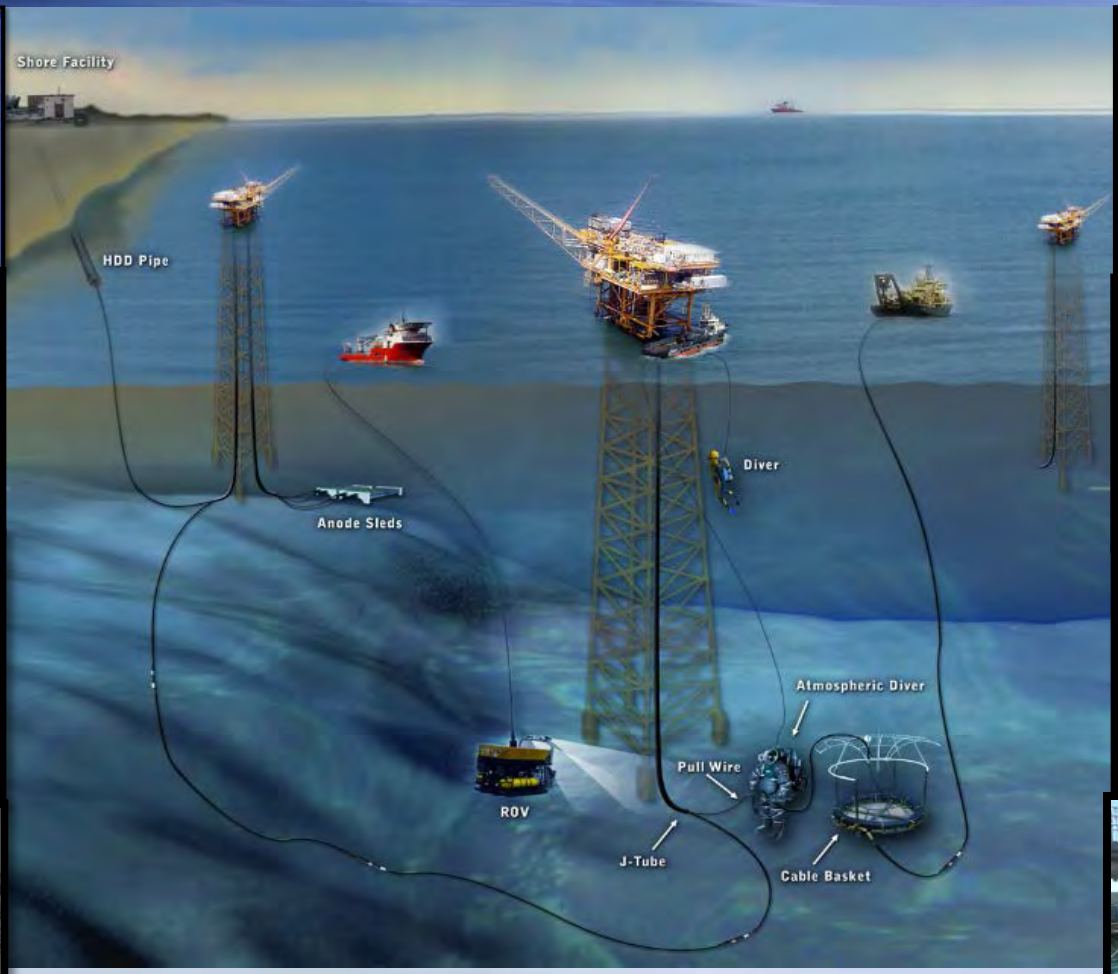
Quality Policy
L-3 MariPro, Inc. will continually improve the effectiveness of its work processes that enable MariPro to provide systems, hardware and services that satisfy customer specification, cost and schedule requirements.

MariPro

Marine Services







Commercial Marine Power and Data Cable
Engineering and Installation Services

MariPro

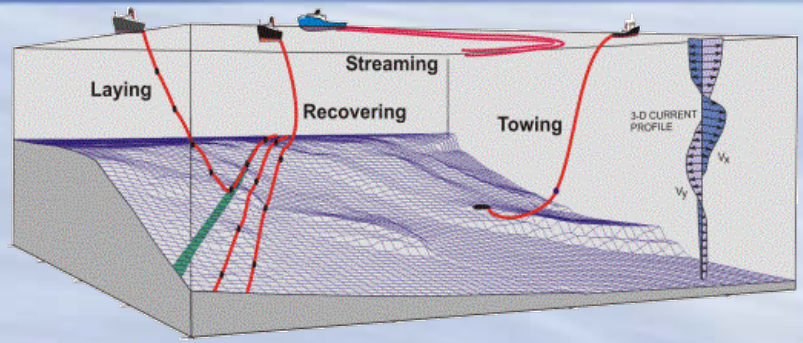
L-3 MariPro Goleta, CA
Shop & Yard Facilities

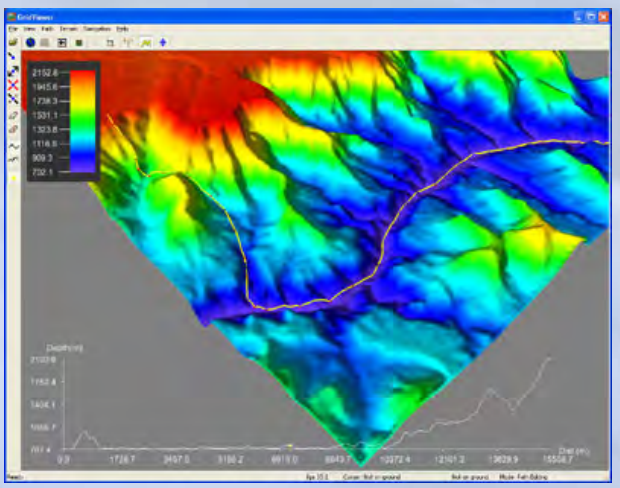
Machine Shop, Manufacturing, Testing Facilities, Equipment & Cable Yard
1440 Cook Place, Goleta, CA 93117

MariPro

Professional Engineering Services

- Cable Route Engineering - Makai
- Cable Applications Engineering
- Hydrodynamic Modeling
- Mooring Design & Analysis
- Finite Element Analysis
- 3D CAD Modeling - SolidWorks
- PE Ocean Engineering
- PE Mechanical Engineering
- Marine Engineering
- Naval Architecture Management
- ABS / DNV / BV / Lloyds Certified Designs
- API Certified Designs
- AS 9100:2009 Certification





MariPro

Behavior Based EH&S

- 3 yr rolling average TRIR = 0
- 2015 to date TRIR = 0

L-3 MariPro EH&S Statement

L-3 MariPro is committed to conducting all operations in a manner that provides and maintains safe and healthful working conditions and protects the environment. In meeting this commitment it is our policy that no employee shall engage in any conduct that violates any environmental, health or safety law or is otherwise inconsistent with the highest levels of corporate responsibility and best practices for the health and safety of all personnel and the environment. All L-3 MariPro operations are conducted in full compliance with OSHA, Cal OSHA, USCG, ABS, ADC, NETA and BSEE's Safety and Environmental Management Systems (SEMS) regulations. L-3 MariPro is committed to a culture of behavior based safety, the continual improvement of its environmental management systems, its environmental health and safety programs and to the prevention of pollution.

MariPro

Recent Power & Fiber-Optic Cable Installations

Power Cable Lay
US Navy
30 Kilometers
Kauai, HI
2014

MariPro

Recent Power & Fiber-Optic Cable Installations

US Navy
Kwajalein
Pacific Missile Scoring System
54 Kilometers Cable
2014

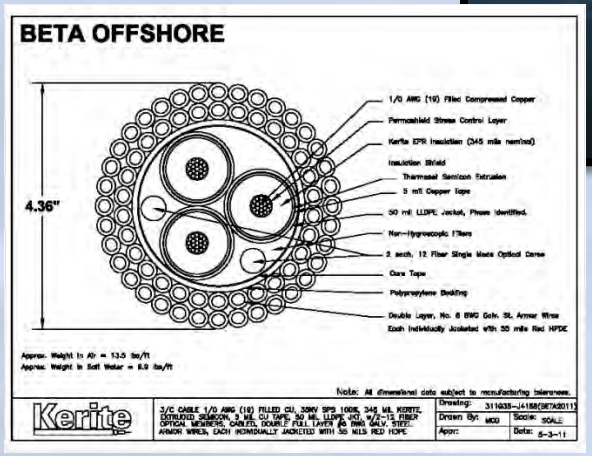
Comprehensive Nuclear-Test-ban Treaty Organization
Juan Fernandez Is, Chile
Hydro-acoustic Monitoring System
67 Kilometers Cable
2014

MariPro

Oil Platform Power & Fiber-Optic Cable Installations

Fiberweb
788 km Length
Linking Fiber-Optics to
7 Platforms in the
Gulf of Mexico
1999

Beta Offshore
Power & Optics Cable Lay
Platform Edith to Elly
35Kv, 4.36" O.D.
8,500 ft Length
Huntington Beach, CA
2012

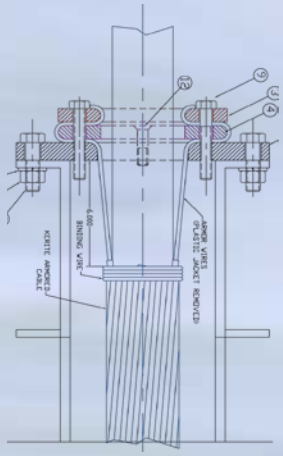


Beta Offshore - Platform Edith to Elly Power and Fiber-Optic Cable Installation

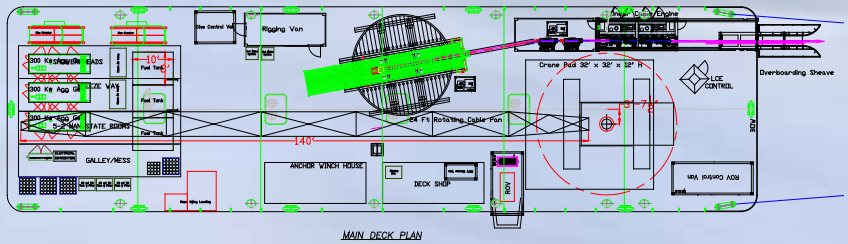
MariPro

7500 ft

- Cable Installation 8 Days
- New I-Tubes Installed 12 Days
- Emissions Under 6 tons
- No Anchoring Required
- All Local Support & Vessels



Cable Hang-off Fixture



Lay Barge Deck Plan

MariPro

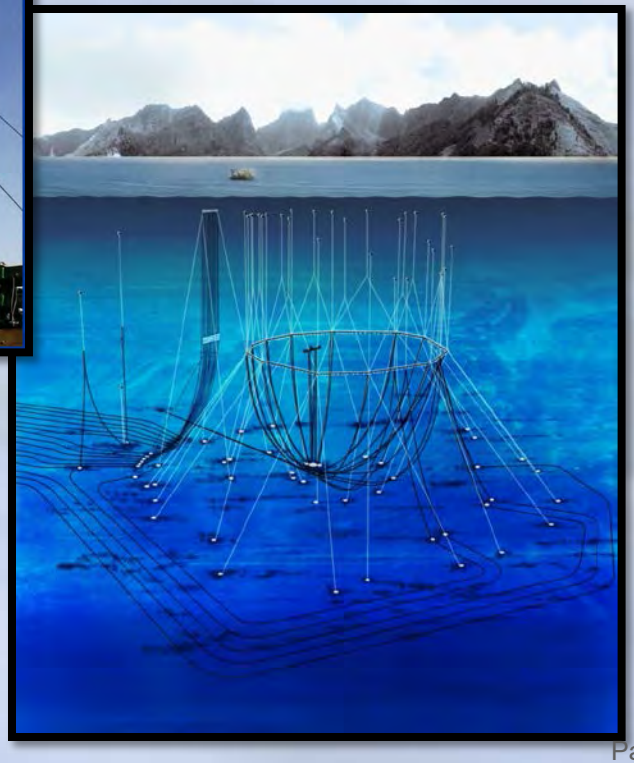
Power Cable Installations

Power Cable Lay
U.S. Navy
12.5Kv, 5.74” O.D.
16,500 ft Length
Ketchikan, Alaska
1993

Power Cable Lay
Chelan County
Public Utility District
25Kv, 6” O.D.
3,400 ft Length
Lake Chelan, Washington
2008

Power & Fiber-Optic Cable Installations

Power & FO Trunk Cable Pull
U.S. Navy
22 Conductors, 48Fibers
1.6” Dia. – 6900 ft Long
San Clemente Island, CA
2009



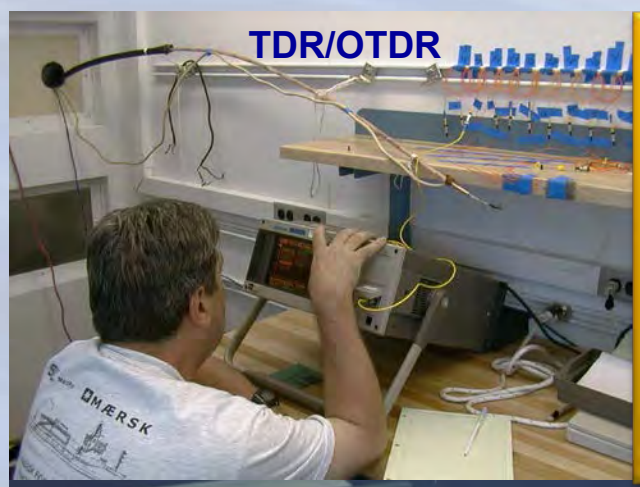
Power & FO Cable Installation
Subsurface ISMS Acoustic Array
U.S. Navy NSWC
36 Fibers, Overall Length 94,000 ft
Lake Pend Oreille, Idaho
1995

Middle: 180 Metric Tons Capacity Modular Powered Rotating Cable Pan and Cable Gantry

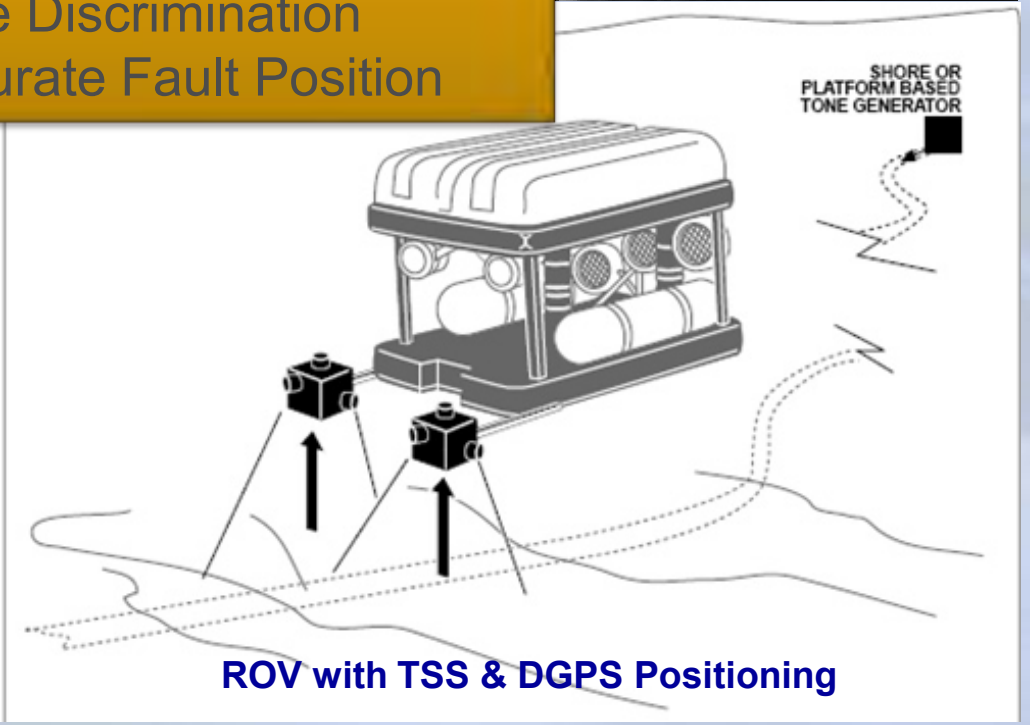
MariPro

Identifying Cable Fault Position

(126 Power & Fiber Splice Repairs Completed)



- Distance to Cable Fault
- Depth of Burial to 10m
- Cable Fault Identification
- Vehicle Skew Angle
- Look Ahead Information
- Tone Discrimination
- Accurate Fault Position



MariPro

Power Cable Repairs

Linear Cable Engine

Splice Termination
&
Lay-Down Loop

Power Cable Repair
Pacific Operators Offshore
Platform Hogan
Santa Barbara Channel, CA
2008

Marine Cable Lay & Repair Equipment

MariPro

Modular A-Frame System

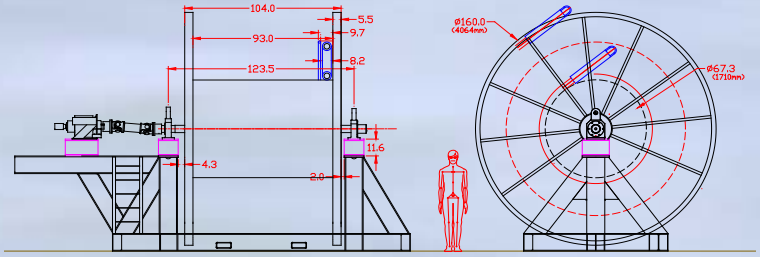
Linear Cable Engine

Cable Haulers

180 Metric Tons Capacity Modular Powered Rotating Cable Pan and Cable Gantry

Cable Motion Compensator

3m Overboard Sheave



Power Cable Reels

Portable Cable Pans

MariPro

HDD Installations

2014 KMISS Kwajalein
- 5” Bore
- 500 m, (1640 ft)

2009 BSURE Kauai, HI
- (2) 5” Bores
- 1,510 m (4,954 ft) ea

2014 USWTR Jacksonville, FL
- 3.75 Bore
- 1220 m (4000 ft)

2011 RSN Pacific City OR
- (2) 5” Bores
- 1,533 m (5031 ft) ea

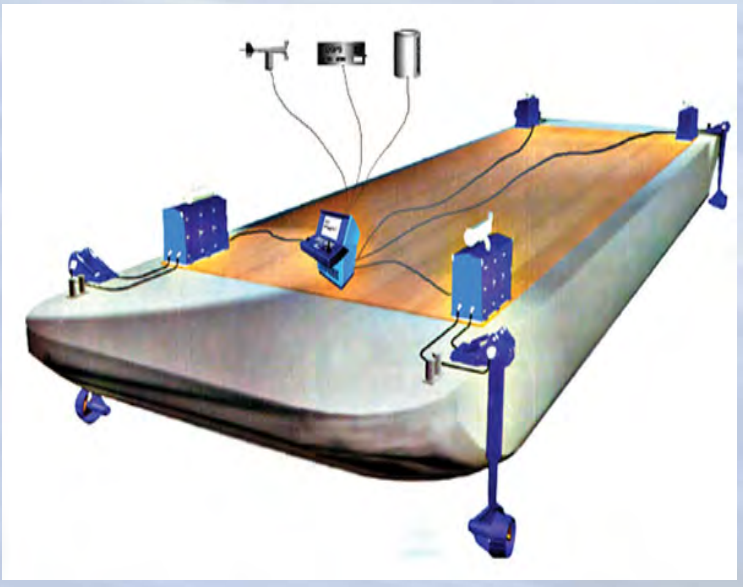
2008 SOAR San Clemente Island, CA
(4) 5” Bores
914 m (3,000 ft) ea

MariPro

Worldwide Vessel & Barge Operations

Singapore/Diego Garcia

GOM/Chile Juan Fernandez



Modular DP Navigation and Bridge Unit

GOM / Ascension Island

Japan / Wake Island

Thruster and Hydraulic Power Unit

MariPro

Machine Shop & Fabrication Services

Full Service Welding & Machine Shop

Machine Shop Services:

- Certified General Machinists
- Precision & Close Tolerance Machining
- CNC Machining
- All Metals & Plastics
- Large Inventory of Support Equipment

Welding Services:

- Certified Welders ANSI/AWS
- In-shop or In-field
- MIG, TIG, SMAW, FCAW
- Plasma Cutting, Air Arc, Flame Cutting
- All Metals Including Titanium

4 Lathes from 32” to 14” with beds up to 120”

5 Mills including Haas VF-3 Automated Axis Bed Mill

MariPro

Testing Facilities & Services

- Hydro-Test Chamber to 10,000 psi
- Climate Test Chambers
- Temperature Controlled Tanks
- Submergence Tanks

10,000 psi Hydro-Test Tank

Optical Time-Domain Reflectometer (OTDR)

Cable Termination Test Rack

- Time-Domain Reflectometer (TDR) Cable Testing
- Optical Time-Domain Reflectometer (OTDR) Fiber Optic Cable Testing
- Cable & Wire Termination Pull Testing to 20,000 lbs

Appendix 2-2
Support Vessels

AQUEOS
EXCELLENCE | PROFESSIONALISM | SAFETY

OSV CLEAN OCEAN

California Air Emission Compliant

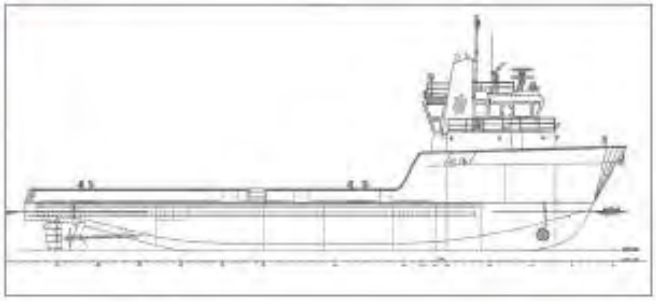
This versatile workboat/supply vessel has large open deck space and 18 ton telescopic boom crane. The vessel can be equipped with a complete Surface Air and Gas diving system, Remotely Operated Vehicle System (ROV), A-frame, winches, and mooring system to accommodate project needs.

The comfortable berths, full galley and laundering facilities allow the boat to accommodate 12 personnel plus crew for 25 days.

- Marine Construction
- Marine Abandonments and Decommissioning
- Platform and Pipeline Inspections and Repairs
- Pipeline Tie-Ins and Hot Taps
- Power Cable Installation and Inspections
- Mooring Installation, Overhaul and Inspections
- Surface Air Diving
- Surface Gas Diving
- ROV Operations
- Surveys – Bathymetry and Side Scan Sonar
- Coring Operations
- Supply Vessel
- Oil Spill Response Vessel

PERFORMANCE	
Maximum Speed:	12 Knots
Cruising Speed:	10 Knots
Maximum Fuel Consumption:	60 usg/hr
Cruising Fuel Consumption:	55 usg/hr
CAPACITIES	
Fuel:	39,119 usg
Liquid Mud**:	1,195 bbl
Potable Water:	14,250 usg
Drill Water:	59,312 usg
Recovered Oil:	1,400 bbl

Size & Class:	155' OSV/OSRV
ABS:	International Load Line
USCG:	COI, USCG Sub L, OSV
DIMENSIONS	
Gross Tonnage:	99 U.S. Tons
Length Overall:	155'
Draft:	9' – 9"
Breadth:	36'
Clear Deck Space:	97' x 30' (2910 sf)
MACHINERY	
Main Engines:	Cummins QSK 19 – Tier 3
Brake Horsepower:	1500
Reduction Gears:	Twin Disc MG-520
Bow Thruster:	Cummins QSL 9 – Tier 3
Generators:	(2) 99Kw / John Deere – Tier 3
Liquid Mud Circulation:	Magnum 5x4x14
Crane	18 ton



**Recovered Oil Tanks. Can be reversed to Liquid Mud

*All details believed correct but not guaranteed and are subject to alteration.

Gulf of Mexico
101 Millstone Rd. | Broussard, LA 70518
P: (337) 714-0033 | F: (337) 839-8354

West Coast
2550 Eastman Avenue, Suite 8 | Ventura, CA 93003
P: (805) 676-4330 | F: (805) 676-4335

aqueossubsea.com

M/V ADELE ELISE

Platform Supply Vessel DPI

Built 2007

M/V Adele Elise 225' DP1 PSV

REGISTRATION

Owner	Gulf Offshore Logistics, LLC
Delivered	2007
Builder	Trinity Gulf Ship Services LLC
Flag	USA
Classification Official No.	A1 C.O.C. Certified, ABS Loadline DP 1 1182858

MAIN PARTICULARS

Length Overall	225 Ft
Beam	46 Ft
Depth	16 Ft
Light Draft	6 Ft
Loaded Draft	18 Ft 6.375 In
Deadweight Tonnage	3,468 Tons 1281 IRC - 999 Gross

CAPACITIES

Drink/Potable Water	134,430 USG
Fuel	110,000 USG
Bulk Mud	6 @ 1030 Cu Ft
Liquid Mud	8,000 Bbls

CARGO DECK

Length	148 Ft
Width	44 Ft
Clear Deck Area	6,512 Sq Ft

MACHINERY

Main Engines	(2) Caterpillar 3516 @ 2150 BHP
Z-Drives	(2) Rolls-Royce 360 Degree Azimuth Thrusters
Gensets	(2) Cummins K-19 500 KW
Bow Thrusters	(1) 500
Bow Thruster Engines	(1) CAT 10M @ 560 BHP
Liquid Mud Pumps	(2) 250 Hp Mission Magnum 8x8x14
Circulating Pumps	(2) 40 Hp Mission Magnum 8x8x12
Bulk Compressor	Colip W Local
Emergency Genset	(1) John Deere 80KW

DISCHARGE RATES

Ballast/Drill Water	400 GPM @ 200PT
Fuel	300 GPM @ 200PT
Liquid Mud	700 GPM @ 200PT
Potable Water	400 GPM @ 200PT

DRY BULK

Dry Bulk	50 PSI 20 (Cement)

ACCOMMODATION

Cabins/Berths	018
Mess	18
Lounge	1
Hands	4

ELECTRONICS

Radar	(2) Furuno FR-8122
GPS	(2) SAT Marine MX 200
Autopilot	Simrad NCS 2003
VHF	(2) Furuno FM-8500S, ICOM M40, Icom IC M304
AIS	Furuno FA-150
Depth Sounder	Furuno FCV-620
GMDSS	Furuno FEC-3510 Cyttrak Packet-Net
Dynamic Positioning	Simrad NCS 2003 DP 1
Email & Comm	OCEANSAT/MSL KVH/ KSAT Broadband
Electronic Charts	Nautech Navigator Pro

FIRE FIGHTING

Fire Monitor 1500 GPM	

OTHER FEATURES

Steel Engine Mats	
Rescue Boat	
Electric Welding Machine	
Motorola Unlimited VHF	
Sea Chief Engine Monitoring System	

NOTICE: The data contained herein is provided for convenience of reference to allow users to determine the suitability of the Company's equipment. The data may vary from the current condition of equipment which can only be determined by physical inspection. Company has exercised due dili-

Castagnola Tug Service Inc.

M/V "Danny C"

GENERAL DETAILS
- Vessel Name: "DANNY C"
- Vessel Type: Utility Vessel
- Vessel Builder: Blount Marine
- Hull Type: Steel
- Displacement: 95 Tons
- U.S. Coast Guard: COI
- Vessel Approved as "Tow Boat"

PROPULSION
- Engines: Twin 3406C Catterpillar
- Generators:Single Phase Northern Lights 20 Kw
- Generators: Single Phase Isuzu 27 Kw
- Economical Speed: 9 Knots
- Maximum Speed: 10 Knots
- BHP:730
- Bollard Pull: 8 Tons
- Hydraulic Steering w/Jog Stick

DECK MACHINERY
- Main Deck /Tow Winch 7 ton Pull W/Bare Drum - Will hold 1,000' of 3/4 wire
- AC/DC Electric Welder
- Cutting Gas and Torch
- Pressure Washer
- 18" diameter Stern Roller
- 10 ton Digital Scale w/Remote Control
- Crane Lift (retracted 10 tons) Extended @ 55' 1/2 Ton

DIMIENSIONS
- Length Overall: 77'
- Beam: 25'
- Draft: 7'

CAPACITIES
- Personnel : 16 plus crew
- Deck Cargo 38 Tons 4' Center of Gravity
- Deck Cargo Area: 20'x50'
- Dry Hold Storage (2) 3'6'5h
- 6'800 Gals Grade "D" Cargo
- Potable Water 12,400 Gals (NSF Approved Coated)
- Fuel: 4,500 Gals
- Range: 2,000 N. Miles

ANCHORING SYSTEM
- 3 Point Spread
- 1,000' of 5/8 Wire with 80' of Chain (Each System)
- 4th Anchor (Cat Head Retrieval)

ELECTRONICS
- SSB Radio
- (2) Marine VHF Radios
- Furuno DGPS -GP35
- Autonav - Auto Pilot
- Intercom System
- 38 Mile Furuno Radar
- Simrad AIS
- Sitex Color Plotter with WASS
- Furuno Color Fathometer
- (2) Data / Video Monitors

ACCOMMODATIONS
- Full Equipped Galley
- Head and Shower
- Bunks for 7 Inc. Crew
- 4 Man Berthing unit available upon request

The equipment above enables the vessel to function as a support vessel for deep-water diving and salvage operations. The Danny C has been used for many marine construction projects such as pile driving, pipeline laying and removal, maintenance and repair, mooring installations, coring, ROV ops and side scan sonar surveys. The Danny C can also act as a cargo and OSRV vessel (certified to carry 6890 gal. Grade D cargo. The roughly 50' x 20' deck (see attachment for available deck) provides ample room for equipment.

Castagnola Tug Service, Inc., P.O.Box 40627 Santa Barbara, CA 93140 (805) 963-4961 24 Hour
Angelo Castagnola: castug@cs.com -Cell (805)689-6302 Danny Castagnola: dannycastagnola@cox.net - Cell (805)895-9005

Vessel Name: Lillian G.

USCG Vessel Description	Conventional Push Tug/Tow Boat
Official Number	1110974
Call Sign	
Material	Steel
LOA	55'
Beam	17.3'
Draft	10'
G.T. / N.T. / Disp.	63/51
H.P.	
Gals/Hour (Cruising Light)	
Gals/Hour (Working)	
Fuel Capacity	
Fresh Water Capacity	
Speed	
Bollard Pull	
Range (N.M.)	
Main Engines	
Generator(s)	
Deck Machinery	Hydraulic winches on aft deck

Supplier Specifications

Image Gallery

Click the thumbnails for a full image view.

Our Services Include

- Harbor & Ocean Towing
- Crew Boat / Launch / Water Taxi Service
- Freight Hauling/PUC Services
- Barges
- Marine Spill Response, Containment and Removal
- Marine Construction
- Marine Salvage
- Specialty Vessels & Marine Equipment Sal
- Government Contracting/ Manning
- Teaming
- GSA Sales

Appendix 4-1
Annotated Bibliography, Regional Marine Biology Scientific Literature

APPENDIX 4-1

Selected Annotated Bibliography, Marine Biology

General:

Kaplan, B., CJ Beegle-Krause, D. French McCay, A. Copping, S. Geerlofs, eds. 2010. Updated Summary of Knowledge: Selected Areas of the Pacific Coast. U.S. Dept. of the Interior, Bureau of Ocean Energy Management, Regulation, and Enforcement, Pacific OCS Region, Camarillo, CA. OCS Study BOEMRE 2010-014.

> Large compilation of research papers covering everything from the benthos, infauna, plankton, fish, turtles, birds (pelagic, seabirds, and shorebirds), marine mammals, and so forth. Also includes physical oceanography. This would be a good document to use as a reference for individual species. Info isn't very spatially resolved, just discusses southern area. Good species accounts for ESA listed species.

Invertebrates:

Butler, J. et al. 2009. Status Review Report for Black Abalone. NMFS Southwest Region.

> Species ranges from Pt. Arena to Bahia Tortugas in Mexico. Susceptible to withering foot syndrome, and all known populations south of Monterey County have experienced major decreases in population size. All harvest is illegal in California from 1993 on. In many locations the density of the species has decreased to the point where successful fertilization may not be possible. Species may become effectively extinct in 30 years. Populations in the Channel Islands and Pt. Conception/Vandenberg area have known occurrences of withering foot syndrome. This species resides in the shallowest waters of the abalone species, and primarily occurs from high intertidal to ~6m depth. Great reference document. Species not likely to be affected by CalWave unless rocky intertidal will be impacted.

Goddard, J.H.R., and M.S. Love. 2010. Megabenthic Invertebrates on Shell Mounds Associated with Oil and Gas Platforms off California. *Bulletin of Marine Science*. Vol. 86 (3), pp. 533-544.

> Looked at 15 platforms including Irene and Hidalgo (surveyed 1997-2001, and 2004-2005). Found large numbers of sea stars, anemones, sea slugs, rock crabs, spot prawns, and a few sea urchins. Large masses of a non-native bryozoan were present at one platform. Echinoderms (sea stars and brittle stars) were the most abundant taxa. Except for filter feeders the dominant species were carnivorous or omnivorous and depended on mussels and other fouling organisms.

Hobday, A.J., and M.J. Tegner. 2000. Status review of white abalone (*Haliotis sorenseni*) throughout its range in California and Mexico. NOAA Technical Memorandum NMFS. US Department of Commerce, NOAA-TM-NMFS-SWR-035. 20 90 pp.

> Populations have declined by several orders of magnitude since 1970. Estimate of total abundance is around 1600 animals which is less than 0.1% of the estimated pre-exploitation population size. Authors suggest that without protection and intervention that the species could go extinct in California within 10 years. This is a deeper living species than most other west coast abalone with depths ranging from 20-60 meters. Paper provides a great species account and population estimates, but these may be slightly dated.

Page, H.M. et al. 1999. Effects of an offshore oil platform on the distribution and abundance of commercially important crab species. *Marine Ecology Progress Series*. Vol. 185 pp. 47-57.

> Found higher densities of large, highly mobile crab species on and under platforms when compared to nearby soft bottom areas. Conducted off of Platform Holly, results are likely applicable to other platforms in the area.

National Marine Fisheries Service. 2008. White Abalone Recovery Plan (*Haliotis sorenseni*). National Marine Fisheries Service, Long Beach, CA.

> Species listed as endangered from Pt. Conception to Punta Abreojos in Baja California in 2001, this came after the comprehensive status review from Hobday and Tegner (2000). Describes population ending at Pt. Conception, but is also out at Channel Islands. Population estimates are higher than reported in Hobday and Tegner (2000), with approximately 12,820 individuals estimated at Tanner Bank, and 7,360 at Cortes Bank.

Fish:

Bence, J.R., D. Roberts, W.H. Lenarz. 1992. An Evaluation of the Spatial Distribution of Fishes and Invertebrates off Central California in Relation to EPA Study Areas with Emphasis on Midwater Ichthyofauna. Unpublished Report to the National Marine Fisheries Service, Tiburon, CA.

> Study on spatial distribution of fish and invertebrates collected during NMFS research surveys and CalCOFI ichthyoplankton surveys. Overall abundance of adult fish of potential commercial and recreational value was highest at the shallower bottom depths of the study. Provides good species descriptions and expected depth ranges for species.

Love, M.S., and A. York. 2005. A Comparison of the fish assemblages associated with an oil/gas pipeline and adjacent seafloor in the Santa Barbara Channel, Southern California Bight. *Bulletin of Marine Science*. Vol 77 (1), pp. 101-117.

> Surveyed waters that were 95-235m deep along a 20mm pipeline between Platforms Gail and Grace, and between Grace and the mainland. Identified four different areas, shallow and deep pipeline, and shallow and deep seafloor. Fish densities were about 7 times higher on the shallow pipeline versus shallow seafloor. Rockfish composed 84% of fish. Densities of cowcod in deeper parts of the pipeline were higher than has been observed at over 80 natural outcrops and 10 platforms. Provides good list of species found in the area, these species are commonly associated with areas of low relief.

Love, M.S., D.M. Shroeder, and W.H. Lenarz. 2005. Distribution of Bocaccio (*Sebastes Paucispinis*) and cowcod (Sebastes levis) around oil platforms and natural outcrops off California with implications for larval production. *Bulletin of Marine Science*. Volume 77 (3) pp. 397-408.

> Long discussion of distribution of Bocaccio and cowcod at offshore oil platforms. Densities of mature bocaccio were generally very low at both natural reefs and platforms, but had a higher overall mean at platforms than reefs. This equates to a higher potential larval production than other areas. Estimated that removing Platform Gail would be equivalent to removing 12.57 ha of average producing habitat for cowcod and 29.94 ha for Bocaccio.

Love, M.S., D.M. Shroeder, and M.M. Nishimoto. 2003. The Ecological Role of Oil and Gas Production Platforms and Natural Outcrops on Fishes in Southern and Central California: A Synthesis of Information. Marine Science Institute, University of California, Santa Barbara, CA.

> Paper discusses oil platforms including "shell mounds" around them, and decommissioning. Shell mounds are created when mussels and other invertebrates are dislodged during cleaning and storms. A rock outcrop (North Reef) by Platform Hidalgo sampled annually. Most of surveys on nine structures (Platforms Irene, Hidalgo, Harvest, and others further south). Surveys included the shallower areas (1995-2000) and deeper areas (1995-2001). Platform midwaters were generally "nursery" areas for rockfish, and other demersal fish (generally young of the year). Shell mounds around platforms support a rich and diverse species assemblage largely for small fish and young-of-the-year (YOY) fish. Compared densities at Hidalgo to North Reef which is ~1000 meters from the platform. Assemblages were similar, but densities were generally higher at the platform. YOY generally 100 times denser at platform than north reef. Includes good metrics on species diversity and abundance, including different age classes.

Love, M.S. J. Caselle, and L. Snook. Fish Assemblages on Mussel Mounds Surrounding Seven Oil Platforms in the Santa Barbara Channel and Santa Maria Basin. *Bulletin of Marine Science*. Vol. 65 (2) pp. 497-513.

> Discusses how mussel shell mounds surround all offshore oil and gas platforms in California. They surveyed fish assemblages at 7 platforms including Irene and Hidalgo. They observed at least 35 fish species, and 18 of these were rockfish (Sebastes sp.). Researchers determined that species richness, density, and mean lengths were less than on the platform bottoms, but these values are more similar to the platform bottom than other mounds and these mounds should be considered an integral part of the oil platform system, and not distinct communities. Paper includes species lists.

Love, M. S. and M. M. Nishimoto. 2012. Completion of Fish Assemblage Surveys around Manmade Structures and Natural Reefs off California. BOEM OCS Study 2012-020 Marine Science Institute, University of California, Santa Barbara, California. BOEM Cooperative Agreement No.: M10AC2001.

> Author discusses how the oil platforms may play a role in the recovery of important groundfish populations in southern California. Bocaccio and cowcod are both species of concern. Bocaccio were once considered for listing as threatened under ESA. Four federally declared overfished species have been observed at platforms. Rockfish are dominant species at platforms (~84% of all fish). Midwaters are "nursery" area for YOY fish, platform bottoms primarily composed of subadult and adult rockfish, shell mounds included more dwarf species. Primarily discusses platforms further to the southeast (off Santa Barbara).

Love, M.S., M. Nishimoto, S. Clark, and D.M. Schroeder. 2012. Recruitment of Young-of-the-Year Fishes to Natural and Artificial Offshore Structure Within Central and Southern California Waters, 2008-2010. *Bulletin of Marine Science*. Volume 88 (4), pp. 863-882.

> Survey looked at comparisons of recruitment at oil platforms, reefs, and shipwrecks. Goal to analyze whether there were differences in recruitment for structures that didn't crest the surface of the water. Found that there is likely little effect for rockfish, but that blacksmith recruitment will likely decrease. Relevant in that the CalWave facility may provide recruitment habitat for YOY fish.

Page, H.M., et al. 2007. Trophic links and condition of a temperate reef fish: comparisons among offshore oil platform and natural reef habitats. *Marine Ecology Progress Series*. Vol. 344, pp. 245-256.

> Compared fish health between artificial structures and natural reefs and correlated this with small invertebrate prey base. Researchers found that the artificial structures (oil platforms) had higher densities of invasive exotic species (caprellids). But the native fish fed heavily on the exotic species and this had a positive effect on fish condition.

Schroeder, D.M., and M.S. Love. 2002. Recreational Fishing and Marine Life Populations in California. CalCoFI Report. Vol. 43, pp 182-190.

> Compared rockfish assemblages among three differently fished areas (one open to all fishing, another open to only recreational fishing, and a de facto marine protected area [Platform Gail]). Area open to all fishing had the highest density of fish (7,212 fish/ha), but size structure and species composition were dominated by small fish. Area open to only recreational fishing had 423 fish/ha, and similar species composition and size as the area open to all fishing. Protected area had high density (5,623 fish/ha) and a size structure and species composition shifted towards larger fish. Two federally listed as overfished species (bocaccio and cowcod) had 32-fold and 408-fold higher densities in protected area versus recreational-only area and 8-fold and 18-fold higher densities than the area open to all fishing. Demonstrates damaging effects of catch and release fisheries.

Turtles:

Benson, S.R., K.A. Forney, J.T. Harvey, J.V. Carretta, P.H. Dutton. 2007. Abundance, distribution, and habitat of leatherback turtles (Dermochelys coriacea) off California, 1990-2003. *Fish. Bull*. 105: pp. 337-347

> Surveys conducted by airplane over waters less than 92 meters deep. Leatherback turtles are regularly observed off of the U.S. West Coast, where they forage on jellyfish in the summer and fall. Greatest densities were off central California. Nearshore waters off California represent an important foraging region. Species is critically endangered, partly due to by-catch in drift gillnet fisheries. Most commonly encountered between August and November, but overall rare in South Central California. Nearest detection to CalWave was off Point Arguello.

Plotkin, P.T. (Editor). 1995. National Marine Fisheries Service and U. S. Fish and Wildlife Service Status Reviews for Sea Turtles Listed under the Endangered Species Act of 1973. National Marine Fisheries Service, Silver Spring, Maryland

> Goes over status reviews for loggerhead, leatherback, hawksbill, Kemp's ridley, and olive ridley sea turtles. Does not discuss green sea turtle. Document includes good species descriptions including general ranges and population estimates. Brief discussion of incidental catch and entanglement of species, primarily from longlines and drift/gillnets. Good references regarding entanglement, but they all deal with shrimp trawlers, or drift/gill nets.

Birds:

Adams, J., J.Y.Takekawa, H.R. Carter. 2004. Foraging Distance and Home Range of Cassin's Auklets nesting at two colonies in the California Channel Islands. *Condor*. Volume 106 (3), pp. 618-637

> Measured home range size of 99 radio-marked Cassin's auklets nesting in two colonies (Prince Island and Scorpion Rock). They generally foraged within 30 km from each colony, Prince Island foraging was northeast of the colony over the insular shelf near the shelf break (somewhat near

Hidalgo, Harvest, and Irene). Foraging areas ranged from 654 km2 (Prince Island) to 204 km2 (Scorpion Rock).

Ainley, D.G., S.G. Allen, L.B. Spear. Offshore Occurrence Patterns of Marbled Murrelets in Central California.

Researchers assessed occurrence patterns offshore of Waddell Creek, in Central California primarily in June 1986-1994. Majority of the sightings were within 10km of Point Ano Nuevo, directly offshore of breeding habitat. Three sightings occurred 12-24km offshore.

Ainley, D.G. et al. 1995. Variations in Marine Bird Communities of the California Current, 1986-1994. CalCoFI Rep. Vol. 36, pp. 72-77

Did sampling off of central and southern California and found fluctuations in several of California's most numerous seabirds. Found that when sea surface temperatures were high that cold-water species were scarce and warm water species were abundant, and vice versa. Point Conception/Vandenberg area is included in the southern survey area. Includes estimates on population densities by square kilometer.

Burkett, E.E., N.A. Rojek, A.E. Henry, M.J. Fluharty, L. Comrack, P.R. Kelly, A.C. Mahaney, and K.M. Fien. 2003. Report to the California Fish and Game Commission: Status Review of Xantus's Murrelet (*Synthliboramphus hypoleucus*) in California. Calif. Dept. of Fish and Game, Habitat Conservation Planning Branch Status Report 2003-03. 96 pp. + appendices.

Includes good life history and distribution of the species (at the time of this paper it was considered a single species with two subspecies, now it is two distinct species). Also includes good info on threats to the species, in particular oil spills and artificial light pollution. Species is also known to get entangled in drift gill nets off the coast of British Columbia. These mesh sizes ranged from 2.75" to 9". As of this report there was no documented bycatch in California.

Carter, H.R., D.L. Whitsworth, J.Y., T.W. Keeney, and P.R. Kelly. 2000. At-sea threats to Xantus' Murrelets (Synthliboramphus hypoleucus) in the Southern California Blight. Proceedings of the Fifth Channel Islands Symposium, pp. 435-447.

10,000-20,000 breeding individuals of Xantus' murrelet breed and forage in the Southern California Blight (SCB), this is the northern limit of the breeding range. Between April to June in 1995 to 1997 the radio-marked murrelets from Santa Barbara Island were distributed widely in the northwestern SCB. Authors determined that the species primary threat was oil production, especially spills. Figure 2 is a good map showing locations of birds, appear to be further offshore from Platform Irene. Additional threats are incidental by-catch in gill-net fisheries, attraction to bright lights from vessels and platforms at sea. Alcids were reportedly killed only once in gill-net fisheries between 83 and 94 based on observer data, but Canadian data shows by catch. It is deemed unlikely that large numbers are killed this way. Also attracted to strong lights, sometimes striking them and causing injury.

Carter, H.R., et al. 1992. Breeding Populations of Seabirds in California, 1989-1991. Pacific Outer Continental Shelf Region of the Mineral Management Service.

Lots of info on specific seabird species. Use as a reference. Includes population estimates for various regions.

Henry, R.W., W.B. Tyler, and M.Z. Peery. 2012. Abundance and Productivity of Marbled Murrelets off Central California during the 2010 and 2011 Breeding Seasons. The Luckenbach and Command Oil Spill

Trustees, 2012. Unpublished Report, UC Santa Cruz, Santa Cruz, CA, and University of Wisconsin-Madison, Madison, WI.

At-sea surveys between Half Moon Bay and Santa Cruz in Conservation Zone 6. Estimated population at 336 in 2010 and 320 in 2011. Did not conduct surveys south of Santa Cruz.

Mason, J.W. et al. 2007. At-sea distribution and abundance of seabirds off Southern California: A 20-year comparison. Cooper Ornithological Society. *Studies in Avian Biology*, Number 33.

Provides good species overviews of birds that may be in the area. Surveys conducted in ocean waters off southern California, and focused on the Southern California Blight. Study area extended between Cambria and Mexican border. Platform Irene is in Sub-area 1, this extends from Pt. Piedras Blancas to Point Conception. Central mainland coast (CMC) is a focused area within sub-area 1 and this includes areas between Point Arguello to Point Dume, North mainland coast (NMC) is between Cambria and Point Arguello. Densities of birds were generally the highest in January. Provides estimates of density for individual species in January, May, and September for CMC area. Also has maps showing the density for the species over the different months. Good as reference.

McGrath, T., and J. Feenstra. 2007. Checklist to the Pelagic Birds of Southern California.

Paper just includes figures that show seasonal abundances of pelagic birds. Great visual of when species are in the area.

McIver, W.R., A.L. Harvey, H.R. Carter. 2014. Monitoring and Restoration of Ashy Storm-Petrels and Santa Cruz Island, California, in 2012. Unpublished Report for Montrose Settlements Trustee Council.

Colony size at Orizaba Rock in the Channel Islands increased in 2012 to 34 egg-laying pairs. Documents numbers of individuals and nest success.

Robinette, D.P, R. Ball, J. Miller, and J. Howard. 2013. Monitoring and Management of the Endangered California Least Tern and the Threatened Western Snowy Plover at Vandenberg Air Force Base, 2013. Unpublished Report, Point Blue Conservation Science, Petaluma, CA.

VAFB contains approximately 13.8 linear miles of coastal breeding habitat for California least tern and Western snowy plover. Least tern colony is at Purisma Point, and is one of only three colonies between Monterey Bay and Point Conception. In 2013 there was an estimated 15 breeding pairs at this colony. Species appears to forage in the vicinity Platform Irene (and CalWave site). Historic colonies have been closer to the site than the existing colony, there was one historic colony at the mouth of the Santa Ynez River. Western snowy plover breeds throughout the 13.8 miles of coastal beach habitat. Mean number of adults on Vandenberg was 240 individuals.

Rodriguez, D.A., A. Chapman, R. Cartwright. 2011. Shorebird Abundance and Distribution on Beaches of Ventura County, California 2007-2010. Unpublished Report submitted to BOEM.

Surveyed area between La Conchita (Rincon) and Leo Carillo. Provides good info on numbers and species accounts, but likely not particularly relevant to bird populations in the vicinity of the project area.

Takekawa, J.Y., et al. 2004. At-Sea Distribution and Abundance of Seabirds and Marine Mammals in the Southern California Bight: 1999-2003. Unpublished summary report, U.S. Geological Survey, Western Research Center, Vallejo, CA; and Humboldt State University, Department of Wildlife, Arcata, CA 309 pp.

Excellent reference for species counts and locations of observations of seabirds and marine mammals. Includes estimated densities per square kilometer near project area in January, May, and September for birds and marine mammals. Also includes radio-telemetry data for Cassin's auklet and Xantus's Murrelet.

Takekawa, J.Y., and J. Adams. At-sea distribution of radio-marked ashy storm-petrels, Oceanodroma homochroa, captured on the California Channel Islands. *Marine Ornithology* Vol. 36: pp. 9–17.

Study re-located 57 of 70 radio-marked ashy storm petrels that were captured at three colonies in the Channel Islands: Scorpion Rocks, Santa Barbara Island, Prince Island. Study conducted in the summertime and the storm-petrels were aggregated over the continental slope from Pt. Conception to Pt. Buchon, and the Santa Cruz basin between Santa Cruz, San Nicolas, and Santa Barbara Islands. Individuals ranged more than 600 km. and located as far north as the Farallones. Map on page 13 shows distribution near CalWave project area.

Whitworth, D.L. et al. 2006. Initial Recovery of Xantus's Murrelets following rat eradication on Anacapa Island, CA. *Marine Ornithology*. Vol. 33, pp. 131-137

Species nests in sea caves, and after eradication of rats they moved back into areas that they historically nested in, but were excluded due to nest predation by rats. As eradication proceeds the species range could expand.

Whitworth, D.L., H.R. Carter, A.L. Harvey and F. Gress. 2009. Nest monitoring of Xantus's Murrelets at Anacapa Island, California: 2009 annual report. Unpublished report, California Institute of Environmental Studies, Davis, California (prepared for the American Trader Trustee Council and Channel Islands National Park). 37 p.

Study conducted to assess recovery of species after the eradication of black rats. In 2009 there was a higher nest occupancy and hatching success than in any year since 2000. Twelve new nest sites established at Anacapa. Population may increase in coming years.

Marine Mammals:

Fissipeds:

Riedman, L.M., and L.A. Estes. 1990. The Sea Otter (*Enhydra lutris*): Behavior, Ecology, and Natural History. Biological Report. Volume 90 (14) pp. 1-136

Somewhat outdated text in terms of population size and locations, but provides good info on ecology, feeding behavior, and description of the species. Largest cause of death in CA seem to be incidental drowning in commercial fishing nets. The nets that were causing the highest mortality were gill and trammel nets. Both small nets and "entanglement nets" (> 3inch mesh) were causing mortality. Law closed gill and trammel net fishery (net mesh >= 3.5") within the 15-fathom isobaths.

U.S. Fish and Wildlife Service (USFWS). 2003. Final Revised Recovery Plan for the Southern Sea Otter (*Enhydra lutris*). Portland, Oregon. 64 pp. plus appendix.

As of 2003, the population estimated to be about 2,150 animals. The translocated colony at San Nicholas Island contains about 27 individuals. Provides good species account, and description of the status and risks to the population. Appendices and recovery plan document that coastal set-nets

(gillnets and similar) and fish/crab traps (referred to as “pots” in this document) are a risk for the species.

U.S. Fish and Wildlife Service (USFWS). 2014. Stock Assessment Report for Southern sea otter. *Federal Register* Vol. 79, No. 14, pp. 3612-3614

Population is estimated to be 2,924 individuals as of late 2013: mainland population of 2,882, and 59 at San Nicolas Island. Losses in gillnet fisheries are estimated to be at or near zero individuals. This is likely due to depth restrictions and regulations that prohibit setting nets in closure areas. In areas from Point Reyes to Point Arguello, the fishery is restricted to depths greater than 60 fathoms. Set gillnet sizes are > 3.5” for halibut and white seabass. Drift gillnets are > 3.5” to < 14” for California yellowtail, barracuda, and white seabass, and >14” drift gillnet fisheries for California thresher shark/swordfish. Five-inch funnels are required on live-fish traps to exclude otters. Other mortality is largely disease and shark-bite related.

Pinnipeds:

Lowry, M.S., J.V. Carretta, K.A. Forney. 2008. Pacific Harbor Seal Census in California during May-July 2002 and 2004. *California Fish and Game.* Vol. 94 (4) pp. 180-193.

Aerial surveys conducted from May to July (molt period) in 2002 and 2004 to document hauled out seals. In 2012, 3,878 harbor seals counted onshore at the Channel Islands, 21,433 total statewide. In 2014, 4,344 in Channel Islands, and 26,333 statewide. Correction factor for total seals is presumed to be 1.65, so multiply numbers by that correction factor to get estimate of total population. In Southern California 70% of the seals were found at Santa Cruz, Santa Rosa, and San Miguel Islands.

MMCG and SAIC. 2011. Annual report, monthly marine mammal surveys, Vandenberg Air Force Base, California. 1 February 2010 through 31 January 2011.

Includes discussions of population size and haulouts. A series of landslides at Weaner Cove, a harbor seal haulout site, buried the cove. Harbor seal has largely abandoned this cove now. There have also been increased occurrences of coyotes in the vicinity of the haulouts the may be causing localized decreases in population. Coyote are known to prey on harbor seals, particularly pups.

Takekawa, J.Y., et al. 2004. At-Sea Distribution and Abundance of Seabirds and Marine Mammals in the Southern California Bight: 1999-2003. Unpublished summary report, U.S. Geological Survey, Western Research Center, Vallejo, CA; and Humboldt State University, Department of Wildlife, Arcata, CA 309 pp.

Excellent reference for species counts and locations of observations of seabirds and marine mammals. Includes estimated densities per square kilometer near project area in January, May, and September for birds and marine mammals. Also includes radio-telemetry data for Cassin’s auklet and Xantus’s Murrelet.

DeLong, R.L., and S.R. Melin. 2000. Thirty Years of Pinniped Research at San Miguel Island. Pp. 401-406 in: D.R. Browne, K.L. Mitchell, and H.W. Chaney (eds.), Proceedings of the Fifth California Islands Symposium, 29 March to 1 April 1999, Santa Barbara Museum of Natural History, Santa Barbara, CA. Sponsored by the U.S. Minerals Management Service, Pacific OCS Region, 770 Paseo Camarillo, Camarillo, CA 93010. OCS Study No. 99-0038.

Study began in 1968 on San Miguel Island after a small colony of breeding northern fur seals was discovered in 1968. As of 1999, the populations of Northern fur seal, California sea lion, harbor seal,

and northern elephant seal have increased up to three-fold, while Steller sea lions no longer breed on the island. Researchers found that El Nino events cause changes in pinniped population dynamics at the island. Paper provides good graphs of population size of species on the island.

Cetaceans:

Sund, P.N., and J.L. O'Connor. 1973. Aerial Observations of Gray Whales during 1973. *Marine Fisheries Review*, Vol. 36, Paper 1057, pp. 51-52

Aircraft observations between Monterey Bay and Point Sur in January 1973. Study to test effectiveness of shore based observers versus aircraft observers. All aerial observations were within 7 miles of the shoreline even though survey area extended 25 miles offshore. 94% of observations were within 1 mile of the shoreline suggesting their migration in this area is very close to the coastline.

Irvine LM, Mate BR, Winsor MH, Palacios DM, Bograd SJ, et al. (2014) Spatial and Temporal Occurrence of Blue Whales off the U.S. West Coast, with Implications for Management. *PLoS ONE* 9(7): e102959. doi:10.1371/journal.pone.0102959.

Fifteen-year satellite tracking study of 170 tagged blue whales documents a "home range" area around the western Channel Islands and extending north past and a "Core Area" that is a smaller area closer to the Channel Islands. Discusses management concerns having to do with mortality from vessel strikes.

Appendix 4-2
References Consulted, Regional Marine Biology and Regulatory Permitting

APPENDIX 4-2

References Consulted for Marine Biology and Environmental Permitting

TABLE 4-2/1

Marine Biology Scientific Literature References

Topic	Author	Year	Title	Synopsis
Birds	Carter, H.R., et al.	1992	Breeding Populations of Seabirds in California, 1989-1991	Pacific Outer Continental Shelf Region of the Mineral Management Service. Lots of info on specific seabird species. Use as a reference. Includes population estimates for various regions.
Birds	Ainley, D.G. et al	1995	Variations in Marine Bird Communities of the California Current, 1986-1994. CalCoFI Rep. Vol. 36, pp. 72-77	Did sampling off of central and southern California and found fluctuations in several of California's most numerous seabirds. Found that when sea surface temperatures were high that cold-water species were scarce and warm water species were abundant, and vice versa. Point Conception/Vandenberg area is included in the southern survey area. Includes estimates on population densities in km2.
Birds	Carter, H.R., D.L. Whitsworth, J.Y., T.W. Keeney, and P.R. Kelly	2000	At-sea threats to Xantus' Murrelets (Synthliboramphus hypoleucus) in the Southern California Blight. Proceedings of the fifth Channel Islands Symposium, pp. 435-447	10,000-20,000 breeding individuals of Xantus' murrelet breed and forage in the Southern California Blight (SCB), this is the northern limit of the breeding range. Between April to June in 1995 to 1997 the radio-marked murrelets from Santa Barbara Island were distributed widely in the northwestern SCB. Authors determined that the species primary threat was oil production, especially spills.
Birds	Burkett, E.E., N.A. Rojek, A.E. Henry, M.J. Fluharty, L. Comrack, P.R. Kelly, A.C. Mahaney, and K.M. Fien	2003	Report to the California Fish and Game Commission: Status Review of Xantus's Murrelet (Synthliboramphus hypoleucus) in California. Calif. Dept. of Fish and Game, Habitat Conservation Planning Branch Status Report 2003-03. 96 pp. + appendices.	Includes good life history and distribution of the species (at the time of this paper it was considered a single species with two subspecies, now it is two distinct species). Also includes good info on threats to the species, in particular oil spills and artificial light pollution. Species is also known to get entangled in drift gill nets off the coast of British Columbia. These mesh sizes ranged from 2.75" to 9". As of this report there was no documented bycatch in California, but there is a chance.
Birds	Adams, J., J.Y.Takekawa, H.R. Carter	2004	Foraging Distance and Home Range of Cassin's Auklets nesting at two colonies in the California Channel Islands. Condor. Volume 106 (3), pp. 618-637	Measured home range size of 99 radio-marked Cassin's auklets nesting in two colonies (Prince Island and Scorpion Rock). They generally foraged within 30 km from each colony, Prince Island foraging was northeast of the colony over the insular shelf near the shelf break (somewhat near Hidalgo, Harvest, and Irene). Foraging areas ranged from 654 km2 (Prince Island) to 204 km2 (Scorpion Rock).

TABLE 4-2/1

Marine Biology Scientific Literature References

Topic	Author	Year	Title	Synopsis
Birds	Takekawa, J.Y., et al	2004	At-Sea Distribution and Abundance of Seabirds and Marine Mammals in the Southern California Bight: 1999-2003. Unpublished summary report, U.S. Geological Survey, Western Research Center, Vallejo, CA; and Humboldt State University, Department of Wildlife, Arcata, CA 309 pp.	Excellent reference for species counts and locations of observations of seabirds and marine mammals. Includes estimated densities per km2 near project area in January, May, and September for birds and marine mammals. Also includes radio-telemetry data for Cassin's auklet and Xantus's Murrelet.
Birds	Whitworth, D.L. et al	2006	Initial Recovery of Xantus's Murrelets following rat eradication on Anacapa Island, CA. Marine Ornithology. Vol. 33, pp. 131-137	Species nests in sea caves, and after eradication of rats they moved back into areas that they historically nested in, but were excluded due to nest predation by rats. As eradication proceeds the species range could expand.
Birds	Mason, J.W. et al	2007	At-sea distribution and abundance of seabirds off Southern California: A 20-year comparison. Cooper Ornithological Society. Studies in Avian Biology, Number 33	Provides good species overviews of birds that may be in the area. Surveys conducted in ocean waters off southern California, and focused on the Southern California Blight. Study area extended between Cambria and Mexican border.
Birds	McGrath, T., and J. Feenstra	2007	Checklist to the Pelagic Birds of Southern California	Paper just includes figures that show seasonal abundances of pelagic birds. Great visual of when species are in the area.
Birds	Whitworth, D.L., H.R. Carter, A.L. Harvey and F. Gress	2009	Nest monitoring of Xantus's Murrelets at Anacapa Island, California: 2009 annual report. Unpublished report, California Institute of Environmental Studies, Davis, California (prepared for the American Trader Trustee Council and Channel Islands National Park). 37 p	Study conducted to assess recovery of species after the eradication of black rats. In 2009 there was a higher nest occupancy and hatching success than in any year since 2000. Twelve new nest sites established at Anacapa, but population may increase in coming years.
Birds	Rodriguez, D.A., A. Chapman, R. Cartwright	2011	Shorebird Abundance and Distribution on Beaches of Ventura County, California 2007-2010. Unpublished Report submitted to BOEM.	Surveyed area between La Conchita (Rincon) and Leo Carillo. Provides good info on numbers and species accounts, but likely not very relevant to bird populations in the vicinity of the project area.
Birds	Henry, R.W., W.B. Tyler, and M.Z. Peery	2012	Abundance and Productivity of Marbled Murrelets off Central California during the 2010 and 2011 Breeding Seasons	The Luckenbach and Command Oil Spill Trustees, 2012. At sea surveys between Half Moon Bay and Santa Cruz in Conservation Zone 6. Estimated population at 336 in 2010 and 320 in 2011. Did not conduct surveys south of Santa Cruz.
Birds	Robinette, D.P, R. Ball, J. Miller, and J. Howard	2013	Monitoring and Management of the Endangered California Least Tern and the Threatened Western Snowy Plover at Vandenberg Air Force Base, 2013. Unpublished Report, Point Blue Conservation Science, Petaluma, CA.	VAFB contains approximately 13.8 linear miles of coastal breeding habitat for California least tern and Western snowy plover. Least tern colony is at Purisma Point, and is one of only three colonies between Monterey Bay and Point Conception. In 2013 there was an estimated 15 breeding pairs at this colony.

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Marine Biology Scientific Literature References

Topic	Author	Year	Title	Synopsis
Birds	McIver, W.R., A.L. Harvey, H.R. Carter	2014	Monitoring and Restoration of Ashy Storm-Petrels and Santa Cruz Island, California, in 2012. Unpublished Report for Montrose Settlements Trustee Council.	Colony size at Orizaba Rock in the Channel Islands increased in 2012 to 34 egg-laying pairs. Documents numbers of individuals and nest success. Likely not that relevant of a document other than the numbers of individuals.
Birds	Ainley, D.G., S.G. Allen, L.B. Spear	1995	Offshore Occurrence Patterns of Marbled Murrelets in Central California	Researchers assessed occurrence patterns offshore of Waddell Creek, in Central California primarily in June 1986-1994. Majority of the sightings were within 10km of Point Ano Nuevo, directly offshore of breeding habitat. Three sightings occurred 12-24km offshore.
Birds	Takekawa, J.Y., and J. Adams	2004	At-sea distribution of radio-marked ashy storm-petrels, Oceanodroma homochroa, captured on the California Channel Islands. Marine Ornithology Vol. 36: pp. 9–17	Study re-located 57 of 70 radio-marked ashy storm petrels that were captured at three colonies in the Channel Islands; Scorpion Rocks, Santa Barbara Island, Prince Island. Study conducted in the summertime and the storm-petrels were aggregated over the continental slope from Pt. Conception to Pt. Buchon, and the Santa Cruz basin between Santa Cruz, San Nicolas, and Santa Barbara Islands. Individuals ranged more than 600 km. and located as far north as the Farallones. Good map on page 13 showing distribution near project area.
Fish	Bence, J.R., D. Roberts, W.H. Lenarz	1992	An Evaluation of the Spatial Distribution of Fishes and Invertebrates off Central California in Relation to EPA Study Areas with Emphasis on Midwater Ichthyofauna. Unpublished Report to the National Marine Fisheries Service, Tiburon, CA.	Study on spatial distribution of fish and invertebrates collected during NMFS research surveys and CalCOFI ichthyoplankton surveys. Overall abundance of adult fish of potential commercial and recreational value was highest at the shallower bottom depths of the study. Provides good species descriptions and expected depth ranges for species.
Fish	Schroeder, D.M., and M.S. Love	2002	Recreational Fishing and Marine Life Populations in California. CalCoFI Report. Vol. 43, pp 182-190.	Compared rockfish assemblages among three differently fished areas (one open to all fishing, another open to only recreational fishing, and a de facto marine protected area (Platform Gail)).
Fish	Love, M.S., D.M. Shroeder, and M.M. Nishimoto	2003	The Ecological Role of Oil and Gas Production Platforms and Natural Outcrops on Fishes in Southern and Central California: A Synthesis of Information. Marine Science Institute, University of California, Santa Barbara, CA.	Paper discusses oil platforms including “shell mounds” around them, and decommissioning. Most of surveys on nine structures (Platforms Irene, Hidalgo, Harvest, and others further south and included the shallower areas (1995-2000) and deeper areas (1995-2001). Platform midwaters were generally “nursery” areas for rockfish, and other demersal fish (generally young of the year).

TABLE 4-2/1

Marine Biology Scientific Literature References

Topic	Author	Year	Title	Synopsis
Fish	Love, M.S., and A. York.	2005	A Comparison of the fish assemblages associated with an oil/gas pipeline and adjacent seafloor in the Santa Barbara Channel, Southern California Bight. Bulletin of Marine Science. Vol 77 (1), pp. 101-117.	Surveyed waters that were 95-235m deep along a 20mm pipeline between Platforms Gail and Grace, and between Grace and the mainland. Identified four different areas, shallow and deep pipeline, and shallow and deep seafloor. Fish densities were about 7 times higher on the shallow pipeline versus shallow seafloor. Rockfish composed 84% of fish. Densities of cowcod in deeper parts of the pipeline were higher than has been observed at over 80 natural outcrops and 10 platforms. Provides good list of species found in the area, these species are commonly associated with areas of low relief.
Fish	Love, M.S., D.M. Shroeder, and W.H. Lenarz.	2005	DISTRIBUTION OF BOCACCIO (SEBASTES PAUCISPINIS) AND COWCOD (SEBASTES LEVIS) AROUND OIL PLATFORMS AND NATURAL OUTCROPS OFF CALIFORNIA WITH IMPLICATIONS FOR LARVAL PRODUCTION. Bulletin of Marine Science. Volume 77 (3) pp. 397-408.	Long discussion of distribution of Bocaccio and cowcod at platforms. Densities of mature Bocaccio were generally very low at both natural reefs and platforms, but had a higher overall mean at platforms than reefs. This equates to a higher potential larval production than other areas. Estimated that removing Platform Gail would be equivalent to removing 12.57 ha of average producing habitat for cowcod and 29.94 ha for Bocaccio.
Fish	Page, H.M., et al	2007	Trophic links and condition of a temperate reef fish: comparisons among offshore oil platform and natural reef habitats. Marine Ecology Progress Series. Vol. 344, pp. 245-256.	Compared fish health between artificial structures and natural reefs and correlated this with small invertebrate prey base. Researchers found that the artificial structures (oil platforms) had higher densities of invasive exotic species (caprellids). But the native fish fed heavily on the exotic species and this had a positive effect on fish condition. Not very relevant for project, but good info to have if agencies question habitat value of the facility.
Fish	Love, M. S. and M. M. Nishimoto	2012	Completion Of Fish Assemblage Surveys Around Manmade Structures and Natural Reefs off California. BOEM OCS Study 2012-020 Marine Science Institute, University of California, Santa Barbara, California. BOEM Cooperative Agreement No.: M10AC2001.	Author discusses how the oil platforms may play a role in the recovery of important groundfish populations in southern California. Bocaccio and cowcod are both species of concern, Bocaccio were once considered for listing as threatened under ESA. Four federally declared overfished species have been observed at platforms. Midwaters are “nursery” area for YOY fish, platform bottoms primarily composed of subadult and adult rockfish, shell mounds included more dwarf species.
Fish	Southern California Waters	2008-2010	Bulletin of Marine Science. Volume 88 (4), pp. 863-882.	Survey looked at comparisons of recruitment at oil platforms, reefs, and shipwrecks. Found that there is likely little effect for rockfish, but that blacksmith recruitment will likely decrease. Relevant in that the CalWave facility may provide recruitment habitat for YOY fish.

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Marine Biology Scientific Literature References

Topic	Author	Year	Title	Synopsis
Fish	Love, M.S. J. Caselle, and L. Snook	1999	Fish Assemblages on Mussel Mounds Surrounding Seven Oil Platforms in the Santa Barbara Channel and Santa Maria Basin. Bulletin of Marine Science. Vol. 65 (2) pp. 497-513.	Discusses how mussel shell mounds surround all offshore oil and gas platforms in CA. They surveyed fish assemblages at 7 platforms including Irene and Hidalgo. They observed at least 35 fish species, and 18 of these were rockfish (Sebastes sp.).
General	Kaplan, B., CJ Beegle-Krause, D. French McCay, A. Copping, S. Geerlofs, eds.	2010	Updated Summary of Knowledge: Selected Areas of the Pacific Coast. U.S. Dept. of the Interior, Bureau of Ocean Energy Management, Regulation, and Enforcement, Pacific OCS Region, Camarillo, CA. OCS Study BOEMRE 2010-014.	Huge compilation of research papers covering everything from the benthos, infauna, plankton, fish, turtles, birds (pelagic, seabirds, and shorebirds), marine mammals, physical oceanography and so forth. This would be a good document to use as a reference for individual species. Info isn't very spatially resolved, just discusses southern area. Good species accounts for ESA listed species.
Invertebrates	Page, H.M. et al	1999	Effects of an offshore oil platform on the distribution and abundance of commercially important crab species. Marine Ecology Progress Series. Vol. 185 pp. 47-57.	Found higher densities of large, highly mobile crab species on and under platforms when compared to nearby soft bottom areas. Conducted off of Platform Holly, results are likely applicable to other platforms in the area.
Invertebrates	Hobday, A.J., and M.J. Tegner	2000	Status review of white abalone (Haliotis sorenseni) throughout its range in California and Mexico. NOAA Technical Memorandum NMFS. US Department of Commerce, NOAA-TM-NMFS-SWR-035. 20 90 pp.	Populations have declined by several orders of magnitude since 1970. Estimate of total abundance is around 1600 animals which is less than 0.1% of the estimated pre-exploitation population size. Authors suggest that without protection and intervention that the species could go extinct in California within 10 years.
Invertebrates	National Marine Fisheries Service	2008	White Abalone Recovery Plan (Haliotis sorenseni). National Marine Fisheries Service, Long Beach, CA.	Species listed as endangered from Pt. Conception to Punta Abreojos in Baja California in 2001, this came after the comprehensive status review from Hobday and Tegner (2000). Describes population ending at Pt. Conception, but is also out at Channel Islands. Population estimates are higher than reported in Hobday and Tegner (2000), with approximately 12,820 individuals estimated at Tanner Bank, and 7,360 at Cortes Bank.
Invertebrates	Butler, J. et al.	2009	Status Review Report for Black Abalone. NMFS Southwest Region.	Species ranges from Pt. Arena to Bahia Tortugas in Mexico. Susceptible to withering foot syndrome, and all known populations south of Monterey County have experienced major decreases in population size. In many locations the density of the species has decreased to the point where successful fertilization may not be possible. Species may become effectively extinct in 30 years.
Invertebrates	Goddard, J.H.R., and M.S. Love.	2010	Megabenthic Invertebrates on Shell Mounds Associated with Oil and Gas Platforms off California. Bulletin of Marine	Looked at 15 platforms including Irene and Hidalgo (surveyed 1997-2001, and 2004-2005). Found large numbers of sea stars, anemones, sea slugs, rock crabs, spot prawns, and a few sea urchins. Large masses

TABLE 4-2/1

Marine Biology Scientific Literature References

Topic	Author	Year	Title	Synopsis
			Science. Bulletin of Marine Science. Vol. 86 (3), pp. 533-544.	of a non-native bryozoan were present at one platform.
Marine Mammals/Fissipeds	Riedman, L.M., and L.A. Estes	1990	The Sea Otter (Enhydra lutris): Behavior, Ecology, and Natural History. Biological Report. Volume 90 (14) pp. 1-136	Somewhat outdated text in terms of population size and locations, but provides good info on ecology, feeding behavior, and description of the species. Largest cause of death in CA seem to be incidental drowning in commercial fishing nets. The nets that were causing the highest mortality were gill and trammel nets.
Marine Mammals/ Fissipeds	U.S. Fish and Wildlife Service (USFWS)	2003	Final Revised Recovery Plan for the Southern Sea Otter (Enhydra lutris). Portland, Oregon. 64 pp. plus appendix.	As of 2003, the population estimated to be about 2,150 animals. Provides good species account, and description of the status and risks to the population. Appendices and recovery plan document that coastal set-nets (gillnets and similar) and fish/crab traps (referred to as "pots" in this document) are a risk for the species.
Marine Mammals/ Fissipeds	U.S. Fish and Wildlife Service (USFWS)	2014	Stock Assessment Report for Southern sea otter. Federal Register Vol. 79, No. 14, pp. 3612-3614	They make a statement that losses in gillnet fisheries are estimated to be at or near zero individuals. This is likely due to depth restrictions though and regulations that prohibit setting nets in closure areas. Other mortality is largely disease and shark bite related.
Marine Mammals/ Pinnipeds	DeLong, R.L., and S.R. Melin	2000	Thirty Years of Pinniped Research at San Miguel Island. Pp. 401-406 in: D.R. Browne, K.L. Mitchell, and H.W. Chaney (eds.), Proceedings of the Fifth California Islands Symposium, 29 March to 1 April 1999, Santa Barbara Museum of Natural History, Santa Barbara, CA. Sponsored by the U.S. Minerals Management Service, Pacific OCS Region, 770 Paseo Camarillo, Camarillo, CA 93010. OCS Study No. 99-0038.	Study began in 1968 on San Miguel Island after a small colony of breeding northern fur seals was discovered in 1968. As of 1999 the populations of Northern fur seal, CA sea lion, harbor seal, and northern elephant seal have increased up to three-fold, while Steller sea lions no longer breed on the island. Researchers found that El Nino events cause changes in pinniped population dynamics at the island. Paper provides good graphs of population size of species on the island.
Marine Mammals/ Pinnipeds	Takekawa, J.Y., et al	2004	At-Sea Distribution and Abundance of Seabirds and Marine Mammals in the Southern California Bight: 1999-2003. Unpublished summary report, U.S. Geological Survey, Western Research Center, Vallejo, CA; and Humboldt State University, Department of Wildlife, Arcata, CA 309 pp.	Excellent reference for species counts and locations of observations of seabirds and marine mammals. Includes estimated densities per km2 near project area in January, May, and September for birds and marine mammals. Also includes radio-telemetry data for Cassin's auklet and Xantus's Murrelet.

TABLE 4-2/1

Marine Biology Scientific Literature References

Topic	Author	Year	Title	Synopsis
Marine Mammals/ Pinnipeds	Lowry, M.S., J.V. Carretta, K.A. Forney	2008	Pacific Harbor Seal Census in California during May-July 2002 and 2004. California Fish and Game. Vol. 94 (4) pp. 180-193	In 2012, 3,878 harbor seals counted onshore at the Channel Islands, 21,433 total statewide. In 2014, 4,344 in Channel Islands, and 26,333 statewide. In Southern California 70% of the seals were found at Santa Cruz, Santa Rosa, and San Miguel Islands.
Marine Mammals/Pinnipeds	MMCG and SAIC	2011	Annual report, monthly marine mammal surveys, Vandenberg Air Force Base, California. 1 February 2010 through 31 January 2011	Includes discussions of population size and haulouts. A series of landslides at Weaner Cove, a harbor seal haulout site, buried the cove and the harbor seal has abandoned this cove now. There have also been increased occurrences of coyotes in the vicinity of the haulouts the may be causing localized decreases in population. Coyote are known to prey on harbor seals, particularly pups.
Marine Mammals/ Whales	Sund, P.N., and J.L. O'Connor	1973	Aerial Observations of Gray Whales during 1973. Marine Fisheries Review, Vol. 36, Paper 1057, pp. 51-52	Aircraft observations between Monterey Bay and Point Sur in January 1973. Study to test effectiveness of shore based observers versus aircraft observers. All aerial observations were within 7 miles of the shoreline even though survey area extended 25 miles offshore. 94% of observations were within 1 mile of the shoreline suggesting their migration in this area is very close to the coastline.
Turtles	Plotkin, P.T. (Editor)	1995	National Marine Fisheries Service and U. S. Fish and Wildlife Service Status Reviews for Sea Turtles Listed under the Endangered Species Act of 1973. National Marine Fisheries Service, Silver Spring, Maryland	Goes over status reviews for loggerhead, leatherback, hawksbill, Kemp's ridley, and olive ridley sea turtles, but does not discuss green sea turtle. Document includes good species descriptions including general ranges and population estimates. Good references regarding entanglement, but they all deal with shrimp trawlers, or drift/gill nets.
Turtles	Benson, S.R., K.A. Forney, J.T. Harvey, J.V. Carretta, P.H. Dutton	2007	Abundance, distribution, and habitat of leatherback turtles (Dermochelys coriacea) off California, 1990-2003. Fish. Bull. 105: pp. 337-347	Surveys conducted by plane in waters less than 92 meters deep indicated that leatherback turtles are regularly observed off of the U.S. west coast, where they forage on jellyfish in the summer and fall. Greatest densities were off central California and nearshore waters off California represent an important foraging region. Species is critically endangered, partly due to by-catch in drift gillnet fisheries. Would CalWave facility have potential for entanglement?

TABLE 4-2

Environmental Permitting References

Topic	Author	Year	Title	Synopsis
General	Duke Engineering & Services	2001	Moss Landing Power Plant, Morro Bay Power Plant, South Bay Power Plant. Marine Mammal Act Small Take Permit Application	As of 2001, there was no lethal take of marine mammals associated with the operation of the plants. Southern sea otter not covered in IHA or LOA, as they are administered by USFWS. This document could be used as support, particularly with population estimates, but there is more recent data out there - use other LOAs and IHAs first.
General	Leonhard, S.B. et al	2002	Effects of the Horns Rev1 Offshore Wind Farm on Fish Communities. Unpublished Report prepared for the Danish Energy Authority	Looked at changes in fish communities after installation of a windfarm in Danish waters. The installation of the wind farm in soft bottom habitat introduced hard bottom to a relatively homogenous environment. Minor changes were seen to the fish community and species diversity and significant changes were seen with the most commonly occurring fish in the region.
General	Plains Exploration & Production Company	2012	Revisions to the Platform Hidalgo Development and Production Plan to Include Development of the Western Half NW/4 of Lease OCS-P 0450	Proposal to develop two additional wells on western half of OCS-P-0450 from the existing platform. Found drilling had a 100m potential effect radius on whales, and no impact on fishing or boating.
General	Plains Exploration & Production Company	2012	Revisions to the Platform Hidalgo Development and Production Plan to Include Development of the Western Half NW/4 of Lease OCS-P 0450 Accompanying Information Volume Environmental Evaluation	Contains great info in Section 4.1 on oceanographic conditions and oceanographic studies and includes citations to these studies. Biological info from Section 4.2 is excellent see excerpts in the annotated bibliography.
General	PG&E	2012	Central Coastal California Seismic Imaging Project. Request for an Incidental Harassment Authorization to Allow the Incidental Take of Marine Mammals During a Marine Geophysical Survey	Use revised document for latest info. Area of offshore investigation doesn't cover the CalWave project area, ends around Pt. Sal. The project descriptions have great species accounts and latest population estimates (as of 2012). Great reference document.
General	Padre Associates, Inc	2012	Draft Environmental Assessment of Marine Geophysical Surveys by the U/V Marcus G. Langseth for the Central Coastal California Seismic Imaging Project. Draft EA submitted to the National Science Foundation	Discusses onshore and offshore resources. Good Species Account for Black Abalone and White Abalone in Pt. Conception south.
General	Bureau of Ocean Energy Management	2013	Findings Summary for the Environmental Assessment for Revisions to the Platform Hidalgo Development and Production Plan to Include Development of the Western Half of the Northwest Quarter of Lease OCS-P-0450	This document states that no new or supplemental EIS is necessary, and no further NEPA analysis is necessary for the proposed project as the existing EA covered it. PXP had several measures that were recommended, including the measures IDed in the section above regarding murrelets.

TABLE 4-2

Environmental Permitting References

Topic	Author	Year	Title	Synopsis
General	NOAA	2013	Request for Letter of Authorization for the Incidental Harassment of Marine Mammals Resulting from Office of Coast Survey Hydrographic Survey Projects	For surveys throughout U.S. Coastal and Great Lakes waters each year. Document provides latest stock assessment numbers through January 2013, also sources to calculate densities of species.
General	Partnership for Interdisciplinary Studies of Coastal Oceans (PISCO)	2013	Request for Marine Mammal protection Act Incidental Harassment Authorization	This is for the authorization to conduct intertidal sampling and surveys throughout the west coast, dealt with flushing of individuals, and not sound. This may be relevant if there is any onshore/nearshore work at the sites that may flush marine mammals but isn't necessarily going to exceed the noise thresholds.
General	Naval Air Warfare Center Weapons Division	2013	Petition for Regulations Pursuant to Section 101 (a) (5) of the Marine Mammal Protection Act Covering Taking of Marine Mammals Incidental to Target and Missile Launch Activities for the Period 2014-2019 at San Nicolas island, California (50 CFR Part 216, Subpart I). Unpublished Report submitted to Office of Protected Resources, National Oceanographic and Atmospheric Administration	Point Mugu Sea Range hugs follows the coastline a few miles offshore through up to Cambria area. Area is likely outside of CalWave project area. Previous survey work from the Navy has shown that hauled out pinnipeds have a limited response to launch activities, and that sea otters don't show an effect.
General	National Marine Fisheries Service	2013	Finding of No Significant Impact for the Environmental Assessment on the Issuance of Regulations to Take Marine Mammals by Harassment Incidental to U.S. Navy Missile Launch Activities at San Nicolas Island, California	NMFS found no significant impact for the project on the Marine Environment or resources under their jurisdiction associated with the missile launch project. This LOA was submitted for fisheries sampling that included but wasn't limited to trawl surveys, acoustic surveys, plankton nets, pelagic longlines, and ROV surveys. Vast majority of info isn't relevant, but there are good species accounts included.
General	URS	2013	Draft Programmatic Environmental Assessment for Fisheries Research Conducted and Funded by the Southwest Fisheries Science Center. Unpublished report prepared for the National Marine Fisheries Service	Provides an overview of all potentially effected species for the fisheries research project. Table 4.2-7 includes good info about take of marine mammals in trawls during SWFSC surveys from 2008 to 2012. Provides good info on effects to various species, can be used as a reference document.
General	Marine Mammal Consulting Group (MMCG) and Science Applications International Corporation (SAIC)	2013	Application for a five-year programmatic permit for small takes of marine mammals incidental to launching of space launch vehicles, intercontinental ballistic missiles, and aircraft and helicopter operations at Vandenberg Air Force Base,	Good reference material, but similar information as is contained in other Tranquillon Ridge EIRs, EAs, and LOA/IHAs.

TABLE 4-2

Environmental Permitting References

Topic	Author	Year	Title	Synopsis
			California. Unpublished Report prepared for the United States Air Force	
General	ExxonMobil Production Company	2014	Incidental Harassment Authorization Application. Harmony Platform, Santa Ynez Production Unit. Submitted to Office of Protected Resources, National Marine Fisheries Service	IHA application to install six conductor pipes at Harmony platform. Conductor pipe hammering could result in Level A and/or Level B disturbance to marine mammals. See table 3-1 for information about species and potential for occurrence. Good species accounts in Section 4.
General	NOAA Fisheries	2014	Environmental Assessment for Issuance of an Incidental Harassment Authorization to ExxonMobil Production Company to Take Marine Mammals by Harassment Incidental to Conductor Pipe Installation Activities at Harmony Platform in the Santa Barbara Channel offshore of California	EA required all activities to stop if a Northern Pacific right whale is sighted, regardless of where it is located. Revised take estimates based on number of days of exposure rather than aggregated hours of exposure. Marine Mammal prey (fish and invertebrates) and the impacts on them from the sound are discussed in Pena et al. 2013.
General	California State Lands Commission	2014	Mitigated Negative Declaration: ExxonMobil Santa Ynez Unit (SYU) Offshore Power System Reliability – B Phase 2 Project	Table 3.5-2 Marine/Coastal Bird Species Seasonality and Abundance has great citations going over seasonality of species. These were from the citations below. Mitigation measures require pre-construction marine biological surveys this must include surveys for hard bottom, eelgrass, kelp, and locations of pipelines.

Appendix 5-1
Public Meeting Summary

APPENDIX 5-1

Public Meeting Summary

Meeting Information:

Date: Tuesday, April 14th, 6pm-8pm

Location: Ludwick Community Center
846 Santa Rosa Street
San Luis Obispo, CA 93401

Participants:

Organization	Name
Congresswoman Lois Capps' Office	Greg Haas
Environmental Defense Center	Kristi Birney
Northern Chumash Tribal Council	Fred Collins
Sierra Club	Mike Thornton
SLO Surfrider	Brad Snook
Surfrider Club	Alex Ly
Tenera Environmental	Joe Phelan
The Nature Conservancy	Steve Rienecke
CalWave Team:	
Cal Poly	Dale Dolan
Cal Poly	Dean Wendt
Cal Poly	Bill Toman
CH2M	Doug Davy
Kearns & West	Anna West
Kearns & West	Kelsey Rugani
Leidos	Rick Williams

Overview Presentation:

Bill Toman, Cal Poly, introduced the CalWave Feasibility Study project and welcomed participants. He provided an overview of the CalWave National Wave Energy Testing Center and the Feasibility Study. Bill shared that the CalWave concept was developed by Cal Poly in 2013 to accelerate wave energy industry

growth in the United States. In 2014, Bill noted that the U.S. Department of Energy (DOE) funded the Feasibility Study in 2014 which gave the CalWave team one year to study potential sites at the Vandenberg Air Force Base and in Humboldt County. The Feasibility Study period includes gathering initial feedback on engineering and environmental costs as well as stakeholder and public engagement considerations. Bill said that the Study will conclude in 2015 and then DOE will determine next steps for funding to develop the project.

Bill explained that there was a similar effort by PG&E called WaveConnect that was cancelled. CalWave builds on WaveConnect's experience and investments, and many of the WaveConnect team members have jointed the CalWave team as well.

CalWave will be an opportunity to test multiple wave energy technologies. Bill shared that the wave energy technologies would be connected to the electric transmission grid with a subsea power cable and a substation connection at Vandenberg. Bill noted that there is potential to use Platform Irene that is already connected to the grid; otherwise, new subsea cables will be installed. CalWave would generate up to 25 MW to 30 MW of power.

Bill introduced the CalWave team and its partners, including the Cal Poly Institute of Advanced Technology and Public Policy, CH2M, Coastal Data Information Program, Columbia Power Technologies, Electric Power Research Institute (EPRI), Humboldt State University, Glosten Associates, Kearns & West, Leidos Maritime Solutions, Lieutenant Governor Gavin Newsom, the National Renewable Energy Laboratory (NREL), Sandia National Laboratories Schatz Energy Research Center, Scripps Institution of Oceanography, UC Davis, and Virginia Tech University.

Bill then showed the CalWave Testing Area study area map showing the five candidate sites whose micro-siting will be informed by stakeholder input and regulatory agencies consultations. Bill noted that the Testing Center would have four berths which will be designed to operate simultaneously.

Doug Davy, CH2M, discussed the licenses and permits that would need to be acquired if the CalWave project continues, including federal, state and local agencies. He noted that the BOEM lease and the FERC license will be the master authorizations.

Questions and Answers:

Following the presentation, there was a dialogue between workshop participants and the CalWave team:

- **Question** (Q): What is the amount of fluid on each wave energy device in terms of gallons?
  - **Response** (R): Rick Williams, Leidos, was not sure but knew that the amount of rotating equipment on a fishing boat is about 20 gallons and there would be less. With wave energy devices, some would not have lubricating oil.
- **Q**: Would the amount of fluid on each device pass the Endangered Species Act (ESA) and California Endangered Species Act (CESA) regulations? Have there been tests done on the legality of these types of hydraulic fluids impacts on the range from large species to microbial species?
  - **R**: Certain fluids can be on boats and the CalWave Center would follow the relevant regulations.
- **Q**: Along Point Conception are some of the more treacherous waters in California which could lead to more wave potential and ship wrecks. The Northern Chumash Tribal Council (NCTC) are proposing a National Marine Sanctuary along the coastline and one of the things NOAA Fisheries will consider is the ability to dive among sunken treasures. Has the CalWave team looked into whether the facility would overlap sunken vessels?

  - **R**: The State Lands Commission has a database that shows where the sunken vessels are. The CalWave team has charted data and historical data to make sure the facility would not be near a wreck. A pre-lay survey with side scan sonar techniques will help the team map the area and choose where the cables will go.

- **Comment** (C): There is submerged cultural ancestry and submerged archaeology near the proposed CalWave site. Since Vandenberg is one of the more pristine Chumash areas left, the CalWave team should engage the Native American community and also consider submerged archaeology as it could relate to permitting the project. The representative from NCTC expressed support for having the CalWave project and a National Marine Sanctuary co-exist.
  - **R**: The CalWave team will involve the Chumash Nation in understanding submerged archaeology better and will engage with them throughout the CalWave development process.
- **Q**: How far will the converters or substations be spaced apart?
  - R: Each station would have an unobstructed wave front so that the testing is more credible. The CalWave team is using the most conservative anchoring system that a mariner would use to figure out where to anchor. Each station will be at least one nautical mile apart (a nautical mile is 10-15% longer than a regular mile).
- **Q**: Can the CalWave team rate the technologies based on their ocean noise and also their impact on species?
  - **R**: The technologies would be engineered to minimize the acoustic noise. An advantage of having a test center is to actually test what the developer thinks a technology will do. Issues will be dealt with through adaptive management. From a marine biology standpoint, the study area is close to shipping lanes that are noisy and close to platforms such as Irene that are noisy. The technologies at the Center would not add significantly to the already existing noise.
- **Q**: There has been some speculation about these types of projects and their shadow effect. Would they have impacts downfield of the Center?
  - **R**: SLO Surfrider was interested in the impacts of the Center on surfing. CalWave will impact waves slightly but not significantly. CalWave will be advanced; arrays of devices will be tested not just a specific devices.
- **Q**: How will CalWave be funded?
  - **R**: CalWave will be largely, if not entirely, funded by federal and state resources with the hope of selling power to Vandenberg and charging user fees through a Power Purchase Agreement. Ultimately, CalWave ownership will be a public/private consortium so data is available and transparent.
- **Comment** (C): The CalWave Testing Center is a great opportunity to collect data on issues that don't have a lot of data currently. It would be helpful to share a list of what data will be collected and what issues will be addressed with stakeholders.
- **C**: WaveConnect's public engagement process was positive and headed in the right direction when the project ended. That process would be a good model to use for CalWave's stakeholder engagement.
- **Q**: Regarding Platform Irene, is it possible for the Testing Center to connect to the power line and grid even if the platform is decommissioned?

  - **R**: BOEM has a policy in place about this that involves removing all of the oil related utility when a platform is decommissioned. Platform Irene is a special case since it is in a niche location off of Vandenberg. The waves south of Point Conception are not good for wave technologies which is another reason why the team is looking at Platform Irene.

- **C**: A decommissioned platform would be an asset for research.
- **Q**: Is there potential that more than 25 MW would be needed for the research project?
  - **R**: The Testing Center could be expanded and new cables could be installed.

After the question and answer portion of the meeting, participants were able to participate in an open house and interact with the CalWave team at stations around the room. The stations included information on the project overview and timeline, the proposed study area, the resource potential of worldwide and U.S. wave energy, the permitting processes, and wave energy technologies.

Appendix 5-2
Regulatory Agency Meeting Summary

APPENDIX 5-1

Regulatory Agency Meeting Summary

Meeting Information:

Date: Thursday, April 16th, 6am-2pm

Location: BOEM Pacific Region Office
760 Paseo Camarillo
Camarillo, CA

Participants:

Organization	Name
Bureau of Energy Management (BOEM)	Ellen Aronson
Bureau of Energy Management (BOEM)	Joan Barminski
Bureau of Energy Management (BOEM)	Doug Boren
Bureau of Energy Management (BOEM)	Tracy Logan
Bureau of Energy Management (BOEM)	Susan Zaleski
Bureau of Safety and Environmental Enforcement (BSEE)	Mohammed Ashtaq
Bureau of Safety and Environmental Enforcement (BSEE)	John Keith
California Coastal Commission	Tom Luster (phone)
California Department of Fish and Wildlife	Bill Paznokas (phone)
California Department of Fish and Wildlife	Eric Wilkins
California Natural Resources Agency	Chris Potter
California State Lands Commission	Cheryl Hudson (phone)
California State Lands Commission	Holly Wyer
Federal Energy Regulatory Commission (FERC)	Jim Hastreiter (phone)
Federal Energy Regulatory Commission (FERC)	Annie Jones (phone)
Federal Energy Regulatory Commission (FERC)	Tim Konnert (phone)
NOAA Channel Islands National Marine Sanctuary	Julia Leo
NOAA Fisheries	Steve Edmondson (phone)
NOAA Fisheries	Bill Foster
United States Army Corps of Engineers (USACE)	Crystal Huerta
United States Coast Guard	Brenda Doris
United States Coast Guard	Jevon James
United States Department of Energy	Tim Ramsey (phone)
United States Fish and Wildlife Service (USFWS)	Rachel Henry

Vandenberg Air Force Base	Ken Domako
Vandenberg Air Force Base	Sarah Wagner
CalWave Team:	
Cal Poly	Sam Blakeslee
Cal Poly	Bill Toman
Leidos Maritime Solutions	Rick Williams
CH2M	Doug Davy
Kearns & West	Anna West
Kearns & West	Kelsey Rugani

Introductions and Session Overview

Anna West, Kearns & West, opened the meeting and thanked BOEM for hosting. Meeting participants on the phone and in the room introduced themselves. Anna reviewed the agenda and meeting objectives.

CalWave Overview

Bill Toman, Cal Poly, introduced the CalWave Feasibility Study project. He provided an overview of the CalWave National Wave Energy Testing Center and the Feasibility Study. Bill shared that the CalWave concept was developed by Cal Poly in 2013 to accelerate wave energy industry growth in the United States. In 2014, Bill noted that the U.S. Department of Energy (DOE) funded the Feasibility Study in 2014 which gave the CalWave team one year to study potential sites near the Vandenberg Air Force Base and in Humboldt. The Feasibility Study period includes gathering initial feedback on engineering and environmental costs as well as stakeholder and public engagement considerations. Bill said that the Study will conclude in June 2015 and then DOE will determine next steps for funding to develop the project.

Bill explained that there was a similar effort by PG&E called WaveConnect that was cancelled. CalWave builds off WaveConnect's experience and investments, and many of the WaveConnect team members have jointed the CalWave team as well.

CalWave will be an opportunity to test multiple wave energy technologies. Bill shared that the wave energy technologies would be connected to the electric transmission grid with a subsea power cable and a substation connection at Vandenberg. Bill noted that there is potential to use Platform Irene that is already connected to the grid; otherwise, new subsea cables will be installed. CalWave would generate up to 25 MW to 30 MW of power.

Bill introduced the CalWave team and its partners, including the Cal Poly Institute of Advanced Technology and Public Policy, CH2, Coastal Data Information Program, Columbia Power Technologies, Electric Power Research Institute (EPRI), Humboldt State University, Glosten, Kearns & West, Leidos, Lieutenant Governor Gavin Newsom, the National Renewable Energy Laboratory (NREL), Sandia National Laboratories Schatz Energy Research Center, Scripps Institution of Oceanography, UC Davis, and Virginia Tech University.

Bill then showed the CalWave Testing Area study area map showing the five candidate sites. The specific site selection from these five candidate sites will be informed by stakeholder input and regulatory agencies consultations. Bill noted that the Testing Center would have four berths each with an array of the wave technology for testing which will be designed to operate simultaneously.

Rick Williams, Leidos Maritime Solutions, reviewed the CalWave conceptual diagram showing two of the four planned test berths which will be designed to be operated simultaneously. The CalWave Center will have five cables total, four individual cables and one spare. Rick explained that the intent is to have four test berths and four different WEC Developers, but if a Developer needed more than one berth, the CalWave Center could allow for two adjacent berths. He shared that the test center should be as inviting as possible for an array of wave energy devices over multiple decades. Rick explained that the current design is based on repairing power conditioning equipment on land rather than at sea.

Bill then described types of wave energy devices that could be installed at the CalWave test center including the linear attenuator, point absorber, floating oscillating water column, and rotating mass.

Doug Davy, CH2M, reviewed the permitting matrix outlining what permits, authorizations, and consultations CalWave would need to acquire and what data will need to be gathered in order to understand the project's impacts. He noted that the BOEM lease and the FERC license will be the master authorizations. Doug asked participants what information the CalWave team should start looking at now and what information might be needed in the future.

Doug clarified that BOEM is responsible for leasing energy uses on the Outer Continental Shelf (OCS) and that FERC is responsible for licensing energy uses for marine hydrokinetic projects wherever they exist (within state waters or on the OCS). He added that there are state responsibilities pertaining to CalWave, as well. Doug emphasized that the CalWave team wants to get the study plans right and fully understand what the key issues are and what issues might emerge through the permitting process.

Doug shared that the CalWave Center would be considered a research lease and not a commercial project. Rick mentioned that the CalWave team will be thoughtful of navigation safety and will follow all of the standards necessary.

Doug shared that the CalWave team learned a lot about what information is needed for the necessary permits during the WaveConnect process. He mentioned that there was a Humboldt Advisory Group established during the WaveConnect process to engage a cross section of interested stakeholders as well as regulatory agencies. Anna added that the Advisory Group met monthly to inform the Humboldt pilot program; WaveConnect ended before an Advisory Group could be formed in the Central Coast. Anna shared that the Advisory Group worked intensely to discuss information needs, monitoring and adaptive management. The Humboldt group process was very effective and WaveConnect ultimately had a lot of support from the community because of it.

Participants had the following comments and questions about the CalWave Feasibility Study Overview:

- **Question** (Q): In previous layouts, it looked like CalWave was parallel to the coast but the current study area looks more perpendicular. Is that based on different designs of the devices?
  - **Response** (R): Rick shared that this may be because WaveConnect and CalWave have different designs. WaveConnect needed to be within state controlled waters so the layout was different and more parallel. For CalWave, the team is looking at how to use the waves that would provide the maximum benefit for the four test berths. A perpendicular siting improves the ability to capture wave energy as proposed for CalWave. The CalWave team has deeper and shallower design layouts as well.
- **Q**: Why isn't CalWave in state waters?
  - **R:** There is no place offsite of Vandenberg Air Force Base in state waters that has the preferred 100 meter depths so CalWave is in federal waters.

- **Q**: How much space will be in between the berths?
  - **R**: There will approximately be one nautical mile in between the berths. Each array of devices will have one cable. The reasoning behind having a spare cable is that it could take almost a year to get one replaced, if it becomes necessary, so it is better to have a back-up cable.

Anticipated Baseline Study Needs

Doug then reviewed a spreadsheet listing preliminary baseline information including the ESA-listed species likely to be impacted and an initial assessment of environmental issues and analyses. Doug mentioned that the list of species includes only the species out in the location of the test facility; other species will be potentially impacted (cable to shore and onshore) and those impacts will also be addressed.

Participants had the following comments and questions about the anticipated baseline study needs:

- **Comment** (C): Southern sea otter is fully protected by the state of California.
- **Q**: Does air quality impacts include construction or other emissions if developers change out the devices?
  - **R**: Yes, construction and maintenance are both included under air quality impacts. Additionally, when a new developer goes into a berth and installs a new technology, a separate permitting action will need to occur.
- **C:** If marine protected areas (MPAs) will be impacted then the whole area would have to be evaluated and investigated.
- **C**: The CalWave team should add the United States Environmental Protection Agency (EPA) to the permitting matrix.
- **C**: Some impacts will be eliminated depending on how extensive the CalWave project will be. If the project draws in sea water, more impacts might occur.
  - **R**: None of the current devices available today use sea water as an operating or cooling fluid in the deeper water, but there could be devices near shore that use sea water. The CalWave Team will factor this in.
- **C**: The CalWave Team should add in habitat modification for laying new cable, maintenance cable and general cable moving.

Doug noted that this is a test facility that will be permitted before the CalWave team knows exactly what technology will go into the facility. The CalWave Team will have information about methods and models and could also reach out to gather information about similar operations overseas.

Doug shared that the CalWave Team is hoping to add to the current baseline information list and noted that the onshore footprint will be very small. He described that an environmental study will be completed for each new wave energy technology coming to the Center and that each technology will have to quality with the facility's permitting conditions. Rick noted that the export cable from the berths would be stationary, but the umbilical cables from the device to the sea bottom may not. The CalWave team would need to address both types of cables in the permits.

Participants had the following questions and comments on CalWave permitting:

- **C**: It is important to designate who will be the lead federal agency. This project may need to obtain a USACE 404 permit and comply with the Rivers and Harbors Act. The other federal agencies will need to closely coordinate with the lead agency.
- **C**: FERC is the lead NEPA agency. FERC could draft a memorandum of understanding with BOEM stating that the two agencies will coordinate with each other. Then, the agencies could move forward with issuing a BOEM lease for the site and processing the FERC license. Once an application has been filed, FERC invites other agencies to be cooperators. At that point, USACE could join as a cooperating agency and get involved in the NEPA review process.
- **C**: What is described above is similar to a process currently taking place in Oregon where USACE is a cooperating agency and FERC and BOEM are working together on the federal permits. Collaboration is essential.
- **C**: Since there is some uncertainty about how the technology will interface with the facility, it is not clear what consultations will be required with NOAA Fisheries. NOAA Fisheries will need a more specific project description.
- **C**: Entanglement and sound are issues NOAA Fisheries will need to understand. Expedited permitting would be a challenge for NOAA Fisheries and more specific information is needed to understand the impacts.
- **C**: Since there are a lot of moving parts, the CalWave team might want to consider all the potential impacts for every potential device. Something similar was done recently for a land-based HCP. This would make the permits more programmatic and hopefully, then the specific technology will fit into the impacts already permitted for.
  - **R**: Since this is a marine hydrokinetic project, a collaborative working group could be developed that functions as part of the FERC licensing process.
- **C**: For a similar project in Oregon, the Alternative Licensing Process (ALP) is being used which is more collaborative compared to the Traditional Licensing Process (TLP). The CalWave team might consider this approach.
- **Q**: Could CalWave choose the Integrated Licensing Process (ILP).
  - **R**: The ILP can also be collaborative, but can also have tighter deadlines. The applicant can request the preferred process and seek FERC approval.
- **C**: The similar Oregon process is still considering whether a task force or collaborative working group would be valuable.
- **C**: Wildlife field surveys and scientific collecting will need to be included in the monitoring plan.
- **C**: Do the offshore platforms all have cables to shore or cables to other facilities?
  - **R**: The platforms being evaluated have both cables to shore and cables to other facilities.
- **C**: The CalWave team should select the one of the five sites before the agencies get too involved.
  - **R**: The permitting requirements between the five sites would not be that different. Stakeholder input will play a large role in which site is ultimately selected. Currently, the CalWave team prefers a site that can connect to the Vandenberg Air Force Base. The CalWave team will also want stakeholder input on the five sites.

- **C:** For the California State Lands Commission, its jurisdiction will include the power cables crossing state lands. Is there information about the existing cables for platform Irene?
  - **R**: A cable retrofit program was permitted last year. Doug will circulate a link to that document.
- **C**: It would be helpful to know how much power is running through that existing cable and how that would change for CalWave.
  - **R**: The CalWave team has information from BOEM on the existing cable and plans to meet with the owner of Platform Irene to get more information. The State Lands Commission also has information about existing power running through the cable.
- **C**: USGS Mapping can show hard bottom habitat and soft bottom habitat in that area, but doesn't have as much nearshore information.
- **C**: The CalWave Team has a confidential list of cables within the applicant siting area and will be careful to avoid them.
- **Q**: The main concern of the Coast Guard is about navigation. Will the facility be a restricted area?
  - **R**: The CalWave Center will use the proper marking for an energy facility. It is difficult to enforce restricted areas, and there are few fishermen that work in that area so a fully restricted area is not envisioned. The Team is looking into using virtual AIS for the corners of the area and maybe using marker buoys.
- **C**: The State Lands Commission has authority on the project if there will be a new cable onto shore. The Commission would likely be the California Environment Quality Act (CEQA) lead. The Commission would also prefer to a complete a joint CEQA/NEPA document.
- **Q**: Would Santa Barbara County have any authority?
  - **R**: If CalWave is a federal project, the County would not have authority.

Integrated Agency Timeline

Doug shared a draft coordinated agency timelines outlining the permitting process for CalWave. Doug Boren, BOEM, explained the process of issuing a research lease. BOEM will determine that the lease holder (either Cal Poly or a state agency) is legally able to hold the lease and will then put out a request of interest to make sure there is no competitive interest. If there is no interest, then CalWave can move into the FERC licensing process.

Jim Hastreiter, FERC, described the FERC licensing process and its general timeline. Jim described that when the applicant files the notice intent, the licensing process is initiated. The pre-application document (PAD) discusses the project in general and discusses environmental baseline information, including what the assumed impacts of the project would be. Jim shared that the applicant then prepares a study plan and collects all existing baseline information. Studies will take approximately 1-2 years to complete. FERC and the cooperating agencies will need to be on board with the initial set of studies completed. Post filing (after the applicant files a license application) take takes approximately a year and a half to complete; this is when FERC will work on the NEPA document with any cooperating agencies. Jim noted that the ALP and ILP processes could have a shorter timeframe. He also mentioned that the licensing process would be done in concert with BOEM as well as with the state and other federal agencies. A 401 certification needs to be obtained, ESA consultations with USFWS and NOAA Fisheries need to be completed, and the Historic

Preservation Act and the Marine Mammal Protection Act need to be complied with before FERC issues a license.

Participants had the following questions and comments on the integrated agency timeline:

- **Q**: Will there be any fees associated with applying for the research lease?
  - **R**: No, because it is a BOEM lease. The Test Center will provide public value and the usual rent would not be charged.
- **Q**: When would the notice of intent be filed?
  - **R**: Once the feasibility study is complete and DOE determines the next steps, a notice of intent could be filed within the next 12-18 months.
- **Q**: When and how does FERC solicit cooperating agencies?
  - **R**: FERC would issue a notice to invite the federal and state agencies to join as cooperating agencies right after or during the project scoping phase.
- **C**: FERC cannot issue a preliminary permit in federal waters.
- **C**: Providing terms for mitigation concerns is a very important step.
- **C**: The Coast Guard will look into whether they can participate as a cooperating agency.

Actions

1. CalWave Team to circulate full list of baseline information to meeting participants.
2. CalWave Team to circulate a link to the cable retrofit program document completed in 2014.

Appendix 5-3
Meeting Posters

CalWave – Cal Poly National Wave Energy Testing Facility Overview

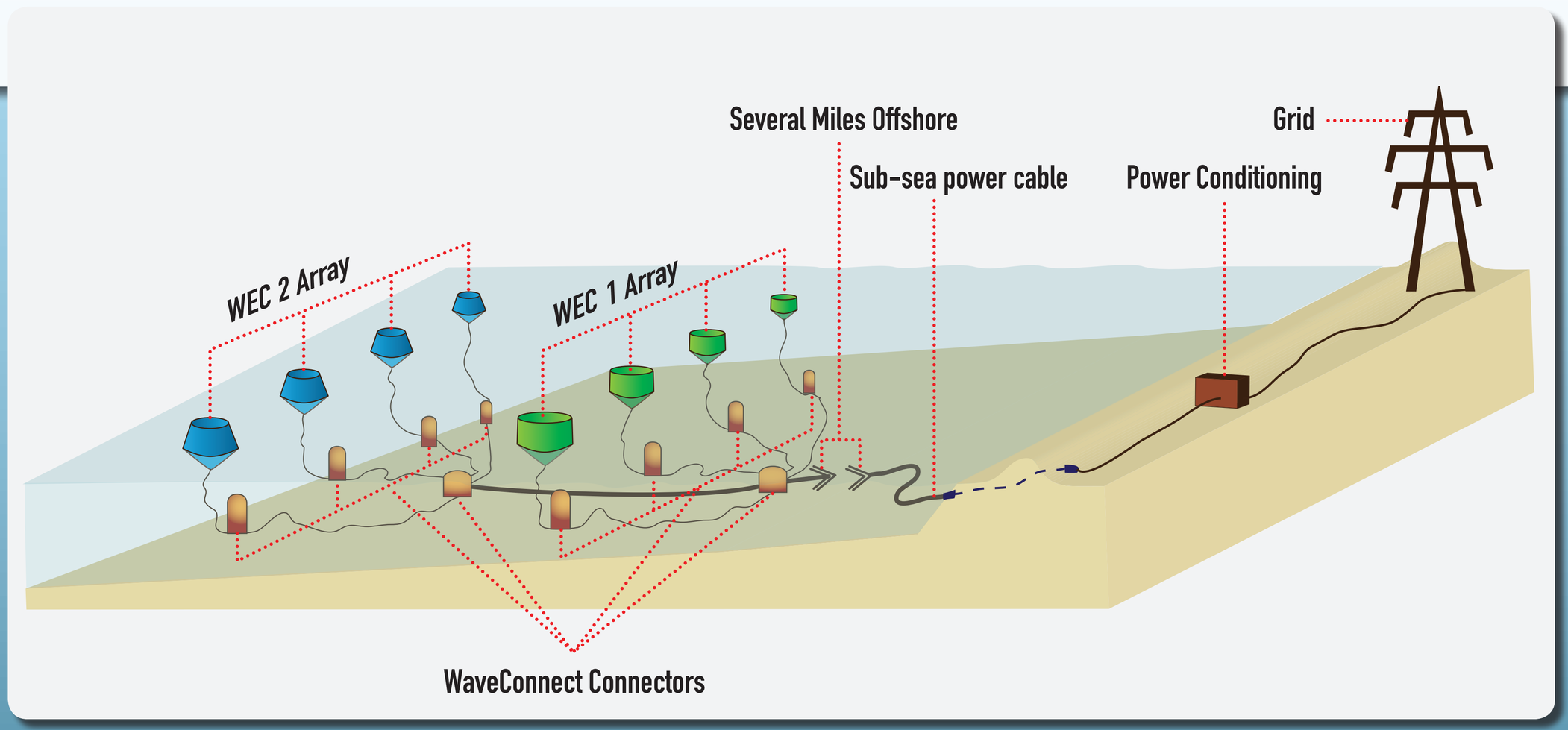
What is the CalWave Cal Poly National Wave Energy Testing Facility Feasibility Study?

In June 2014, California Polytechnic State University, San Luis Obispo, Institute for Advanced Technology and Public Policy received cooperative funding from the U.S. Department of Energy to conduct a feasibility study for a potential site for an offshore national wave energy tasting and research facility. This funding enables the Cal Poly team to review existing information, review the study area to explore options for the facility location, reach out to stakeholders, and complete additional research on potential wave energy devices to understand whether a site off the cost of Central California might be suitable for a wave energy test facility. A national wave energy testing facility would serve to jumpstart the emerging wave energy industry in the United States by enabling wave energy devices to be installed, connected with the power grid and tested.

Since June, the Cal Poly team has determined that the most appropriate potential future wave energy facility site would be off the coast of Vandenberg Air Force Base. This particular area appears to have the least conflict with existing uses, sensitive habitats and it enhances the Air Force's desire to utilize the renewable energy generated by the wave energy devices.

The Cal Poly team is now reviewing this potential National Wave Energy Test Center location with stakeholders to understand interests associated with the potential site. In June 2015, the Cal Poly team will submit the feasibility study including preliminary design alternatives, project cost estimates, a plan for permitting and stakeholder engagement and a project schedule. With additional funding from the U.S. Department of Energy and others, the Cal Poly team would further refine the potential project site and begin the environmental review process.

A diagram of wave energy convertors (WECs) connecting to the power grid is below.



CalWave

Cal Poly
San Luis Obispo

U.S. Department of Energy

CalWave National Wave Energy Testing Facility Feasibility Study Public Meeting

Wednesday, April 15th, 6pm-8pm

Ludwick Community Center

846 Santa Rosa Street, San Luis Obispo

Meeting Objectives:

- Enable information exchange about the CalWave National Wave Energy Testing Facility Feasibility Study
- Gather feedback on engineering, environmental, and public engagement considerations for a future CalWave National Wave Energy Testing Facility
- Gather feedback on proposed project siting area

Agenda:

6:00 pm – 6:20 pm: Welcome, Participants Gather

Welcome and informal information exchanges. Refreshments will be served.

6:20 pm – 7:00 pm: Overview Presentation and Q&A

CalWave National Wave Energy Testing Facility Feasibility Study overview

- Project Manager Bill Toman

7:00 pm – 8:00 pm: Open House

CalWave team members will be available to discuss specific aspects of the proposed project and answer questions

Stations:

- Project Overview and Timeline: Learn about the overall process plan for the proposed CalWave project
- Project Map: Review maps of the proposed project area
- Resource Potential: Learn about the resource potential of worldwide and U.S. wave energy
- Permitting Processes: Learn about the anticipated CalWave permitting processes
- Wave Energy Technologies: Learn about some of the wide range of wave energy technologies, and what might be tested with the proposed CalWave project.
- Comment Station: An opportunity to submit written comments

8:00 pm: Adjourn

CalWave

Cal Poly San Luis Obispo

U.S. Department of Energy

Roles of Licensing and Permitting Agencies

Agency	Permit or Authorization	Purpose	Authority
1. Federal Agencies			
United States Air Force, Vandenberg Air Force Base (VAFB)	• Onshore lease agreement, utility sale agreement	• Project host, interconnection with VAFB grid	• On-shore facilities land owner
Bureau of Ocean Energy Management	• Offshore Research Lease	• Sole authority to lease areas in the Outer Continental Shelf (OCS) for Energy Development	• Federal Power Act, 30 Code of Federal Regulations (CFR) 585
Federal Energy Regulatory Commission	• Hydrokinetic Project License • National Environmental Policy Act (NEPA) review	• Responsible for siting and operation of grid-connected hydrokinetic power facilities. Lead NEPA agency.	• Federal Power Act, 18 CFR 5 • National Environmental Policy Act
U.S. Fish and Wildlife Service	• Incidental Take Authorization (terrestrial species)	• Protection and recovery of threatened and endangered species	• Federal Endangered Species Act
National Marine Fisheries Service	• Incidental Take Authorization (marine species) • Marine Mammal Permit (non-listed marine mammals) • Essential Fish Habitat Analysis	• Protection and recovery of threatened and endangered species and marine mammals and Essential Fish Habitat	• Federal Endangered Species Act • Marine Mammal Protection Act • Magnuson-Stevens Fishery Conservation and Management Act
U.S. Army Corps of Engineers	• Section 10 RHA Permit • Section 404 CWA permit	• Responsible for use of navigable waterways • Protect water quality and wetlands	• Rivers and Harbors Act • Clean Water Act
U.S. Coast Guard	• Private Aids to Navigation	• Responsible for siting of navigation aids in coastal waters	• 33 CFR 66
2. State Agencies			
California Coastal Commission	• Coastal Zone Consistency Determination, Coastal Development Permit (submerged lands)	• Responsible for development in the Coastal Zone; ensures public access to the Coastal Zone	• California Coastal Act • Coastal Zone Management Act
California State Lands Commission	• Submerged Lands Lease • California Environmental Quality Act Certification	• Leasing of state-owned submerged lands • Responsible development of projects on state submerged lands	• Submerged Lands Act/California Public Resources Code Section 6702 • California Environmental Quality Act
California Department of Fish and Wildlife	• Incidental Take Authorization • Streambed Alteration Agreement (if stream crossing)	• Protection and recovery of threatened and endangered species	• California Endangered Species Act, Section 2081 • California Fish and Game Code, Section 1603
Central Coast Regional Water Quality Control Board	• Section 401 Water Quality Certification • Waste discharge requirements (if waters of the state) • General National Pollution Discharge Elimination System Permits for construction and operation	• Protect and manage water quality	• Federal Clean Water Act • Porter-Cologne Water Quality Control Act
California Office of Historic Preservation	• Section 106 compliance review	• Protect and manage historic properties and other cultural resources	• National Historic Preservation Act
3. Local Agencies			
Santa Barbara County	• Encroachment Permit/Coastal Development Permit (if shore facilities were placed on non-federal lands)	• Applies only if on-shore facilities placed outside of VAFB (non-federal land)	• Santa Barbara County Code

Other Non-Permitting Interested Governmental Agencies and Entities

Federal Agencies

- U.S. Department of Energy, National Renewable Energy Laboratory – Funded CalWave Project design and permitting feasibility study

State Agencies

- California Ocean Protection Council – Conducts research and formulates policy focused on protecting California's marine resources
- California Energy Commission – Fosters renewable energy development and conservation in California
- California Coastal Conservancy – Protects, restores, and enhances coastal resources

Local Entities

- California Polytechnic University, Science and Ecosystem Alliance – Conducts research on marine resources along the Central California Coast
- California Polytechnic University, College of Science and Mathematics - Conducts research on renewable energy and marine resources

Native American Tribes

- California Chumash (Santa Ynez, Coastal, Barbareño, Northern)
- Yak Tityu Tityu

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Cal Poly National Wave Energy Testing Facility Project Timeline

YEAR 1

Feasibility Study:

- Select the test facility siting area
- Develop preliminary design alternatives and select preferred alternative
- Develop conceptual construction and operation cost estimates
- Prepare a plan and cost estimates for permitting and stakeholder support
- Prepare a schedule for project permitting, design, and construction

YEAR 2

- CalWave team conducts early-stage public engagement, including public meetings
- Final siting for the Test Center, on-shore facilities, and transmission line
- Distribute RFI to wave energy converter developers
- Initiate preliminary engineering design
- BOEM conducts Determination of No Competitive Interest
- File an initial lease application with BOEM
- File Notice of Intention and Preliminary Application Document with FERC
- FERC conducts Scoping Process and approves Study Plans
- Conduct environmental field studies
- Prepare Draft FERC license application and Draft Biological Assessment

YEAR 3

- BOEM and FERC conduct joint environmental review process under NEPA
- Submit applications for ancillary permits:
  - State Lands Commission lease application and CEQA process
  - California Coastal Commission Coastal Development Permit and Coastal Zone Management Act Consistency Determination
  - Clean Water Act Section (CWA) 401 Water Quality Certification
  - Rivers and Harbors Act Section 10/CWA 404 permit
- Federal agency consultation under:
  - Endangered Species Act
  - Marine Mammal Protection Act
  - Magnuson-Stevens Fishery Conservation and Management Act
  - National Historic Preservation Act
- State agency consultation under California Endangered Species Act
- CalWave team continues public engagement
- Submit Final FERC license application
- Submit Final Biological Assessment
- Finalize preliminary Design

YEAR 4

- Initiate detailed design
- CalWave team continues public engagement
- CalWave team files final licensing proposal and license application with BOEM
- BOEM and FERC produce a joint environmental document
- BOEM issue lease and FERC issues license
- Federal and state agencies issue permits and authorizations
- WEC developers submit applications to lease test berths
- Awards for initial test berths
- Complete detailed design
- Initiate procurement of long lead-time components (ie, sub-sea cables)
- Schedule directional drill equipment and installation vessels

YEAR 5

- Initiate CalWave construction
- Install shore infrastructure
- Install sea-based infrastructure
- Complete CalWave construction
- Initiate project commissioning
- Install initial wave energy converter(s) in test berths

YEAR 6

- Install wave energy converters in all test berths
- Complete project commissioning

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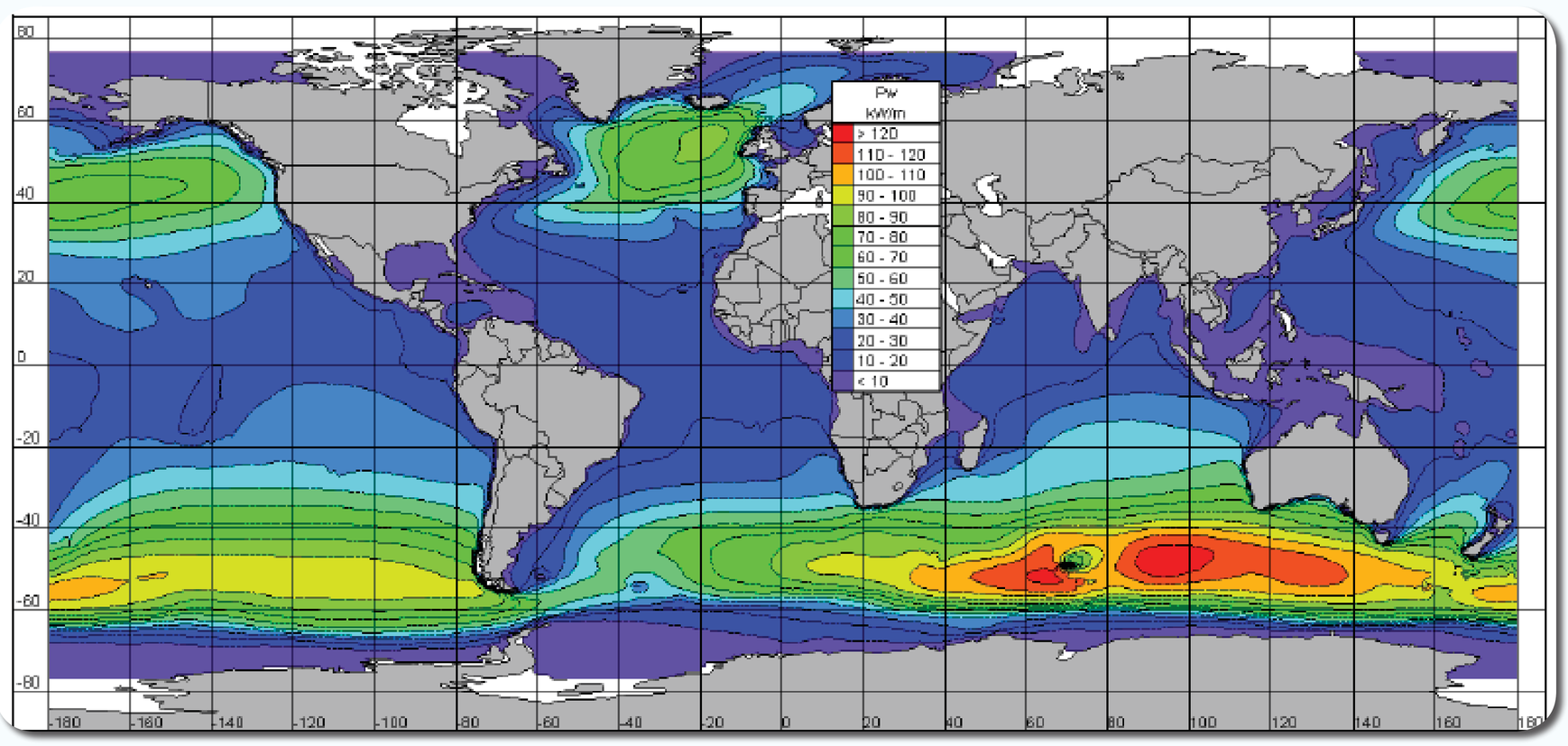
Wave Energy Resource Potential

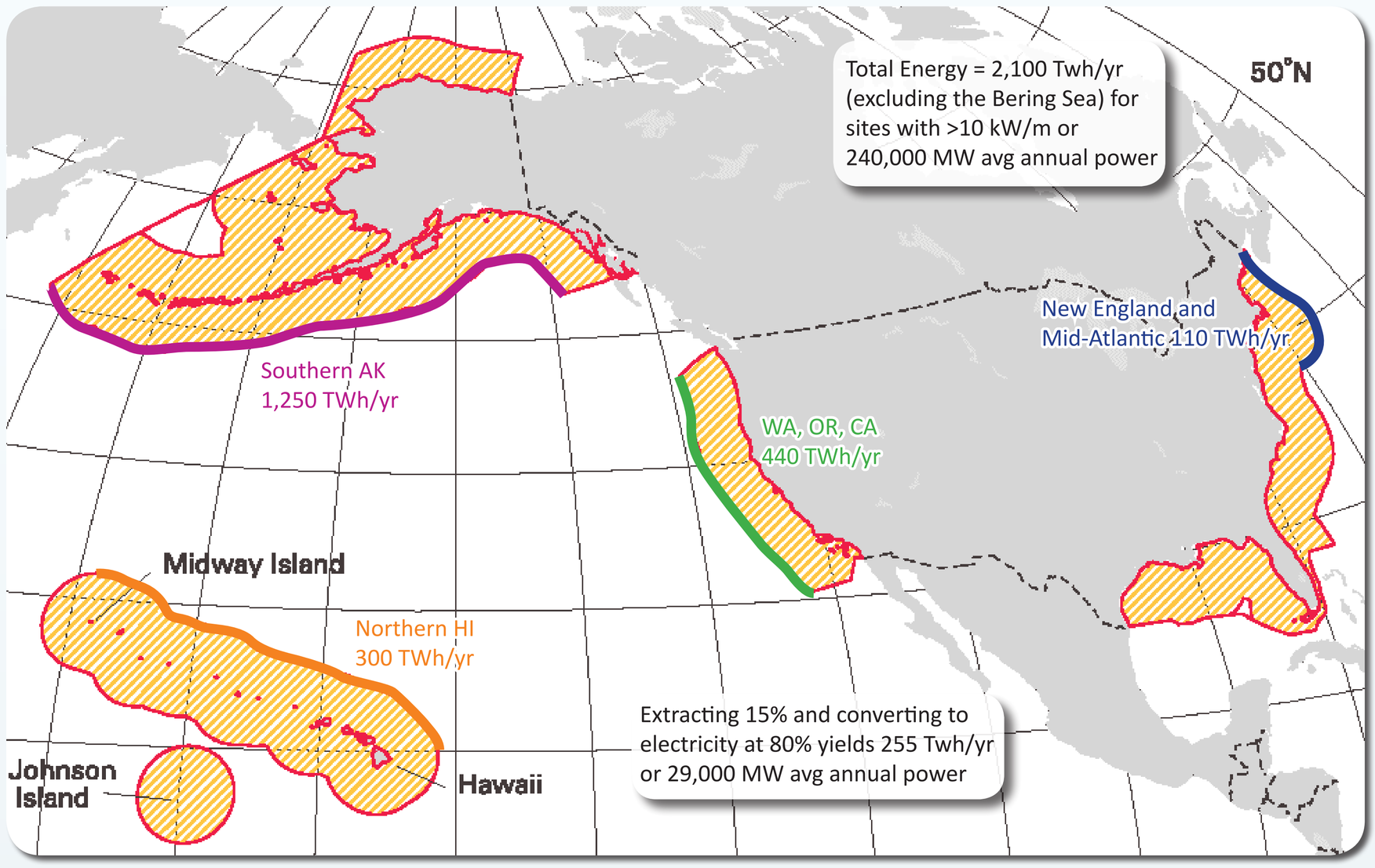
Worldwide Wave Power Density

This worldwide wave power density map shows that the coast lines with the highest potential wave energy are facing west, with a large ocean to the west and north, with southern latitudes of about 30 to 60 degrees.



U.S. Wave Energy Resources

According to an EPRI study, the available wave energy resource of the U.S. is about 2,100 terawatt-hours (TWh) per year (1 TW = 1,000,000 megawatt). Assuming that society in the future will develop 15% of the potential wave energy with typical efficiencies, the U.S. potential is about 255 TWh per year. This is about 6.5% of total U.S. electricity generation. This is enough to power about 22 million homes (the typical U.S. home uses an average of about 1.3 kilowatt).



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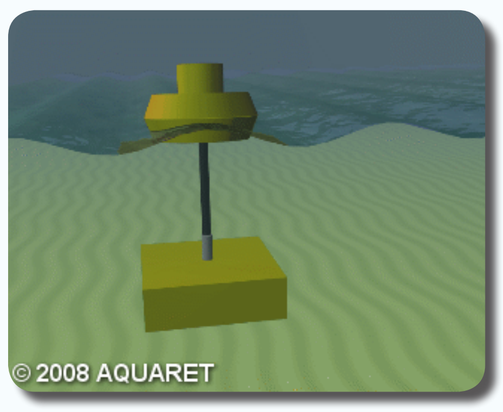
Wave Energy Technologies

Wave Energy Convertor Devices and Technologies

Waves have the potential to provide a sustainable source of energy, which can be captured and converted into electricity by wave energy converter (WEC) machines. These wave energy technologies have been developed to convert wave motion into electricity when placed in locations ranging from on the shoreline out to deeper waters offshore. Examples of wave energy technologies are described below.

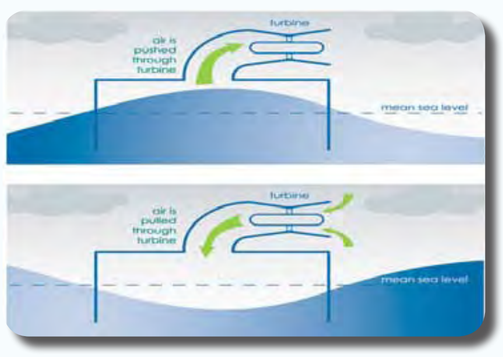
Point Absorber

A point absorber is a floating structure which absorbs energy from all directions through its movements at or near the water surface. It converts the motion of the buoyant top relative to a stabilized base into electrical power. The power take-off system may take a number of forms, depending on the configuration of displacers or reactors. (Source: European Marine Energy Centre [emec.org.uk])



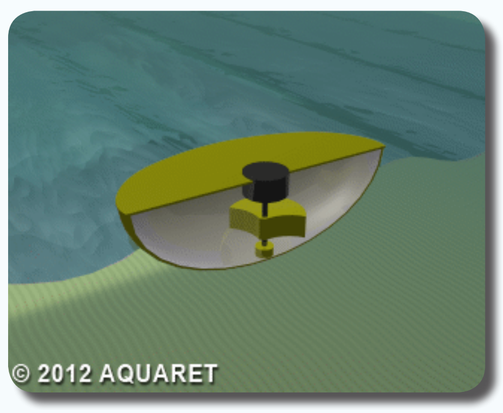
Floating Oscillating Water Column

An oscillating water column is a partially submerged, hollow structure. It is open to the sea below the water line, enclosing a column of air on top of a column of water. Waves cause the water column to rise and fall which, in turn, compresses and decompresses the air column. This trapped air flows back and forth through an air turbine that can rotate regardless of the direction of the airflow. The rotation of the turbine is used to generate electricity. (Source: European Marine Energy Centre [emec.org.uk]) (Source: http://finecommittee.org/about-wave-energy-devices/)



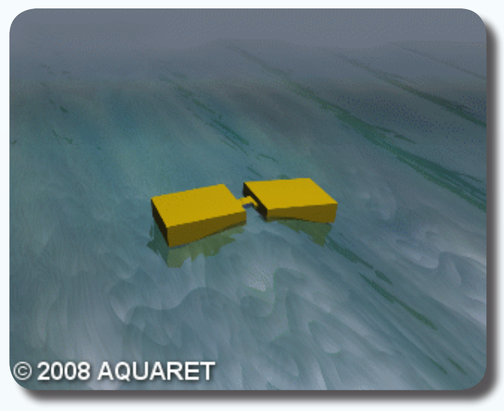
Rotating Mass

Two forms of rotation are used to capture energy by the movement of the device heaving and swaying in the waves. This motion either drives an eccentric weight, or a gyroscope causes precession (change in rotational axis). In both cases, the movement is attached to an electric generator inside the device. (Source: European Marine Energy Centre [emec.org.uk])



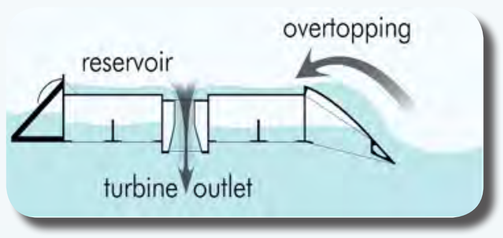
Linear Attenuator

An attenuator is a cylindrical, floating, segmented device that is aligned perpendicular to the wave crest and moves up and down as the wave passes. These devices capture energy from the relative motion of two or more linked segment. (Source: European Marine Energy Centre [emec.org.uk])



Overtopping/Terminator Device

Overtopping devices capture water as waves break into a storage reservoir. The water is then returned to the sea passing through a conventional low-head turbine that generates power. An overtopping device may use ‘collectors’ to concentrate the wave energy. (Source: European Marine Energy Centre [emec.org.uk])
Source: http://finecommittee.org/about-wave-energy-devices/



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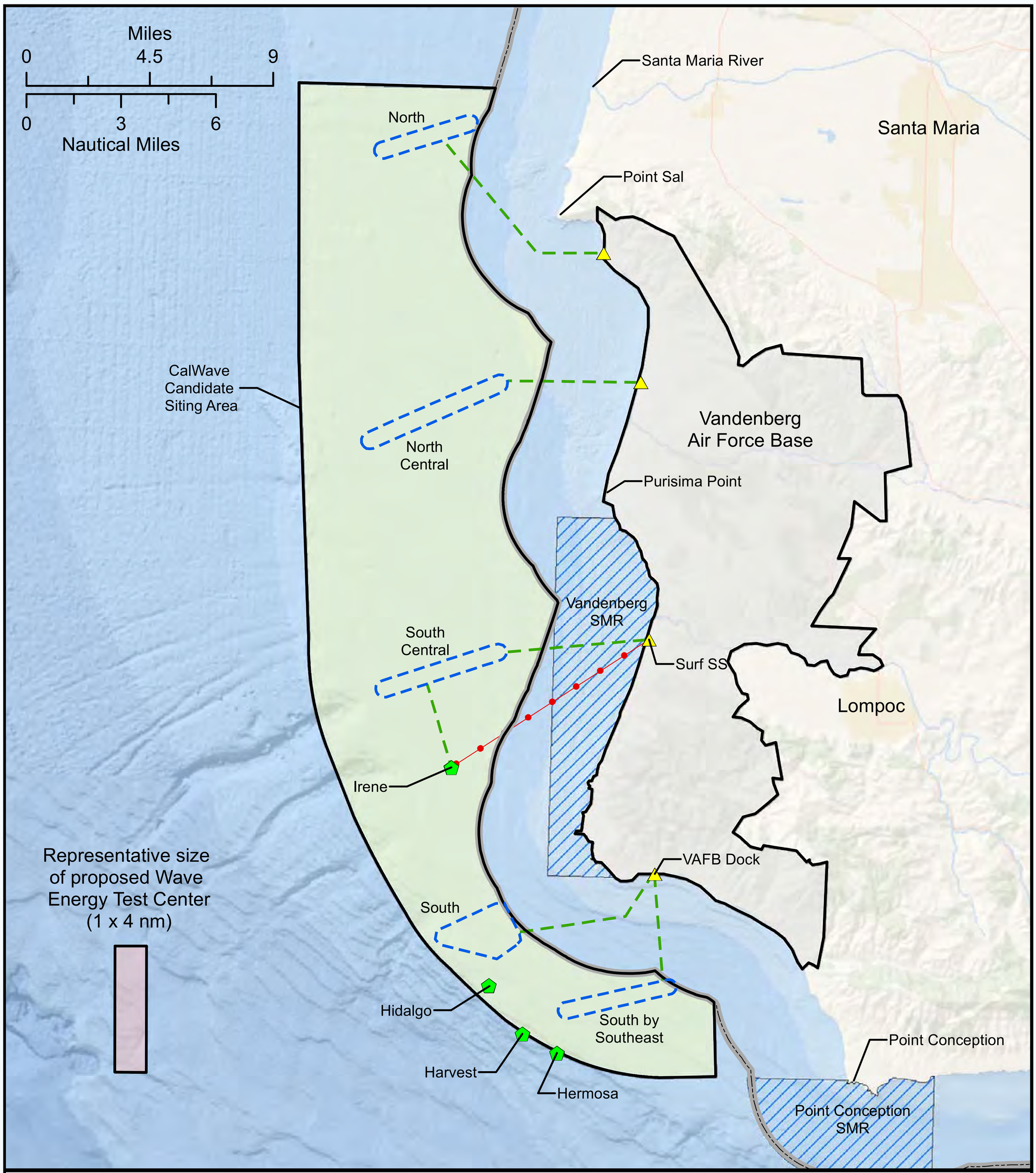
Study Area Map



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CalWave Permitting 1 - Prepare Lease, License, and Permit Applications

BOEM ACTIONS TO ISSUE RESEARCH LEASE

Determine No Competitive Interest

Joint NEPA Scoping with FERC

Review and Comment on Admin Draft Env Document

CALWAVE ACTIONS TO OBTAIN BOEM LEASE AND FERC LICENSE

Notice of Intent (NOI) and Pre-Application Document (PAD) to FERC

Draft Study Plans

Final Study Plans to FERC

Conduct Field Studies and Environmental Analyses

License Application, BA to FERC

Prepare and Submit Applications :

- USACE RHA Section 10/CWA Section 404
- RWQCB CWA Section 401
- CSL submerged Lands Lease and CEQA compliance
- Coastal Development Permit/CZMA Consistency
- US Coast Guard Aids to Navigation

FERC ACTIONS TO ISSUE MARINE HYDROKINETIC FACILITY LICENSE

FERC Scoping Document 1

Public and Agency Scoping Comments

Approve Study Plans

FERC Scoping Document 2

Ready for Env Analysis/ Request for Comment

FERC Issues DRAFT Env Document (BOEM Cooperation)

Color Key

BOEM | CalWave | FERC | Federal Agency | State Agency

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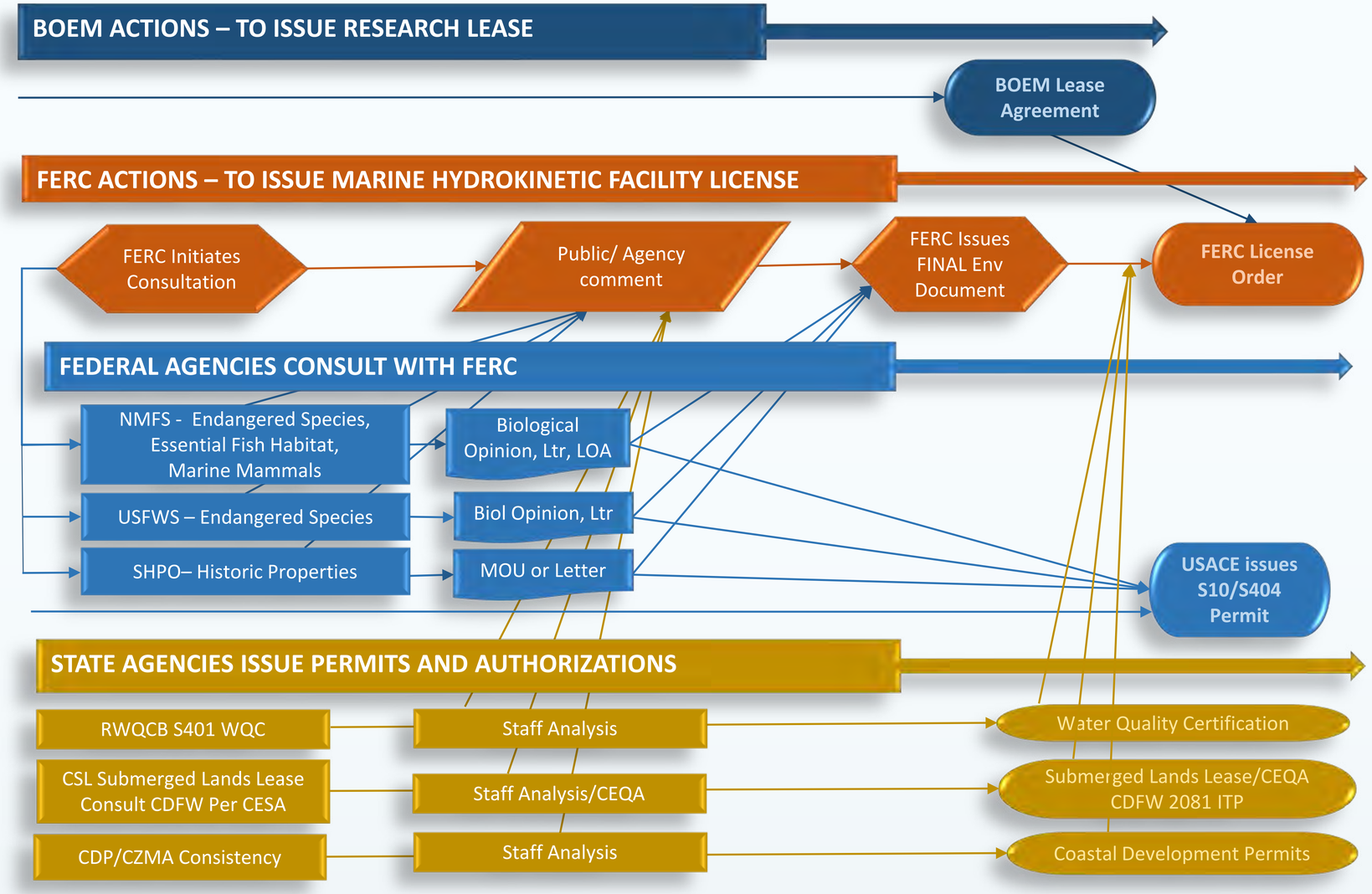
CalWave Permitting 2 - Agencies Process Applications and Permit CalWave



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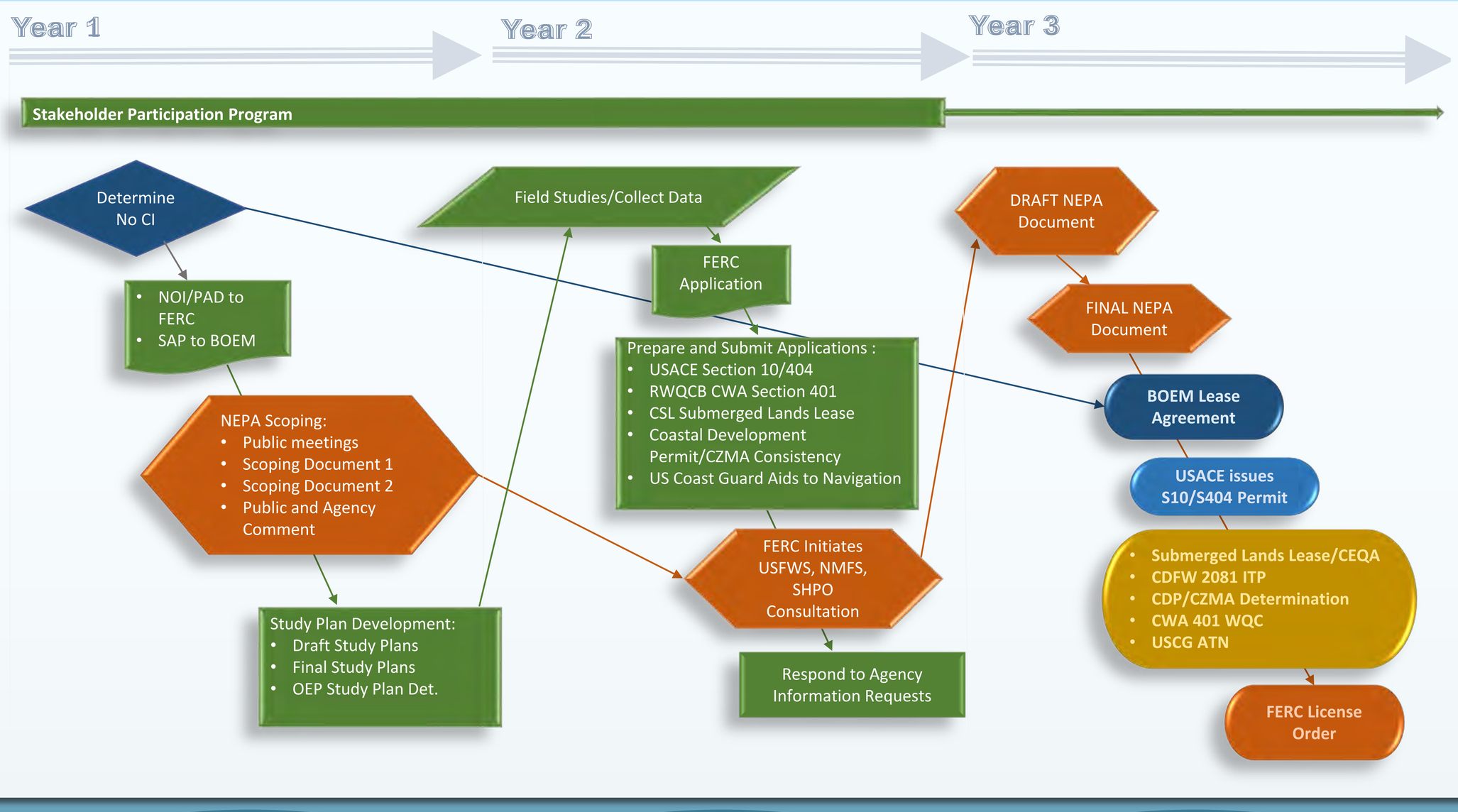
CalWave Permitting Timeline



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Appendix 6-1
Wave Climate Characterization for VAFB Waters

APPENDIX 6-1

Wave Climate Characterization for VAFB Waters

By Colin Sheppard and Andrew Harris, Schatz Energy Research Center, Humboldt State University

The CalWave team conducted an analysis of the wave climate at each potential berth location for the CalWave project. The approach involved running a ten-year hindcast of wave conditions using the *Simulating WAves Nearshore* (SWAN) model from Delft University of Technology at http://swanmodel.sourceforge.net/.

The modeling approach was based on similar work performed by Sandia National Laboratories for other regions of interest for wave power development (Dallman et al. 2014). The hindcast covered an ~1800 square-mile region near Vandenberg Air Force Base, as shown in Figure 1. The temporal range spanned from August 1994 through July 2004, as these dates have fairly complete input data available for the geographic region. The boundary conditions were extracted from a 30-year WaveWatch III hindcast reanalysis performed by NOAA in 2011. Spectral model outputs were generated for the five potential CalWave berth sites in addition to the existing Scripps Buoy (CDIP 071) within the model domain.

The spectral data output generated by the SWAN model was processed using a MATLAB script originally developed by Dallman et al. (2014) to generate six wave metrics of interest: omnidirectional wave power, significant wave height, energy period, spectral width, direction of maximally resolved power, and the directionality coefficient. The script was also adapted to export directionally resolved wave energy flux estimates for each time period of the hindcast for use in producing wave energy roses.

Results

The SWAN model was validated by comparing outputs to observed wave characteristics at CDIP Buoy 071. See the next section for the results of this analysis.

Table 1 presents the summary results from the processed SWAN model outputs by site and by year (including an annual average value) for the 10-year hindcast. Note that the partial years of 1994 and 2004 were combined in the outputs and are represented as a single full year (2004) for comparability across years.

Wave energy roses were produced for a single berth location in each site (Figure 2-Figure 7). In addition, we also summarize wave energy flux for each site so as to evaluate the inter-annual variability (Figure 8), seasonal variation (Figure 9), and the spatial variation across berth locations within the CalWave alternative test sites (Figure 10). Finally, in Figure 11 and Table 2 through Table 5, we produced wave power resource frequency matrices to characterize the frequency of occurrence of various seas states (i.e., for various combinations of significant wave height and peak period).

Figure 1: SWAN Computational Grid and Output Points. The 19 numbered points are the potential CalWave berth sites, with the remaining point being an active buoy. The yellow line gives the approximate boundary of the SWAN simulation.

Table 1: Results from SWAN simulation by site and year for 6 wave parameters. ite	Year	Hm0	Energy Flux (kW/m)	Peak Power Direction	Te	Directionality Coefficient	Spectral Width
CDIP 071	1995	2.56	45.5	292	10.8	0.983	0.232
	1996	2.48	37.9	290	11.0	0.983	0.231
	1997	2.59	43.4	289	11.1	0.982	0.232
	1998	2.90	60.8	293	11.4	0.982	0.231
	1999	2.63	45.0	291	11.2	0.981	0.232
	2000	2.51	42.0	293	11.2	0.981	0.233
	2001	2.60	43.4	296	10.8	0.982	0.232
	2002	2.41	38.5	293	10.6	0.981	0.232
	2003	2.42	37.0	288	11.2	0.982	0.232
	2004	2.49	39.2	294	10.9	0.982	0.232
	Annual Mean	**2.56**	**43.3**	**292**	**11.0**	**0.982**	**0.232**
North	1995	2.27	39.5	288	10.9	0.983	0.236
	1996	2.16	31.0	285	11.0	0.983	0.236
	1997	2.30	37.0	285	11.1	0.980	0.236
	1998	2.54	51.8	288	11.4	0.983	0.237
	1999	2.26	36.3	286	11.2	0.982	0.238
	2000	2.16	34.9	287	11.2	0.981	0.238
	2001	2.25	36.2	290	10.8	0.982	0.236
	2002	2.10	32.8	288	10.7	0.982	0.236
	2003	2.10	30.8	283	11.1	0.982	0.238
	2004	2.13	32.0	288	11.1	0.984	0.237
	Annual Mean	**2.23**	**36.2**	**287**	**11.0**	**0.982**	**0.237**

North Central	1995	2.36	41.9	289	10.8	0.983	0.235
	1996	2.26	33.7	287	11.0	0.984	0.235
	1997	2.39	39.7	286	11.1	0.982	0.235
	1998	2.66	55.7	290	11.4	0.983	0.236
	1999	2.38	40.1	288	11.2	0.983	0.237
	2000	2.27	37.9	289	11.2	0.982	0.237
	2001	2.37	39.3	292	10.8	0.983	0.235
	2002	2.21	35.3	290	10.7	0.983	0.235
	2003	2.20	33.3	285	11.1	0.983	0.237
	2004	2.24	34.9	290	11.0	0.984	0.236
	Annual Mean	**2.33**	**39.2**	**289**	**11.0**	**0.983**	**0.236**
South	1995	2.41	41.6	290	10.7	0.984	0.235
	1996	2.33	34.6	287	10.9	0.983	0.234
	1997	2.42	39.5	286	10.9	0.981	0.236
	1998	2.70	54.5	289	11.2	0.982	0.236
	1999	2.45	40.3	288	11.0	0.981	0.237
	2000	2.33	37.7	289	11.0	0.981	0.237
	2001	2.43	39.4	292	10.7	0.981	0.235
	2002	2.27	35.0	290	10.5	0.982	0.235
	2003	2.26	33.6	285	11.0	0.982	0.236
	2004	2.31	35.2	290	10.8	0.983	0.236
	Annual Mean	**2.39**	**39.1**	**289**	**10.9**	**0.982**	**0.236**
South by Southeast	1995	2.12	33.5	285	10.5	0.984	0.249
	1996	2.02	26.8	282	10.7	0.984	0.249
	1997	2.13	31.3	281	10.8	0.982	0.249
	1998	2.35	43.0	283	11.1	0.982	0.252
	1999	2.11	30.1	282	10.9	0.981	0.253
	2000	2.03	29.1	283	10.9	0.981	0.252

	2001	2.08	29.7	286	10.5	0.982	0.252
	2002	1.97	27.4	285	10.3	0.983	0.249
	2003	1.97	26.1	279	10.8	0.982	0.250
	2004	1.99	26.9	284	10.6	0.983	0.252
	Annual Mean	**2.08**	**30.4**	**283**	**10.7**	**0.983**	**0.251**
South Central	1995	2.38	43.1	290	10.8	0.984	0.236
	1996	2.29	35.0	287	10.9	0.984	0.236
	1997	2.41	40.8	286	11.1	0.982	0.236
	1998	2.68	57.4	290	11.3	0.983	0.237
	1999	2.42	41.6	288	11.1	0.982	0.238
	2000	2.30	39.2	289	11.1	0.982	0.238
	2001	2.40	40.7	292	10.8	0.982	0.236
	2002	2.24	36.3	290	10.6	0.983	0.236
	2003	2.23	34.4	285	11.1	0.983	0.237
	2004	2.27	36.2	290	10.9	0.984	0.237
	Annual Mean	**2.36**	**40.5**	**289**	**11.0**	**0.983**	**0.237**

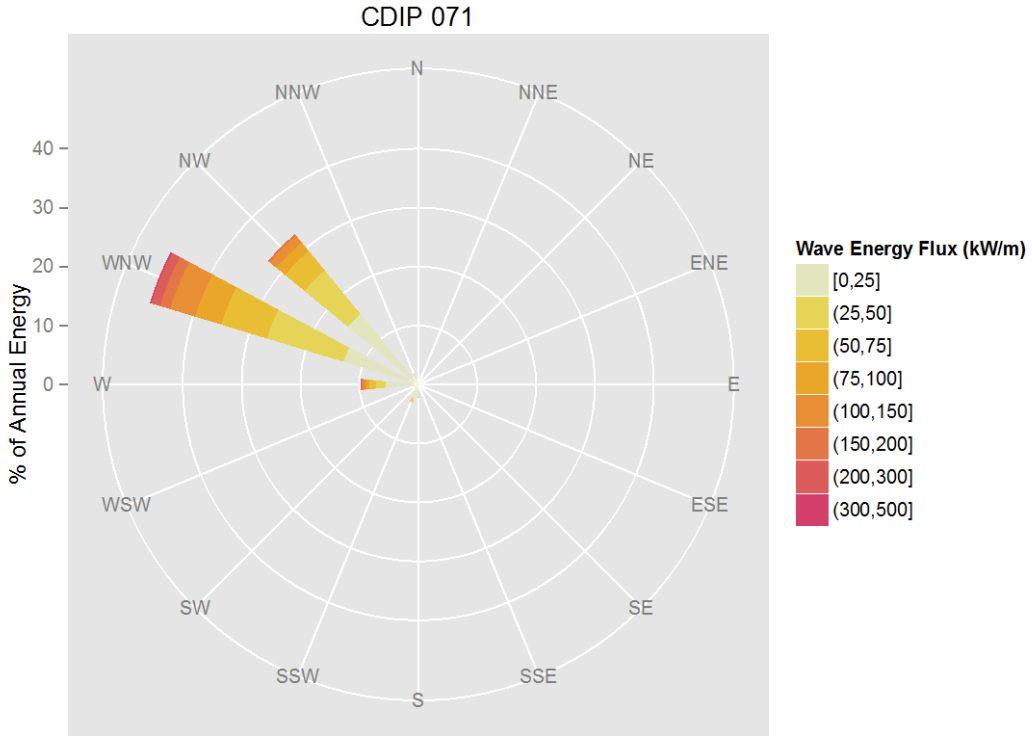


Figure 2: Percent of annual wave energy from each direction binned by energy flux for CDIP 071.

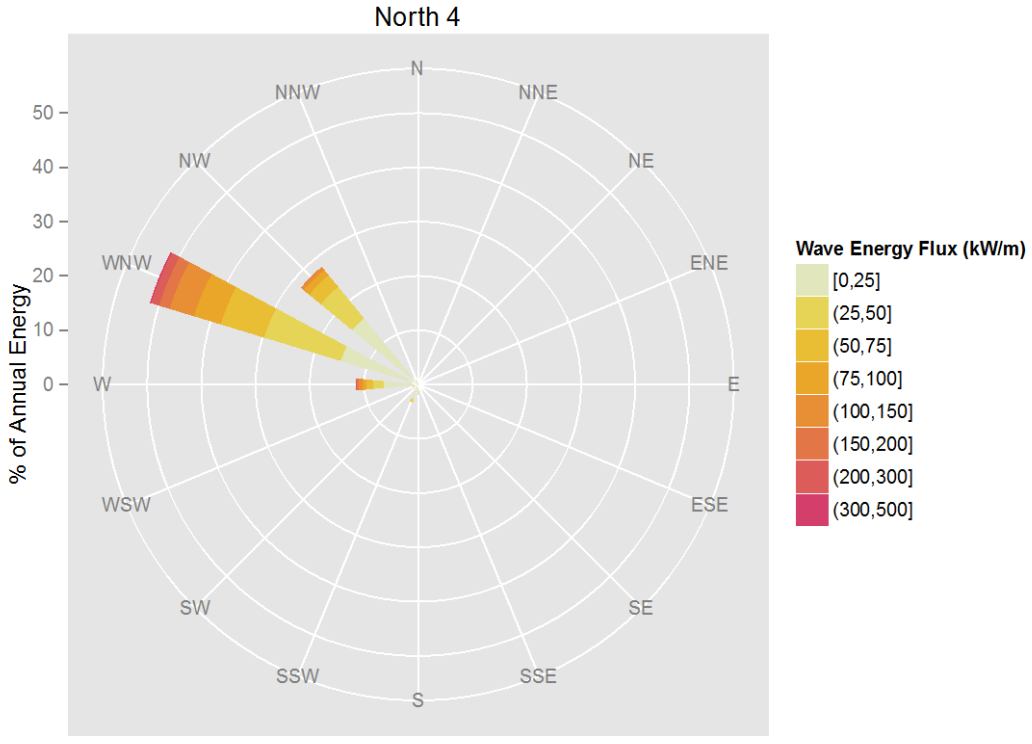


Figure 3: Percent of annual wave energy from each direction binned by energy flux for North 4.

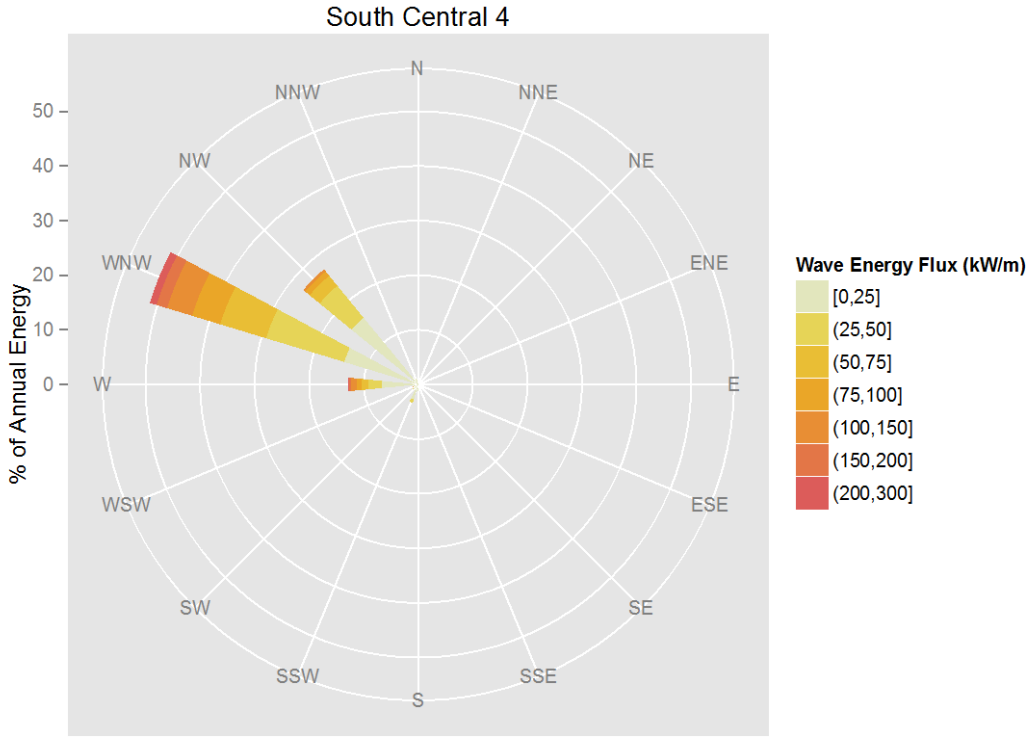


Figure 4: Percent of annual wave energy from each direction binned by energy flux for South Central 4.

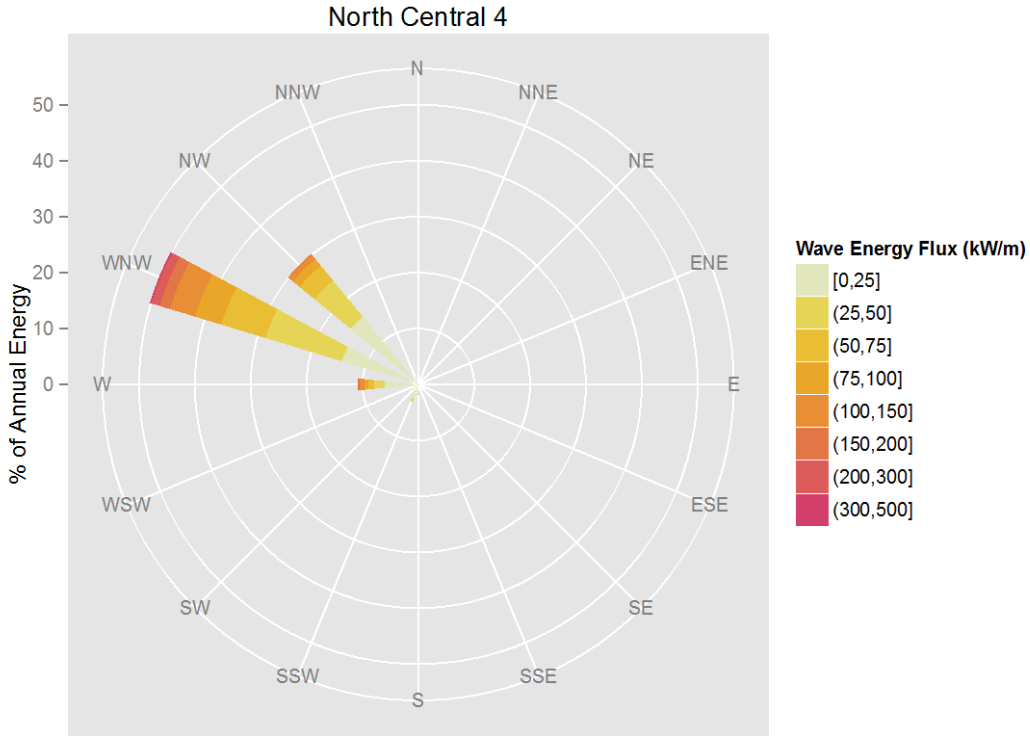


Figure 5: Percent of annual wave energy from each direction binned by energy flux for North Central 4.

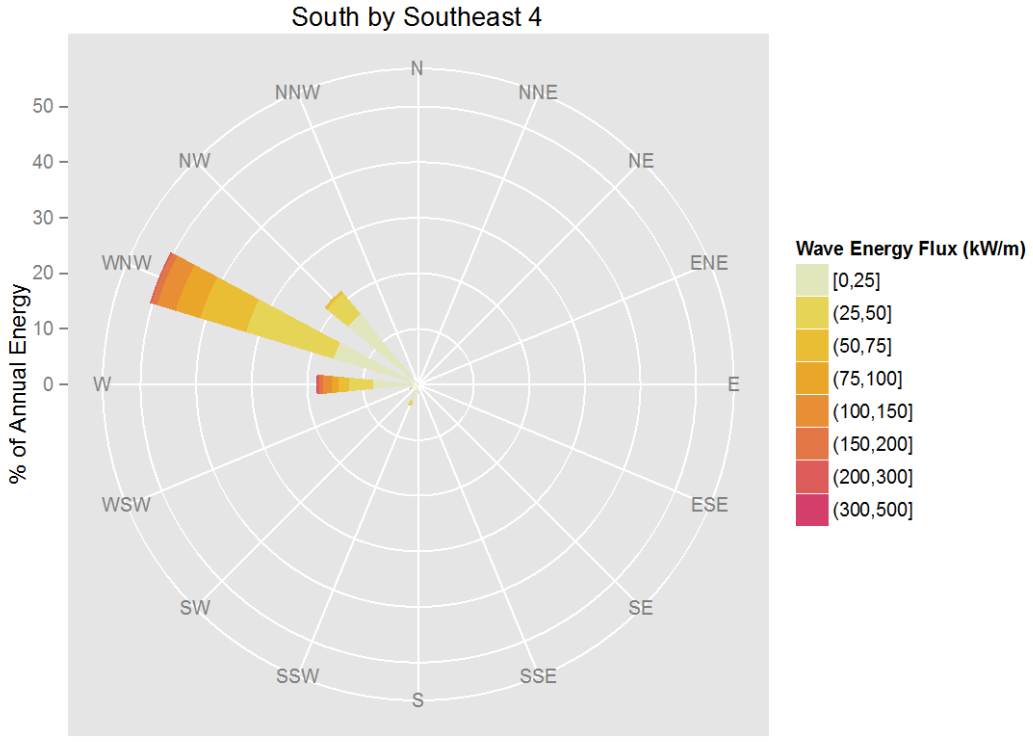


Figure 6: Percent of annual wave energy binned by energy flux for South by Southeast 4.

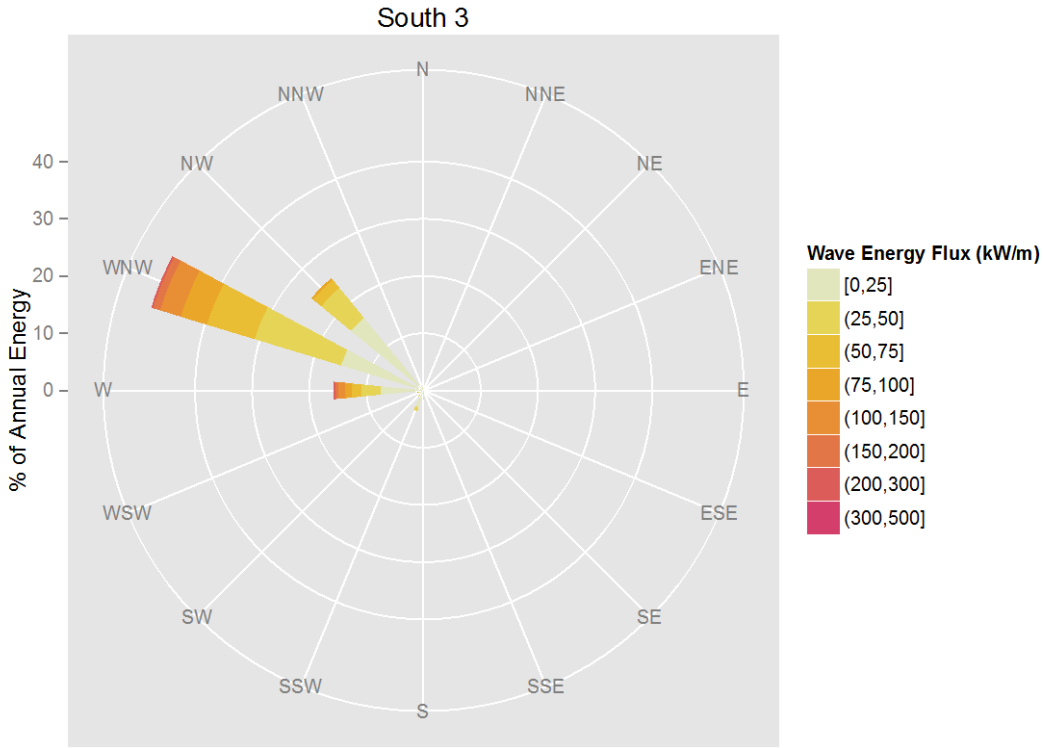


Figure 7: Percent of annual wave energy from each direction binned by wave energy flux for South 3.

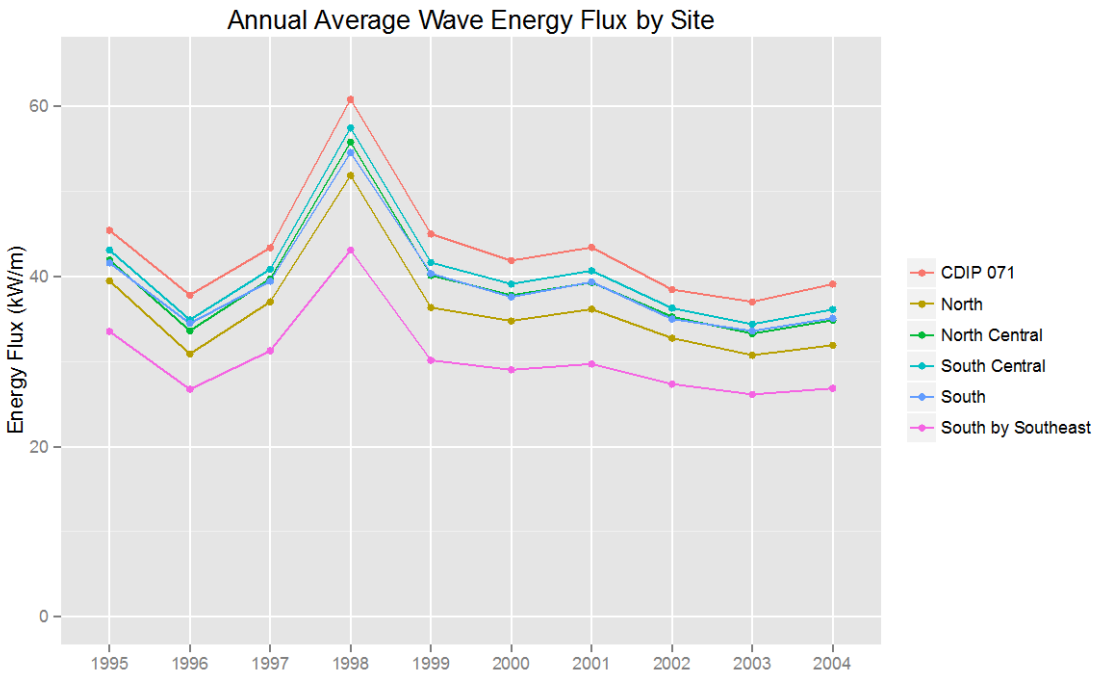


Figure 8: Inter-annual variability in wave energy flux by site.

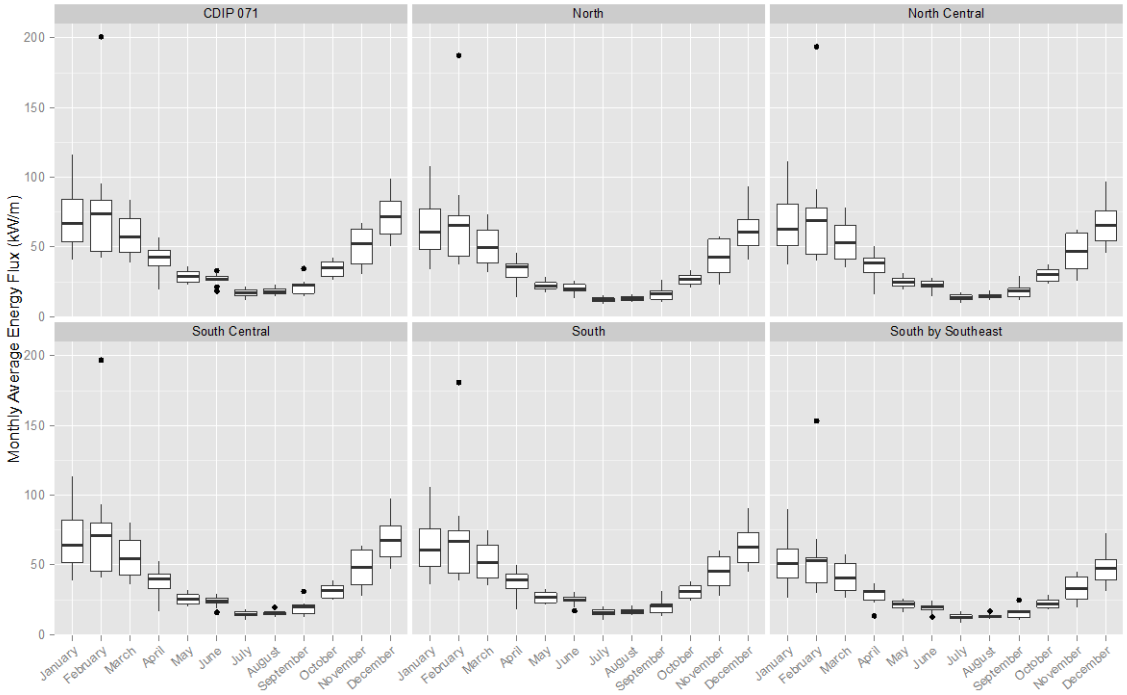


Figure 9: Seasonal variability in wave energy flux by site.

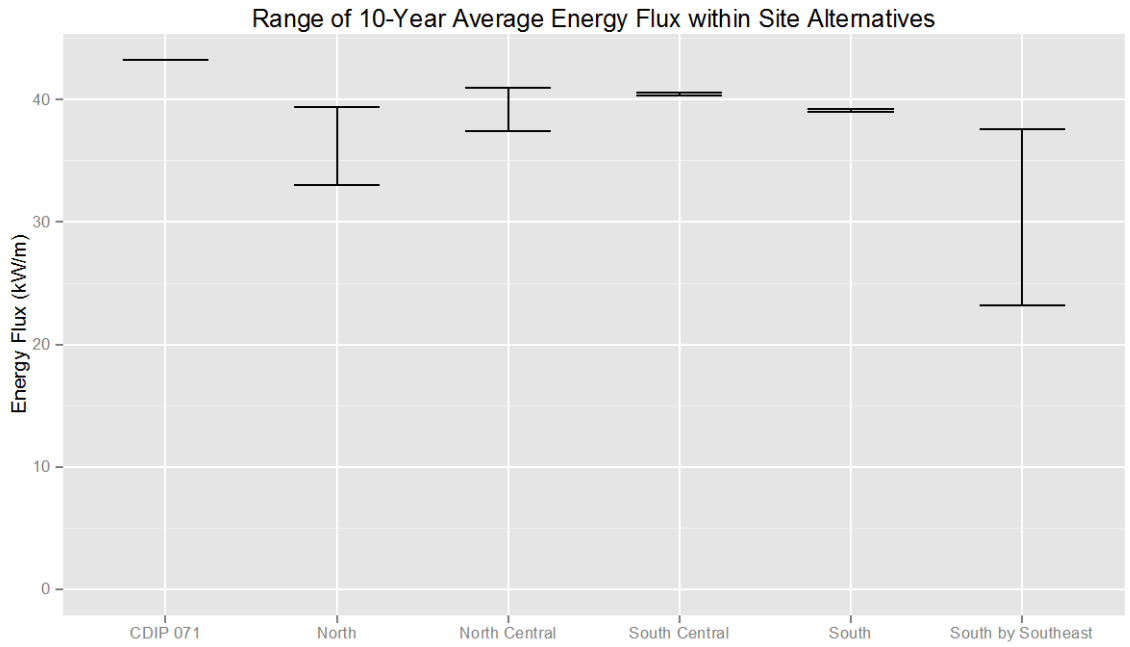


Figure 10: Spatial variability of mean wave energy flux by site. Error bars represent max and min of the 10-year average energy flux observed at distinct berth locations within each site.

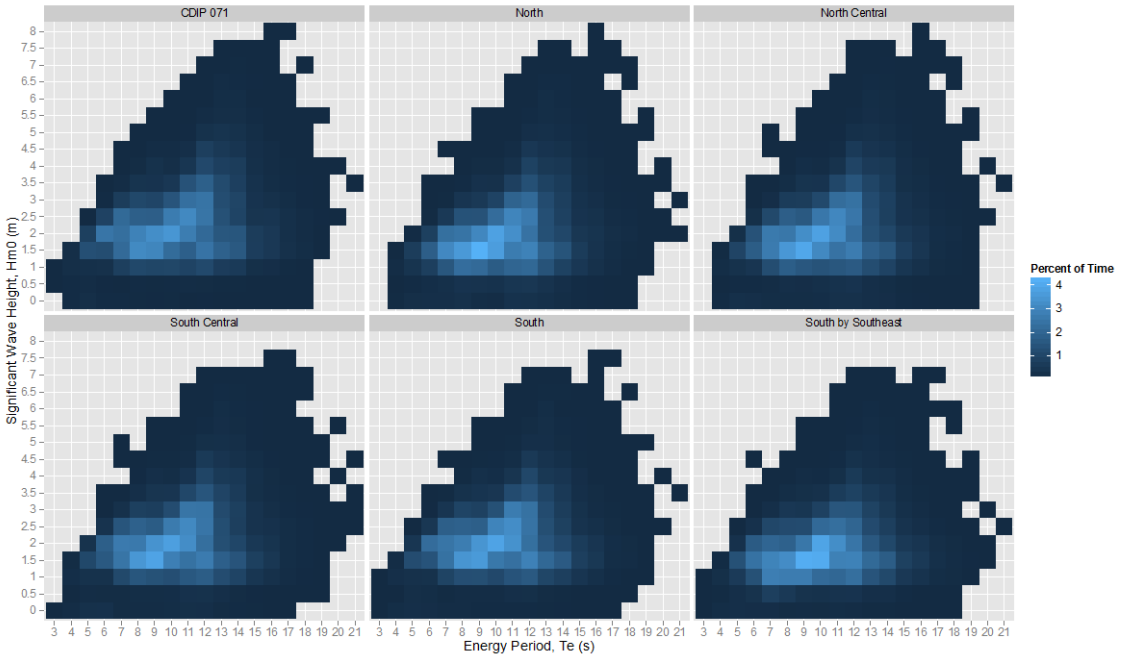


Figure 11: Wave power resource matrix, color is scaled to the frequency of occurrence of each height and period combination.

Table 2: Wave power resource matrix for South 1. Values are % of the time the sea state is in the Height/Period bin.

	Energy Period (s)																		
Sig. Height (m)	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
0.0	0.0	0.1	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.5	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.0	0.0	0.1	0.3	0.2	0.9	1.3	1.3	1.0	1.4	1.6	1.0	0.7	0.4	0.2	0.1	0.0	0.0	0.0	0.0
1.5	0.0	0.1	1.1	1.4	2.4	3.5	3.7	2.6	2.3	2.8	2.0	1.6	0.7	0.4	0.1	0.1	0.0	0.0	0.0
2.0	0.0	0.0	0.4	2.2	2.6	2.8	3.4	3.9	3.3	2.3	1.4	1.0	0.6	0.4	0.1	0.1	0.0	0.0	0.0
2.5	0.0	0.0	0.0	0.4	1.8	1.8	1.8	2.9	3.1	2.4	1.2	0.8	0.3	0.2	0.1	0.0	0.0	0.0	0.0
3.0	0.0	0.0	0.0	0.0	0.4	0.9	0.7	1.3	2.6	2.3	1.1	0.7	0.3	0.1	0.1	0.0	0.0	0.0	0.0
3.5	0.0	0.0	0.0	0.0	0.1	0.3	0.3	0.4	1.1	1.4	0.9	0.5	0.2	0.1	0.0	0.0	0.0	0.0	0.0
4.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.1	0.3	0.9	0.4	0.4	0.2	0.0	0.0	0.0	0.0	0.0	0.0
4.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.5	0.3	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0
5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 3: Wave power resource matrix for South 3. Values are % of the time the sea state is in the Height/Period bin.

	Energy Period (s)																		
Sig. Height (m)	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
0.0	0.0	0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.5	0.0	0.0	0.2	0.1	0.0	0.1	0.1	0.1	0.2	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.0	0.0	0.2	0.2	0.3	0.9	1.2	1.2	1.0	1.4	1.6	0.9	0.7	0.4	0.2	0.1	0.0	0.0	0.0	0.0
1.5	0.0	0.1	1.2	1.4	2.4	3.5	3.5	2.5	2.3	2.8	2.0	1.6	0.7	0.5	0.1	0.1	0.0	0.0	0.0
2.0	0.0	0.0	0.4	2.3	2.5	2.9	3.4	3.7	3.3	2.3	1.4	1.0	0.6	0.4	0.1	0.1	0.0	0.0	0.0
2.5	0.0	0.0	0.0	0.5	1.9	1.8	1.8	2.9	3.2	2.4	1.2	0.8	0.3	0.2	0.1	0.0	0.0	0.0	0.0
3.0	0.0	0.0	0.0	0.0	0.4	0.9	0.8	1.3	2.7	2.4	1.1	0.6	0.2	0.1	0.0	0.0	0.0	0.0	0.0
3.5	0.0	0.0	0.0	0.0	0.1	0.3	0.3	0.4	1.2	1.4	0.9	0.5	0.2	0.1	0.0	0.0	0.0	0.0	0.0
4.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.2	0.4	1.0	0.5	0.4	0.1	0.0	0.0	0.0	0.0	0.0	0.0
4.5	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.5	0.3	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 4: Wave power resource matrix for South by Southeast 1. Values are % of the time the sea state is in the Height/Period bin.

Sig. Height (m) \ Energy Period (s)	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
0.0	0.0	0.1	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.5	0.0	0.1	0.2	0.5	1.5	0.9	0.5	0.4	0.4	0.4	0.3	0.3	0.1	0.0	0.0	0.0	0.0	0.0	0.0
1.0	0.0	0.2	0.9	2.4	4.6	4.1	4.0	3.1	2.6	2.8	1.8	1.3	0.6	0.4	0.2	0.1	0.0	0.0	0.0
1.5	0.0	0.0	1.5	3.3	3.4	2.7	4.4	5.2	3.4	3.0	2.1	1.7	0.8	0.5	0.2	0.1	0.1	0.0	0.0
2.0	0.0	0.0	0.1	1.1	1.4	1.1	1.6	3.6	3.0	2.6	1.7	1.0	0.4	0.3	0.1	0.1	0.0	0.0	0.0
2.5	0.0	0.0	0.0	0.1	0.2	0.4	0.5	1.2	1.5	1.6	1.0	0.6	0.3	0.1	0.1	0.0	0.0	0.0	0.0
3.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.2	0.6	0.7	0.5	0.4	0.2	0.1	0.0	0.0	0.0	0.0	0.0
3.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.4	0.3	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0
4.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 5: Wave power resource matrix for South by Southeast 4. Values are % of the time the sea state is in the Height/Period bin.

Sig. Height (m) \ Energy Period (s)	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
0.0	0.0	0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.5	0.0	0.0	0.2	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.0	0.0	0.2	0.3	0.3	1.1	1.3	1.3	1.1	1.4	1.7	1.0	0.9	0.4	0.2	0.1	0.0	0.0	0.0	0.0
1.5	0.0	0.1	1.2	1.5	2.5	3.6	3.8	2.9	2.2	2.7	2.0	1.7	0.7	0.5	0.2	0.1	0.0	0.0	0.0
2.0	0.0	0.0	0.4	2.2	2.6	2.7	3.4	4.1	3.4	2.3	1.4	1.0	0.6	0.4	0.2	0.1	0.0	0.0	0.0
2.5	0.0	0.0	0.0	0.4	1.8	1.8	1.7	3.0	3.0	2.3	1.2	0.8	0.3	0.2	0.1	0.0	0.0	0.0	0.0
3.0	0.0	0.0	0.0	0.0	0.3	0.8	0.7	1.3	2.4	2.2	1.2	0.6	0.2	0.1	0.0	0.0	0.0	0.0	0.0
3.5	0.0	0.0	0.0	0.0	0.0	0.2	0.3	0.4	1.0	1.2	0.8	0.5	0.2	0.1	0.0	0.0	0.0	0.0	0.0
4.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.1	0.3	0.8	0.4	0.3	0.2	0.0	0.0	0.0	0.0	0.0	0.0
4.5	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.4	0.2	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0
5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Model Validation

In order to validate the results of the SWAN simulation, spectral data outputs were generated at a location corresponding to the Scripps CDIP Buoy 071. Energy flux was calculated from the SWAN spectra and paired in time with energy flux from CDIP 071. Table 2 presents performance metrics (RMSE = root mean squared error, PE = percent error, SI = scatter index, BIAS = bias, R = linear correlation coefficient) that quantify the degree of agreement between energy flux and significant wave height observed at the buoy and estimated by SWAN (see Garcia-Medina et al. 2014 for complete definitions of each metric). Table 3 compares the monthly mean energy flux from each data set. Figure 12 presents scatterplots of the comparison by month and Figure 13 - Figure 20 present line plots of both time series for a number of years for which there was overlapping periods of record. The overall performance shows the SWAN outputs are biased high by 27% on average for wave energy flux and 16% high for significant wave height. This degree of overbias has been documented in several previous studies that used Wave Watch III reanalysis as boundary conditions for a SWAN model (Dallman et al. 2014, Garcia-Medina et al. 2014, Arinaga and Cheung 2012).

Table 6: Performance metrics for energy flux and significant wave height.

	RMSE	RMSE(%)	PE	SI	BIAS	BIAS (%)	R
J (kW/m)	22	67%	83%	0.67	8.95	27%	0.86
Hs (m)	0.56	25%	28%	0.25	0.34	16%	0.88

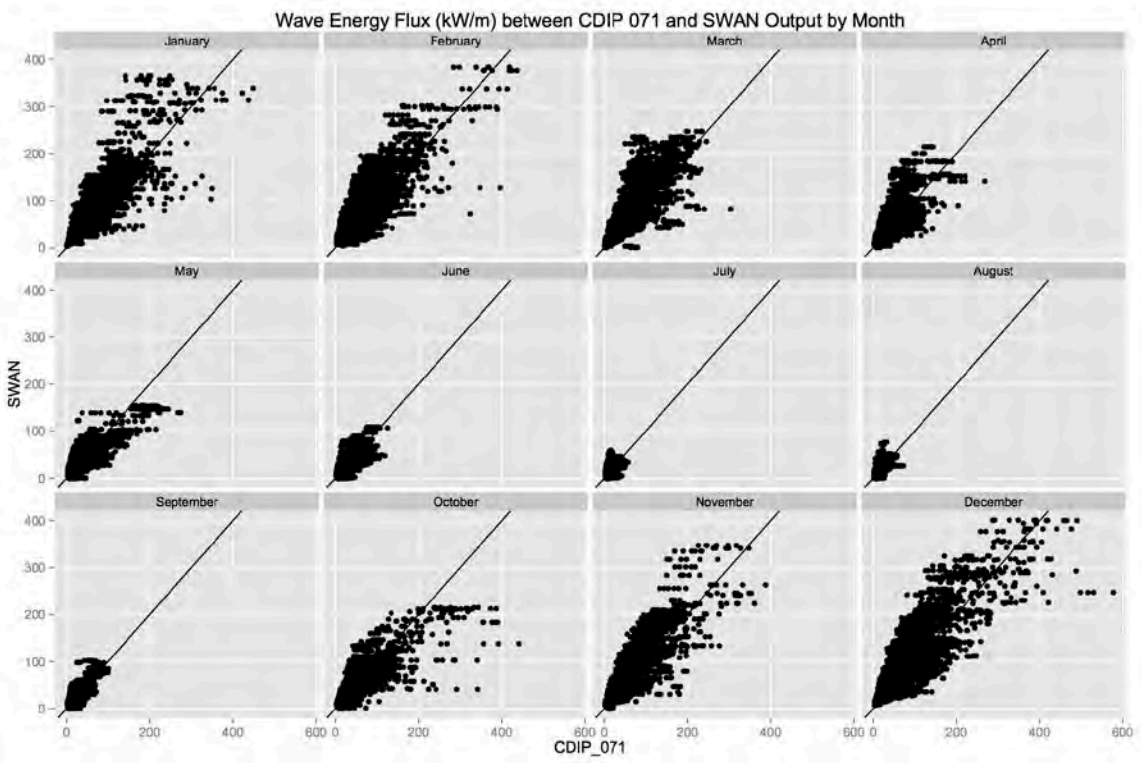


Figure 12: Energy flux from SWAN spectra versus observed spectra at CDIP 071. Black lines represent perfect agreement.

Table 7: Monthly mean energy flux and significant wave higher comparison between CDIP Buoy 071 and SWAN model results.

	Energy Flux (kW/m)			Significant Wave Height (m)		
Month	**CDIP 071**	**SWAN**	**% Difference**	**CDIP 071**	**SWAN**	**% Difference**
January	44.4	60.7	37%	2.4	3.0	17%
February	49.9	66.4	33%	2.6	3.1	17%
March	45.3	58.4	29%	2.6	3.0	13%
April	30.0	38.9	30%	2.2	2.6	14%
May	26.5	30.0	13%	2.2	2.4	10%
June	21.8	26.2	20%	2.0	2.3	12%
July	13.9	17.5	25%	1.7	1.9	13%
August	13.7	18.5	35%	1.7	1.9	14%
September	16.1	20.0	24%	1.7	1.9	11%
October	30.6	33.0	8%	2.1	2.3	9%
November	42.5	53.6	26%	2.4	2.8	15%
December	59.4	73.1	23%	2.8	3.2	14%
Annual Mean	**32.8**	**41.3**	**26%**	**2.2**	**2.5**	**13%**

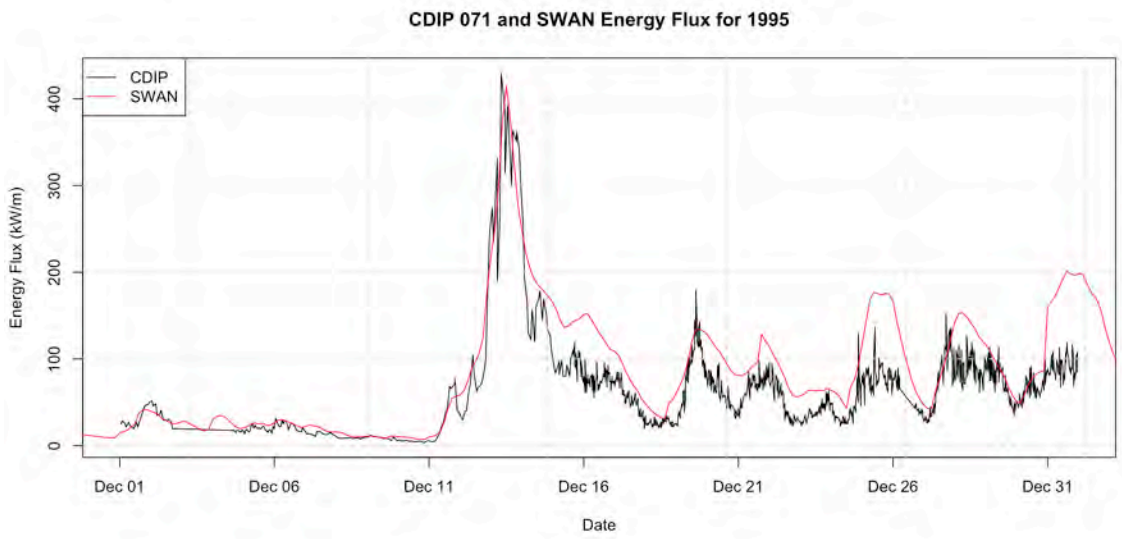


Figure 13: Energy flux from SWAN spectra versus observed spectra at CDIP 071.

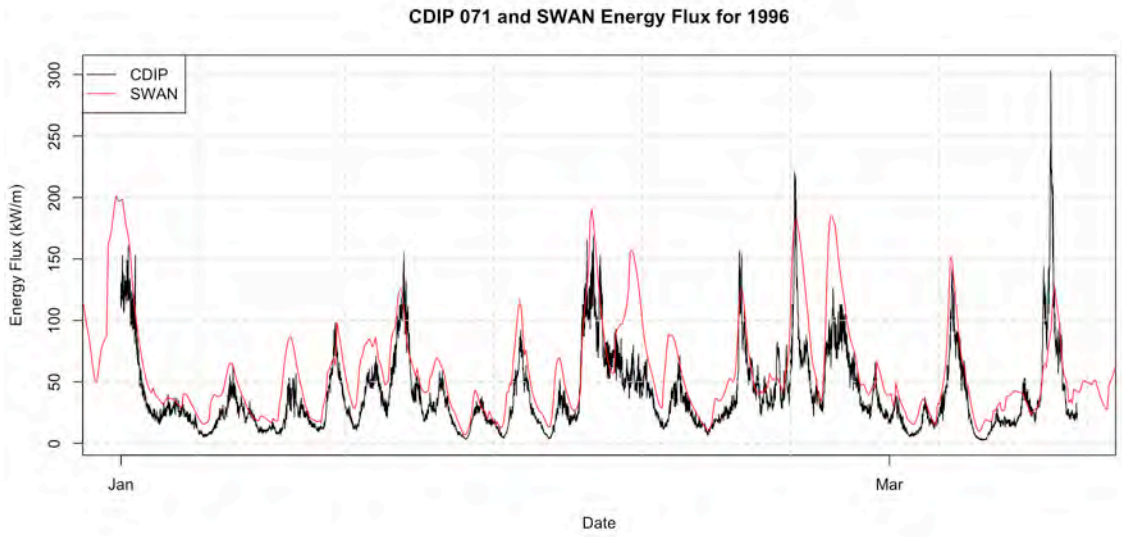


Figure 14: Energy flux from SWAN spectra versus observed spectra at CDIP 071.

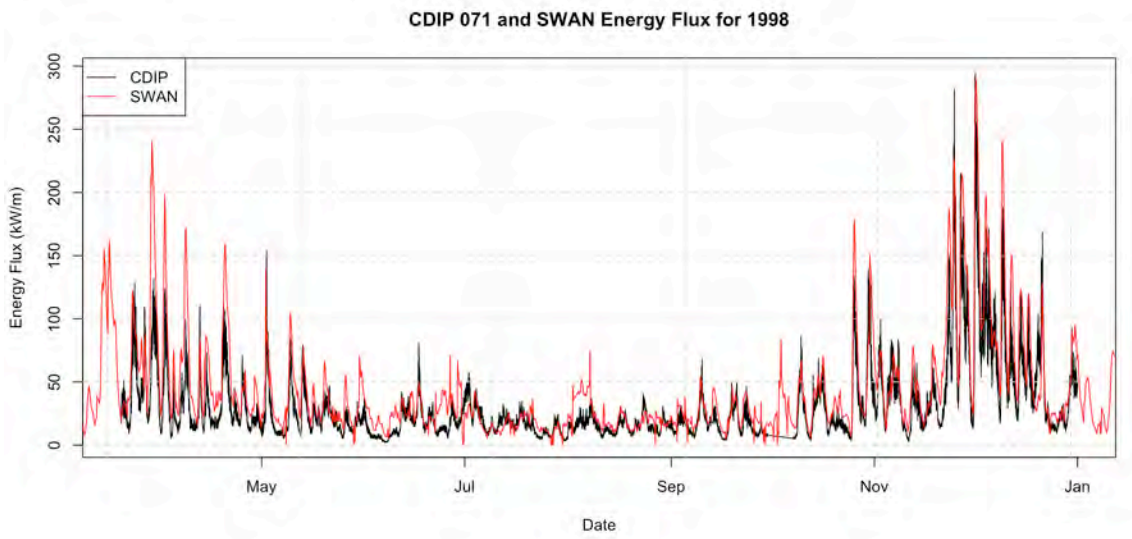


Figure 15: Energy flux from SWAN spectra versus observed spectra at CDIP 071.

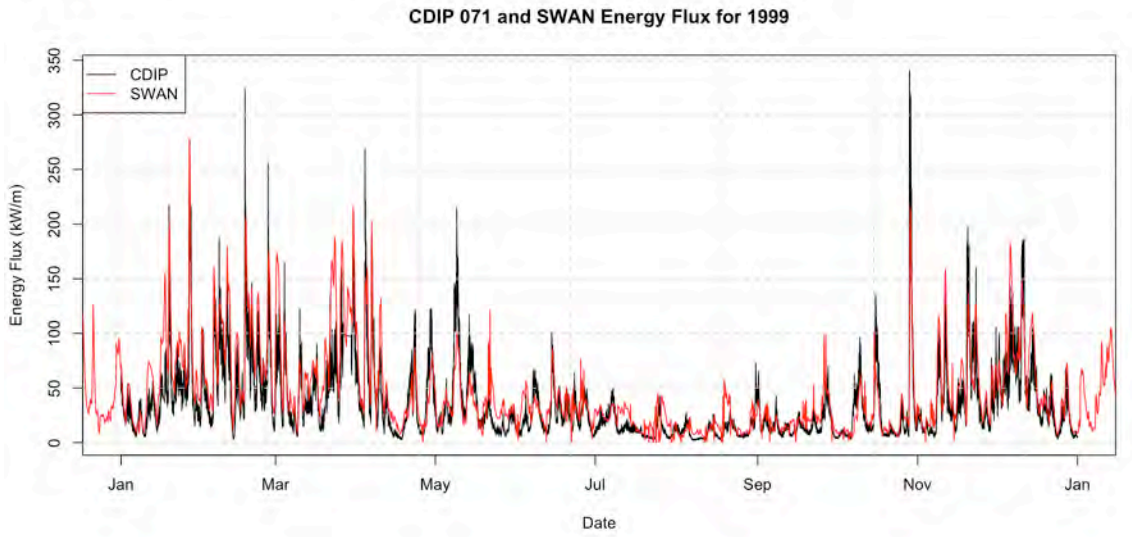


Figure 16: Energy flux from SWAN spectra versus observed spectra at CDIP 071.

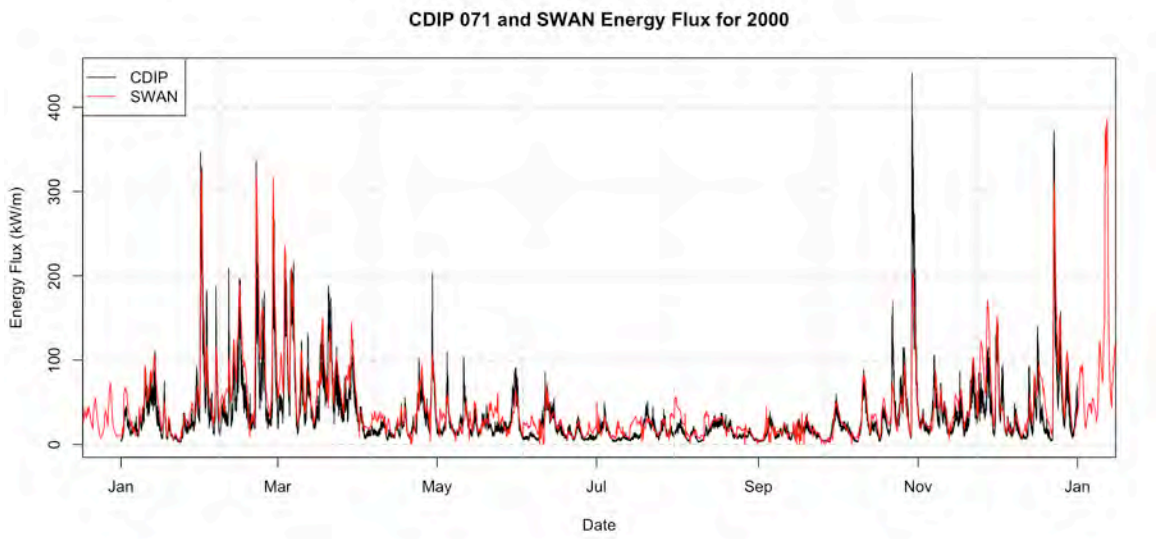


Figure 17: Energy flux from SWAN spectra versus observed spectra at CDIP 071.

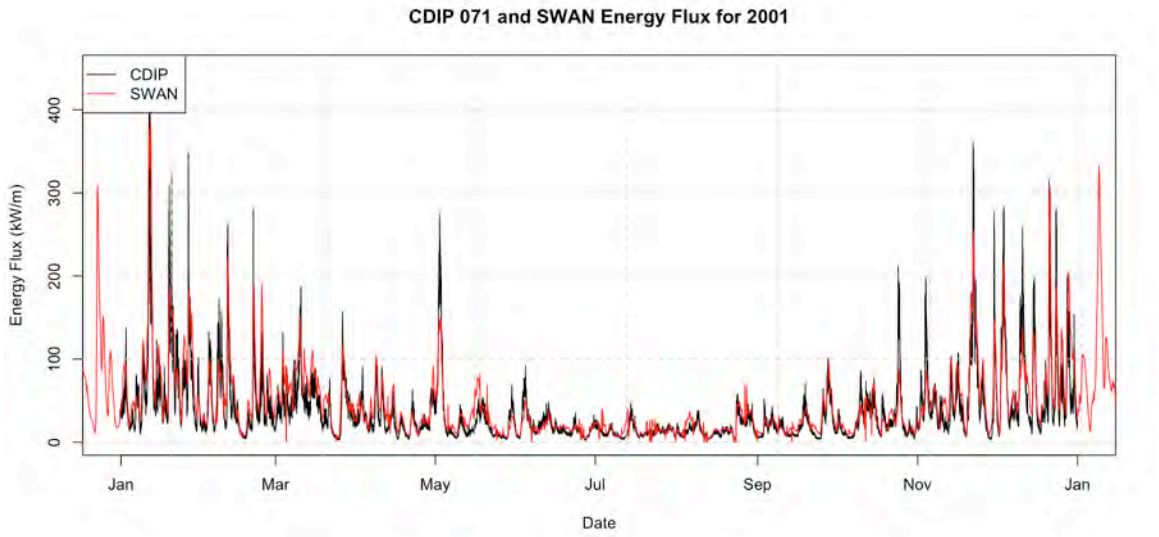


Figure 18: Energy flux from SWAN spectra versus observed spectra at CDIP 071.

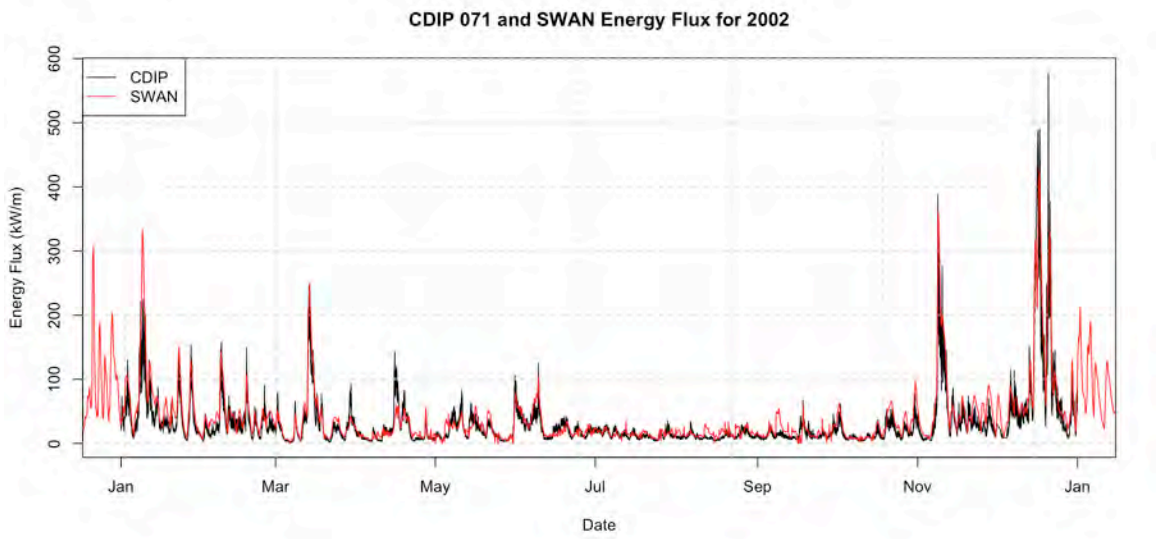


Figure 19: Energy flux from SWAN spectra versus observed spectra at CDIP 071.

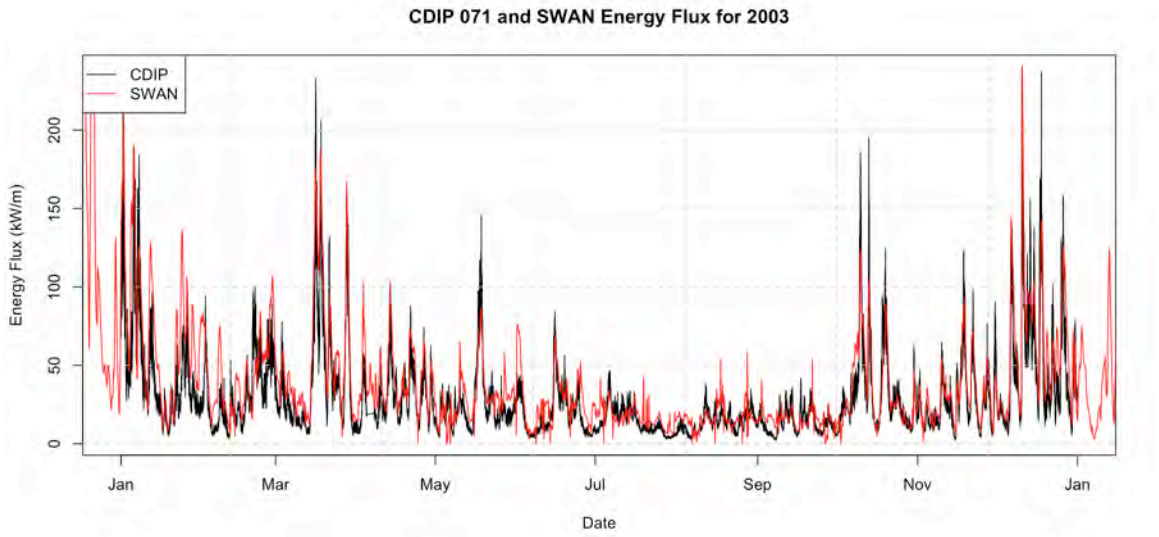


Figure 20: Energy flux from SWAN spectra versus observed spectra at CDIP 071.

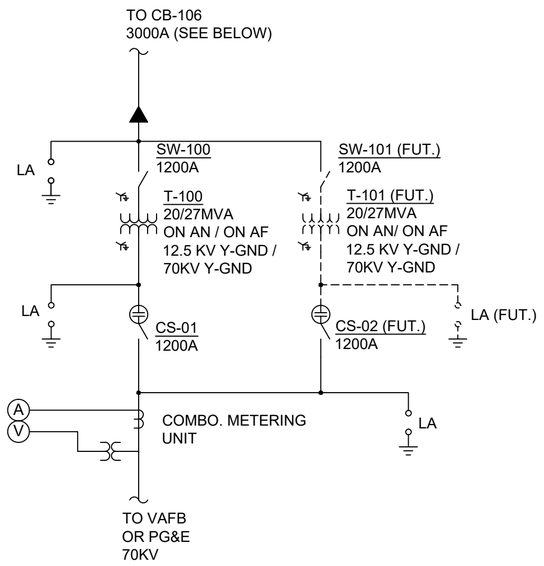
References

Arinaga, Randi A. and Kwok Fai Cheung (2012) Atlas of global wave energy from 10 years of reanalysis and hindcast data. Renewable Energy: 39 (2012) 49-64.

Dallman, A.R., Neary, V.S., Stephenson, M. (2014) Investigation of Spatial Variation of Sea States Offshore of Humboldt Bay, CA Using a Hindcast Model, SAND2014-18207. Sandia National Laboratories, Albuquerque, NM, 2014.

Garcia-Medina, Gabriel, H. Tuba Ozkan-Haller, and Peter Ruggiero (2014) Wave resource assessment in Oregon and southwest Washington, USA. Renewable Energy: 64 (2014) 203-214.

Appendix 7-1
Electrical Engineering Drawings

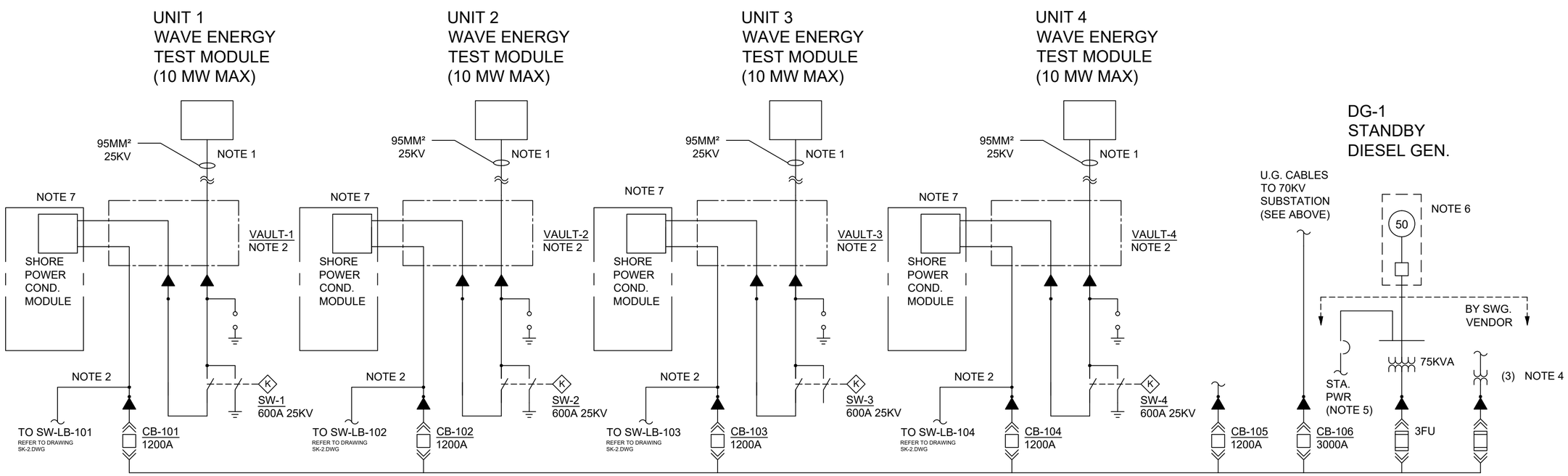


CALWAVE 70KV SUBSTATION SINGLE LINE DIAGRAM

SCALE: NONE

NOTES

1. OFFSHORE WAVE ENERGY SYSTEM IS RATED AT 10 MW MAXIMUM @ 0.8PF.
2. SPACE IS ALLOWED FOR (2) POSSIBLE FUTURE TRANSFORMERS FOR INPUT & OUTPUT OF SHORE POWER CONDITIONER, IF REQUIRED BY VENDOR EQUIPMENT.
3. (1) SPARE 3/C SUBMARINE CABLE NOT SHOWN FOR CLARITY.
4. PROTECTION, CONTROL & INSTRUMENTATION NOT SHOWN FOR CLARITY.
5. STATION POWER SERVICES LOCAL HVAC, BATTERY CHARGER, LIGHTING, UPS (IF REQ'D) & SHORE POWER.
6. DG-1 TO PROVIDE EXCITATION POWER FOR WAVE ENERGY SYSTEM FOR WAVE ENERGY MODULES, IF REQUIRED, TO ALLOW POSSIBLE ISLANDED OPERATION OF V.A.F.B. POWER SYSTEM.
7. SHORE POWER CONDITIONING MODULES TO BE 25KV IN / 12.5KV OUT, OR AS REQUIRED BY WEC SUPPLIER.



CALWAVE SHORE FACILITY SINGLE LINE DIAGRAM

SCALE: NONE

NO.	DATE	REVISION	BY
1	4/14/15	ISSUED FOR REVIEW & COMMENT	BVL
2	5/1/15	ISSUED FOR REVIEW & COMMENT	BVL

DWG TITLE

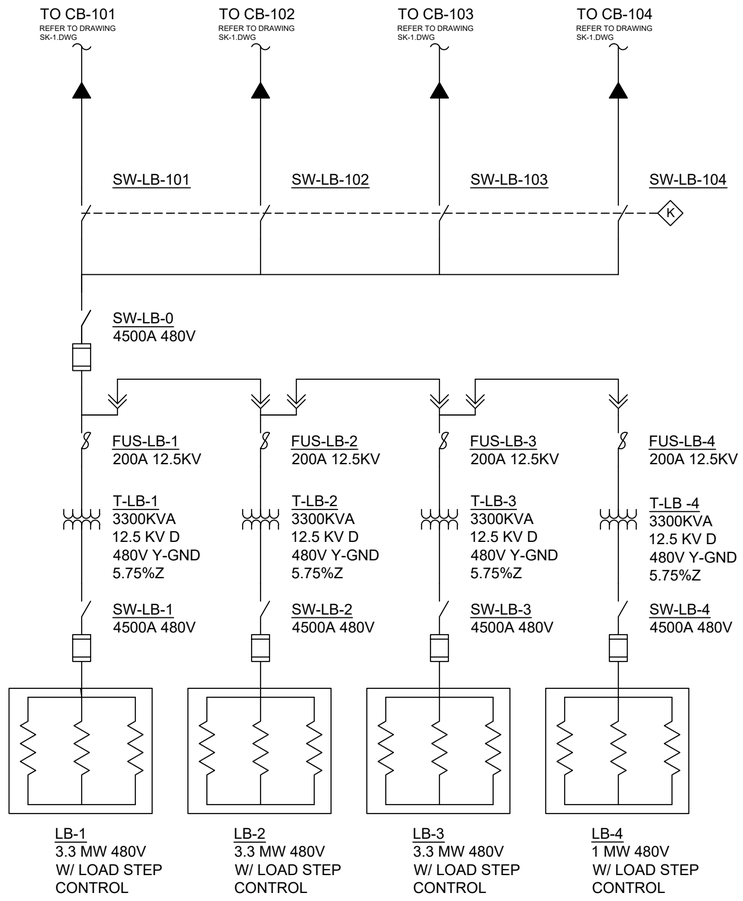
CALWAVE
SINGLE LINE

ENGINEER	CHECKED BY B. VANLOON
JOB NO	DRAWN BY B. VANLOON
SCALE No Scale	DATE 4/14/15
DWG NO SK-1	
SHEET NO	

CAD DWG FILE

NOTES

1.



CALWAVE LOAD BANK SINGLE LINE DIAGRAM

SCALE: NONE

NO.	DATE	REVISION	BY
1	5/5/2015	ISSUED FOR REVIEW & COMMENT	BVL

DWG TITLE

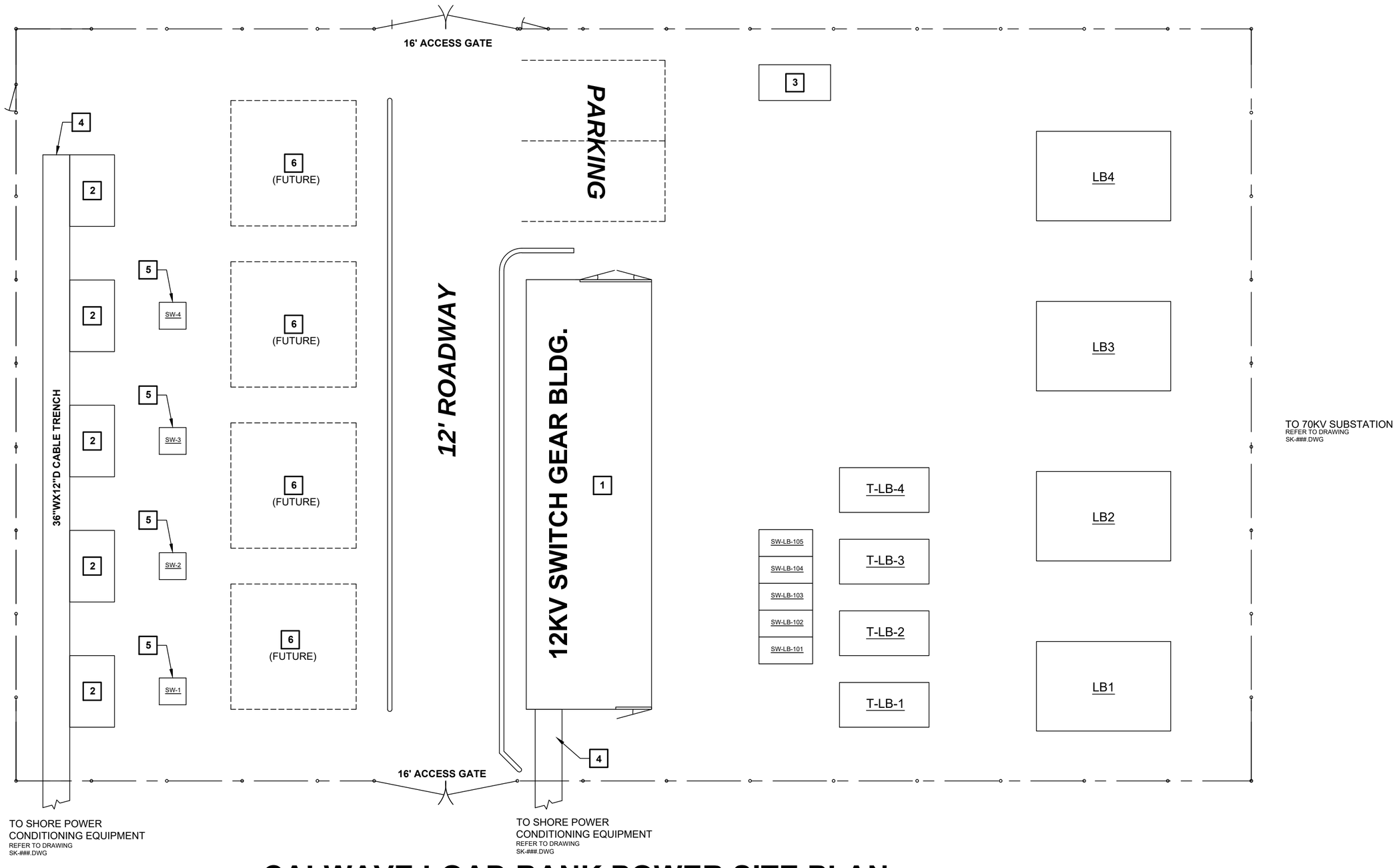
CALWAVE
LOAD BANK
SINGLE LINE

ENGINEER	CHECKED BY: B. VANLOON
JOB NO	DRAWN BY: B. VANLOON
SCALE: No Scale	DATE: 4/14/15
DWG NO: SK-2	
SHEET NO	

CAD DWG FILE

☐ REFERENCE NOTES

1. SWITCH GEAR BUILDING 14'WX48'LX10'H.
2. UNDER GROUND VAULT 6'WX8'LX8'D.
3. DIESEL GENERATOR SET 50KW 4'X8'.
4. CABLE TRENCH 36"WX12"D.
5. SW-1, SW-2, SW-3, SW-4 3'WX3'LX12'H.
6. TRANSFORMERS 14'WX14'LX14'H OUTSIDE DIMENSION INCLUDES OIL CONTAINMENT CURB (FUTURE IF REQUIRED).



CALWAVE LOAD BANK POWER SITE PLAN

SCALE: 1/4" - 2'-0"

NO.	DATE	REVISION	BY
1	5/5/15	ISSUED FOR REVIEW & COMMENT	BVL

DWG TITLE

CALWAVE
POWER SITE PLAN

ENGINEER
CHECKED BY B. VANLOON
JOB NO
DRAWN BY B. VANLOON
SCALE 1/4"–2'–0"
DATE 4/14/15
DWG NO SK–3
SHEET NO

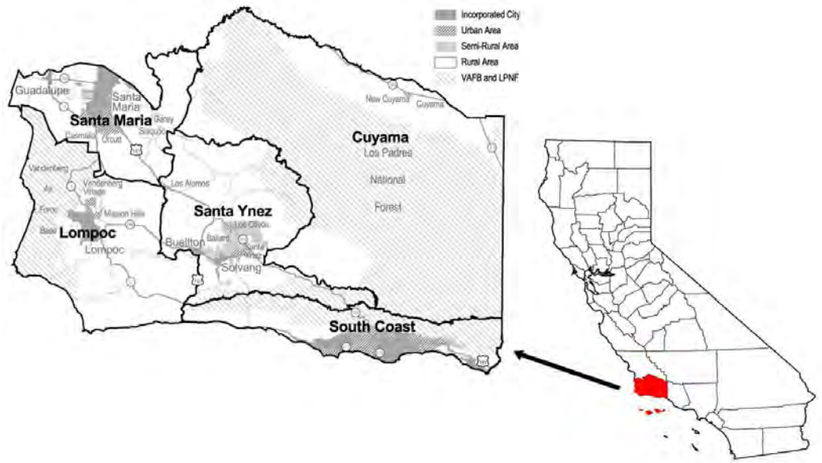
CAD DWG FILE

Appendix 7-2
Civil Engineering Drawings

Institute for Advanced Technology and Public Policy

NATIONAL WAVE ENERGY TEST FACILITY

June 2015



N **LOCATION MAP**

N **VICINITY MAP**

DRAWING INDEX

DESIGNATION	SHEET	DESCRIPTION
G-1	1 OF 8	COVER SHEET
C-1	2 OF 8	SITE PLAN 1
C-2	3 OF 8	SITE PLAN 2
C-3	4 OF 8	SITE PLAN 3
C-4	5 OF 8	SITE PLAN 4
C-5	6 OF 8	TOPO MAP
C-6	7 OF 8	SECTION
C-7	8 OF 8	ALT. DRILL SITE

THIS PROJECT REQUIRES A CLASS 'A'
GENERAL ENGINEERING CONTRACTORS LICENSE

FEASIBILITY STUDY
NOT FOR CONSTRUCTION

VANDENBERG AFB: CAL POLY CALWAVE PLANS

DRAWING TITLE:
COVER SHEET

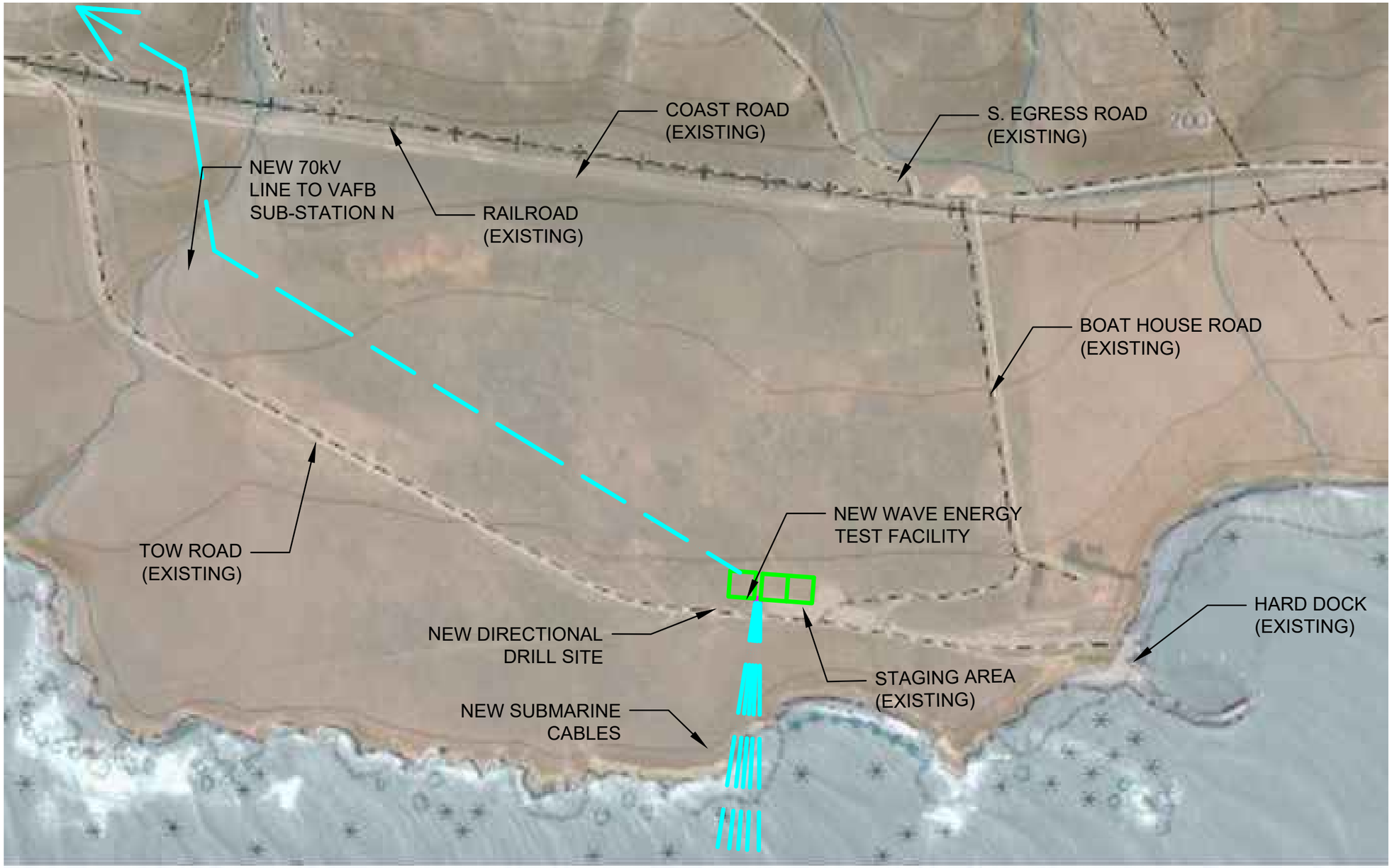
REVISION DATES:

SHEET NO.:
G-1

DRAWN BY:
KYLIN VAIL

DATE:
5/28/15

SCALE:



SITE
ELECTRICAL

N

0' 500' 1000'

CALWAVE CAL POLY

VANDENBERG AFB: CAL POLY CALWAVE PLANS

DRAWING TITLE:
SITE MAP 1

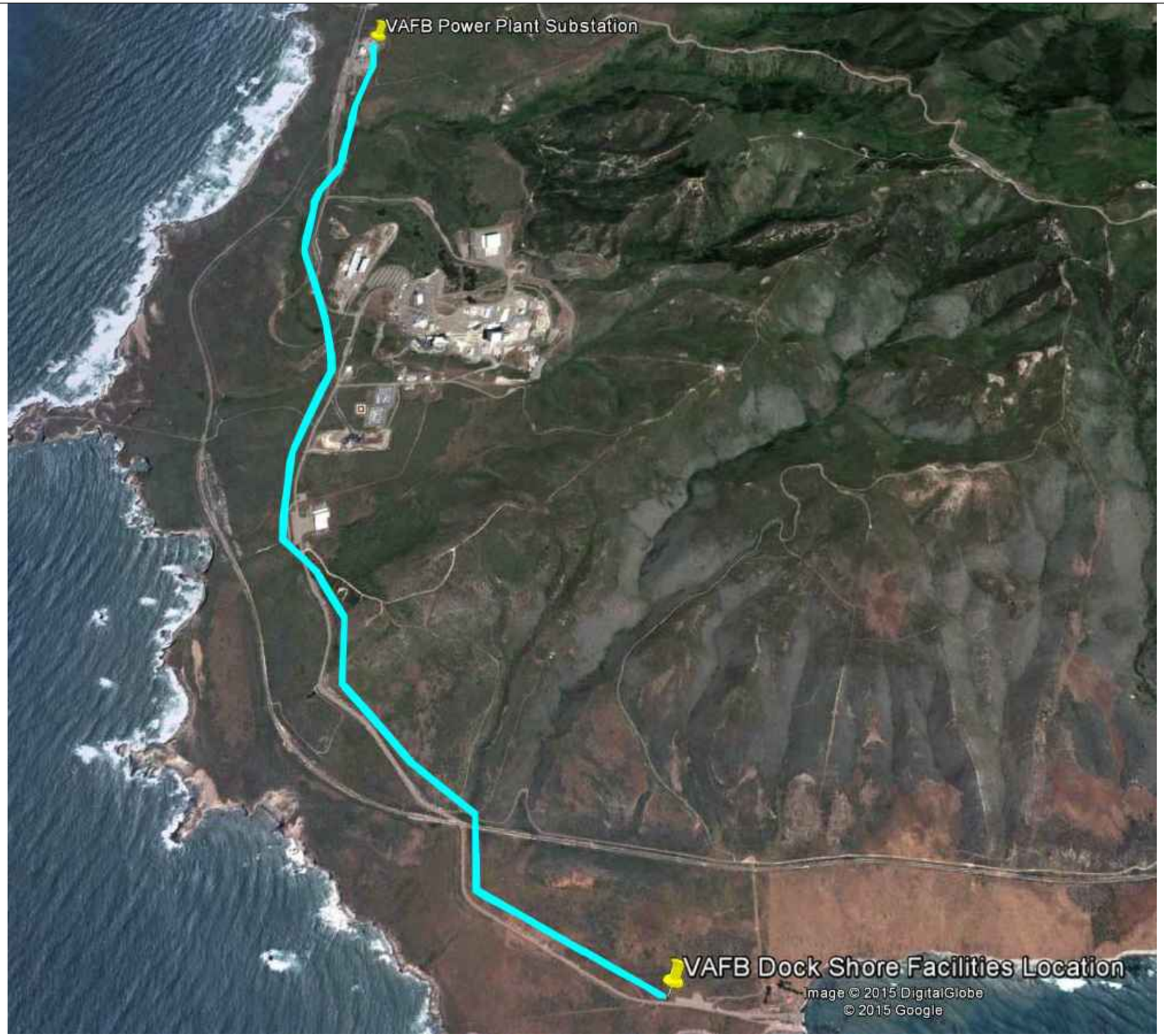
REVISION DATES:

SHEET NO.:
C-1

DRAWN BY:
KYLIN VAIL

DATE:
5/28/15

SCALE:
SEE MAP



DESCRIPTION:
NOTIONAL 70kV EXTENSION LINE ROUTE TO VAFB SUB-STATION N

APPROX. LENGTH OF EXTENSION LINE = 4 MILES

N

CalWave
Cal Poly

VANDENBERG AFB: CAL POLY CALWAVE PLANS

DRAWING TITLE:
SITE MAP 2

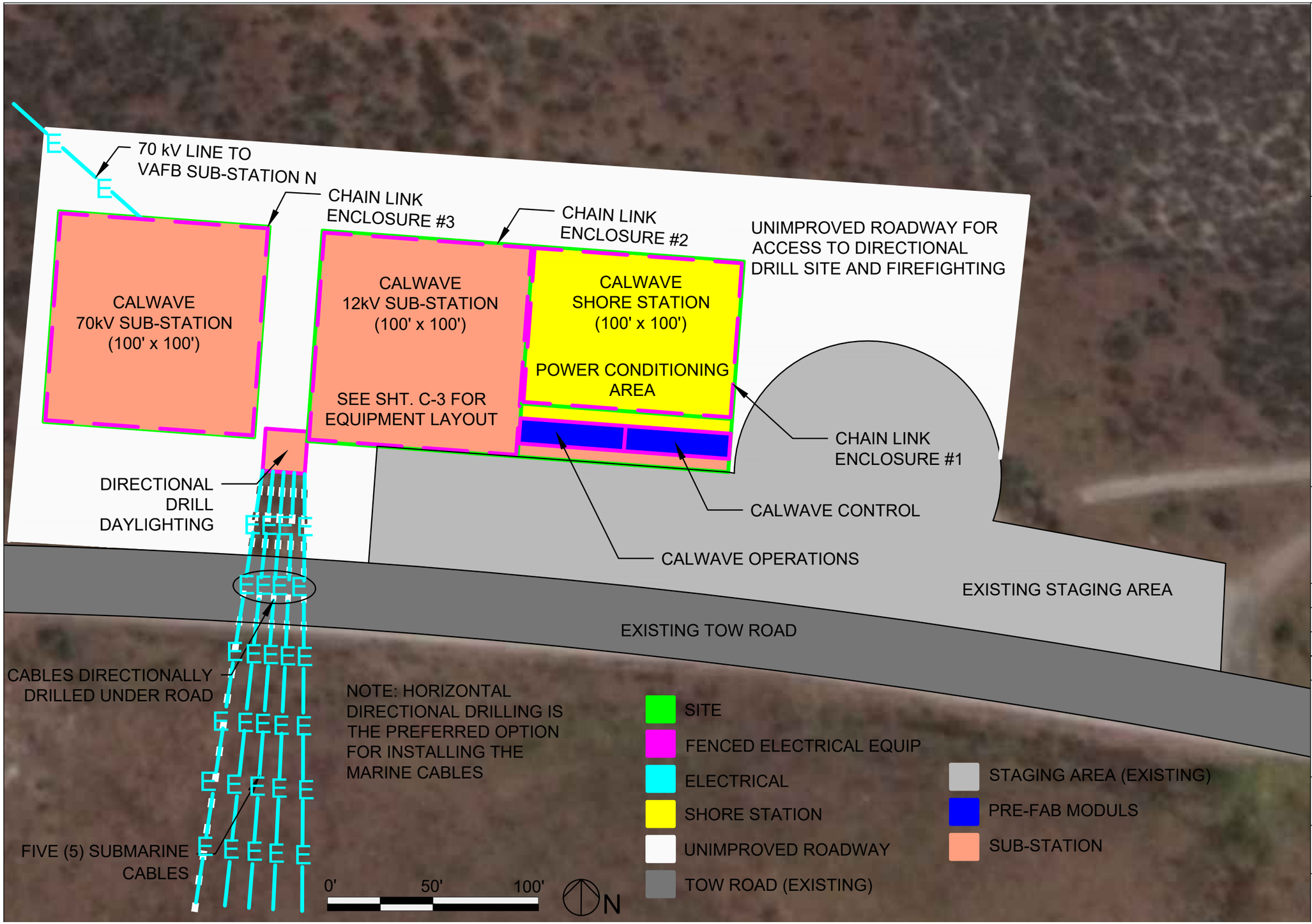
REVISION DATES:

SHEET NO.:
C-2

DRAWN BY:
KYLIN VAIL

DATE:
5/28/15

SCALE:
SEE MAP



CalWave
CalPoly

VANDENBERG AFB: CAL POLY CALWAVE PLANS

DRAWING TITLE:
SITE MAP 3

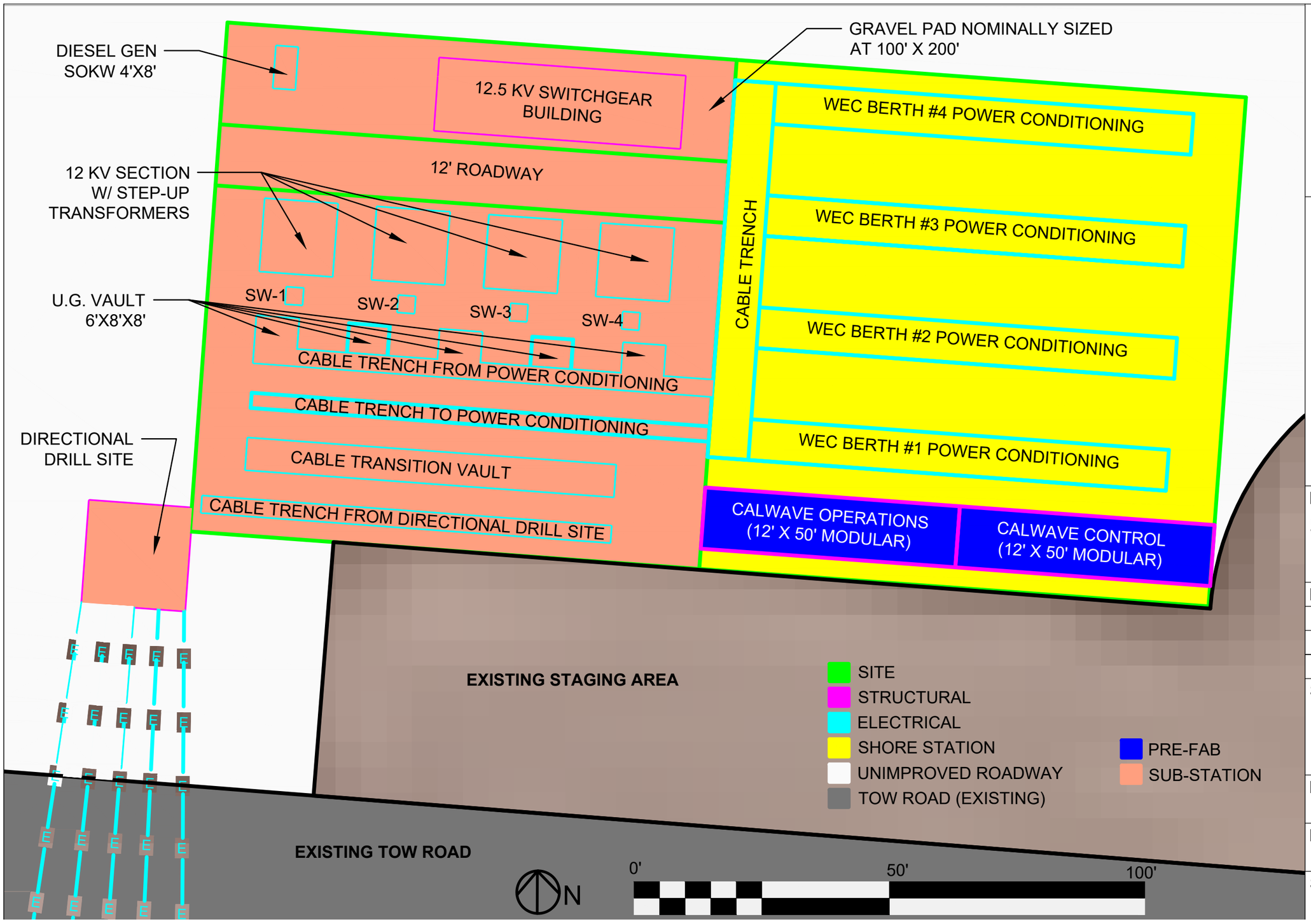
REVISION DATES:

SHEET NO.:
C-3

DRAWN BY:
KYLIN VAIL

DATE:
5/28/15

SCALE:
SEE MAP



CALWAVE CAL POLY

VANDENBERG AFB: CAL POLY CALWAVE PLANS

DRAWING TITLE:
SITE MAP 4

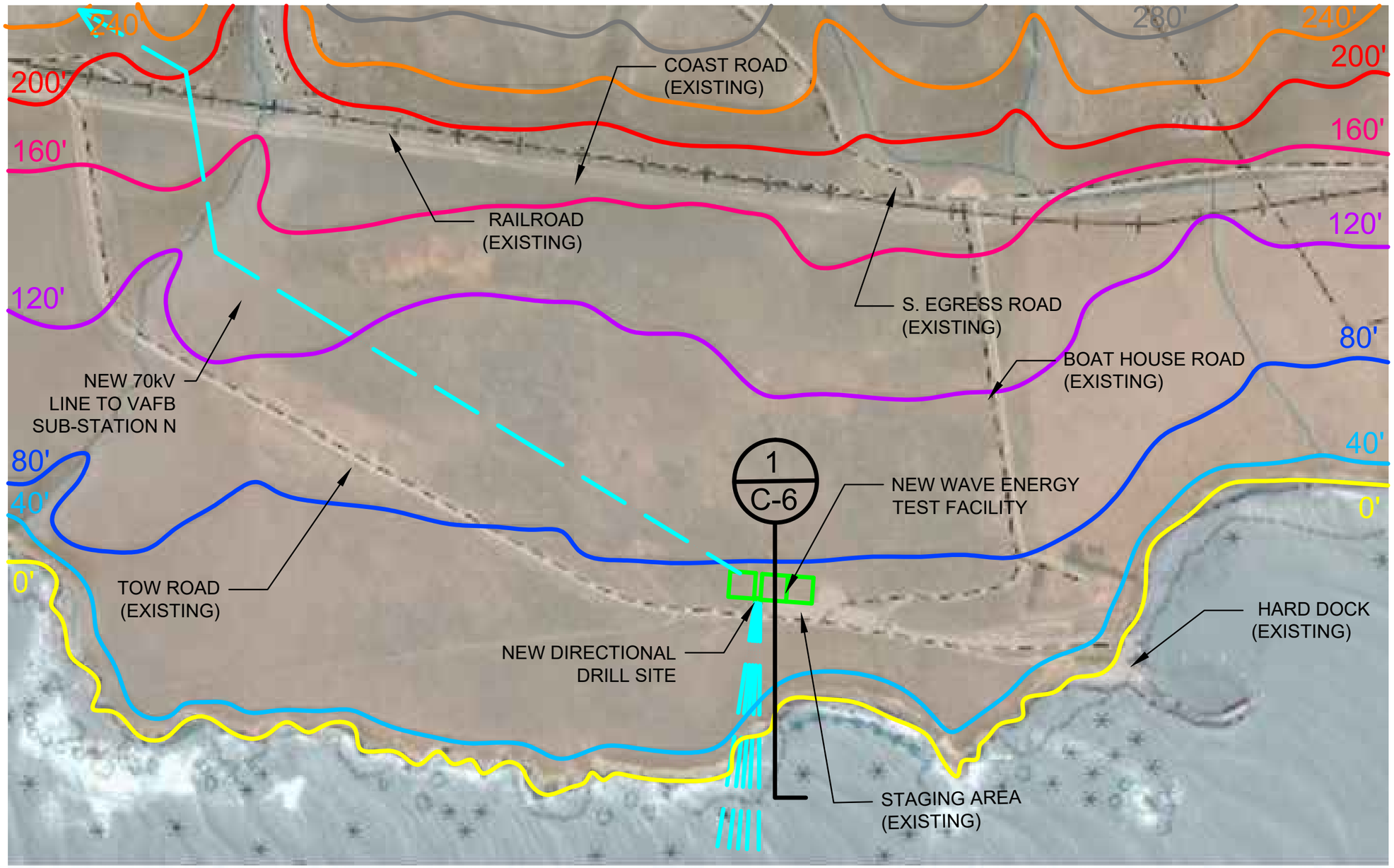
REVISION DATES:

SHEET NO.:
C-4

DRAWN BY:
KYLIN VAIL

DATE:
5/28/15

SCALE:
SEE MAP



SITE
ELECTRICAL

0'
40'
80'

120'
160'
200'

240'
280'

N

0' 500' 1000'

CAL WAVE
CAL POLY

VANDENBERG AFB: CAL POLY CALWAVE PLANS

DRAWING TITLE:
TOPO MAP

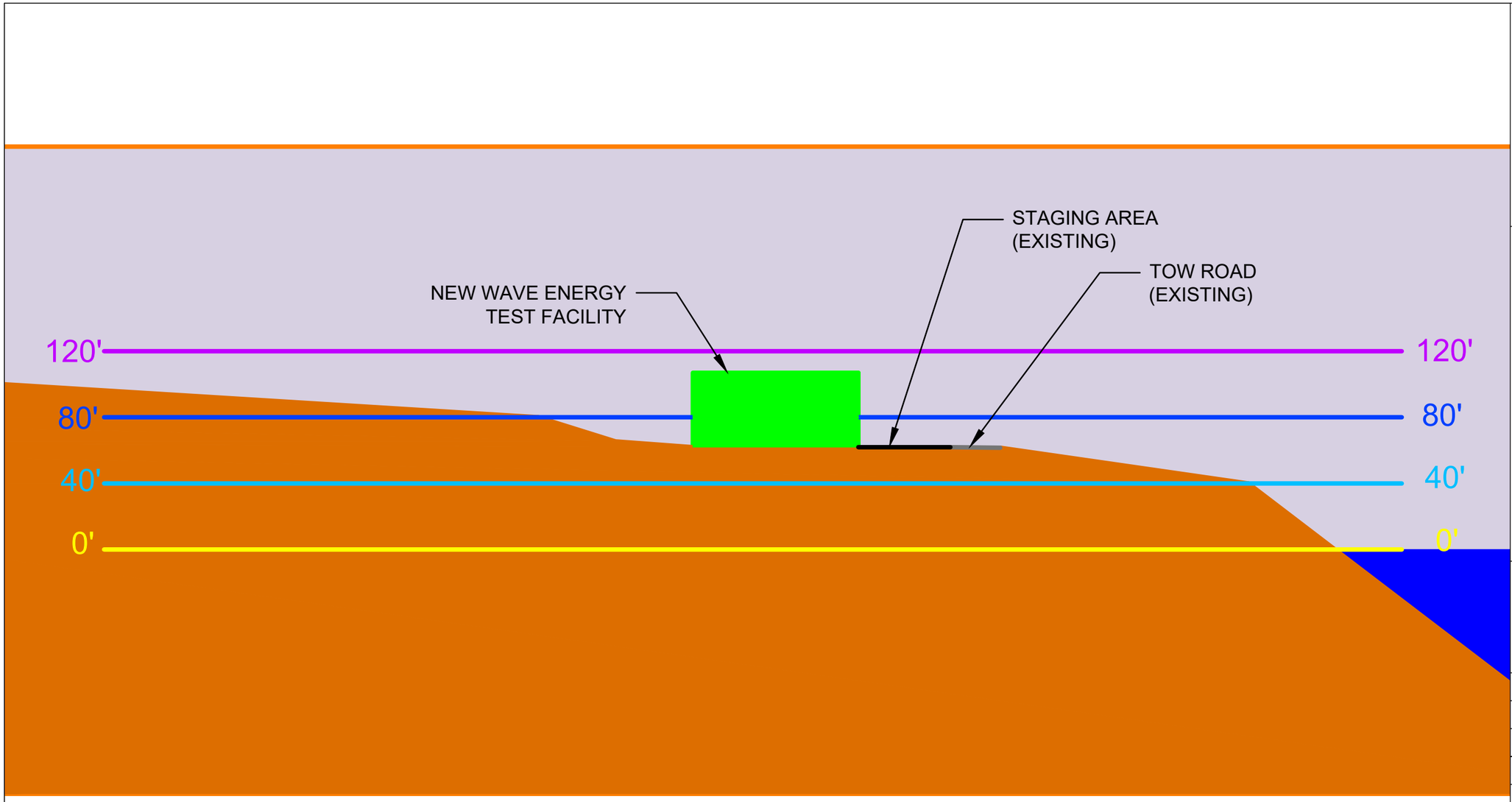
REVISION DATES:

SHEET NO.:
C-5

DRAWN BY:
KYLIN VAIL

DATE:
5/28/15

SCALE:
SEE MAP



SITE
TOW ROAD (EXISTING)
STAGING AREA (EXISTING)

0'
40'
80'

120'
GROUND
ABOVE GROUND

1/C-6 SECTION A

0' 50' 100'

N

CALWAVE CAL POLY

VANDENBERG AFB: CAL POLY CALWAVE PLANS

DRAWING TITLE:
SECTION

REVISION DATES:

SHEET NO.:
C-6

DRAWN BY:
KYLIN VAIL

DATE:
5/28/15

SCALE:
SEE MAP

CalWave
Cal Poly

VANDENBERG AFB: CAL POLY CALWAVE PLANS

DRAWING TITLE:
ALTERNATE DRILL SITE

REVISION DATES:

SHEET NO.:
C-7

DRAWN BY:
KYLIN VAIL

DATE:
5/28/15

SCALE:
SEE MAP

Appendix 7-3
Architectural Drawings

VANDENBERG ARCHITECTURAL INFLUENCE

June 2015

MARINER MISSILE DOCK

SITE PLAN

MARINER MISSILE DOCK

HISTORICAL BOATHOUSE

HISTORICAL BOATHOUSE

HISTORICAL BOATHOUSE

CalWave Cal Poly

VANDENBERG AFB: CAL POLY CALWAVE ARCHITECTURE

DRAWING TITLE:
ARCH. FACADE

REVISION DATES:

SHEET NO.:
A-1

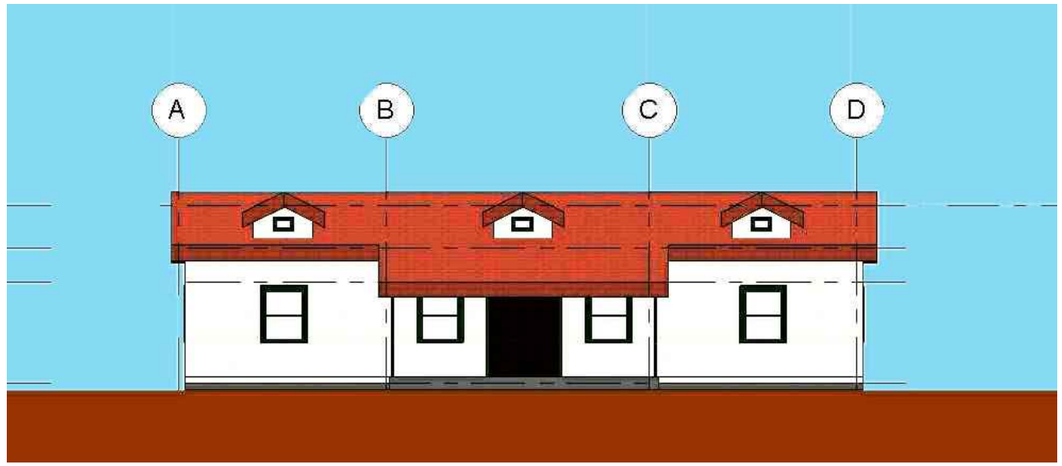
DRAWN BY:
KYLIN VAIL

DATE:
6/15/15

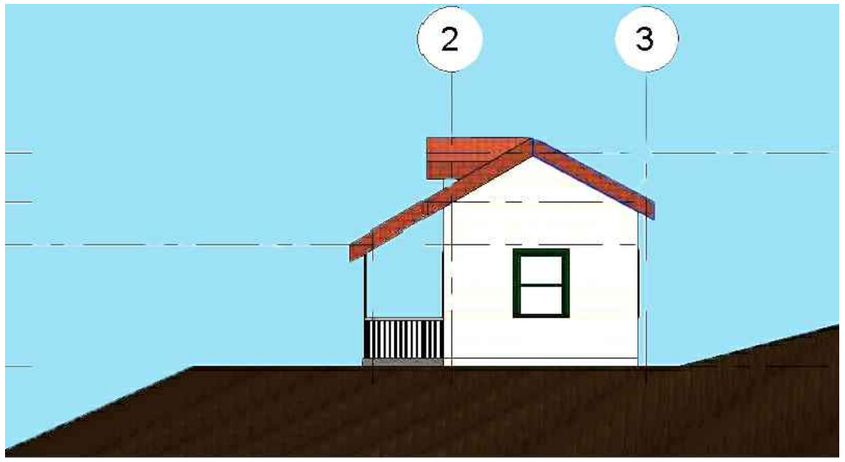
SCALE:

ARCHITECTURAL FAÇADE RENDERS

June 2015



SOUTH ELEVATION



EAST ELEVATION

3D VIEW

CALWAVE CAL POLY

VANDENBERG AFB: CAL POLY CALWAVE ARCHITECTURE

DRAWING TITLE:
ARCH. FACADE

REVISION DATES:

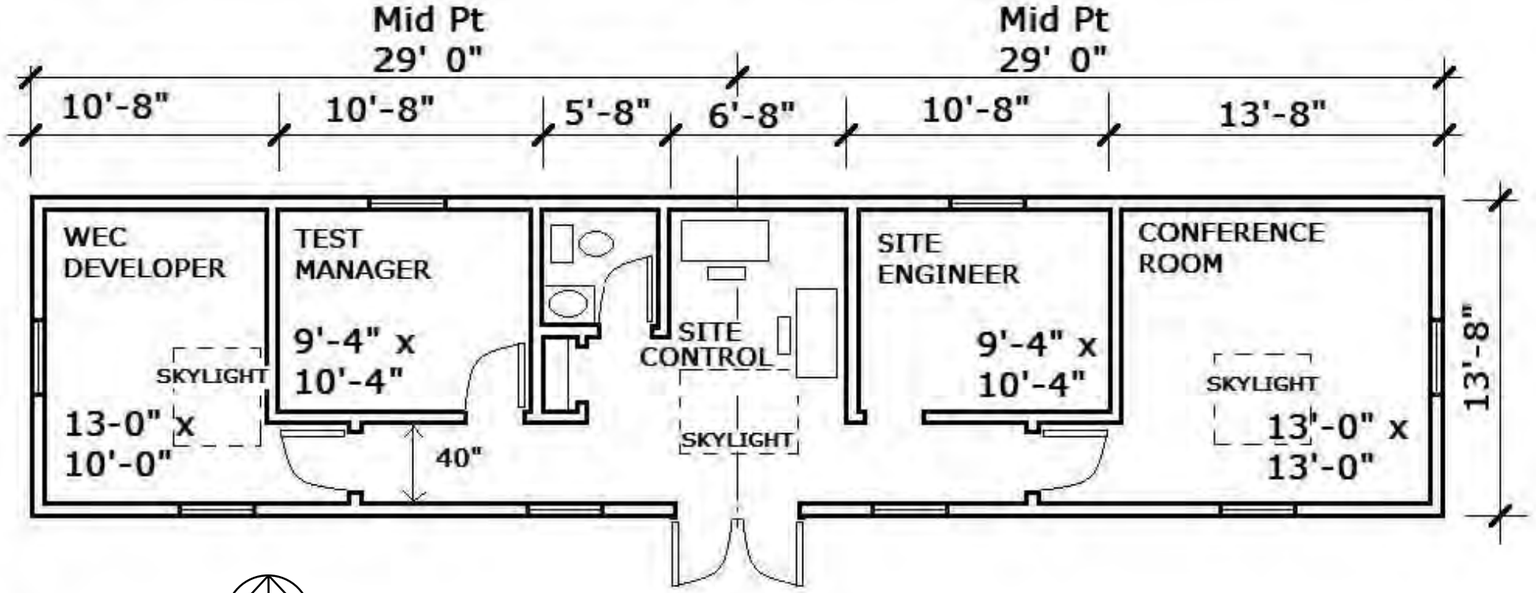
SHEET NO.:
A-2

DRAWN BY:
KYLIN VAIL

DATE:
6/15/15

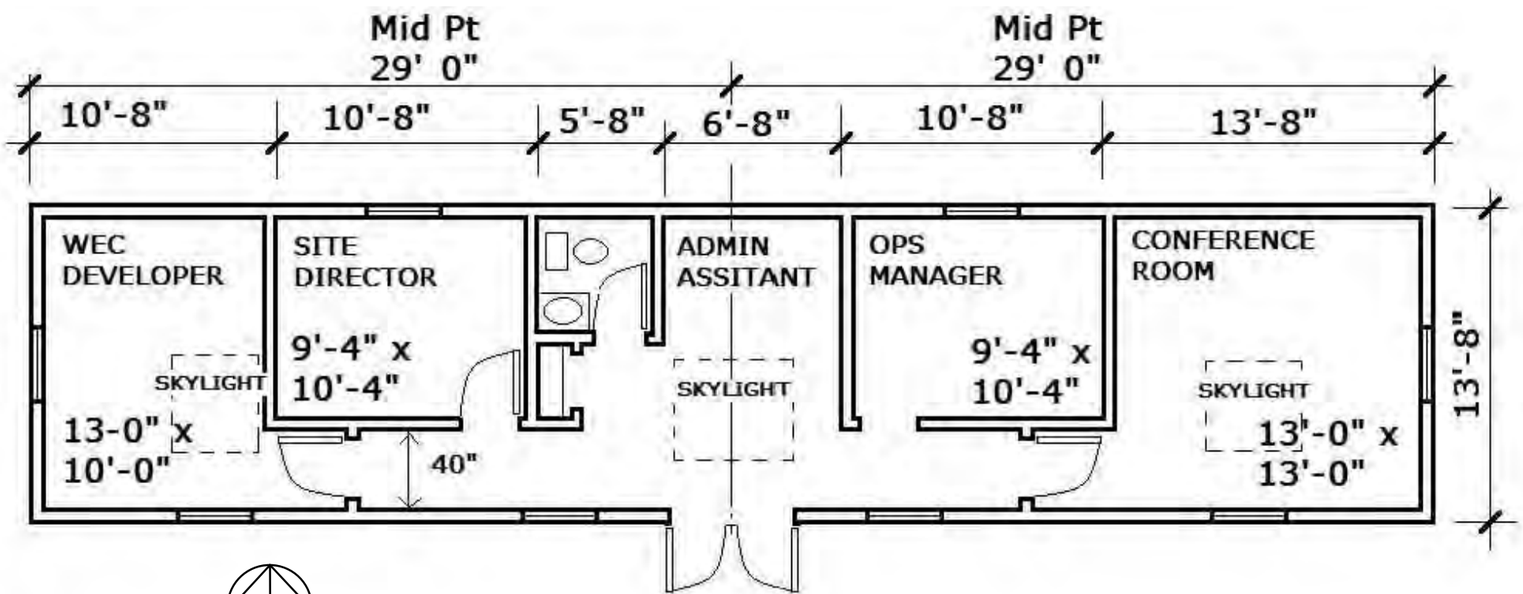
SCALE:

MODULAR FLOOR PLANS



N

EAST MODULAR FLOOR PLAN



N

WEST MODULAR FLOOR PLAN

VANDENBERG
AFB: CAL POLY
CALWAVE
ARCHITECTURE

DRAWING TITLE:
ARCH.
FACADE

REVISION DATES:

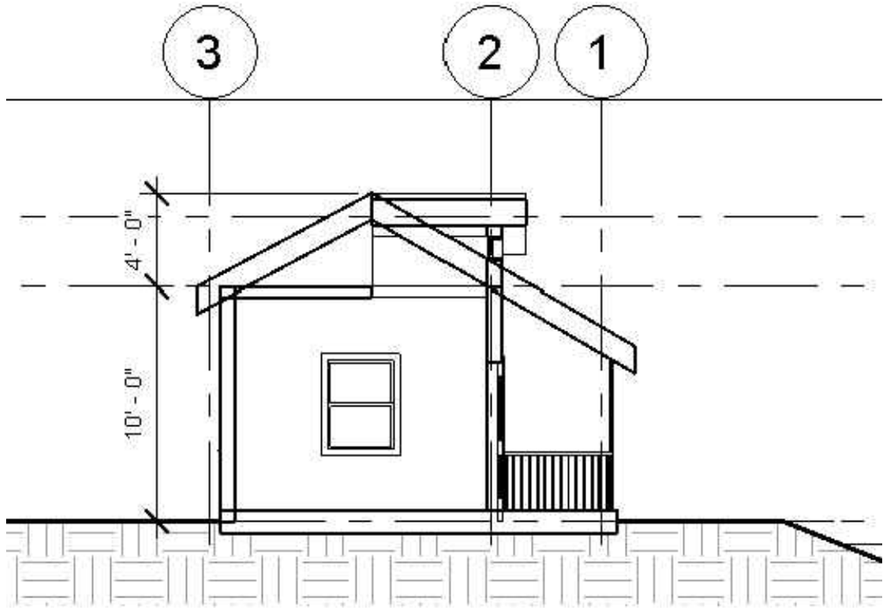
SHEET NO.:
A-3

DRAWN BY:
KYLIN VAIL

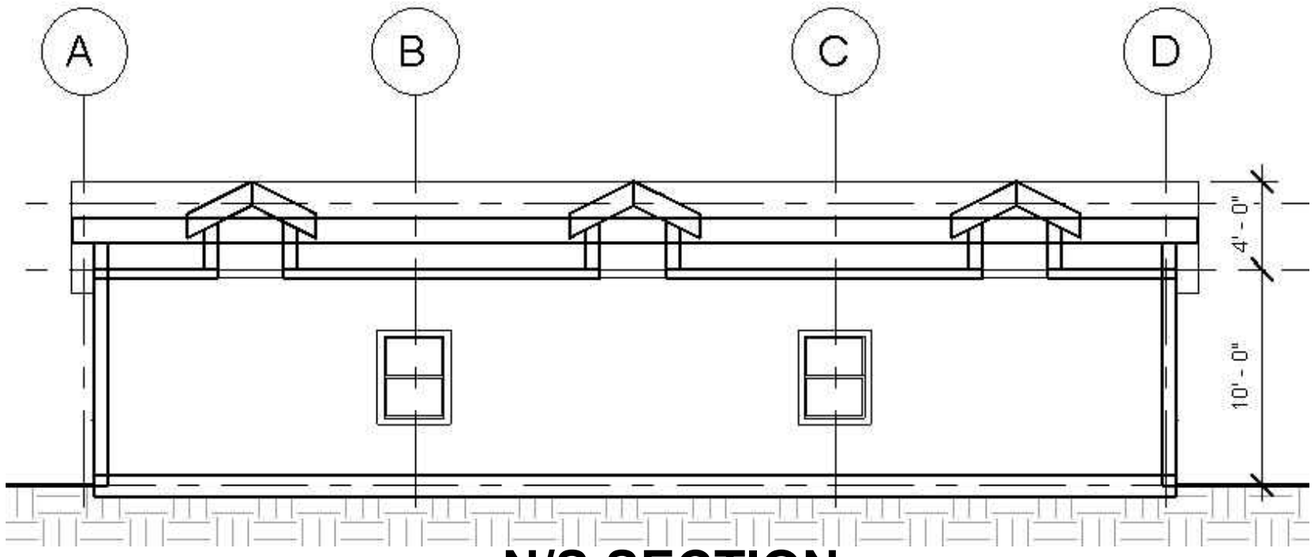
DATE:
6/15/15

SCALE:

SECTIONS



E/W SECTION



N/S SECTION

CALWAVE CAL POLY

VANDENBERG AFB: CAL POLY CALWAVE ARCHITECTURE

DRAWING TITLE:
ARCH.
FACADE

REVISION DATES:

SHEET NO.:
A-4

DRAWN BY:
KYLIN VAIL

DATE:
6/15/15

SCALE:

Appendix 8-1
Basis of Cost Estimate

APPENDIX 8-1A

Basis of Cost Estimate

The electrical requirements drove the site requirements. The electrical estimate was prepared for the shore facilities includes a 1.8% per year cost escalation, escalated 3 years from 2015. Other costs do not include this escalation.

Table 8-1/1 are the major scope areas of the estimate, and the contributors to the estimate:

TABLE 8-1/1
Major Scope Areas of, and Contributors to, the Estimate

Item	Scope Item	Included in estimate?	Lead Contributor
1	Shore Electrical Facilities including switchgear buildings, diesel generator, load banks (10MW), and interconnection facilities	Y	Omega
2	Site Civil & Structural works (site grading & foundations for shore electrical facilities, excluding 70 kV substation)	Y	Cal Poly, SLO
3	70 kV Substation to interconnect Shore Electrical Facilities	Y	Omega
4	70 kV Transmission Line	Y	Omega
5	Substation facilities at Vandenberg power plant substation	Y	Omega
6	Submarine Cables – 4 runs, + 1 spare	Y	PDC
7	Shore Power Conditioning facilities (equipment & facilities to condition power generated by wave energy devices)	N	-
8	Wave Energy Converter, anchoring and mooring, umbilical, services	N	-

1. Shore Electrical Facilities including switchgear buildings, diesel generator, load banks (10MW), and interconnection facilities to the local 12.5 kV distribution system for shore power.

   The anticipated sequence of development for the project will consist of an initial interconnection to the site 12.5 kV system. This interconnection is estimated to be able to accommodate approximately 2 MW of generation capacity. The 70 kV substation and transmission facilities (scope items 3, 4 and 5, below) may be deferred until such time as the interconnection capacity warrants this expenditure.

   The interconnection to the base 12.5 kV system adjacent to the west side of the site.

   Single line diagrams of these facilities are presented in Appendix 7-1 and a concept level General Arrangement is presented in Appendix 7-2. A conceptual layout of the Power and Control building is presented in Appendix 7-2.

2. Site Civil and Structural works (site grading & foundations for shore electrical facilities). This consists of site grading, concrete foundations and concrete slabs, and any administrative office buildings required to support the shore facility.

3. 70 kV Substation to interconnect Shore Electrical Facilities. A simplified single line diagram of this is presented in Appendix 7-1. This is arranged so that a transformer of approximately 50% of the ultimate capacity will be initially installed, with a second transformer installed as site capacity increases. It should be noted that the estimate does not include the cost of this future transformer and foundations.

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4. 70 kV Transmission Line. The possible upgrade of the existing 12 kV transmission line to 70 kV would follow a route similar to that presented in Figure 3-1 of the report. The structure would be a typical 70 kV Transmission Structure, Vertical Construction *(see USDA RUS Bulletin_1728F-810; wood construction, estimate basis spun concrete).*

   The 70 kV vertical construction is understood to be 477 kcmil Hawk conductor, spun concrete, with 12.5 kV #2 ACSR underbuild, built in new ROW. 2 road crossings, 3 medium angles (20 degrees) & 2 heavy angles, plus deadends are included with direct embedment in lieu of footings. Good access (within 100 yards of roadway the entire length) is assumed.

5. 70 kV Substation facilities at Vandenberg power plant substation. An additional substation bay with two breakers is proposed with associated buswork and steel structures & relaying. Adequate space appears to be available to the extreme left and in the center of the substation, assuming no major underground obstructions.

6. Submarine Cables – 4 runs, + 1 spare

   Four submarine cables have been assumed as included in the scope. This scope is articulated in the report by Power Delivery Consultants, Inc. (PDC), presented below. The cables come ashore in a concrete cable termination vault.

7. Shore Power Conditioning facilities

   These facilities are expected to be the responsibility of the Wave Energy Converter (WEC) vendor. They will stabilize the power and voltage as outputted by the WEC equipment to provide a stable generation source to the local Vandenberg 70 kV system.

The Electrical facility Estimate was prepared by: Omega Power Engineers, LLC, Randall M. Connett, CO PE #20658

TABLE 8.1/2
Electric Facility Estimate

Item	Initial Estimate	Notes: In coordination with Cal Poly
1. Submarine Cable facilities	Estimate for installation of 5 runs of submarine cable to one site, including directional boring from shore power facilities to point beyond surfline. Termination of each cable offshore.	Interconnection costs between all platforms, facilities to termination point of submarine cable (i.e. 'umbilicals'), cost of all offshore facilities not specifically mentioned.
2. Shore Power Facilities (not the power conditioning facilities)	Everything inside of fenceline, (including fencing) except as noted.	• Site civil/ rough & finish grading • Offsite utilities – water, sewer, etc. • Offsite access roads
3. Power Conditioning Facilities	• Gravel surfacing • Grounding • Fencing • Power connections to/from shore facilities • Allowance for PC modules	Site estimate, unless specifically noted to left
4. 70 kV substation	Allowance provided for all-in cost of substation, including all equipment,	• Site civil/ rough & finish grading • Offsite utilities – water, sewer, etc.

Draft

TABLE 8.1/2
Electric Facility Estimate

Item	Initial Estimate	Notes: In coordination with Cal Poly
	labor & construction inside of substation fenceline	• Offsite access roads – outside of fenceline
5. 70 kV Transmission line	Allowance of cost per mile for overhead line, standard construction.	• Destination Sub-Station N
6. Modifications to Power Plant Substation	Allowance for costs to add 1 bay to substation	

A8.1 Electrical Facilities Basis of Estimate

The cost estimate for this project is assumed to be a **Class 4** estimate as defined by the AACE. This estimate is assumed to have a tolerance of -30 to + 50%, due to the relatively low stage of development of engineering. As a result, scope increases may occur, resulting in cost increases.

The American Association of Cost Engineers (AACE) International Recommended Practice No. 18R-97 provides the matrix shown in Table A8-3:

TABLE 8-1/3
AACE Cost Estimate Classification Matrix for the Process Industries

	Primary Characteristic	Secondary Characteristic		
Estimate Class	**Maturity Level of Project Definition Deliverables - Expressed as % of complete definition**	**End Usage Typical - Purpose of estimate**	**Methodology - Typical estimating method**	**Expected Accuracy Range - Typical variation in low and high ranges [a]**
Class 5	0% to 2%	Concept screening	Capacity factored, parametric models, judgment, or analogy	-20% to -50% +30% to +100%
Class 4	1% to 15%	Study or feasibility	Equipment factored or parametric models	-15% to -30% +20% to +50%
Class 3	10% to 40%	Budget authorization or control	Semi-detailed unit costs with assembly level line items	-10% to -20% +10% to +30%
Class 2	30% to 75%	Control or bid/tender	Detailed unit cost with forced detailed take-off	-5% to -15% +5% to +20%
Class 1	65% to 100%	Check estimate or bid/tender	Detailed unit cost with detailed take-off	-3% to -10% +3% to +15%

A8.1.1 Structure and Format

The estimate is assembled into 33 Divisions, according to the Construction Standards Institute (CSI®) structure. Quantities were developed based upon the estimator's judgement in order to have a basis of estimate. These quantities are judged to be representative of the amount of the material required for

Draft

the installation of the engineered equipment noted, but does not imply that the project has matured to a level of detail beyond that noted below.

Each Division represents a craft specialty or a potential subcontract. Each Division captures the quantities of labor and materials required to perform the scope noted. Labor costs are developed as noted below. Costs expressed constitute only the 'direct' costs, and do not include construction contractor or subcontractor overheads, profits, or indirect costs.

Each line item in a Division contains the quantity of the items to perform the work, the unit material pricing, the labor hours to install the item, and the equipment costs. Equipment costs are to account for large equipment rental, such as cranes, excavation equipment, man lifts, etc.

Since this is primarily an electrical project, the estimate assumes the electrical contractor is the Prime, or General Contractor.

The following Divisions contain relevant portions of the Estimate:

TABLE 8-1/4
Divisions Pertaining to the Estimate

Division	Title	Remarks
2	General Requirements	Contractor field management
4	Concrete	Not Included – by others
26	Electrical	Bulk of work is included here
27	Communications	This contains an allowance for telephony equipment for site communications equipment
28	Electronic Safety & Security	This contains an allowance for security systems for the site.
31	Earthwork	Trenching for electrical installation only. Earthwork for site improvements, concrete foundations, etc. is not included & is estimated by others.
33	Utilities	70 kV Substation & Transmission line costs and costs of improvements at the receiving substation are captured here. These are all-in costs, including all concrete & civil works.

Other Divisions do not contain scope under this project, and are not presented.

A8.1.2 Assumptions and Estimate Basis

Following are discussions about assumptions affecting the estimate. The Shore Station estimate summary is found in Attachment 1 to this document. Additional detail is available on request.

Labor:

- Cost Adjustment for San Luis Obispo: +1.064 over national average
- Labor costs include benefits, supervision, small tools & consumables, crew truck, & 2 ton crane
- A 10 hour per day work day is assumed.
- 50% of labor is assumed to be traveler and is given a Per Diem of $100.00 per day.
- Craft labor reporting location is assumed to be at the Vandenberg Main Gate, with a 30 minute travel time to the project site, decreasing labor productivity (this is accounted for by increasing the hourly cost of labor by 10/9, or 11%).

Draft

Subsurface Conditions:

- Subsurface conditions assume no rock drilling or blasting for shore facilities
- Directional boring is assumed to be through very firm local sandstone.

Materials:

Where appropriate, vendor quotations were solicited for engineered equipment. For this estimate, quotations were solicited for the following:

- Power & Control Building, including switchgear & batteries
- Load Banks (3@ 3.33 MW)

Other material costs are as noted in RS Means, 2015.

- Sales Tax at a local rate of 8% has been applied to all materials and engineered equipment

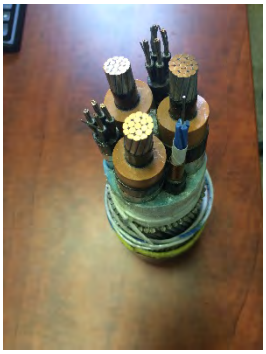
General:

- RS Means 2015 Electrical Cost Data was used as the basis for unit labor and material rates.
- Where items are noted as 'Allowance' the cost noted is an all-inclusive figure for costs not supported by a specific quantity takeoff, but are judged as reasonable in the opinion of the preparer.
- Costs are prepared as if construction were occurring in 2015, then overall escalation is applied for a construction start in year 2018 (**3 years**). Compounded annual escalation is assumed to be **1.8% per year, totaling 5.5%.**
- Foundation, excavating, drilling and concrete encasement costs are provided by others, unless specifically noted.
- Trenching costs for conduit & grounding are included.
- Cost of submarine cable, directional boring, and termination thereof are provided by others.
- No land acquisition, Right-of-Way, or permitting has been included
- No hazardous waste disposal is included
- Field Indirect costs are captured through additional General Contractor Overhead.
- A Performance & Payment Bond has been included at 1%
- A 10% owner contingency and 10% quantity contingency has been applied, totaling 20%.
- It is assumed in the submarine cable estimate that no sales tax is required, assuming that Calwave may be able to structure the contract delivery point so no tax is assessed, but this should be confirmed with appropriate entities.
- Permitting costs are not included in this estimate
- Land acquisition or Right-of-Way costs are not included.

A8.1.3 Submarine Cable Estimate – Power Delivery Consultants

PDC was requested by the CalWave team to develop design and high-level supply and installation costs for the inter-array submarine cables for the proposed project. The following work scope data has been provided as a basis for the cost estimates.

- ***Cable Specification***: Submarine cable, 3/c 25kV, EPR, 133% insulation, 'wet' design – 95mm^2 copper conductor, with two 600V class control quads & 1 fiber optic element installed in the intertices, as shown in the adjacent photograph.



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- ***Lengths***: The cable will commence at an on-shore vault then directional drill through 1,000 to 4000 linear feet of very firm sandstone and come up at a point beyond the surf line in about 30 to 50 feet of water, then an additional 5 miles out to the center of wave energy site in about 270 ft of water. Five cables are considered, four as active cables, with a fifth as a spare. The fifth cable will be sealed and laid on the seafloor for future use.
- ***Terminations***: There will be 5 cable vaults onshore to receive each cable (each initially estimated at 8 ft x 8 ft x 8 ft) through which the cable will be routed to an air termination on a switch stand. The stand will contain an air switch, a grounding switch, and a surge arrestor.
- ***Bathymetry & Ocean Bottom***: Assume sandy bottom and that the cables will either be surface lay or buried using water-jetting equipment.

Submarine Cable Design

The constructional details of the proposed submarine cable design developed by PDC are shown in Table 1. The cable weights in air and in water are estimated to be 14.2 kg/m (9.6 lbs/ft) and 8.8 kg/m (5.9 lbs/ft), respectively. The delivered power rating is up to 12.3 MW.

TABLE 8-1/5
Construction Detail of the Proposed 25 kV 10 MW 3/Core Submarine Cable

No.	Elements and Construction	Thickness (mils/mm)	Diameter (mils/mm)
1	Conductor: 95 mm	Plain copper wires	460/11.7
2	Conductor Screen:	Extruded compound 40/1.0	540/13.7
3	Insulation:	EPR "wet-design" 1902/48.3	1185/30.1
4	Insulation screen: specify	Extruded compound 50/1.25	1283/32.6
5	Metallic Tape Screens: specify or Metallic Sheath: specify	Tinned copper tapes 5/0.13	1299/33.0
6	Optical Element: outer diameter	-	
7	Two 600V Quad control elements	-	
8	Filler	Polypropylene	-
9	Synthetic Core Binder Tapes: specify	Synthetic tape	2843/72.2
10	Bedding Layer: specify	Polypropylene yarn 125/3.2	3094/78.6
11	Armor Wire Layer: specify no. and diameter or profile of wires	No. 45 2 round wires 197/5.0	3488/88.6
12	Serving: Layer of Polypropylene Yarn	157/4.0	3803/96.6

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Budgetary Cost Estimates

The following budgetary costs include Ex Works costs for the proposed cable design, as provided by suppliers. Estimates of the budgetary costs of submarine cable laying and burial costs and horizontal directional drilling have been provided by PDC:

TABLE 8/1-6
Cable Cost Estimate

Item	Cost Estimate
Ex Works cost of 29 miles (46.6 km) of submarine cable	$ 11.6 Million
Installation cost of 29 miles (46.6 km) submarine cable	$ 22.3 Million
HDD cost of 4-mile (6.4-km) bore, 14-in diameter, 8-in HDPE ducts:	$ 6.3 Million
Total Supply and Installation Budgetary Cost:	$ 40.2 Million

For comparison purposes, reference is made to two similar projects:

- Fundy Bay Tidal Energy Project, Nova Scotia, Canada: Fundy Ocean Research Centre for Energy (FORCE) has installed four 34.5 kV 3/core EPR wet-design cables in October 2014. The total length was 11 km (6.9 miles) and the reported cable supply and installation cost was $11 Million.
- Iberdrola Renovables Offshore Deutschland GmbH awarded a Wikinger Offshore Wind Farm (German Baltic Sea) contract in February 2015 for the supply and installation of 81 km of 33 kV 3/core submarine cables. The reported cost of the contract is 60 Million Euros ($67.8 Million)

The per cable-km costs are as follows:

- Calwave: $ 0.863 Million/km
- FORCE: $ 1.0 Million/km
- Wikinger: $ 0.837 Million/km

HDD Cost

A separate price quotation for a horizontal directional drill (HDD) of 1.4 miles was obtained from HDD, Inc. and is included as Attachment 2 to this Appendix, along with a profile drawing of a prospective HDD route.

Estimating

Attachment 3 to this Appendix is a sample cost estimating worksheet for electrical engineering.

Draft

ATTACHMENT 1

CONSTRUCTION COST ESTIMATE SUMMARY - CALWAVE SHORE STATION COMPONENT

OMEGA POWER ENGINEERS

Title:	**Feasability Stage Construction Cost Estimate-Class 4**			**Based on**
Facility:	**CalWave Shore Station Electrical Facilities**	**Estimated By:**	**R Connett**	**2% Design**
Project #	**Omega Project No 1505**	**Date:**	**5/27/2015**	**Sheet: 1of 27**

	PRIME CONTRACTOR					SUBCONTRACTOR					
DESCRIPTION	**MATERIAL**		**LABOR**		**EQUIPMENT**	**MATERIAL**		**LABOR**		**EQUIPMENT**	**TOTAL**
	%	**TOTAL**	**%**	**TOTAL**	**TOTAL**	**%**	**TOTAL**	**%**	**TOTAL**	**TOTAL**	
DIRECT COSTS		**1,863,429**		**880,270**	**4,600**		**3,009,877**		**1,714,512**	**184,750**	
Sales Tax-Material *	**8%**	**149,074**			**368**	**0**	**240,790**			**14,780**	
Labor Burdens (incuded):		-	-	-			-	-	-		
SUBTOTAL		**2,012,504**		**880,270**	**4,968**		**3,250,667**		**1,714,512**	**199,530**	
Overhead *	**10%**	**201,250**	**0**	**88,027**	**497**	**0**	**260,053**	**0**	**137,161**	**15,962**	
SUBTOTAL		**2,213,754**		**968,297**	**5,465**		**3,510,720**		**1,851,673**	**215,492**	
Profit *	**6%**	**132,825**	**0**	**58,098**	**328**	**0**	**210,643**	**0**	**111,100**	**12,930**	
SUBTOTAL		**2,346,579**		**1,026,395**	**5,793**		**3,721,363**		**1,962,773**	**228,422**	
Prime Commission on Sub *						**0**	**223,282**	**0**	**117,766**	**13,705**	
SUBTOTAL		**2,346,579**		**1,026,395**	**5,793**		**3,944,645**		**2,080,540**	**242,127**	**9,646,079**
Contingency (10% contractor, 10% owner)										20%	1,929,216
SUBTOTAL											**11,575,295**
Performance Bond *										1%	115,753
SUBTOTAL											**11,575,295**
Prof Services: Owner's Eng & Const Mgmt										10%	1,157,529
SUBTOTAL											**12,732,824**
Escalation * **YEAR:** **2018** (3 years)										5.5%	700,023
TOTAL ENGINEERING & CONSTRUCTION COST											**$13,432,848**
										Round off to:	**$ 13,400,000**

Labor Cost & Burdens Calculation:

National Cost (Means) 7 person crew, per day:	$	3,767	
Per labor-hour:	$	67.26	Includes benefits, supv, truck, 2T crane, small tools & consumables
Cost Adj for San Luis Obispo labor, (Means):		1.064	
Adjusted Hourly Rate:	$	71.57	
Average hours worked per day:		10	
Equiv. rate for 10 hour day:		78.72	Average cost per hr w/ OT
Reporting location @ V'Berg gate - add 1hour:	$	87.47	Cost includes travel time thru AFB
% of crew as travellers		50%	
Per Diem allowance for traveller labor (daily)	$	100.00	
Equivalent uplift per hour:	$	5.00	
ALL IN HOURLY RATE:	**$**	**92.47**	**Per hour**

THE HDD COMPANY

HEAD OFFICE
3161 Cameron Park Drive, Suite 215
Cameron Park, CA 95682
P. 530.676.5705 F. 530.676.3605
thehddcompany.com

June 19, 2015

Richard B. Williams, PMP
Chief Engineer, CalWave
Supporting Cal Poly, San Luis Obispo

Leidos Maritime Solutions
18000 S Shiloh Lane
Oregon City, OR 97045
(503) 484-4415

The HDD Company, Inc. is pleased to submit the following **budgetary** quote to Horizontal Directionally Drill and place approximately 7600 feet of a 14", SDR 9, HDPE pipe in five separate holes, each approximately 1500' feet long terminating offshore, at a site within Vandenberg AFB, CA.

Scope of The HDD Company Inc:

- Provide all required insurance coverages.
- Provide any written submittals and qualifications required.
- Provide a "maxi" drill rig with sufficient capabilities to install the outfalls, a "closed loop" mud system, mud pumps, vacuum trucks, dump trucks, and all support equipment necessary to install the outfalls (no marine support included).
- Locate and / or pothole all existing utilities in the immediate vicinity of the bores.
- Provide all required union labor for the drilling operations.
- Provide preliminary drawings and final as-built drawings.
- Provide stamped pipe stress and pullback analysis.
- Provide a stamped frac out analysis.
- Provide storage for water (for drilling operations)
- Provide, fuse and test the HDPE pipe.
- Provide manpower and equipment to assist marine contractor to tow pipe offshore for pullback.
- Provide 14" pulling heads.
- Provide and mix Rhodamine fluorescent dye with drilling fluids for offshore monitoring.
- Provide a bond at cost at 1.25%. (Bond NOT included in Bid Price).

Scope of Others

- Provide all necessary permits for the project.
- Establish entry points and provide coordinates for exit points.

- Provide an area adjacent to the shore line within 5 mile of the project site, to fuse the HDPE pipe in continuous strings.
- Provide water for drilling operations.
- Provide a semi level work pad large enough to support drilling equipment (approx.. 150' x 150')
- Provide offshore monitoring for fluorescent dye.
- Provide all final on-shore site restoration.
- Provide marine support, including but not limited to the following activities:
  - Excavate sump pits at each exit point to contain drilling fluids that escape from the holes (approx. 20' x 10' x 7' deep). Exact size TBD.
  - Containment and disposal of excavated material from sump pits.
  - Have divers verify actual exit point on each bore following bit exit.
  - Tow each ~1520' pipeline off shore, to project site and line up with bore-hole.
  - Tend the pipelines as they are towed to the site.
  - Sink the end of the HDPE and hook up to drill pipe in exit sump.
  - Divers to monitor the HDPE pipes as they are pulled into the hole.
  - Divers to assist with installation of pull cables in each pipeline.
  - Provide a barge to hold storage tanks for drilling fluids airlifted from sump pits.
  - Divers to assist with airlift of drilling fluids from sump pits, into storage tanks.

Lump Sum Quote: $ 2,800,000.00

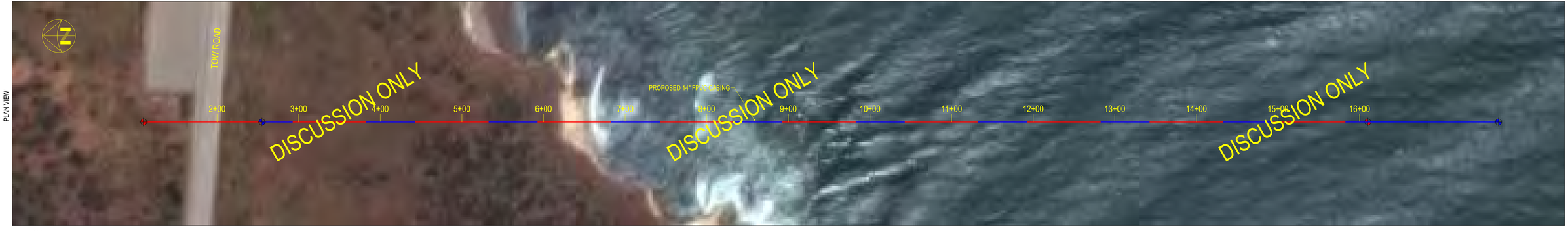
Notes:

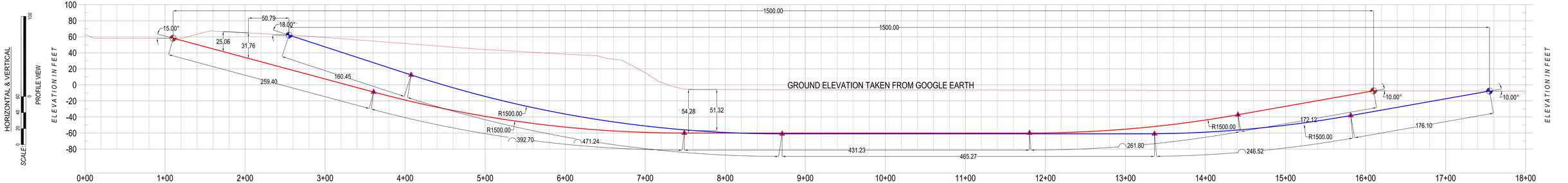
1. **Prices for all labor and materials were figured at current rates.**
2. **HDPE Pipe price was calculated at $1 per pound.**
3. **It was assumed that the use of excavated sump pits would be an agency requirement.**
4. **It was assumed that the use and monitoring of fluorescent dye in the drilling fluids would be an agency requirement.**
5. **Typically monitoring is done during the pilot hole drilling only. Not during reaming. Monitoring consists of towing a fluorimeter over and adjacent to each bore-hole alignment using a small vessel.**

The HDD Company, Inc. appreciates the opportunity to furnish you with a **budgetary** quote on this project and look forward to working with you further. Should any of the bid items or responsibilities above need further clarification, please do not hesitate to contact us.

Sincerely,
The HDD Company, Inc.

Rick Evans
V.P. Engineering/Estimating





NOTES:

1). HORIZONTAL DISTANCE IS THE DISTANCE FROM ENTRY POINT TO EXIT POINT.
2). ALL DISTANCES AND ELEVATIONS ARE APPROXIMATE AND FOR DISCUSSION ONLY
3). CURVE DISTANCE IS THE ACTUAL DISTANCE OF THE PLANNED CROSSING.
4). ALL DIMENSIONS TO CENTERLINE OF PIPE AS SHOWN.
5). ALL INFORMATION ON THE PLAN AND PROFILE VIEWS FOR OUR DRAWING WAS TAKEN FROM INFORMATION PER EMAIL BETWEEN R. EVANS AND R. WILLIAMS.

IMPORTANT:
Any drilling plans or profiles submitted by The HDD Company are based upon the design information in the contract documents and upon The HDD Company's knowledge and experience in addition to its operational expertise over the past three decades. However, The HDD Company and its personnel are not engineers. Therefore, any such plans or profiles submitted by The HDD Company are subject to review and approval by the Owner and/or the Owner's Engineers.

REV.	DATE	REVISION DESCRIPTION	CHK'D	BY	APP'D
0	6/18/15	PRODUCED DRAWING			

ENTRY - CURVE DATA		PROJECT INFORMATION		EXIT - CURVE DATA		ENTRY - CURVE DATA		PROJECT INFORMATION		EXIT - CURVE DATA	
ENTRY ANGLE	= 15.00°	PIPE DIAMETER	= 14" FPVC	EXIT ANGLE	= 10.00°	ENTRY ANGLE	= 18.00°	PIPE DIAMETER	= 14" FPVC	EXIT ANGLE	= 10.00°
ENTRY TANG.	= 259.40'	HORIZ. DISTANCE	= 1500.00'	EXIT TANG.	= 172.12'	ENTRY TANG.	= 160.45'	HORIZ. DISTANCE	= 1500.00'	EXIT TANG.	= 176.10'
ENTRY CURVE	= 392.70'	CURVE DISTANCE	= 1517.25'	EXIT CURVE	= 261.80'	ENTRY CURVE	= 471.24'	CURVE DISTANCE	= 1519.58'	EXIT CURVE	= 246.52'
HORIZ.-TANG.	= 431.23'	RUN CASING	=	HORIZ.-TANG.	= 431.23'	HORIZ.-TANG.	= 465.27'	RUN CASING	=	HORIZ.-TANG.	= 465.27'
RADIUS	= 1500.00'	SOIL DISTANCE	=	RADIUS	= 1500.00'	RADIUS	= 1500.00'	SOIL DISTANCE	=	RADIUS	= 1500.00'
F.31'	= 1.18"	ROCK DISTANCE	=	F.31'	= 1.18"	F.31'	= 1.18"	ROCK DISTANCE	=	F.31'	= 1.18"

JOB NO. | REVISION NO. 0 | DATE 18 JUNE 2015
DRAWN BY MPC | SCALE AS NOTED | SHEET NO. 1 OF 1 | DRAWING NO. 001
FILE NAME: 042-001 (1 Plan-Profile).dwg

- [X] FOR DISCUSSION ONLY
- [ ] APPRVD. FOR CONSTRUCTION
- [ ] AS - BUILT SUBMITTAL

DRAFTED BY / DATE | REVIEWED BY / DATE | APPROVED BY / DATE

THE HDD COMPANY

THE HDD COMPANY INC
2161 CASSILIS PARK DRIVE
UNIT 1
CAMERON PARK, CA. 95682
Phone: (530) 676-5705
Fax: (530) 676-5685
www.hddcompany.com

CLIENT: CALWAVE CALPOLY

OWNER:

CAL POLY - CALWAVE
NATIONAL WAVE ENERGY TEST FACILITY
VAFB SUBMARINE CABLES OUTFALLS
HDD PLAN-PROFILES

Appendix 8.1c

Example of Cost Estimating Take-off (Conceptual - Feasibility Study)

Title : CalWave
Location: South Base (Notional)

ITEM DESCRIPTION
Div.26-Electrical
SHORE POWER AREA
Grounding grid - Shore Power Facility, 10' grounding grid, 4/0 copper @ 12" depth
Ground rods-sectionalized, 10', 3/4" copperweld
Cadweld - cross
Cadweld - eqpt
Cadweld - ground rod
Fence grounding
Power Cable - 15 kV, 2/0 CU to load bank transformers
Equipment Ground - 2/0 bare cu 8' pigtail & connectors
15 kV Terminations - heat shrink
UG Conduit - 6" PVC to load bank transformers
Power Cable - 750 kcmil THWN CU to load banks (incl gnd)
Lugs - NEMA 2 hole for 750 kcmil
36" Cable Tray - Transformer to Load bank
Power Cable - 15 kV, 4/0 CU to Shore Pwr Conditioning Modules
Grounding conductor - 2/0 bare cu
15 kV Terminations - heat shrink
UG Conduit - 6" PVC to Trench
Conduit elbow - 90 sweep ell, 6" Galv
Conduit elbow - 90 sweep ell, 6", Galv - @ pwr condx
Other misc conduit fittings - allowance
Control Cable - 12/c#14 (Allowance)
Power cable - misc power, # 10 THW
P&C Conduit, 3", PVC below grade
P&C Conduit, 1", PVC, below grade
3" Conduit Elbows
1" Conduit Elbows
Diesel Generator
480 V power cable to diesel gen, #6
P&C Conduit, 3" to Diesel
Terminations - misc LV P&C
Air switch, 15 kV 1200A, w/ Ground sw & stand
Surge arrestor, 15 kV, Station class
Cable Trench, 36"
Fencing-Shore Power

Lighting (allowance)
Outdoor 15 kV Metal Enclosed gear, 6 bays
Load Bank, 3 MW
3300 kVA transformers, 12.5kV - 480v, pad mt
Power & Control Building - Includes 15 kV switchgear, battery room, batteries, protection & control devices , & 480 & 240/120v equipment, & int & ext lighting
75 kVA transformer, 12.5kV - 480v, pad mt
480 V power cable to/from xfrmr, 4/c #6
Power Cable - 15 kV, 2/0 CU to local OH dist system
Riser pole (Allowance) includes, guying, 60' class 2 pole, cable, arrestor & terminators
6" sleeve to outside fence
Commissioning (allowance)
Power Terminations, crimp, 600V, #8
Control Terminations, crimp, 600V, #12
SHORE POWER CONDITIONING AREA
Fencing-Shore Conditioning area
Shore Power Conditioning modules (Allowance - if not furnished by WEC supplier) - NOT INCLUDED
Enclosure for shore power conditioning - NOT INCLUDED
Grounding grid - Shore Power Condx area, 10' grounding grid, 4/0 copper @ 12" depth
Ground rods-sectionalized, 10', 3/4" copperweld
Cadweld - cross
Cadweld - eqpt
Cadweld - ground rod
Fencing-Shore Power Conditioning Area
Fence grounding
Div.33-Utilities
70 kV-12.5 kV Substation, including primary metering, steel structures, rigid aluminum buswork, (1) primary circuit switcher, (1) 20/26.7 MVA transformer with LTC & oil containment foundation, plus provision for 1 additional (future) transformer, incoming deadend structure, gravel surfacing, grounding grid, 8' high chain link fencing, (2) 16' vehicle gates, (1) 3' personnel gate, site lighting, intrusion detection & CCTV system. Protection & control & battery & control house NOT INCLUDED - included in adjacent shore power facility.
Secondary power cabling,15 kV, 750 kcmil CU 3 x 3 phase runs in UG duct
6" conduit, PVC
Conduit elbow - 90 sweep ell, 6" Galvanized
15 kV Terminations - heat shrink
Trenching-24"w x 36"D
Concrete encasement
Transmission line - 70 kV vertical construction, 477 kcmil Hawk conductor, spun concrete, with 12.5 kV #2 ACSR underbuild, built in new ROW. 2 road crossings, 3 medium angles (20 degrees) & 2 heavy angles, plus deadends are included direct embed. Good access (within 100 yards of roadway the entire length) is assumed.
Upgrade or demiolition of existing 12.5 kV #2 ACSR distribution line
Allowance for new substation bay at Power Plant sub (2 breakers @ 70 kV, 1 bay, + relaying, foundations, steel, & associated works)

Quarterly Technical Progress Report
(First Quarter)
COVER PAGE

Federal Agency to which Report is submitted: DOE EERE – Wind & Water Power Program

Recipient: Cal Poly Corporation; DUNS Number 02-932-6246
Award Number: DE-EE0006517
Project Title: California Wave Energy Test Center (CalWave)
Project Period: One year, June 1, 2014 to May 31, 2015

Principle Investigator: Sam Blakeslee; Director, Institute for Advanced Technology and Public Policy at California Polytechnic State University, San Luis Obispo, California;
email: sblakesl@calpoly.edu; Phone: (805) 756-1694.

Report Submitted by: William Toman; CalWave Project Manger;
email: wtoman@calpoly.edu; Phone: (707) 731-9261

Date of Report: November 4, 2014
Covering Period: June 1, 2014 to September 30, 2014 (1st Quarter)
DOE Funding Released: June 11, 2014
Report Frequency: Quarterly

Working Partners:
Vendors (F&A included as match)
Leidos (vendor); Rick Williams; richard.b.williams@leidos.com; (503) 484-4415
CH2M HILL (vendor); Doug Davy; Doug.Davy@ch2m.com; (916) 286-0278
Columbia Power Technologies (vendor); Reenst Lesemann; rlesemann@columbiapwr.com; (541) 368-5033

National Labs (F&A is not allowed)
National Renewable Energy Laboratory (NREL); Rick Driscoll; Frederick.Driscoll@nrel.gov; (303) 384-7153
Sandia National Laboratories; Rich Jepsen; rajepse@sandia.gov; (505) 284-2767

Subrecipient (F&A included as match)
Electric Power Research Institute (EPRI) (subaward); Paul Jacobson; pjacobson@epri.com; (410) 489-3675
Humboldt State University (subaward); Arne Jacobson; Arne.Jacobson@humboldt.edu; (707) 826-4302
Virginia Tech (subaward); George Hagerman; hagerman@vt.edu; (757) 340-1921
Scripps Institution Of Oceanography, UC San Diego (subaward); Julie Thomas; jot@cdip.ucsd.edu; (858) 534-3034

Consultants (F&A included as match)
William Lyte (consultant); wlyte@aol.com; (424) 477-7853

Cost-Sharing Partners:

Cal Poly Corporation
Columbia Power Technologies
William Lyte
Humboldt State Univ.
Virginia Tech

DOE Project Team: DOE HQ Program Manager – Jose Zayas
DOE Field Contract Officer – Pamela Brodie
DOE Field Grants Management Specialist – Yvette Peterson
DOE Field Project Officer – Tim Ramsey
DOE/CNJV Project Monitor – Andrew Buckspan

Signature of Submitting Official:

William Toman
CalWave Project Manager
California Polytechnic State University, San Luis Obispo, California

ACCOMPLISHMENTS

Project Objective:
Support the U.S. Department of Energy's Wind & Water Power Program with a yearlong study to identify and evaluate a primary offshore test site along California's coast, which may be suitable for the establishment of a national wave energy testing facility appropriate for Technical Readiness Level 8-9 (TRL) Wave Energy Converters (WECs).

Project Goals:

- Identification of a national test facility site that meets the resource and support criteria for testing full-scale WEC devices;
- Developing a preliminary facility design based on an evaluation of:
  - International WEC test facilities such as the European Marine Energy Center (EMEC) and the U.K. Wave Hub,
  - U.S. based WEC test facilities such as Marine Corps Base Hawaii (MCBH) and the Northwest National Marine Renewable Energy Center (NNMREC),
  - National Renewable Energy Laboratory's (NREL's) analogous National Wind Technology Center (NWTC), the TUV Rheinland Photovoltaic Testing Laboratory, and in service off-shore wind production facilities;
- Estimating the cost and schedule for site development and facility construction;
- Assessing the specifics and costs of the environmental studies and permitting that will be necessary to facilitate deployment of the above devices;
- Estimating the annual facility operating and maintenance cost; and
- Estimating the cost of testing and evaluating mechanisms for eventual cost recovery at the facility.

Goal Status:
Statement Of Proposed Objectives (SOPO) Task 1:
Develop and Use Criteria to Rank and Finalize Choice for Candidate Ocean Test Sites

Task 1 Result
The Vandenberg site was selected as the primary site for the CalWave study. The Humboldt site will serve as the alternate site[1].

Task 1 Activities
This task was to evaluate how the two proposed candidate study sites, the area offshore of Humboldt Bay in Humboldt County, CA (the Humboldt site) and the area offshore of Vandenberg Air Force Base in Santa Barbara County, CA (the Vandenberg site) in order to select which should be the primary site for focusing the remainder of the SOPO tasks and resources.

[1] S Blakeslee, *California Wave Energy Test Center (CalWave) Primary Site Decision, S Blakeslee [CalWave PI], 10-14-2014* (California Polytechnic State University, San Luis Obispo, California, October 2014)

Task 1 has 10 subtasks:

Task Number	Task or Subtask Title	Milestone Description
1.0	*Develop and Use Criteria to Rank and Finalize Choice for Candidate Ocean Test Sites*	Based on economic and rankings with inputs from Subtasks 1.1-1.10. ***Decision to Select Preferred Ocean Test Site***
1.1	*WEC design flexibility*	WEC RFI. Summary report of WEC needs and preferences. Specifics of WECs as needed for regulatory and permitting needs. Bathymetry data summarized. Report.
1.2	*Cable lay cost*	Estimation of cable costs, preparation of Cable Lay RFI. Report.
1.3	*Manufacturing / shipbuilding and infrastructure support ports*	Initial summary of infrastructure and support availability on West Coast. Report.
1.4	*Variability of sea states*	Statistical description of weather and sea states, estimates of power production. Report.
1.5	*Mooring costs*	Summary of mooring needs, costs, and safety estimates. Report.
1.6	*Accessibility for maintenance*	Description of maintenance support infrastructure and windows of O&M time. Report.
1.7	*Cost for grid interconnect and existing infrastructure*	Evaluation of existing and necessary electrical infrastructure and cost estimation. Report.
1.8	*Pre-existing EIRs to support regulatory and licensing efforts*	Survey of available data and support documents that can be used to assist CalWave teams in decision making. Report.
1.9	*Public acceptance*	Survey of available data and support documents showing major issues of concerns that can be used to assist CalWave teams in decision making, including outreach to stakeholders. Report.
1.10	*Long-term growth potential*	Assessment of long term growth potential based on Subtasks 1.1-1.9. Report.

A siting subcommittee made up of Sandia National Laboratories (SNL), National Renewable Energy Laboratory (NREL), and the Electric Power Research Institute (EPRI) was formed to review the preliminary site characterization findings provided by the CalWave team for both the

Humboldt and Vandenberg sites and to recommend the primary site to focus deeper characterization efforts.[2]

"The CalWave team collaboratively developed a scoring matrix that considered twenty site characteristic items, guidelines for score selection, and weighted the score for each item based on their relative importance. For each site, only areas in federal waters were considered for development and since the Vandenberg site is in close proximity to offshore oil and gas platforms with electrical cables running to shore two Vandenberg scenarios were considered, with and without access to an electrical cable, for a total of three scenarios evaluated. The CalWave team then collaboratively populated the scoring matrix for the Humboldt site and Vandenberg site with and without access to a shore run electrical cable.

A panel of SNL, NREL and EPRI staff participated in the CalWave team weekly calls to develop the selection criteria and has reviewed the scoring matrix with the associated justifications that has been accomplished to date in order to rate the two sites of interest, near Humboldt and Vandenberg, CA. The review panel comments will be categorized in two topic areas. The first and foremost topic area directly addresses the scope of the work for this particular project to evaluate the scoring matrix for the purposes of primary site selection. The secondary comments are related to the value of this work with regard to other DOE Water Power applications beyond the scope of the work here. Specifically, the panel sees strong potential for the site scoring framework to be adopted as a means to evaluate wave energy sites nationally and globally.

For the scoring matrix results, the review finds that the method of using weighted scoring was beneficial and the overall outcome has come to a reasonable conclusion that, although the Humboldt site has many attractive qualities, the Vandenberg site is more suitable for a WEC test center. There are several specific comments and recommendations related to each scoring item that are represented in the summary table. The review also recommends developing a general summary of findings for each category, especially if this information is going to be presented to DOE or outside review."[3]

The site scoring matrix originally considered six siting scenarios,

a. Humboldt, State Waters (within 3 nm of shore)
b. Humboldt, Federal Waters (greater than 3 nm from shore)
c. Vandenberg with access to Platform Irene infrastructure[4], State Waters
d. Vandenberg without access to Platform Irene infrastructure, State Waters
e. Vandenberg with access to Platform Irene infrastructure, Federal Waters
f. Vandenberg without access to Platform Irene infrastructure, Federal Waters

[2] R Jepson, *CalWave subcommittee review report 10_8* (Sandia National Laboratory, October, 2014)
[3] R Jepson, *CalWave subcommittee report*
[4] Platform Irene is an existing oil and gas drilling platform located in Federal waters offshore of Vandenberg Air Force Base. Its integrated electric infrastructure consists of the platform electric system itself, a submarine power cable connecting it to an onshore electric substation which ties directly into the regional grid. Platform Irene's infrastructure is privately owned and permission to co-use it will need to be secured in the future.

Examination of the water depths that some WECs may require for deployment and testing at CalWave revealed that there was nowhere in either sites' State waters region that had depths of at least 120 m, which the team judged as a necessity whereas both sites had contiguous stretches of seabottom in Federal waters which could accommodate four test berths with depths between 75 m and 120 m within 8 nm of shore. Therefore, consideration the State waters scenarios was eliminated.

A summary of the results of the CalWave site evaluation matrix is found in Table 1.

Table 1, CalWave Site Evaluation Matrix

	Site Requirements	Scoring Guidelines 0 to 2	3 to 6	7 to 10	Reqt Wtd Factor (0 to 10)	Humb Fed'l	VAFB w/ P,C&SS Fed'l	VAFB No P,C&SS Fed'l
1	Wave energy resource for a test center, Pmin 30 KW/m, months per year	Wave energy flux 10 to 100 kW/m < 5,000 hrs/yr	Wave energy flux 10 to 100 kW/m 5,000 to 7,000 hrs/yr	Wave energy flux 10 to 100 kW/m > 7,000 hrs/yr	7.9	8	8	8
2	Variability of sea states for a test center	Hs < 1.5 m for two or more days in a row < 20 times/year	Hs < 1.5 m for two or more days in a row 20 to 40 times/year	Hs < 1.5 m for two or more days in a row > 40 times/year	5.6	8	6	6
3a	3a - Flexibility to accommodate different WEC designs, compactness for a range of depths >75m	4 x 1,000 m diameter circular bays facing incident waves would fit within > 5 sq nm or cannot be fit at all	4 x 1,000 m diameter circular bays can be fit facing incident waves within 5 sq nm	4 x 1,000 m diameter circular bays can be fit facing incident waves within 2.5 sq nm	4.8	8	6	6
3b	3b - Sea bottom terrain	Significant sloping, rocky, broken sea bottom	Modest sloping (depth gradient 15-30 m/km), mostly sandy sea bottom	Flat, sandy sea bottom (depth gradient < 15 m/km)	3.6	10	10	10
4	Extreme event design environment	offshore 100-yr Hs > 10m; high onshore potential for ground shaking & tsunami inundation	offshore 100-yr Hs 8 to 10m; high onshore potential for ground shaking & tsunami inundation	offshore 100-yr Hs < 8m; low onshore potential for ground shaking & tsunami inundation	2.0	4	6	6

5	Operations port suitability/capability and affordability of ocean engineering equipment	Piers exposed to incident weather and surge. Need to mob offload equipment (high capacity land cranes and floater cranes)from outside of region. Need to mob equipment (high capacity land cranes, floater cranes, and tugs) for transfer to ocean site outside of region.Expensive mob, day rates and demob due to no other entities using assets: Lack of large pier cranes. Lack of large land cranes. Lack of floater cranes. Lack of ocean-going tugs. Lack of crew boats and support vessels.	Piers protected from incident weather and surge. Availability of offload equipment in geographic region. Availability of equipment (high capacity land cranes, floater cranes, and tugs) for transfer to ocean site in geographic region.Less-expensive mobilization, day rates and demobilization due to few entities using assets: Large pier cranes in region. Large land cranes in region. Floater cranes in region. Ocean-going tugs in region. Crew boats and support vessels in region.	Piers protected from incident weather and surge. Multiple piers. Reinforced piers. Installed pier cranes. Availability of offload equipment in local area. Availability of equipment (high capacity land cranes, floater cranes, and tugs) for transfer to ocean site in local area. Affordable mob, day rates and demob, with multiple entities using assets, due to: Large pier cranes in local area. Large land cranes in local area. Floater cranes in local area. Ocean-going tugs in local area. Crew boats and support vessels in local area.	6.6	**3**	**6**	**6**

6	Operations port proximity and ability to accomplish tasks in a day charter	Requires 16 hr or overnight tug and tow charter to transit, conduct 4 hrs on-site services, and return. Requires 16 hr or overnight tug charter to transit, conduct 4 hr on-site services, and return. Requires 16 hr or overnight monitoring boat charter to transit, conduct 4 hr on-site services, and return. Requires 16 hr or overnight crew boat charter to transit, conduct 4 hr on-site services, and return.	Requires 12 hr tug and tow charter to transit, conduct 4 hrs on-site services, and return. Requires 12 hr tug charter to transit, conduct 4 hr on-site services, and return. Requires 12 hr monitoring boat charter to transit, conduct 4 hrs on-site services, and return. Requires 12 hr crew boat charter to transit, conduct 4 hr on-site services, and return.	Ability to use 8 hr tug and tow charter to transit, conduct 4 hrs on-site services, and return. Ability to use 8 hr tug charter to transit, conduct 4 hrs on-site services, and return. Ability to use 8 hr monitoring boat charter to transit, conduct 4 hrs on-site services, and return. Ability to use 8 hr crew boat charter to transit, conduct 4 hrs on-site services, and return.	5.4	**7**	**7**	**7**

7	Construction accessibility for both sea-based and shore-based infrastructure	Shore site inaccessible by large trucks and cranes. At-sea site close to restricted navigation area. Launch site constraints require large cranes or floater cranes that are not available in region.	Shore site accessible by large trucks and cranes with reinforcement. At-sea site stands off from restricted navigation area. Launch site able to use large cranes or floater cranes that are available in region.	Shore site routinely used by large trucks and cranes with reinforcement. At-sea site clear of restricted navigation area. Launch site routinely used by large cranes or floater cranes that are available in local area.	5.1	**3**	**9**	**9**
8	Regional heavy manufacturing / marine supply chain capability	light manufacturing	medium manufacturing	heavy marine manufacturing	4.8	**5**	**9**	**9**
9	Regional industrial marine support operations capability	Lack of heavy marine fabrication capability in region. Lack of marine hardware vendor. Lack of diesel/marine electrical/marine refrigeration service vendors.	Heavy marine fabrication capability in region. Marine hardware vendor in region. Diesel/marine electrical/marine refrigeration service vendors in region.	Heavy marine fabrication capability in local area. Marine hardware vendor in local area. Diesel/marine electrical/marine refrigeration service vendors in local area.	5.5	**2**	**8**	**8**
10	Certainty / length of regulatory and permitting pathway	poorly understood, potentially as lengthly as WaveConnect	somewhat understood, potentially faster than WaveConnect	fairly well understood, potentially faster than WaveConnect	5.1	**7**	**7**	**5**

11	Ease of interconnection for 30 MW	substantial upgrading	moderate upgrading	little upgrading	7.0	6	8	5
12	Power sales potential for 30 MW	**No Interest Identified:** No particular entity has been identified who may be interested in purchasing power from a wave energy test facility.	**Tentative Interest Identified:** One or more entities have been identified and have expressed some interest in the idea of purchasing power.	**Strong Interest Demonstrated:** One or more entities have expressed strong interest in purchasing power and have formally documented their interest.	5.5	7	10	10
13	Academic/research community proximity	Few to no discipline areas present on campus, with few to no faculty engaged in research relevant to marine energy.	Gaps in some discipline areas, or gaps in disciplines where faculty are engaged in research relevant to marine energy.	All discipline areas present on campus, with a faculty research community with capacity to engage in work related to marine energy in all areas.	2.2	9	9	9
14	Existing infrastructure for co-use, substation	no SS nearby	PG&E SS nearby	contracted private SS co-use	5.1	8	9	8
15	Existing infrastructure for co-use, submarine cable	no cable nearby	cable nearby, needs upgrading	cable nearby, no upgrading	5.9	0	9	0
16	Stakeholder support	substantial overlap with comm fishing	moderate overlap	little overlap	5.8	7	7	6

17	Site commercial buildout potential	no commercial interest	nearby FERC/BOEM process underway	FERC license issued	3.6	**3**	**8**	**8**
18	Ease of interconnection for 300 MW	substantial upgrading	moderate upgrading	little upgrading	3.1	**1**	**5**	**5**
19	Proximity to shipbuilding facility for WEC fabrication	Need to transport WECs from distant shipyards by land or sea. Constraints in land transport routes. Need to mobilize sea transport from outside of region.	Availability of shipyard facility in geographic region. Ability to move large loads on land transport routes. Availability of sea transport in geographic region.	Availability of shipyard facility in local area Routine movement of large loads on land transport routes. Availability of short-sea transport in local area.	5.5	**2**	**7**	**7**
				Weighting Factor Sum:	100.0	5.4	7.7	6.8
						Site Scenario Weighted Average Scores		

Plans for Next Quarter:
Building upon the knowledge gained from the siting priority exercise, the CalWave team will work in parallel on these SOPO tasks in the 2nd quarter of the project:

SOPO Task Number	Title / Task Description
2	Shore-Side Support Infrastructure
3	Utility Grid Interconnection
4	Known Environmental Constraints and Progress on Permitting
5	Permitting and Stakeholder Consultation
6	Top-Level Requirements and Site Selection Criteria
7	Develop Preliminary Design Drawings
8	Develop Estimates of Construction Quantities and Costs
9	Develop Operating, Maintenance, and Testing Cost Estimates
10	Develop Schedule for Site Development and Facility Construction

All of these topics were addressed at a high level during the site scoring. We will now pursue a more detailed understanding of them.

Please see the CalWave Project Schedule & Milestones table (Excel template), under TAB A.

PRODUCTS / DELIVERABLES

Products / Deliverables:
During the course of the CalWave investigation this quarter, the following products were developed:

- CalWave Site Evaluation Matrix for Siting Priority Subcommittee 2014-10-17a.xls
    - Excel spreadsheet which organizes relevant wave energy test site information and uses it to quantify a comparative evaluation of the Vandenberg and Humboldt sites.

- Memorandum Of Understanding (M0U) Between 30th Space Wing (30 SW) At Vandenberg Air Force Base ("VAFB") And Cal Poly Corporation, San Luis Obispo Regarding The Evaluation Of Energy Security Projects Using Ocean Wave Generation And Wind Generation
    - A 3-year agreement to facilitate collaboration with Vandenberg AFB regarding the integration of the proposed CalWave test center with Vandenberg.

PARTICIPANTS & OTHER COLLABORATING ORGANIZATIONS

Individuals:

Name	**Sam Blakeslee**
Organization	Cal Poly
Project Role	Principal Investigator (PI)
Nearest Person Month worked	1 month
Contribution to Project	Dr. Blakeslee has overseen the development of the project workplan and execution. He has rendered his decision that the primary site to be further investigated by the CalWave team is to be Vandenberg.
Funding Support	NA
Collaborated w/ individual in foreign country	No
Country(ies) of foreign collaborator	NA
Traveled to foreign country	No
If traveled to foreign country, duration of stay	NA

Name	**Christine Robertson**
Organization	Cal Poly
Project Role	Project Coordinator
Nearest Person Month worked	1 month
Contribution to Project	Ms. Robertson has overseen the development of the project workplan and execution. She assists in facilitating Cal Poly resources supporting the project.
Funding Support	NA
Collaborated w/ individual in foreign country	No
Country(ies) of foreign collaborator	NA
Traveled to foreign country	No
If traveled to foreign country, duration of stay	NA

Name	**William Toman**
Organization	Cal Poly
Project Role	Project Manager
Nearest Person Month worked	3 months
Contribution to Project	Mr. Toman has led the development of the project workplan and its execution. He reports project progress to the PI and provides analysis and suggestions to the PI regarding project issues.
Funding Support	NA
Collaborated w/ individual in foreign country	No
Country(ies) of foreign collaborator	NA
Traveled to foreign country	No
If traveled to foreign country, duration of stay	NA

Name	**Dale Dolan**
Organization	Cal Poly
Project Role	University research
Nearest Person Month worked	1 month
Contribution to Project	Dr. Dolan has assisted in engineering evaluations of the site comparison.
Funding Support	NA
Collaborated w/ individual in foreign country	No
Country(ies) of foreign collaborator	NA
Traveled to foreign country	No
If traveled to foreign country, duration of stay	NA

Name	**Arne Jacobson**
Organization	Humboldt State University
Project Role	University research
Nearest Person Month worked	1 month
Contribution to Project	Dr. Jacobson manages the regional site information acquisition for the Humboldt area. Led team in seabottom characterizations and test site layouts.
Funding Support	NA
Collaborated w/ individual in foreign country	No
Country(ies) of foreign collaborator	NA
Traveled to foreign country	No
If traveled to foreign country, duration of stay	NA

Name	**George Hagerman**
Organization	Virginia Tech University
Project Role	University research
Nearest Person Month worked	1 month
Contribution to Project	Dr. Hagerman provided important perspectives on wave energy resource analysis. He also provided knowledge of the Atlantic seaboard MHK and offshore wind industry.
Funding Support	NA
Collaborated w/ individual in foreign country	No
Country(ies) of foreign collaborator	NA
Traveled to foreign country	No
If traveled to foreign country, duration of stay	NA

Name	**Julie Thomas**
Organization	Scripps Institution of Oceanography, University of California, San Diego
Project Role	University research
Nearest Person Month worked	1 month
Contribution to Project	Dr. Thomas provided important perspectives on wave energy resource analysis. She also provided knowledge of coastal data information.
Funding Support	NA
Collaborated w/ individual in foreign country	No
Country(ies) of foreign collaborator	NA
Traveled to foreign country	No
If traveled to foreign country, duration of stay	NA

Name	**Paul Jacobson**
Organization	Electric Power Research Institute (EPRI)
Project Role	Utility industry research
Nearest Person Month worked	1 month
Contribution to Project	Dr. Jacobson served on the Siting Priority subcommittee. He provided broad MHK industry knowledge.
Funding Support	NA
Collaborated w/ individual in foreign country	No
Country(ies) of foreign collaborator	NA
Traveled to foreign country	No
If traveled to foreign country, duration of stay	NA

Name	**Rick Williams**
Organization	Leidos
Project Role	Marine industry engineering
Nearest Person Month worked	1 month
Contribution to Project	Captain Williams (USN, Ret) led the data gathering and analysis of port and supply chain infrastructure as well as construction and operations best practices.
Funding Support	NA
Collaborated w/ individual in foreign country	No
Country(ies) of foreign collaborator	NA
Traveled to foreign country	No
If traveled to foreign country, duration of stay	NA

Name	**Doug Davy**
Organization	CH2M Hill
Project Role	Environmental permitting / Stakeholder engagement
Nearest Person Month worked	1 month
Contribution to Project	Dr. Davy led the analysis of permitting issues, licensing path and stakeholder issues.
Funding Support	NA
Collaborated w/ individual in foreign country	No
Country(ies) of foreign collaborator	NA
Traveled to foreign country	No
If traveled to foreign country, duration of stay	NA

Name	**Reenst Lesemann**
Organization	Columbia Power Technologies
Project Role	WEC technology requirements advisor
Nearest Person Month worked	1 month
Contribution to Project	Mr. Lesemann provided test site configuration analysis for WEC integration.
Funding Support	NA
Collaborated w/ individual in foreign country	No
Country(ies) of foreign collaborator	NA
Traveled to foreign country	No
If traveled to foreign country, duration of stay	NA

Name	**Rich Jepson**
Organization	Sandia National Laboratory
Project Role	National Lab research
Nearest Person Month worked	1 month
Contribution to Project	Dr. Jepson chaired the Siting Priority subcommittee. He provided broad MHK industry knowledge and insights into DOE program goals.
Funding Support	NA
Collaborated w/ individual in foreign country	No
Country(ies) of foreign collaborator	NA
Traveled to foreign country	No
If traveled to foreign country, duration of stay	NA

Name	**Rick Driscoll**
Organization	National Renewable Energy Laboratory
Project Role	National Lab research
Nearest Person Month worked	1 month
Contribution to Project	Dr. Driscoll served on the Siting Priority subcommittee. He provided broad MHK industry knowledge and insights into DOE program goals.
Funding Support	NA
Collaborated w/ individual in foreign country	No
Country(ies) of foreign collaborator	NA
Traveled to foreign country	No
If traveled to foreign country, duration of stay	NA

Name	**William Lyte**
Organization	Consultant
Project Role	Electric transmission and port operations
Nearest Person Month worked	1 month
Contribution to Project	Mr. Lyte provided analysis of California grid capabilities and planning. He assisted on port infrastructure identification.
Funding Support	NA
Collaborated w/ individual in foreign country	No
Country(ies) of foreign collaborator	NA
Traveled to foreign country	No
If traveled to foreign country, duration of stay	NA

Organizations:
California Polytechnic State University, San Luis Obispo, California (Awardee)
1 Grand Ave, San Luis Obispo, CA 93405
Sam Blakeslee, sblakesl@calpoly.edu; (805) 756-1694

Contribution to Project
- Financial support: DOE Award DE-EE0006517 (this grant)
- In-kind support: Contributed salaries and overheads
- Facilities: Campus offices
- Collaborative research: NA
- Personnel Exchanges: NA

Leidos (vendor);
11951 Freedom Drive, Reston, VA 20190
Rick Williams; richard.b.williams@leidos.com; (503) 484-4415

Contribution to Project
- Financial support: DOE Award DE-EE0006517 (this grant)
- In-kind support: NA
- Facilities: Corporate offices
- Collaborative research: NA
- Personnel Exchanges: NA

CH2M Hill (vendor)
9191 South Jamaica Street, Englewood, CO 80112
Doug Davy; Doug.Davy@ch2m.com; (916) 286-0278

Contribution to Project
- Financial support: DOE Award DE-EE0006517 (this grant)
- In-kind support: NA
- Facilities: Corporate offices
- Collaborative research: NA
- Personnel Exchanges: NA

Columbia Power Technologies (vendor);
236 East High Street, Charlottesville, VA 22902
Reenst Lesemann; rlesemann@columbiapwr.com; (541) 368-5033

Contribution to Project
- Financial support: NA
- In-kind support: Contributed engineering
- Facilities: Corporate offices
- Collaborative research: NA
- Personnel Exchanges: NA

Humboldt State University (subaward);
1 Harpst Street, Arcata, CA 95521
Arne Jacobson; Arne.Jacobson@humboldt.edu; (707) 826-4302**;**

Contribution to Project
- Financial support: DOE Award DE-EE0006517 (this grant)
- In-kind support: Contributed salaries and overheads
- Facilities: Campus offices, Schatz Energy Research Center (SERC)
- Collaborative research: NA
- Personnel Exchanges: NA

Virginia Polytechnic Institute and State University (subaward);
1 Harpst Street, Arcata, CA 95521

Arne Jacobson; Arne.Jacobson@humboldt.edu; (707) 826-4302**;**

Contribution to Project
- Financial support: DOE Award DE-EE0006517 (this grant)
- In-kind support: Contributed engineering and marine science
- Facilities: Campus offices, Schatz Energy Research Center (SERC)
- Collaborative research: NA
- Personnel Exchanges: NA

Sandia National Laboratory
1515 Eubank SE, Albuquerque, NM 87123
Rich Jepsen; rajepse@sandia.gov; (505) 284-2767

Contribution to Project
- Financial support: Direct DOE funding
- In-kind support: NA
- Facilities: Laboratory offices
- Collaborative research: NA
- Personnel Exchanges: NA

National Renewable Energy Laboratory
15013 Denver West Parkway, Golden, CO 80401
Rick Driscoll; Frederick.Driscoll@nrel.gov; (303) 384-7153

Contribution to Project
- Financial support: Direct DOE funding
- In-kind support: NA
- Facilities: Laboratory offices
- Collaborative research: NA
- Personnel Exchanges: NA

Electric Power Research Institute (EPRI) (subaward);
3420 Hillview Avenue, Palo Alto, CA 94304
Paul Jacobson; pjacobson@epri.com; (410) 489-3675

Contribution to Project
- Financial support: DOE Award DE-EE0006517 (this grant)
- In-kind support: NA
- Facilities: Corporate offices
- Collaborative research: NA
- Personnel Exchanges: NA

William Lyte (Consultant);
27607 W. Muir Grove Way, Castaic, CA 91384
William Lyte; wlyte@aol.com; (424) 477-7853

Contribution to Project
- Financial support: NA
- In-kind support: Contributed time
- Facilities: Corporate offices
- Collaborative research: NA
- Personnel Exchanges: NA

CHANGES / PROBLEMS

There has been a reconfiguration of workscope assignments, budgets and recipient cost share in this quarter. This is the result of two of the original CalWave team members, Burns & McDonnell and Brendan Dooher, exiting the project.

Proposed team reconfiguration: Existing team members Cal Poly and CH2M Hill, along with William Lyte, working as an independent consultant, will absorb the workscopes previously assigned to Burns & McDonnell and to Brendan Dooher. The sum of the budget for these original workscopes is $9,000 + $15,000 = $24,000. The cost share total is $39,000.

CH2M Hill, Cal Poly and William Lyte have all agreed to this proposed reconfiguration in workscope, budget and cost share.

The reconfigured budget captures this:

Original	Original Budget	Original Cost Share
Burns & McDonnell	$9,000	$39,000
B Dooher	$15,000	$0
Total:	$24,000	$39,000

Reconfigured	Budget Enhancement	Reconfigured Cost Share
CH2M Hill	$19,000	$0
Cal Poly	$5,000	$0
William Lyte, independent consultant	$0	$39,000
Total:	$24,000	$39,000

Original team configuration:

Burns & McDonnell

Workscope: Two cases:

1. If using Platform Irene, the onshore Surf substation and the submarine power cable connecting the two.
    a. Connectivity of Platform Irene's electrical system to experimental wave energy systems
    b. Use of wave energy-generated electricity on Platform Irene, and/or transfer of that electricity to shore via the existing submarine cable
    c. Receipt of that electricity from Platform Irene via the submarine cable at the Surf substation located across the fence from Vandenberg AFB
    d. Modification of the Surf substation to receive and redistribute electricity from Platform Irene into Vandenberg AFB

e. Assessment of the Vandenberg AFB electrical grid to determine whether the electricity generated by wave energy can be used at the base, and/or distributed through the base grid and into the PG&E grid

2. If not using the Platform Irene system and instead having to lay a new submarine power cable between the experimental wave energy systems and Vandenberg AFB's onshore electric system.
   a. Receipt of electricity generated from the wave energy system via the submarine cable at a new substation located on Vandenberg AFB
   b. Assessment of the Vandenberg AFB electrical grid to determine whether the electricity generated by wave energy can be used at the base, and/or distributed through the base grid and into the PG&E grid

Budgeted: $48,000 ($9,000 net of cost share)
Cost Share: $39,000 of contributed salary for services of William Lyte, a full-time employee

Brendan Dooher (Consultant)

Workscope: Assist the CalWave project manager in budget and scheduling tasks for the execution of the CalWave project. Assist Leidos to prepare and execute a Request for Information (RFI) for release to the wave energy converter (WEC) industry in order to provide the wave energy test center designers relevant characteristics of their devices. Assist team in writing and editing the CalWave final report.

Budgeted: $15,000
Cost Share: NA

Proposed Workscope and Cost Share Reconfiguration

Proposed CH2M Hill enhanced workscope

Budget available for CH2M Hill's enhanced workscope: $19k, no cost share requirement

Transmission and Distribution (T&D) Related Services (Lead)

Develop a conceptual electrical infrastructure analysis workscope and budget for the following future electrical grid elements:

Two cases:

1. If using the Freeport McMoRan, Inc. (FMI) owned offshore oil production system consisting of Platform Irene, the onshore Surf substation and the submarine power cable connecting the two.
   a. Receipt of that electricity from Platform Irene via the submarine cable at the Surf substation located across the fence from Vandenberg AFB

   b. Modification of the Surf substation to receive and redistribute electricity from Platform Irene into Vandenberg AFB
   c. Assessment of the Vandenberg AFB electrical grid to determine whether the electricity generated by wave energy can be used at the base, and/or distributed through the base grid and into the PG&E grid

2. If not using the Platform Irene system and instead having to lay a new submarine power cable between the experimental wave energy systems and Vandenberg AFB's onshore electric system.
   a. Receipt of electricity generated from the wave energy system via the submarine cable at a new substation located on Vandenberg AFB
   b. Assessment of the Vandenberg AFB electrical grid to determine whether the electricity generated by wave energy can be used at the base, and/or distributed through the base grid and into the PG&E grid

<u>WEC Request for Information (RFI) (Support)</u>

Assist Leidos in preparing and executing a Request for Information (RFI) for release to the wave energy converter (WEC) industry in order to provide the wave energy test center designers relevant characteristics of their devices.

Proposed Cal Poly enhanced workscope

Budget available: $5k, no cost share requirement

<u>Transmission and Distribution (T&D) Related Services (Support)</u>

Assist CH2M Hill in developing a conceptual electrical infrastructure analysis workscope and budget for the following future electrical grid elements:

Two cases:

1. If using the Freeport McMoRan, Inc. (FMI) owned offshore oil production system consisting of Platform Irene, the onshore Surf substation and the submarine power cable connecting the two
   a. Receipt of that electricity from Platform Irene via the submarine cable at the Surf substation located across the fence from Vandenberg AFB
   b. Modification of the Surf substation to receive and redistribute electricity from Platform Irene into Vandenberg AFB
   c. Assessment of the Vandenberg AFB electrical grid to determine whether the electricity generated by wave energy can be used at the base, and/or distributed through the base grid and into the PG&E grid

2. If not using the Platform Irene system and instead having to lay a new submarine power cable between the experimental wave energy systems and Vandenberg AFB's onshore electric system
   a. Receipt of electricity generated from the wave energy system via the submarine cable at a new substation located on Vandenberg AFB

b. Assessment of the Vandenberg AFB electrical grid to determine whether the electricity generated by wave energy can be used at the base, and/or distributed through the base grid and into the PG&E grid

WEC Request for Information (RFI) (Support)

Assist Leidos in preparing and executing a Request for Information (RFI) for release to the wave energy converter (WEC) industry in order to provide the wave energy test center designers relevant characteristics of their devices.

General Project Management (Support)
Assist the CalWave project manager in budget and scheduling tasks for the execution of the CalWave project. Assist team in writing and editing the CalWave final report.

Proposed William Lyte consultant workscope

Task 1.0 – Project Management Support. This task has included strategy discussions with William Toman since the outset of the project in 2013, participation in weekly team planning meetings, and ongoing preparation of correspondence related to the project.

Activities going forward to June, 2015 will include an estimated 2 hours per week (8 hours per month), including participation in weekly teleconferences and associated separate telephone calls and project correspondence, for a total of 64 hours for the remainder of the program.

Task 2.0 – Technical Research. This task has involved comprehensive analysis of (1) the California utility grid relative to the Humboldt and Vandenberg Air Force Base areas, in support of the Phase I site selection process, and (2) major port and marine services resources available support project operations at either location.

Activities going forward may require additional research on the Vandenberg Air Force Base area electrical grid, industrial setting, project-related economic development, or other required project research. This is estimated to be 32 hours over the duration of the project.

Task 3.0 – Report Preparation. This task has involved preparation of a series of memorandums relative to the findings of Task 2.0.

Activities going forward will require preparation of memorandums addressing the information obtained during project research. This is estimated to be 8 hours over the duration of the project.

Task 4.0 – Co-Funding Support. This task has involved liaison with the State of California and its selected renewable energy grants programs, interface with the California State University COAST leadership, and discussions with private funding sources.

Activities going forward will involve further liaison with potential funding sources, research on upcoming California EPIC program grants, as well as funding from other sources, and referral in an organized manner to the USDOE program management team for follow-up. This is estimated to be 12 hours over the duration of the project.

Task 5.0. Coordination with Industry Partners. This task has involved coordination with major engineering firms, wave energy system developers, and marine services systems operators regarding this project, as implemented at either candidate location.

Activities going forward will involve further discussions with potential industry partners, including potential end-users of the project location, funding sources, technical advisors, suppliers of equipment, and other related entities. This is estimated to be 22 hours over the duration of the project.

The cumulative total of these hours is 252 hours.

Cost share: All hours in this workscope will be contributed cost share with a value of $39,000 which matches the cost share originally associated with Burns & McDonnell's role through contributed hours of their full-time employee, William Lyte.

BUDGETARY INFORMATION

Complete the following tables in the Excel template accordingly:

- Spending Summary – TAB B
- Cost Share Contributions – TAB C
- Spend Plan Data – TAB D

These tables have been completed and are provided to DOE separately.

Quarterly Technical Progress Report
(Second of Four Quarters)
COVER PAGE

Federal Agency to which Report is submitted: DOE EERE – Wind & Water Power Program

Recipient: Cal Poly Corporation; DUNS Number 02-932-6246
Award Number: DE-EE0006517
Project Title: California Wave Energy Test Center (CalWave)
Project Period: One year, June 1, 2014 to May 31, 2015

Principle Investigator: Sam Blakeslee; Director, Institute for Advanced Technology and Public Policy at California Polytechnic State University, San Luis Obispo, California;
email: sblakesl@calpoly.edu; Phone: (805) 756-1694

Report Submitted by: William Toman; CalWave Project Manger;
email: wtoman@calpoly.edu; Phone: (707) 731-9261

Date of Report: February 26, 2015
Covering Period: October 1, 2014 to December 31, 2014 (2nd Quarter)
DOE Funding Released: June 11, 2014
Report Frequency: Quarterly

Working Partners:
Vendors (F&A included as match)
Leidos (vendor); Rick Williams; richard.b.williams@leidos.com; (503) 484-4415
CH2M HILL (vendor); Doug Davy; Doug.Davy@ch2m.com; (916) 286-0278
Columbia Power Technologies (vendor); Reenst Lesemann; rlesemann@columbiapwr.com; (541) 368-5033

National Labs (F&A is not allowed)
National Renewable Energy Laboratory (NREL); Rick Driscoll; Frederick.Driscoll@nrel.gov; (303) 384-7153
Sandia National Laboratories; Rich Jepsen; rajepse@sandia.gov; (505) 284-2767

Subrecipient (F&A included as match)
Electric Power Research Institute (EPRI) (subaward); Paul Jacobson; pjacobson@epri.com; (410) 489-3675
Humboldt State University (subaward); Arne Jacobson; Arne.Jacobson@humboldt.edu; (707) 826-4302
Virginia Tech (subaward); George Hagerman; hagerman@vt.edu; (757) 340-1921
Scripps Institution Of Oceanography, UC San Diego (subaward); Julie Thomas; jot@cdip.ucsd.edu; (858) 534-3034

Consultants (F&A included as match)
William Lyte (consultant); wlyte@aol.com; (424) 477-7853

Cost-Sharing Partners:

Cal Poly Corporation
Columbia Power Technologies
William Lyte
Humboldt State Univ.
Virginia Tech

DOE Project Team: DOE HQ Program Manager – Jose Zayas
DOE Field Contract Officer – Pamela Brodie
DOE Field Grants Management Specialist – Yvette Peterson
DOE Field Project Officer – Tim Ramsey
DOE/CNJV Project Monitor – Andrew Buckspan

Signature of Submitting Official:

William Toman
CalWave Project Manager
California Polytechnic State University, San Luis Obispo, California

ACCOMPLISHMENTS

Project Objective:
Support the U.S. Department of Energy's Wind & Water Power Program with a yearlong study to identify and evaluate a primary offshore test site along California's coast, which may be suitable for the establishment of a national wave energy testing facility appropriate for Technical Readiness Level 8-9 (TRL) Wave Energy Converters (WECs).

Project Goals:

- Identification of a national test facility site that meets the resource and support criteria for testing full-scale WEC devices;
- Developing a preliminary facility design based on an evaluation of:
  - International WEC test facilities such as the European Marine Energy Center (EMEC) and the U.K. Wave Hub,
  - U.S. based WEC test facilities such as Marine Corps Base Hawaii (MCBH) and the Northwest National Marine Renewable Energy Center (NNMREC),
  - National Renewable Energy Laboratory's (NREL's) analogous National Wind Technology Center (NWTC), the TUV Rheinland Photovoltaic Testing Laboratory, and in service off-shore wind production facilities;
- Estimating the cost and schedule for site development and facility construction;
- Assessing the specifics and costs of the environmental studies and permitting that will be necessary to facilitate deployment of the above devices;
- Estimating the annual facility operating and maintenance cost; and
- Estimating the cost of testing and evaluating mechanisms for eventual cost recovery at the facility.

Schedule to Date:
We believe that in order to deliver a quality final report to DOE that we are going to need a little more time. In discussions with DOE, it has been suggested that a no-cost schedule extension be implemented with a CalWave Project effort completion of June 30, 2015. Please note that DOE was not able to release the grant funding until June 11, 2014, which is when the actually project work was begun.

Budget to Date:
As of December 31, 2014, CalWave has documented expenses of $247,108. This is well below the budgeted amount through this date. This is in part due to team members exercising frugality and efficiency in executing their assigned workscope. We believe that the CalWave team has the capacity to accelerate workscope execution to support a new, slightly deferred schedule.

Goal Status:
Statement Of Proposed Objectives (SOPO) Task 1:
Develop and Use Criteria to Rank and Finalize Choice for Candidate Ocean Test Sites

Task 1 Result
As reported in the Q1 RPPR, Task 1 has been completed. The Vandenberg site was selected as the primary site for the CalWave study on October 14, 2014. The Humboldt site will serve as the alternate site[1].

Specific post site selection tasks this quarter included:

- Finalized tables of sensitive species and those listed under the Endangered Species Act to be used as a basis for comparing the permitting feasibility and potential costs of the two sites.
- Finalized analysis of commercial fishing target species, annual commercial fishing value by species, and ports of landing, as a basis to compare potential conflicts between wave energy collection and commercial fish harvesting at each site.
- Finalized inputs to the Site Evaluation Matrix, comparing the candidate sites along the key dimensions of the analysis.
    - Prepared and submitted the site comparison documentation reports for Criterion 10, Certainty of Regulatory Pathway, and 16, Stakeholder Support
- Conducted preliminary literature review primarily consisting in the Top Level System Requirements Statement from the PG&E WaveConnect Project and associated appendices.

Statement Of Proposed Objectives (SOPO) Task 2:
Shore-Side Support Infrastructure

The goal of this task is to investigate existing shore support infrastructure and what would be needed to refurbish/repurpose this and to determine what additional shore support infrastructure would be needed.

Preliminary design alternatives relative to the Vandenberg Air Force Base (Vandenberg AFB) site. Work this quarter included:

- Site visit to Vandenberg AFB
    - Established document transferal protocol
    - Walkdown of base transmission/distribution systems and Delta IV rocket industrial receiving dock
- Developing civil and electrical engineering alternatives for costing
- Created chart of CalWave study area for stakeholder and submarine cable owners

Statement Of Proposed Objectives (SOPO) Task 3:
Utility Grid Interconnection

[1] S Blakeslee, *California Wave Energy Test Center (CalWave) Primary Site Decision, S Blakeslee [CalWave PI], 10-14-2014* (California Polytechnic State University, San Luis Obispo, California, October 2014)

The goal of SOPO Task 3 is to investigate utility grid interconnection alternatives in order to establish cost and schedule estimates for the connection of the test center to the regional grid.

Preliminary design alternatives relative to the Vandenberg Air Force Base (Vandenberg AFB) site. Work this quarter included:

- Site visit to Vandenberg AFB
  - Established base document transferal protocol
  - Walkdown of base transmission/distribution systems
  - Walkdown of Platform Irene's shoreside Surf substation
    - Surf is the interconnection point for Platform Irene's existing submarine power cable with the Pacific Gas and Electric grid

- Initiated systems engineering process
  - Evaluating system boundaries and key interfaces
  - Evaluating requirements
    - Wave Energy Converter Support
    - Sea-based Infrastructure
    - Shore Infrastructure
    - Grid integration
- Preparing for review of civil and electrical design inputs
- Development of a work plan for implementing a SWAN model for the VAFB waters
- Analysis of available bathymetric data sources

Statement Of Proposed Objectives (SOPO) Task 4:
Known Environmental Constraints and Progress on Permitting

The goal of SOPO Task 4 is to prepare a permitting plan that includes an assessment of environmental baseline data that regulatory agencies will require for permitting. The permitting plan will identify the key permits and authorizations needed to begin construction of the CalWave test center, the information requirements for the permits and authorizations, the schedule for obtaining them, and the likely cost of collecting the data and obtaining the permits.

- Conducted a literature search to identify existing baseline data in the scientific literature and drafted an annotated bibliography summarizing the contents of key documents
- Conducted a literature search to identify baseline data in the environmental permitting literature (Environmental Impact Statements, Environmental Assessments) applicable to the project area and drafted an annotated bibliography summarizing the contents of key documents
- Consulted with Cal Poly academic staff, regulatory agency personnel, and other project team members to identify existing on-line databases containing commercial fishing data (species, location, quantity, value)
- Developed a preliminary list of regulatory approvals needed and regulatory agencies to be consulted to obtain permits

Statement Of Proposed Objectives (SOPO) Task 5:
Public Acceptance by Coastal Community and Other Ocean Users

The purpose of this task is to identify key stakeholders who will be involved and key issues that will need to be addressed during full development of the wave energy test center.

- Prepared a list of key political, regulatory, non-governmental, and other stakeholders who will be interviewed regarding their views of the project
- Drafted an interview questionnaire for use during the stakeholder interview phase
- Drafted introduction letters to key stakeholders, informing them about the project and requesting
- Developed initial schedules and plans for the public and regulatory agency meetings
- Executed initial email and follow-up phone calls to select group of stakeholders
    - Overall stakeholder feedback is positive and wish to know more
    - Chumash Nation announced its nomination to NOAA to establish the Chumash Heritage National Marine Sanctuary which would overlay Vandenberg offshore site
    - CalWave initiated meetings to confirm that marine renewables would be considered an compatible use within sanctuary
- Investigated inconstantly charted submarine telecom cable skirting Vandenberg site
    - Researched submarine cable noted on NOAA chart
    - Researched methods for due diligence associated with submarine telecommunications cables
        - Reviewed lessons learned from Public Utility District No. 1 of Snohomish County, Washington's (SnoPUD) Tidal Energy Project telecom cable conflict
        - Initiated contact with International Cable protection Committee (ICPC)
        - Working on timing and content of outreach interface for submarine cable due diligence

Statement Of Proposed Objectives (SOPO) Task 6:
Top-Level Requirements and Device Testing Criteria

- Underway by Leidos, Columbia Power Tech, NREL and Cal Poly

Statement Of Proposed Objectives (SOPO) Task 7:
Develop Preliminary Design Drawings

- Underway by Leidos, Columbia Power Tech and Cal Poly

Statement Of Proposed Objectives (SOPO) Task 8:
Develop Estimates of Construction Quantities and Costs

- Underway by Leidos, Columbia Power Tech and Cal Poly

Statement Of Proposed Objectives (SOPO) Task 9:

Develop Operating, Maintenance, and Testing Cost Estimates

- Underway by Leidos, Columbia Power Tech and Cal Poly

Statement Of Proposed Objectives (SOPO) Task 10:
Task 10: Develop Schedule for Site Development and Facility Construction

- Pending, will depend on information generated in SOPO Tasks 2, 3, 5, 6, 7, 8 and 9.

Plans for Next (3rd) Quarter:
Building upon the knowledge gained from the siting prioritization exercise, the CalWave team will work in parallel on these SOPO tasks in the 3rd quarter of the project:

SOPO Task Number	Title / Task Description
2	Shore-Side Support Infrastructure
3	Utility Grid Interconnection
4	Known Environmental Constraints and Progress on Permitting
5	Permitting and Stakeholder Consultation
6	Top-Level Requirements and Site Selection Criteria
7	Develop Preliminary Design Drawings
8	Develop Estimates of Construction Quantities and Costs
9	Develop Operating, Maintenance, and Testing Cost Estimates
10	Develop Schedule for Site Development and Facility Construction

All of these topics were addressed at a high level during the site scoring. We are pursuing a more detailed understanding of them.

Please see the CalWave Project Schedule & Milestones table (Excel template), under TAB A.

PRODUCTS / DELIVERABLES

Products / Deliverables:
During the course of the CalWave investigation this quarter, the following products were developed:

Continued progress was made this quarter towards the final report deliverable.

PARTICIPANTS & OTHER COLLABORATING ORGANIZATIONS

Individuals:

Name	**Sam Blakeslee**
Organization	Cal Poly
Project Role	Principal Investigator (PI)
Nearest Person Month worked	1 month
Contribution to Project	Dr. Blakeslee has overseen the development of the project workplan and execution. He has rendered his decision that the primary site to be further investigated by the CalWave team is to be Vandenberg.
Funding Support	NA
Collaborated w/ individual in foreign country	No
Country(ies) of foreign collaborator	NA
Traveled to foreign country	No
If traveled to foreign country, duration of stay	NA

Name	**Christine Robertson**
Organization	Cal Poly
Project Role	Project Coordinator
Nearest Person Month worked	1 month
Contribution to Project	Ms. Robertson has overseen the development of the project workplan and execution. She assists in facilitating Cal Poly resources supporting the project.
Funding Support	NA
Collaborated w/ individual in foreign country	No
Country(ies) of foreign collaborator	NA
Traveled to foreign country	No
If traveled to foreign country, duration of stay	NA

Name	**William Toman**
Organization	Cal Poly
Project Role	Project Manager
Nearest Person Month worked	3 months
Contribution to Project	Mr. Toman has led the development of the project workplan and its execution. He reports project progress to the PI and provides analysis and suggestions to the PI regarding project issues.
Funding Support	NA
Collaborated w/ individual in foreign country	No
Country(ies) of foreign collaborator	NA
Traveled to foreign country	No
If traveled to foreign country, duration of stay	NA

Name	**Dale Dolan**
Organization	Cal Poly
Project Role	University research
Nearest Person Month worked	1 month
Contribution to Project	Dr. Dolan has assisted in engineering evaluations of the site comparison.
Funding Support	NA
Collaborated w/ individual in foreign country	No
Country(ies) of foreign collaborator	NA
Traveled to foreign country	No
If traveled to foreign country, duration of stay	NA

Name	**Arne Jacobson**
Organization	Humboldt State University
Project Role	University research
Nearest Person Month worked	1 month
Contribution to Project	Dr. Jacobson manages the regional site information acquisition for the Humboldt area. Led team in seabottom characterizations and test site layouts.
Funding Support	NA
Collaborated w/ individual in foreign country	No
Country(ies) of foreign collaborator	NA
Traveled to foreign country	No
If traveled to foreign country, duration of stay	NA

Name	**George Hagerman**
Organization	Virginia Tech University
Project Role	University research
Nearest Person Month worked	1 month
Contribution to Project	Dr. Hagerman provided important perspectives on wave energy resource analysis. He also provided knowledge of the Atlantic seaboard MHK and offshore wind industry.
Funding Support	NA
Collaborated w/ individual in foreign country	No
Country(ies) of foreign collaborator	NA
Traveled to foreign country	No
If traveled to foreign country, duration of stay	NA

Name	**Julie Thomas**
Organization	Scripps Institution of Oceanography, University of California, San Diego
Project Role	University research
Nearest Person Month worked	1 month
Contribution to Project	Dr. Thomas provided important perspectives on wave energy resource analysis. She also provided knowledge of coastal data information.
Funding Support	NA
Collaborated w/ individual in foreign country	No
Country(ies) of foreign collaborator	NA
Traveled to foreign country	No
If traveled to foreign country, duration of stay	NA

Name	**Paul Jacobson**
Organization	Electric Power Research Institute (EPRI)
Project Role	Utility industry research
Nearest Person Month worked	1 month
Contribution to Project	Dr. Jacobson served on the Siting Priority subcommittee. He provided broad MHK industry knowledge.
Funding Support	NA
Collaborated w/ individual in foreign country	No
Country(ies) of foreign collaborator	NA
Traveled to foreign country	No
If traveled to foreign country, duration of stay	NA

Name	**Rick Williams**
Organization	Leidos
Project Role	Marine industry engineering
Nearest Person Month worked	3 months
Contribution to Project	Captain Williams (USN, Ret) led the data gathering and analysis of port and supply chain infrastructure as well as construction and operations best practices.
Funding Support	NA
Collaborated w/ individual in foreign country	No
Country(ies) of foreign collaborator	NA
Traveled to foreign country	No
If traveled to foreign country, duration of stay	NA

Name	**Doug Davy**
Organization	CH2M Hill
Project Role	Environmental permitting / Stakeholder engagement
Nearest Person Month worked	3 months
Contribution to Project	Dr. Davy led the analysis of permitting issues, licensing path and stakeholder issues.
Funding Support	NA
Collaborated w/ individual in foreign country	No
Country(ies) of foreign collaborator	NA
Traveled to foreign country	No
If traveled to foreign country, duration of stay	NA

Name	**Reenst Lesemann**
Organization	Columbia Power Technologies
Project Role	WEC technology requirements advisor
Nearest Person Month worked	1 month
Contribution to Project	Mr. Lesemann provided test site configuration analysis for WEC integration.
Funding Support	NA
Collaborated w/ individual in foreign country	No
Country(ies) of foreign collaborator	NA
Traveled to foreign country	No
If traveled to foreign country, duration of stay	NA

Name	**Rich Jepson**
Organization	Sandia National Laboratory
Project Role	National Lab research
Nearest Person Month worked	1 month
Contribution to Project	Dr. Jepson chaired the Siting Priority subcommittee. He provided broad MHK industry knowledge and insights into DOE program goals.
Funding Support	NA
Collaborated w/ individual in foreign country	No
Country(ies) of foreign collaborator	NA
Traveled to foreign country	No
If traveled to foreign country, duration of stay	NA

Name	**Rick Driscoll**
Organization	National Renewable Energy Laboratory
Project Role	National Lab research
Nearest Person Month worked	1 month
Contribution to Project	Dr. Driscoll served on the Siting Priority subcommittee. He provided broad MHK industry knowledge and insights into DOE program goals.
Funding Support	NA
Collaborated w/ individual in foreign country	No
Country(ies) of foreign collaborator	NA
Traveled to foreign country	No
If traveled to foreign country, duration of stay	NA

Name	**William Lyte**
Organization	Consultant
Project Role	Electric transmission and port operations
Nearest Person Month worked	1 month
Contribution to Project	Mr. Lyte provided analysis of California grid capabilities and planning. He assisted on port infrastructure identification.
Funding Support	NA
Collaborated w/ individual in foreign country	No
Country(ies) of foreign collaborator	NA
Traveled to foreign country	No
If traveled to foreign country, duration of stay	NA

Name	**Randy Connett**
Organization	Omega Power Engineers, Subcontractor to High Energy, Inc.
Project Role	Transmission System Engineering
Nearest Person Month worked	1 month
Contribution to Project	Led transmission system design studies
Funding Support	NA
Collaborated w/ individual in foreign country	No
Country(ies) of foreign collaborator	NA
Traveled to foreign country	No
If traveled to foreign country, duration of stay	NA

Organizations:

California Polytechnic State University, San Luis Obispo, California (Awardee)
1 Grand Ave, San Luis Obispo, CA 93405
Sam Blakeslee, sblakesl@calpoly.edu; (805) 756-1694

Contribution to Project
- Financial support: DOE Award DE-EE0006517 (this grant)
- In-kind support: Contributed salaries and overheads
- Facilities: Campus offices
- Collaborative research: NA
- Personnel Exchanges: NA

Leidos (vendor);
11951 Freedom Drive, Reston, VA 20190
Rick Williams; richard.b.williams@leidos.com; (503) 484-4415

Contribution to Project
- Financial support: DOE Award DE-EE0006517 (this grant)
- In-kind support: NA
- Facilities: Corporate offices
- Collaborative research: NA
- Personnel Exchanges: NA

CH2M Hill (vendor)
9191 South Jamaica Street, Englewood, CO 80112
Doug Davy; Doug.Davy@ch2m.com; (916) 286-0278

Contribution to Project
- Financial support: DOE Award DE-EE0006517 (this grant)
- In-kind support: NA
- Facilities: Corporate offices
- Collaborative research: NA
- Personnel Exchanges: NA

Columbia Power Technologies (vendor);
236 East High Street, Charlottesville, VA 22902
Reenst Lesemann; rlesemann@columbiapwr.com; (541) 368-5033

Contribution to Project
- Financial support: NA
- In-kind support: Contributed engineering
- Facilities: Corporate offices
- Collaborative research: NA
- Personnel Exchanges: NA

Humboldt State University (subaward);
1 Harpst Street, Arcata, CA 95521
Arne Jacobson; Arne.Jacobson@humboldt.edu; (707) 826-4302**;**

Contribution to Project
- Financial support: DOE Award DE-EE0006517 (this grant)
- In-kind support: Contributed salaries and overheads
- Facilities: Campus offices, Schatz Energy Research Center (SERC)
- Collaborative research: NA
- Personnel Exchanges: NA

Virginia Polytechnic Institute and State University (subaward);
1 Harpst Street, Arcata, CA 95521

Arne Jacobson; Arne.Jacobson@humboldt.edu; (707) 826-4302**;**

Contribution to Project
- Financial support: DOE Award DE-EE0006517 (this grant)
- In-kind support: Contributed engineering and marine science
- Facilities: Campus offices, Schatz Energy Research Center (SERC)
- Collaborative research: NA
- Personnel Exchanges: NA

Sandia National Laboratory
1515 Eubank SE, Albuquerque, NM 87123
Rich Jepsen; rajepse@sandia.gov; (505) 284-2767

Contribution to Project
- Financial support: Direct DOE funding
- In-kind support: NA
- Facilities: Laboratory offices
- Collaborative research: NA
- Personnel Exchanges: NA

National Renewable Energy Laboratory
15013 Denver West Parkway, Golden, CO 80401
Rick Driscoll; Frederick.Driscoll@nrel.gov; (303) 384-7153

Contribution to Project
- Financial support: Direct DOE funding
- In-kind support: NA
- Facilities: Laboratory offices
- Collaborative research: NA
- Personnel Exchanges: NA

Electric Power Research Institute (EPRI) (subaward);
3420 Hillview Avenue, Palo Alto, CA 94304
Paul Jacobson; pjacobson@epri.com; (410) 489-3675

Contribution to Project
- Financial support: DOE Award DE-EE0006517 (this grant)
- In-kind support: NA
- Facilities: Corporate offices
- Collaborative research: NA
- Personnel Exchanges: NA

William Lyte (Consultant);
27607 W. Muir Grove Way, Castaic, CA 91384
William Lyte; wlyte@aol.com; (424) 477-7853

Contribution to Project
- Financial support: NA
- In-kind support: Contributed time
- Facilities: Corporate offices
- Collaborative research: NA
- Personnel Exchanges: NA

Randy Connett (Consultant);
High Energy, Inc.
650 S. Cherry Street, Suite 510, Denver, Colorado 80246;
Randy Connett; randy.connett@omegapower.net; (303) 333-0280

Contribution to Project
- Financial support: NA
- In-kind support: Contributed time
- Facilities: Corporate offices
- Collaborative research: NA
- Personnel Exchanges: NA

CHANGES / PROBLEMS

The team workscope assignments, budgets and recipient cost share reconfiguration mentioned in the Q1 Progress Report was completed in this quarter. Randy Connett (consultant) has been added to the CalWave team to assist in transmission and power engineering analysis. Amy Chen, a Masters student at Cal Poly in Electrical Engineering has joined the team to assist in project management tasks.

Burns & McDonnell has exited the team and William Lyte has become a consultant and continues in the role originally described for Burns & McDonnell.

BUDGETARY INFORMATION

Complete the following tables in the Excel template accordingly:

- Spending Summary – TAB B
- Cost Share Contributions – TAB C
- Spend Plan Data – TAB D

These tables have been completed and are provided to DOE separately.

Quarterly Technical Progress Report
(Third of Four Quarters)
COVER PAGE

Federal Agency to which Report is submitted: DOE EERE – Wind & Water Power Program

Recipient: Cal Poly Corporation; DUNS Number 02-932-6246
Award Number: DE-EE0006517
Project Title: California Wave Energy Test Center (CalWave)
Project Period: One year, June 1, 2014 to May 31, 2015 (originally). Request for a no-cost extension to June 30, 2015 has been granted by DOE.

Principle Investigator: Sam Blakeslee; Director, Institute for Advanced Technology and Public Policy at California Polytechnic State University, San Luis Obispo, California;
email: sblakesl@calpoly.edu; Phone: (805) 756-1694

Report Submitted by: William Toman; CalWave Project Manger;
email: wtoman@calpoly.edu; Phone: (707) 731-9261

Date of Report: May 12, 2015
Covering Period: January 1, 2015 to March 31, 2015 (3nd of 4 Quarters)
DOE Funding Released: June 11, 2014
Report Frequency: Quarterly

Working Partners:
Vendors (F&A included as match)
Leidos (vendor); Rick Williams; richard.b.williams@leidos.com; (503) 484-4415
CH2M HILL (vendor); Doug Davy; Doug.Davy@ch2m.com; (916) 286-0278
Columbia Power Technologies (vendor); Reenst Lesemann; rlesemann@columbiapwr.com; (541) 368-5033

National Labs (F&A is not allowed)
National Renewable Energy Laboratory (NREL); Rick Driscoll; Frederick.Driscoll@nrel.gov; (303) 384-7153
Sandia National Laboratories; Rich Jepsen; rajepse@sandia.gov; (505) 284-2767

Subrecipient (F&A included as match)
Electric Power Research Institute (EPRI) (subaward); Paul Jacobson; pjacobson@epri.com; (410) 489-3675
Humboldt State University (subaward); Arne Jacobson; Arne.Jacobson@humboldt.edu; (707) 826-4302
Virginia Tech (subaward); George Hagerman; hagerman@vt.edu; (757) 340-1921
Scripps Institution Of Oceanography, UC San Diego (subaward); Julie Thomas; jot@cdip.ucsd.edu; (858) 534-3034

Consultants (F&A included as match)
William Lyte (consultant); wlyte@aol.com; (424) 477-7853

Cost-Sharing Partners:

Cal Poly Corporation
Columbia Power Technologies
William Lyte
Humboldt State Univ.
Virginia Tech

DOE Project Team: DOE HQ Program Manager – Jose Zayas
DOE Field Contract Officer – Pamela Brodie
DOE Field Grants Management Specialist – Yvette Peterson
DOE Field Project Officer – Tim Ramsey
DOE/CNJV Project Monitor – Andrew Buckspan

Signature of Submitting Official:

William Toman
CalWave Project Manager
California Polytechnic State University, San Luis Obispo, California

ACCOMPLISHMENTS

Project Objective:
Support the U.S. Department of Energy's Wind & Water Power Program with a yearlong study to identify and evaluate a primary offshore test site along California's coast, which may be suitable for the establishment of a national wave energy testing facility appropriate for Technical Readiness Level 8-9 (TRL) Wave Energy Converters (WECs).

Project Goals:

- Identification of a national test facility site that meets the resource and support criteria for testing full-scale WEC devices;
- Developing a preliminary facility design based on an evaluation of:
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  - U.S. based WEC test facilities such as Marine Corps Base Hawaii (MCBH) and the Northwest National Marine Renewable Energy Center (NNMREC),
  - National Renewable Energy Laboratory's (NREL's) analogous National Wind Technology Center (NWTC), the TUV Rheinland Photovoltaic Testing Laboratory, and in service off-shore wind production facilities;
- Estimating the cost and schedule for site development and facility construction;
- Assessing the specifics and costs of the environmental studies and permitting that will be necessary to facilitate deployment of the above devices;
- Estimating the annual facility operating and maintenance cost; and
- Estimating the cost of testing and evaluating mechanisms for eventual cost recovery at the facility.

Schedule to Date:
We believe that in order to deliver a quality final report to DOE that we are going to need a little more time. In discussions with DOE, it has been suggested that a no-cost schedule extension be implemented with a CalWave Project effort completion of June 30, 2015. Please note that DOE was not able to release the grant funding until June 11, 2014, which is when the actually project work was begun. DOE has approved this no-cost schedule extension.

Budget to Date:
As of December 31, 2014, CalWave has documented expenses of $472,261 or about 46% of budgeted expenditures. This is well below the budgeted amount through this date. We have some concern that the remaining workscope can be accomplished by June 30, 2015; however we also believe that the CalWave team has the capacity to accelerate workscope execution.

We will initiate a remaining workscope gap review and identify solutions to close gaps identified.

Goal Status:
Statement Of Proposed Objectives (SOPO) Task 1:
Develop and Use Criteria to Rank and Finalize Choice for Candidate Ocean Test Sites

Task 1 Result
As reported in the Q1 RPPR, Task 1 has been completed, but there was some follow-up work to support other SOPO tasks. The Vandenberg site was selected as the primary site for the CalWave study on October 14, 2014. The Humboldt site will serve as the alternate site[1].

Design Considerations and Preliminary Analyses
- Clarifications and further analyses
- Developed chart of CalWave study area
- Evaluated additional Test Site Alternatives

Statement Of Proposed Objectives (SOPO) Task 2:
Shore-Side Support Infrastructure

The goal of this task is to investigate existing shore support infrastructure and what would be needed to refurbish/repurpose this and to determine what additional shore support infrastructure would be needed.

Design Considerations and Preliminary Analyses
- Evaluated additional Test Site Alternatives
- Civil and electrical engineering alternatives
- Shore Infrastructure
- Continued systems engineering process
- Evaluated system boundaries and key interfaces
- Evaluated requirements

Statement Of Proposed Objectives (SOPO) Task 3:
Utility Grid Interconnection

The goal of SOPO Task 3 is to investigate utility grid interconnection alternatives in order to establish cost and schedule estimates for the connection of the test center to the regional grid.

Preliminary design alternatives relative to the Vandenberg Air Force Base (Vandenberg AFB) site. Work this quarter included:

Design Considerations and Preliminary Analyses
- Civil and electrical engineering alternatives
- Second site visit at Vandenberg AFB for discussion of electrical infrastructure and siting
- Generated SOW for Cal Poly and Electrical Engineer
- Grid integration

[1] S Blakeslee, *California Wave Energy Test Center (CalWave) Primary Site Decision, S Blakeslee [CalWave PI], 10-14-2014* (California Polytechnic State University, San Luis Obispo, California, October 2014)

- Determined engineering requirements for Notional CalWave Shore Station and Notional CalWave Substation
- Determined systems engineering for Notional CalWave Subsea Power Cables
- Evaluated system boundaries and key system interfaces
- Refinement of electrical design inputs and electrical infrastructure requirements
- Survey of WECs for flexibility of test berth connections.

Statement Of Proposed Objectives (SOPO) Task 4:
Known Environmental Constraints and Progress on Permitting

The goal of SOPO Task 4 is to prepare a permitting plan that includes an assessment of environmental baseline data that regulatory agencies will require for permitting. The permitting plan will identify the key permits and authorizations needed to begin construction of the CalWave test center, the information requirements for the permits and authorizations, the schedule for obtaining them, and the likely cost of collecting the data and obtaining the permits. Work this quarter included:

- Completed a literature search to identify existing baseline data in the scientific literature and drafted an annotated bibliography summarizing the contents of key documents
- Completed a literature search to identify baseline data in the environmental permitting literature (Environmental Impact Statements, Environmental Assessments) applicable to the project area and drafted an annotated bibliography summarizing the contents of key documents
- Consulted with Cal Poly academic staff, regulatory agency personnel, and other project team members to identify existing on-line databases containing commercial fishing data (species, location, quantity, value) and other environmental data
- Completed a preliminary list of regulatory approvals needed and regulatory agencies to be consulted to obtain permits
- Conducted preliminary mapping studies to determine the spatial presence of environmental permitting constraints in the general siting area (marine reserves, sensitive habitats, areas of particular value for commercial fishing, vessel traffic lanes, etc.) and identify suitable areas for specific siting.
- Prepared preliminary list of possible key permitting issues and possible data needs to address the issues, for discussion with regulatory agencies and others at the public and agency meetings.
- Developed conceptual outline of the final report on CalWave environmental licensing and permitting.
- Developed information about regulatory process and timetable for Virginia's obtaining a Section 238 Research Lease from the Bureau of Ocean Energy Management.
- Design Considerations and Preliminary Analyses
    - Researched submarine cable standard specifications and features needed for CalWave permitting
    - Provided input for CalWave Agency outreach meeting supporting permitting
- Estimate Construction Quantities and Costs
    - Provided input for CalWave Public Outreach meeting supporting permitting

Statement Of Proposed Objectives (SOPO) Task 5:
Public Acceptance by Coastal Community and Other Ocean Users

The purpose of this task is to identify key stakeholders who will be involved and key issues that will need to be addressed during full development of the wave energy test center. Work this quarter included:

- Conducted 11 stakeholder interviews, and coordinated fishing community engagement and elected officials outreach with the Cal Poly team.
- Coordinated Chumash Tribe outreach and related plans for the Chumash National Marine Sanctuary proposal.
- Planned and prepared for the public meeting on 4/14 in San Luis Obispo, including notification text, list of invitees, facility logistics, and materials.
- Planned and prepared for the regulatory agency meeting on 4/16, including notification text, list of invitees, facility logistics, and materials.
- Developed a comprehensive stakeholder database representing the cross section of sectors/potential interests in the test facility (fishing community; environmental interests; business interests; Tribes; local, state and federal elected officials and departments, etc.).
- Developed agendas and materials for the public and agency meetings (posters, maps, flow charts of the regulatory process, environmental information gathering, etc.).
- Developed text to augment CalWave website, including comment form

Statement Of Proposed Objectives (SOPO) Task 6:
Top-Level Requirements and Device Testing Criteria

The purpose of this task is to develop top-level requirements (TLRs) and associated listing of specific test site design criteria that will define expectations for each facility element, including the ocean test site, associated service port, and all shore-side ancillary facilities. Work this quarter included:

Work is pending for this task. It is flagged for expediting.

Statement Of Proposed Objectives (SOPO) Task 7:
Develop Preliminary Design Drawings

The purpose of this task is to prepare drawings that depict all elements of the preferred preliminary design in sufficient detail to support completion of facility permitting. Work this quarter included:

Estimate Construction Quantities and Costs

- Additional Architectural Engineer hired to assist in civil engineering and cost estimation of shore station and substation
- Initial drafting of shore station and substation single line drawings - additional Cal Poly students hired
- Developed input for CalWave Agency outreach meeting

Work is pending for this task. It is flagged for expediting.

Statement Of Proposed Objectives (SOPO) Task 8:
Develop Estimates of Construction Quantities and Costs

The purpose of this task is to develop estimates of construction quantities and costs, based on inputs from the above and from preliminary bids from industry (such as offshore cable installers, etc.). Work this quarter included:

Estimate Construction Quantities and Costs

- Coordination with Sandia National Laboratory and preliminary development work on a SWAN model for the VAFB waters
- Conducted a scoping analysis of Central and Southern California Wavewatch III grid points to identify candidate “nursery” sites that could provide a notional quarter-scale open water test site, similar to the Galway Bay and FabTest sites in the British Isles. The candidate site that provides the best quarter-scale match to the CalWave fully energetic wave climate is in the northwest Santa Barbara Channel, just south of Goleta Point.
- Alternative CalWave berth siting analysis including coordination with team members and developing GIS layers for use in siting communications and discussions
- Developed guidance for civil and electrical design inputs

Work is pending for this task. It is flagged for expediting.

Statement Of Proposed Objectives (SOPO) Task 9:
Develop Operating, Maintenance, and Testing Cost Estimates

The purpose of this task is to develop preliminary facility and testing cost estimates based on the preliminary operations, maintenance and logistics plans and infrastructure preliminary designs developed as part of the preliminary site design efforts. Work this quarter included:

- Reviewed previous RFI documents for WECs

Work is pending for this task. It is flagged for expediting.

Statement Of Proposed Objectives (SOPO) Task 10:
Task 10: Develop Schedule for Site Development and Facility Construction

The purpose of this task is to enter into discussions with BOEM in regards to status and expectations for a Section 238 lease to support work in scheduling monitoring efforts, bids for equipment purchases and construction activities, and negotiations with WECTDs who may be interested in testing their devices at the site. Work this quarter included:

Work is pending for this task. It is flagged for expediting.

Plans for Next (4th) Quarter:
We will be expediting work on SOPO tasks 6, 8, 9 and 10 as these are the areas with the most workscope remaining.

SOPO Task Number	Title / Task Description
2	Shore-Side Support Infrastructure
3	Utility Grid Interconnection
4	Known Environmental Constraints and Progress on Permitting
5	Permitting and Stakeholder Consultation
6	Top-Level Requirements and Site Selection Criteria
7	Develop Preliminary Design Drawings
8	Develop Estimates of Construction Quantities and Costs
9	Develop Operating, Maintenance, and Testing Cost Estimates
10	Develop Schedule for Site Development and Facility Construction

Please see the CalWave Project Schedule & Milestones table (Excel template), under TAB A.

PRODUCTS / DELIVERABLES

Products / Deliverables:
During the course of the CalWave investigation this quarter, the following products were developed:

Continued progress was made this quarter towards the final report deliverable.

PARTICIPANTS & OTHER COLLABORATING ORGANIZATIONS

Individuals:

Name	**Sam Blakeslee**
Organization	Cal Poly
Project Role	Principal Investigator (PI)
Nearest Person Month worked	2 months
Contribution to Project	Dr. Blakeslee has overseen the development of the project workplan and execution. He has rendered his decision that the primary site to be further investigated by the CalWave team is to be Vandenberg.
Funding Support	NA
Collaborated w/ individual in foreign country	No
Country(ies) of foreign collaborator	NA
Traveled to foreign country	No
If traveled to foreign country, duration of stay	NA

Name	**Christine Robertson**
Organization	Cal Poly
Project Role	Project Coordinator
Nearest Person Month worked	2 months
Contribution to Project	Ms. Robertson has overseen the development of the project workplan and execution. She assists in facilitating Cal Poly resources supporting the project.
Funding Support	NA
Collaborated w/ individual in foreign country	No
Country(ies) of foreign collaborator	NA
Traveled to foreign country	No
If traveled to foreign country, duration of stay	NA

Name	**William Toman**
Organization	Cal Poly
Project Role	Project Manager
Nearest Person Month worked	9 months
Contribution to Project	Mr. Toman has led the development of the project workplan and its execution. He reports project progress to the PI and provides analysis and suggestions to the PI regarding project issues.
Funding Support	NA
Collaborated w/ individual in foreign country	No
Country(ies) of foreign collaborator	NA
Traveled to foreign country	No
If traveled to foreign country, duration of stay	NA

Name	**Dale Dolan**
Organization	Cal Poly
Project Role	University research
Nearest Person Month worked	3 months
Contribution to Project	Dr. Dolan has assisted in engineering evaluations of the site comparison.
Funding Support	NA
Collaborated w/ individual in foreign country	No
Country(ies) of foreign collaborator	NA
Traveled to foreign country	No
If traveled to foreign country, duration of stay	NA

Name	**Arne Jacobson**
Organization	Humboldt State University
Project Role	University research
Nearest Person Month worked	3 months
Contribution to Project	Dr. Jacobson manages the regional site

	information acquisition for the Humboldt area. Led team in seabottom characterizations and test site layouts.
Funding Support	NA
Collaborated w/ individual in foreign country	No
Country(ies) of foreign collaborator	NA
Traveled to foreign country	No
If traveled to foreign country, duration of stay	NA

Name	**George Hagerman**
Organization	Virginia Tech University
Project Role	University research
Nearest Person Month worked	2 months
Contribution to Project	Dr. Hagerman provided important perspectives on wave energy resource analysis. He also provided knowledge of the Atlantic seaboard MHK and offshore wind industry.
Funding Support	NA
Collaborated w/ individual in foreign country	No
Country(ies) of foreign collaborator	NA
Traveled to foreign country	No
If traveled to foreign country, duration of stay	NA

Name	**Julie Thomas**
Organization	Scripps Institution of Oceanography, University of California, San Diego
Project Role	University research
Nearest Person Month worked	2 months
Contribution to Project	Dr. Thomas provided important perspectives on wave energy resource analysis. She also provided knowledge of coastal data information.
Funding Support	NA
Collaborated w/ individual in foreign country	No
Country(ies) of foreign collaborator	NA
Traveled to foreign country	No
If traveled to foreign country, duration of stay	NA

Name	**Paul Jacobson**
Organization	Electric Power Research Institute (EPRI)
Project Role	Utility industry research
Nearest Person Month worked	2 months
Contribution to Project	Dr. Jacobson served on the Siting Priority subcommittee. He provided broad MHK industry knowledge.
Funding Support	NA
Collaborated w/ individual in foreign country	No
Country(ies) of foreign collaborator	NA
Traveled to foreign country	No
If traveled to foreign country, duration of stay	NA

Name	**Rick Williams**
Organization	Leidos
Project Role	Marine industry engineering
Nearest Person Month worked	6 months
Contribution to Project	Captain Williams (USN, Ret) led the data gathering and analysis of port and supply chain infrastructure as well as construction and operations best practices.
Funding Support	NA
Collaborated w/ individual in foreign country	No
Country(ies) of foreign collaborator	NA
Traveled to foreign country	No
If traveled to foreign country, duration of stay	NA

Name	**Doug Davy**
Organization	CH2M Hill
Project Role	Environmental permitting / Stakeholder engagement
Nearest Person Month worked	6 months
Contribution to Project	Dr. Davy led the analysis of permitting issues, licensing path and stakeholder issues.
Funding Support	NA
Collaborated w/ individual in foreign country	No
Country(ies) of foreign collaborator	NA
Traveled to foreign country	No
If traveled to foreign country, duration of stay	NA

Name	**Reenst Lesemann**
Organization	Columbia Power Technologies
Project Role	WEC technology requirements advisor
Nearest Person Month worked	2 months
Contribution to Project	Mr. Lesemann provided test site configuration analysis for WEC integration.

Funding Support	NA
Collaborated w/ individual in foreign country	No
Country(ies) of foreign collaborator	NA
Traveled to foreign country	No
If traveled to foreign country, duration of stay	NA

Name	**Rich Jepson**
Organization	Sandia National Laboratory
Project Role	National Lab research
Nearest Person Month worked	2 months
Contribution to Project	Dr. Jepson chaired the Siting Priority subcommittee. He provided broad MHK industry knowledge and insights into DOE program goals.
Funding Support	NA
Collaborated w/ individual in foreign country	No
Country(ies) of foreign collaborator	NA
Traveled to foreign country	No
If traveled to foreign country, duration of stay	NA

Name	**Rick Driscoll**
Organization	National Renewable Energy Laboratory
Project Role	National Lab research
Nearest Person Month worked	2 months
Contribution to Project	Dr. Driscoll served on the Siting Priority subcommittee. He provided broad MHK industry knowledge and insights into DOE program goals.
Funding Support	NA
Collaborated w/ individual in foreign country	No
Country(ies) of foreign collaborator	NA
Traveled to foreign country	No
If traveled to foreign country, duration of stay	NA

Name	**William Lyte**
Organization	Consultant
Project Role	Electric transmission and port operations
Nearest Person Month worked	3 months
Contribution to Project	Mr. Lyte provided analysis of California grid capabilities and planning. He assisted on port infrastructure identification.
Funding Support	NA
Collaborated w/ individual in foreign country	No
Country(ies) of foreign collaborator	NA
Traveled to foreign country	No
If traveled to foreign country, duration of stay	NA

Name	**Randy Connett**
Organization	Omega Power Engineers, Subcontractor to High Energy, Inc.
Project Role	Transmission System Engineering
Nearest Person Month worked	2 months
Contribution to Project	Led transmission system design studies
Funding Support	NA
Collaborated w/ individual in foreign country	No
Country(ies) of foreign collaborator	NA
Traveled to foreign country	No
If traveled to foreign country, duration of stay	NA

Organizations:
California Polytechnic State University, San Luis Obispo, California (Awardee)
1 Grand Ave, San Luis Obispo, CA 93405
Sam Blakeslee, sblakesl@calpoly.edu; (805) 756-1694

Contribution to Project
- Financial support: DOE Award DE-EE0006517 (this grant)
- In-kind support: Contributed salaries and overheads
- Facilities: Campus offices
- Collaborative research: NA
- Personnel Exchanges: NA

Leidos (vendor);
11951 Freedom Drive, Reston, VA 20190
Rick Williams; richard.b.williams@leidos.com; (503) 484-4415

Contribution to Project
- Financial support: DOE Award DE-EE0006517 (this grant)
- In-kind support: NA
- Facilities: Corporate offices
- Collaborative research: NA
- Personnel Exchanges: NA

CH2M Hill (vendor)
9191 South Jamaica Street, Englewood, CO 80112
Doug Davy; Doug.Davy@ch2m.com; (916) 286-0278

Contribution to Project
- Financial support: DOE Award DE-EE0006517 (this grant)
- In-kind support: NA
- Facilities: Corporate offices
- Collaborative research: NA
- Personnel Exchanges: NA

Columbia Power Technologies (vendor);
236 East High Street, Charlottesville, VA 22902
Reenst Lesemann; rlesemann@columbiapwr.com; (541) 368-5033

Contribution to Project
- Financial support: NA
- In-kind support: Contributed engineering
- Facilities: Corporate offices
- Collaborative research: NA
- Personnel Exchanges: NA

Humboldt State University (subaward);
1 Harpst Street, Arcata, CA 95521
Arne Jacobson; Arne.Jacobson@humboldt.edu; (707) 826-4302**;**

Contribution to Project
- Financial support: DOE Award DE-EE0006517 (this grant)
- In-kind support: Contributed salaries and overheads
- Facilities: Campus offices, Schatz Energy Research Center (SERC)
- Collaborative research: NA
- Personnel Exchanges: NA

Virginia Polytechnic Institute and State University (subaward);
1 Harpst Street, Arcata, CA 95521

Arne Jacobson; Arne.Jacobson@humboldt.edu; (707) 826-4302**;**

Contribution to Project
- Financial support: DOE Award DE-EE0006517 (this grant)
- In-kind support: Contributed engineering and marine science
- Facilities: Campus offices, Schatz Energy Research Center (SERC)
- Collaborative research: NA
- Personnel Exchanges: NA

Sandia National Laboratory
1515 Eubank SE, Albuquerque, NM 87123
Rich Jepsen; rajepse@sandia.gov; (505) 284-2767

Contribution to Project
- Financial support: Direct DOE funding
- In-kind support: NA
- Facilities: Laboratory offices
- Collaborative research: NA
- Personnel Exchanges: NA

National Renewable Energy Laboratory
15013 Denver West Parkway, Golden, CO 80401
Rick Driscoll; Frederick.Driscoll@nrel.gov; (303) 384-7153

Contribution to Project
- Financial support: Direct DOE funding
- In-kind support: NA
- Facilities: Laboratory offices
- Collaborative research: NA
- Personnel Exchanges: NA

Electric Power Research Institute (EPRI) (subaward);
3420 Hillview Avenue, Palo Alto, CA 94304
Paul Jacobson; pjacobson@epri.com; (410) 489-3675

Contribution to Project
- Financial support: DOE Award DE-EE0006517 (this grant)
- In-kind support: NA
- Facilities: Corporate offices
- Collaborative research: NA
- Personnel Exchanges: NA

William Lyte (Consultant);
27607 W. Muir Grove Way, Castaic, CA 91384
William Lyte; wlyte@aol.com; (424) 477-7853

Contribution to Project
- Financial support: NA
- In-kind support: Contributed time
- Facilities: Corporate offices
- Collaborative research: NA
- Personnel Exchanges: NA

Randy Connett (Consultant);
High Energy, Inc.
650 S. Cherry Street, Suite 510, Denver, Colorado 80246;
Randy Connett; randy.connett@omegapower.net; (303) 333-0280

Contribution to Project
- Financial support: NA
- In-kind support: Contributed time
- Facilities: Corporate offices
- Collaborative research: NA
- Personnel Exchanges: NA

CHANGES / PROBLEMS

A no-cost schedule extension to June 30, 2015 was approved by DOE. The PI and PM feel confident that there is sufficient remaining budget to accomplish the contracted workscope; however we have some concern that there will be enough time. We are going to expedite the workscope elements which are behind plan.

BUDGETARY INFORMATION

Complete the following tables in the Excel template accordingly:

- Spending Summary – TAB B
- Cost Share Contributions – TAB C
- Spend Plan Data – TAB D

These tables have been completed and are provided to DOE separately.

Quarterly Technical Progress Report
(Fourth of Four Quarters)
COVER PAGE

Federal Agency to which Report is submitted: DOE EERE – Wind & Water Power Program

Recipient: Cal Poly Corporation; DUNS Number 02-932-6246
Award Number: DE-EE0006517
Project Title: California Wave Energy Test Center (CalWave[sm])
Project Period: One year, June 1, 2014 to May 31, 2015 (originally). Request for a no-cost extension to June 30, 2015 has been granted by DOE.

Principle Investigator: Sam Blakeslee; Director, Institute for Advanced Technology and Public Policy at California Polytechnic State University, San Luis Obispo, California;
email: sblakesl@calpoly.edu; Phone: (805) 756-1694

Report Submitted by: William Toman; CalWave[sm] Project Manager;
email: wtoman@calpoly.edu; Phone: (707) 731-9261

Date of Report: August 12, 2015
Covering Period: April 1, 2015 to June 30, 2015 (4th of 4 Quarters)
DOE Funding Released: June 11, 2014
Report Frequency: Quarterly

Working Partners:
Vendors (F&A included as match)
Leidos (vendor); Rick Williams; richard.b.williams@leidos.com; (503) 484-4415
CH2M HILL (vendor); Doug Davy; Doug.Davy@ch2m.com; (916) 286-0278
Columbia Power Technologies (vendor); Reenst Lesemann; rlesemann@columbiapwr.com; (541) 368-5033

National Labs (F&A is not allowed)
National Renewable Energy Laboratory (NREL); Rick Driscoll; Frederick.Driscoll@nrel.gov; (303) 384-7153
Sandia National Laboratories; Rich Jepsen; rajepse@sandia.gov; (505) 284-2767

Subrecipient (F&A included as match)
Electric Power Research Institute (EPRI) (subaward); Paul Jacobson; pjacobson@epri.com; (410) 489-3675
Humboldt State University (subaward); Arne Jacobson; Arne.Jacobson@humboldt.edu; (707) 826-4302
Virginia Tech (subaward); George Hagerman; hagerman@vt.edu; (757) 340-1921
Scripps Institution Of Oceanography, UC San Diego (subaward); Julie Thomas; jot@cdip.ucsd.edu; (858) 534-3034

Consultants (F&A included as match)
William Lyte (consultant); wlyte@aol.com; (424) 477-7853

Cost-Sharing Partners:

Cal Poly Corporation
Columbia Power Technologies
William Lyte
Humboldt State Univ.
Virginia Tech

DOE Project Team: DOE HQ Program Manager – José Zayas
DOE Field Contract Officer – Pamela Brodie
DOE Field Grants Management Specialist – Yvette Peterson
DOE Field Project Officer – Tim Ramsey
DOE/CNJV Project Monitor – Michael Carella

Signature of Submitting Official:

William Toman
CalWave[sm] Project Manager
California Polytechnic State University, San Luis Obispo, California

ACCOMPLISHMENTS

Project Objective:
Support the U.S. Department of Energy's Wind & Water Power Program with a yearlong study to identify and evaluate a primary offshore test site along California's coast, which may be suitable for the establishment of a national wave energy testing facility appropriate for Technical Readiness Level 8-9 (TRL) Wave Energy Converters (WECs).

Project Goals:

- Identification of a national test facility site that meets the resource and support criteria for testing full-scale WEC devices;
- Developing a preliminary facility design based on an evaluation of:
  - International WEC test facilities such as the European Marine Energy Center (EMEC) and the U.K. Wave Hub,
  - U.S. based WEC test facilities such as Marine Corps Base Hawaii (MCBH) and the Northwest National Marine Renewable Energy Center (NNMREC),
  - National Renewable Energy Laboratory's (NREL's) analogous National Wind Technology Center (NWTC), the TUV Rheinland Photovoltaic Testing Laboratory, and in service off-shore wind production facilities;
- Estimating the cost and schedule for site development and facility construction;
- Assessing the specifics and costs of the environmental studies and permitting that will be necessary to facilitate deployment of the above devices;
- Estimating the annual facility operating and maintenance cost; and
- Estimating the cost of testing and evaluating mechanisms for eventual cost recovery at the facility.

Schedule to Date:
DOE has granted a no-cost schedule extension be implemented with a CalWave[sm] Project effort completion of June 30, 2015. This represents the Q4, and final quarterly report. The final project report will be submitted to DOE on or before September 30, 2015.

Budget to Date:
As of June 30, 2015 (end of the contract period), CalWave[sm] has documented expenses of $820,008 or 79.0% of budgeted expenditures. There are some trailing invoices from team members which have not yet been incorporated. The full accounting will be reported by September 30, 2015.

Goal Status:
Statement of Proposed Objectives (SOPO) Task 1:
Develop and Use Criteria to Rank and Finalize Choice for Candidate Ocean Test Sites

Task 1 Result

As reported in the Q1 RPPR, Task 1 has been completed, but there was some follow-up work to support other SOPO tasks. The Vandenberg site was selected as the primary site for the CalWave[sm] study on October 14, 2014. The Humboldt site will serve as the alternate site[1].

Design Considerations and Preliminary Analyses
- Clarifications and further analyses
- Developed chart of CalWave[sm] study area
- Evaluated additional Test Site Alternatives

Statement of Proposed Objectives (SOPO) Task 2:
Shore-Side Support Infrastructure

The goal of this task is to investigate existing shore support infrastructure and what would be needed to refurbish/repurpose this and to determine what additional shore support infrastructure would be needed.

Design Considerations and Preliminary Analyses
- Evaluated additional Test Site Alternatives
- Civil and electrical engineering alternatives
- Shore Infrastructure
- Continued systems engineering process
- Evaluated system boundaries and key interfaces
- Evaluated requirements

Statement of Proposed Objectives (SOPO) Task 3:
Utility Grid Interconnection

The goal of SOPO Task 3 is to investigate utility grid interconnection alternatives in order to establish cost and schedule estimates for the connection of the test center to the regional grid.

Preliminary design alternatives relative to the Vandenberg Air Force Base (Vandenberg AFB) site. Work this quarter included:

Design Considerations and Preliminary Analyses
- Civil and electrical engineering alternatives
- Second site visit at Vandenberg AFB for discussion of electrical infrastructure and siting
- Generated SOW for Cal Poly and Electrical Engineer
- Grid integration
- Determined engineering requirements for Notional CalWave[sm] Shore Station and Notional CalWave[sm] Substation
- Determined systems engineering for Notional CalWave[sm] Subsea Power Cables
- Evaluated system boundaries and key system interfaces
- Refinement of electrical design inputs and electrical infrastructure requirements
- Survey of WECs for flexibility of test berth connections.

[1] S Blakeslee, *California Wave Energy Test Center (CalWave) Primary Site Decision, S Blakeslee [CalWave PI], 10-14-2014* (California Polytechnic State University, San Luis Obispo, California, October 2014)

Statement of Proposed Objectives (SOPO) Task 4:
Known Environmental Constraints and Progress on Permitting

The goal of SOPO Task 4 is to prepare a permitting plan that includes an assessment of environmental baseline data that regulatory agencies will require for permitting. The permitting plan (found in the Final Report) will identify the key permits and authorizations needed to begin construction of the CalWave[sm] test center, the information requirements for the permits and authorizations, the schedule for obtaining them, and the likely cost of collecting the data and obtaining the permits. Work this quarter included:

- Finalized and summarized a literature search to identify existing baseline data in the scientific literature and annotated bibliography summarizing the contents of key scientific research documents for the final report.
- Completed and summarized a literature search to identify baseline data in the environmental permitting literature (Environmental Impact Statements, Environmental Assessments) applicable to the project area for the final report.
- Summarized commercial fishing data and information for the final report.
- Prepared a narrative discussion of the regulatory approvals needed and regulatory agencies to be consulted to obtain permits for the final report.
- Finalized preliminary mapping studies to determine the spatial presence of environmental permitting constraints in the general siting area (marine reserves, sensitive habitats, areas of particular value for commercial fishing, vessel traffic lanes, etc.) and identify suitable areas for specific siting for the final report.
- Summarized possible key permitting issues and possible data needs to address the issues for the final report.
- Prepared narrative discussion of the regulatory process and timetable for obtaining a Section 238 Research Lease from the Bureau of Ocean Energy Management and marine hydrokinetic power license from the Federal Energy Regulatory Commission
- Prepared itemized preliminary cost estimates for environmental planning and permitting
- Attended DOE Site Visit on June 4.

Statement of Proposed Objectives (SOPO) Task 5:
Public Acceptance by Coastal Community and Other Ocean Users

The purpose of this task is to identify key stakeholders who will be involved and key issues that will need to be addressed during full development of the wave energy test center. Work this quarter included:

- Summarized the 11 stakeholder interviews, fishing community meetings, and elected official outreach activities for the final report.
- Summarized Chumash Tribe outreach and related plans for the Chumash National Marine Sanctuary proposal for the final report
- Prepared written summary of the public meeting on 4/14 in San Luis Obispo.
- Prepared written summary of the regulatory agency meeting on 4/16.
- Finalized comprehensive stakeholder database representing the cross section of sectors/potential interests in the test facility (fishing community; environmental interests; business interests; Tribes; local, state and federal elected officials and departments, etc.).

- Attended DOE Site Visit on June 4.

Statement of Proposed Objectives (SOPO) Task 6:
Top-Level Requirements and Device Testing Criteria

The purpose of this task is to develop top-level requirements (TLRs) and associated listing of specific test site design criteria that will define expectations for each facility element, including the ocean test site, associated service port, and all shore-side ancillary facilities. Work this quarter included:

Statement of Proposed Objectives (SOPO) Task 7:
Develop Preliminary Design Drawings

The purpose of this task is to prepare drawings that depict all elements of the preferred preliminary design in sufficient detail to support completion of facility permitting. Work this quarter included:

Estimate Construction Quantities and Costs

- Additional Architectural Engineer hired to assist in civil engineering and cost estimation of shore station and substation
- Initial drafting of shore station and substation single line drawings - additional Cal Poly students hired
- Developed input for CalWave[sm] Agency outreach meeting

Statement of Proposed Objectives (SOPO) Task 8:
Develop Estimates of Construction Quantities and Costs

The purpose of this task is to develop estimates of construction quantities and costs, based on inputs from the above and from preliminary bids from industry (such as offshore cable installers, etc.). Work this quarter included:

Estimate Construction Quantities and Costs

- Coordination with Sandia National Laboratory and preliminary development work on a SWAN model for the VAFB waters
- Conducted a scoping analysis of Central and Southern California Wavewatch III grid points to identify candidate “nursery” sites that could provide a notional quarter-scale open water test site, similar to the Galway Bay and FabTest sites in the British Isles. The candidate site that provides the best quarter-scale match to the CalWave[sm] fully energetic wave climate is in the northwest Santa Barbara Channel, just south of Goleta Point.
- Alternative CalWave[sm] berth siting analysis including coordination with team members and developing GIS layers for use in siting communications and discussions
- Developed guidance for civil and electrical design inputs

Statement Of Proposed Objectives (SOPO) Task 9:
Develop Operating, Maintenance, and Testing Cost Estimates

The purpose of this task is to develop preliminary facility and testing cost estimates based on the preliminary operations, maintenance and logistics plans and infrastructure preliminary designs developed as part of the preliminary site design efforts. Work this quarter included:

- Reviewed previous RFI documents for WECs

Statement Of Proposed Objectives (SOPO) Task 10:
Task 10: Develop Schedule for Site Development and Facility Construction

The purpose of this task is to enter into discussions with BOEM in regards to status and expectations for a Section 238 lease to support work in scheduling monitoring efforts, bids for equipment purchases and construction activities, and negotiations with WECTDs who may be interested in testing their devices at the site. Work this quarter included:

Plans for Next Quarter:
The CalWave[sm] feasibility study for the project period has been completes. The final project report will be submitted to DOE by September 30, 2015.

SOPO Task Number	Title / Task Description
2	Shore-Side Support Infrastructure
3	Utility Grid Interconnection
4	Known Environmental Constraints and Progress on Permitting
5	Permitting and Stakeholder Consultation
6	Top-Level Requirements and Site Selection Criteria
7	Develop Preliminary Design Drawings
8	Develop Estimates of Construction Quantities and Costs
9	Develop Operating, Maintenance, and Testing Cost Estimates
10	Develop Schedule for Site Development and Facility Construction

Please see the CalWave[sm] Project Schedule & Milestones table (Excel template), under TAB A.

PRODUCTS / DELIVERABLES

Products / Deliverables:
During the course of the CalWave[sm] investigation this quarter, we prepared a Draft Final Project Report. The report will be finalized for submittal by September 30, 2015.

PARTICIPANTS & OTHER COLLABORATING ORGANIZATIONS

Individuals:

Name	**Sam Blakeslee**
Organization	Cal Poly

Project Role	Principal Investigator (PI)
Nearest Person Month worked	2 months
Contribution to Project	Dr. Blakeslee has overseen the development of the project workplan and execution. He has rendered his decision that the primary site to be further investigated by the CalWave[sm] team is to be Vandenberg.
Funding Support	NA
Collaborated w/ individual in foreign country	No
Country(ies) of foreign collaborator	NA
Traveled to foreign country	No
If traveled to foreign country, duration of stay	NA

Name	**Christine Robertson**
Organization	Cal Poly
Project Role	Project Coordinator
Nearest Person Month worked	2 months
Contribution to Project	Ms. Robertson has overseen the development of the project workplan and execution. She assists in facilitating Cal Poly resources supporting the project.
Funding Support	NA
Collaborated w/ individual in foreign country	No
Country(ies) of foreign collaborator	NA
Traveled to foreign country	No
If traveled to foreign country, duration of stay	NA

Name	**William Toman**
Organization	Cal Poly
Project Role	Project Manager
Nearest Person Month worked	9 months
Contribution to Project	Mr. Toman has led the development of the project workplan and its execution. He reports project progress to the PI and provides analysis and suggestions to the PI regarding project issues.
Funding Support	NA
Collaborated w/ individual in foreign country	No
Country(ies) of foreign collaborator	NA
Traveled to foreign country	No
If traveled to foreign country, duration of stay	NA

Name	**Dale Dolan**
Organization	Cal Poly
Project Role	University research
Nearest Person Month worked	3 months
Contribution to Project	Dr. Dolan has assisted in engineering

	evaluations of the site comparison.
Funding Support	NA
Collaborated w/ individual in foreign country	No
Country(ies) of foreign collaborator	NA
Traveled to foreign country	No
If traveled to foreign country, duration of stay	NA

Name	**Arne Jacobson**
Organization	Humboldt State University
Project Role	University research
Nearest Person Month worked	3 months
Contribution to Project	Dr. Jacobson manages the regional site information acquisition for the Humboldt area. Led team in seabottom characterizations and test site layouts.
Funding Support	NA
Collaborated w/ individual in foreign country	No
Country(ies) of foreign collaborator	NA
Traveled to foreign country	No
If traveled to foreign country, duration of stay	NA

Name	**George Hagerman**
Organization	Virginia Tech University
Project Role	University research
Nearest Person Month worked	2 months
Contribution to Project	Dr. Hagerman provided important perspectives on wave energy resource analysis. He also provided knowledge of the Atlantic seaboard MHK and offshore wind industry.
Funding Support	NA
Collaborated w/ individual in foreign country	No
Country(ies) of foreign collaborator	NA
Traveled to foreign country	No
If traveled to foreign country, duration of stay	NA

Name	**Julie Thomas**
Organization	Scripps Institution of Oceanography, University of California, San Diego
Project Role	University research
Nearest Person Month worked	2 months
Contribution to Project	Dr. Thomas provided important perspectives on wave energy resource analysis. She also provided knowledge of coastal data information.
Funding Support	NA
Collaborated w/ individual in foreign country	No

Country(ies) of foreign collaborator	NA
Traveled to foreign country	No
If traveled to foreign country, duration of stay	NA

Name	**Paul Jacobson**
Organization	Electric Power Research Institute (EPRI)
Project Role	Utility industry research
Nearest Person Month worked	2 months
Contribution to Project	Dr. Jacobson served on the Siting Priority subcommittee. He provided broad MHK industry knowledge.
Funding Support	NA
Collaborated w/ individual in foreign country	No
Country(ies) of foreign collaborator	NA
Traveled to foreign country	No
If traveled to foreign country, duration of stay	NA

Name	**Rick Williams**
Organization	Leidos
Project Role	Marine industry engineering
Nearest Person Month worked	6 months
Contribution to Project	Captain Williams (USN, Ret) led the data gathering and analysis of port and supply chain infrastructure as well as construction and operations best practices.
Funding Support	NA
Collaborated w/ individual in foreign country	No
Country(ies) of foreign collaborator	NA
Traveled to foreign country	No
If traveled to foreign country, duration of stay	NA

Name	**Doug Davy**
Organization	CH2M Hill
Project Role	Environmental permitting / Stakeholder engagement
Nearest Person Month worked	6 months
Contribution to Project	Dr. Davy led the analysis of permitting issues, licensing path and stakeholder issues.

Funding Support	NA
Collaborated w/ individual in foreign country	No
Country(ies) of foreign collaborator	NA
Traveled to foreign country	No
If traveled to foreign country, duration of stay	NA

Name	**Reenst Lesemann**
Organization	Columbia Power Technologies
Project Role	WEC technology requirements advisor
Nearest Person Month worked	2 months
Contribution to Project	Mr. Lesemann provided test site configuration analysis for WEC integration.
Funding Support	NA
Collaborated w/ individual in foreign country	No
Country(ies) of foreign collaborator	NA
Traveled to foreign country	No
If traveled to foreign country, duration of stay	NA

Name	**Rich Jepson**
Organization	Sandia National Laboratory
Project Role	National Lab research
Nearest Person Month worked	2 months
Contribution to Project	Dr. Jepson chaired the Siting Priority subcommittee. He provided broad MHK industry knowledge and insights into DOE program goals.
Funding Support	NA
Collaborated w/ individual in foreign country	No
Country(ies) of foreign collaborator	NA
Traveled to foreign country	No
If traveled to foreign country, duration of stay	NA

Name	**Rick Driscoll**
Organization	National Renewable Energy Laboratory
Project Role	National Lab research
Nearest Person Month worked	2 months
Contribution to Project	Dr. Driscoll served on the Siting Priority subcommittee. He provided broad MHK industry knowledge and insights into DOE program goals.
Funding Support	NA
Collaborated w/ individual in foreign country	No
Country(ies) of foreign collaborator	NA
Traveled to foreign country	No
If traveled to foreign country, duration of stay	NA

Name	**William Lyte**
Organization	Consultant
Project Role	Electric transmission and port operations
Nearest Person Month worked	3 months
Contribution to Project	Mr. Lyte provided analysis of California grid capabilities and planning. He assisted on port infrastructure identification.
Funding Support	NA
Collaborated w/ individual in foreign country	No
Country(ies) of foreign collaborator	NA
Traveled to foreign country	No
If traveled to foreign country, duration of stay	NA

Name	**Randy Connett**
Organization	Omega Power Engineers, Subcontractor to High Energy, Inc.
Project Role	Transmission System Engineering
Nearest Person Month worked	2 months
Contribution to Project	Led transmission system design studies
Funding Support	NA
Collaborated w/ individual in foreign country	No
Country(ies) of foreign collaborator	NA
Traveled to foreign country	No
If traveled to foreign country, duration of stay	NA

Organizations:
California Polytechnic State University, San Luis Obispo, California (Awardee)
1 Grand Ave, San Luis Obispo, CA 93405
Sam Blakeslee, sblakesl@calpoly.edu; (805) 756-1694

Contribution to Project
- Financial support: DOE Award DE-EE0006517 (this grant)
- In-kind support: Contributed salaries and overheads
- Facilities: Campus offices
- Collaborative research: NA
- Personnel Exchanges: NA

Leidos (vendor);
11951 Freedom Drive, Reston, VA 20190
Rick Williams; richard.b.williams@leidos.com; (503) 484-4415

Contribution to Project
- Financial support: DOE Award DE-EE0006517 (this grant)
- In-kind support: NA
- Facilities: Corporate offices
- Collaborative research: NA
- Personnel Exchanges: NA

CH2M Hill (vendor)
9191 South Jamaica Street, Englewood, CO 80112
Doug Davy; Doug.Davy@ch2m.com; (916) 286-0278

Contribution to Project
- Financial support: DOE Award DE-EE0006517 (this grant)
- In-kind support: NA
- Facilities: Corporate offices
- Collaborative research: NA
- Personnel Exchanges: NA

Columbia Power Technologies (vendor);
236 East High Street, Charlottesville, VA 22902
Reenst Lesemann; rlesemann@columbiapwr.com; (541) 368-5033

Contribution to Project
- Financial support: NA
- In-kind support: Contributed engineering
- Facilities: Corporate offices
- Collaborative research: NA
- Personnel Exchanges: NA

Humboldt State University (subaward);
1 Harpst Street, Arcata, CA 95521
Arne Jacobson; Arne.Jacobson@humboldt.edu; (707) 826-4302**;**

Contribution to Project
- Financial support: DOE Award DE-EE0006517 (this grant)
- In-kind support: Contributed salaries and overheads
- Facilities: Campus offices, Schatz Energy Research Center (SERC)
- Collaborative research: NA
- Personnel Exchanges: NA

Virginia Polytechnic Institute and State University (subaward);
1 Harpst Street, Arcata, CA 95521

Arne Jacobson; Arne.Jacobson@humboldt.edu; (707) 826-4302**;**

Contribution to Project
- Financial support: DOE Award DE-EE0006517 (this grant)
- In-kind support: Contributed engineering and marine science
- Facilities: Campus offices, Schatz Energy Research Center (SERC)
- Collaborative research: NA
- Personnel Exchanges: NA

Sandia National Laboratory
1515 Eubank SE, Albuquerque, NM 87123
Rich Jepsen; rajepse@sandia.gov; (505) 284-2767

Contribution to Project
- Financial support: Direct DOE funding
- In-kind support: NA
- Facilities: Laboratory offices
- Collaborative research: NA
- Personnel Exchanges: NA

National Renewable Energy Laboratory
15013 Denver West Parkway, Golden, CO 80401
Rick Driscoll; Frederick.Driscoll@nrel.gov; (303) 384-7153

Contribution to Project
- Financial support: Direct DOE funding
- In-kind support: NA
- Facilities: Laboratory offices
- Collaborative research: NA
- Personnel Exchanges: NA

Electric Power Research Institute (EPRI) (subaward);
3420 Hillview Avenue, Palo Alto, CA 94304
Paul Jacobson; pjacobson@epri.com; (410) 489-3675

Contribution to Project
- Financial support: DOE Award DE-EE0006517 (this grant)
- In-kind support: NA
- Facilities: Corporate offices
- Collaborative research: NA
- Personnel Exchanges: NA

William Lyte (Consultant);
27607 W. Muir Grove Way, Castaic, CA 91384
William Lyte; wlyte@aol.com; (424) 477-7853

Contribution to Project
- Financial support: NA
- In-kind support: Contributed time
- Facilities: Corporate offices
- Collaborative research: NA
- Personnel Exchanges: NA

Randy Connett (Consultant);
High Energy, Inc.
650 S. Cherry Street, Suite 510, Denver, Colorado 80246;
Randy Connett; randy.connett@omegapower.net; (303) 333-0280

Contribution to Project
- Financial support: NA
- In-kind support: Contributed time
- Facilities: Corporate offices
- Collaborative research: NA
- Personnel Exchanges: NA

CHANGES / PROBLEMS

A no-cost schedule extension to June 30, 2015 was approved by DOE.

BUDGETARY INFORMATION

Complete the following tables in the Excel template accordingly:

- Spending Summary – TAB B
- Cost Share Contributions – TAB C
- Spend Plan Data – TAB D

These tables have been completed and are provided to DOE separately.

Quarterly Technical Progress Report
(Fifth of Eight Quarters)
TITLE PAGE

Federal Agency to which Report is submitted:	DOE EERE – Wind & Water Power Program
Recipient:	Cal Poly Corporation; DUNS Number 02-932-6246
Recipient Type:	State University
Award Number:	DE-EE0006517.0005
Award Number:	Grant
Project Title:	California Wave Energy Test Center Phase II (CalWave[sm])
Project Period:	One year, February 19, 2016 to February 28, 2017.

Principal Investigator:	Sam Blakeslee; Director, Institute for Advanced Technology and Public Policy
Email:	sblakesl@calpoly.edu
Phone:	(805) 756-1694
Organization:	California Polytechnic State University, San Luis Obispo, California;

Report Submitted by:	William Toman; CalWave[sm] Project Manager
Email:	wtoman@calpoly.edu
Phone:	(707) 731-9261

Date of Report:	April 30, 2016
Covering Period:	February 19, 2016 to March 31, 2016 (5th of 8 Quarters)
DOE Funding Released:	February 19, 2016
Report Frequency:	Quarterly

Working Partners:

Vendors (F&A included as match)
Leidos (vendor); Rick Williams; richard.b.williams@leidos.com; (503) 484-4415
CH2M (vendor); Doug Davy; Doug.Davy@ch2m.com; (916) 286-0278
Kearns & West (vendor); Anna West; awest@kearnswest.com; (415) 391-7900
Omega Power Engineers, LLC (vendor); Randall M. Connett; randy.connett@omegapower.net; (303) 330 6920
UK Wave Hub (vendor); Stuart Herbert; stuart.herbert@wavehub.co.uk; 01736-800294

National Labs (F&A is not allowed)
National Renewable Energy Laboratory (NREL); Al LiVecchi; Al.LiVecchi@nrel.gov; (303) 384-7138
Sandia National Laboratories; Jesse Roberts; jdrober@sandia.gov; (505) 844-5730

Subrecipient (F&A included as match)
Electric Power Research Institute (EPRI) (subaward); Paul Jacobson; pjacobson@epri.com; (410) 489-3675
Humboldt State University (subaward); Arne Jacobson; Arne.Jacobson@humboldt.edu; (707) 826-4302
Virginia Tech (subaward); George Hagerman; hagerman@vt.edu; (757) 340-1921
Scripps Institution Of Oceanography, UC San Diego (subaward); Julie Thomas; jot@cdip.ucsd.edu; (858) 534-3034

State Government Agency and Utility
California Natural Resources Agency (government agency); Chris Potter; Chris.Potter@resources.ca.gov; (415) 740-9869
Pacific Gas and Electric (utility); Brendan Dooher; bxd6@pge.com; (925) 822-7716

Cost-Sharing Partners:

California Natural Resources Agency
Protean Wave Energy Ltd.
Pacific Gas & Electric Company

DOE Project Team: DOE HQ Program Manager – José Zayas
DOE Field Contract Officer – Pamela Brodie
DOE Field Financial Assistance Specialist – Jane Sanders
DOE Field Project Officer – Tim Ramsey
DOE/CNJV Project Monitor – Nicholas Massey

Signature of Submitting Official:

William Toman
CalWave[sm] Project Manager
California Polytechnic State University, San Luis Obispo, California

Section I. Project Accomplishment Narrative

The CalWave[sm] II project award date began on February 19, 2016 which provided 42 calendar days over which work on this phase has progressed. This quarterly report herein constitutes the 5th quarter of work on the CalWave[sm] project as articulated throughout this report. Due to the shortened duration of this quarter, less progress has been made toward project objectives than will be typically seen in a given quarterly progress report. It should be acknowledged, however, that several CalWave[sm] II project team members/organizations performed work at risk before final agreements were executed in order to expedite the progress of critical path objectives.

The project goals and objectives completed for this reporting period primarily included kicking off the new phase of the project by drafting and executing team member contracting agreements as well as convening weekly team member coordination meetings. Outside of the project kickoff work, Task 11 and Task 13 were to be the primary focus of workflow during this reporting period as these tasks are critical for shaping the workflow and outcome of Task 12.

CalWave[sm] II – TASKS	Quarter (from start of project)			
	5th	6th	7th	8th
Task 11: Develop Engineering Quantities, Cost and Schedule Estimates to Support Financing Plan, Select Preferred Location				
Task 12: Develop Permitting Roadmap to Populate Draft NOI/PAD				
Task 13: Develop List of Stakeholder Concerns and Develop Possible Solutions				

**Dark grey means increased effort for a task, and light grey means decreased effort*

The majority of this reporting period was consumed by the contract administration process between Cal Poly Corporation (CPC), the Institute for Advanced Technology and Public Policy (IATPP), and the various CalWave[sm] II vendors, subcontractors, and other team members. Team members that were critical for 5th quarter project objectives had agreements fast tracked in order to limit impact on schedule. This included CH2M, Leidos Inc., Kearns & West, Inc. and Omega Power Engineers Inc. Leidos, Inc., Protean Wave Energy and CH2M in particular provided critical path duties before final agreements had been reached in order to expedite progress on critical project objectives. Additionally, all of the other CalWave[sm] II partners have agreed to participate in the weekly team coordination meetings before Agreements and Memorandums of Understanding (MOUs) have been executed.

The following agreements were executed by March 31, 2016:

Organization	Scope and Budget Collected	Agreement/MOU Executed
Vendors		
CH2M	1/25/16	3/4/16
Leidos Inc.	1/25/16	3/16/16
Kearns & West, Inc.	3/16/16	4/6/16
Subcontractors		
Omega Power Engineers, LLC	3/31/16	4/20/16
UCSD – Scripps Institution of Oceanography	3/24/16	Out on 4/14/16 for Execution
Virginia Tech Research Center	3/23/16	4/20/16
Electric Power Research Institute	In progress	4/20/16
Humboldt State University	In progress	-
Wave Hub – United Kingdom	Scope collected, finalizing travel	-
Cost Share Partners		
Protean Wave Energy, LLC	In progress	-
Pacific Gas & Electric Company	3/11/16	Cost match letter currently in progress
California Natural Resources Agency	In progress	MOU is partially executed, awaiting 2 more agency signatures

Two weekly team coordination meetings were held with the CalWave[sm] II team members beginning on 3/23/16 and these will recur weekly until the completion of the project. During this reporting period these coordination meetings have covered topics including a general project overview of goals and objectives, scheduling and milestone programming, contracting/agreement needs, scope of work refinement, reporting and deliverable requirements, and coordination/progress discussions primarily for Task 11 and Task 13 as noted in Section 2 below. Representatives from Sandia National Labs and the National Renewable Energy Laboratory (NREL) have also been active and involved in team coordination discussions beginning with the project kickoff meeting.

Section 2. Details of Scope Accomplishments

Task 11 Cal Wave[sm] II Engineering Element (Q4-Q8)

The critical milestone accomplished for the Engineering Element was the execution of final subcontractor and vendor agreements with team members that support this scope of work. Work also began on all 5 of the Task 11 subtasks. The core project management team members including the Principal Investigator, Project Manager, Chief Engineer, Project Administrator, and Grants Analyst collaborated and coordinated scope of work review, refinement, and contracting/agreement administration for the key team members that are responsible for the Engineering Element portion of the project. Cal Poly Civil Engineering and Electrical Engineering Faculty also participated in several weekly team coordination conference calls.

The Systems Engineering and Integration subtask was initiated and discussed between team partners. During the weekly team conference call the need for maximum design flexibility and the interfacing between major systems and sub-systems were key concepts that were examined. Specifically, the system boundary between the wave energy test facility infrastructure and that of future wave energy conversion device manufacturers was carefully deliberated. This included discussion of subsea cable connectors, umbilical cables to WEC devices, submarine transmission cables to shore-side infrastructure requirements, electrical conditioning equipment, and mooring/anchoring requirements. Discussion was also had in regards to site alternatives, shore station alternatives, and the possibility of using Platform Irene's existing infrastructure in order to reduce cost and limit the potential environmental impact of the proposed wave energy test facility. Additionally, a Concept of Operations (CONOPS) was drafted for a potential Wave Energy Convertor (WEC) test deployment off of the Cal Poly Center for Coastal Marine Sciences pier which will further the core team's understanding and expertise off WEC testing and deployment in an environmental context similar to that of the proposed CalWave[sm] wave energy test facility near Vandenberg.

The Design Engineering and Analysis subtask saw comprehensive cross discipline coordination occur specifically between civil, electrical, construction, and ocean engineering fields with an emphasis on progressing the notional project design towards a preliminary design. The aforementioned work products primarily included coordination during weekly conference calls as well as the development and refinement of electrical engineering and cable logistic subcontractor scopes of work. Finally, a thorough amount of data was collected and disseminated in regards to recent subsea cable installation off of the central coast of California.

The Benchmarking of Existing Test Center subtask progressed through preliminary discussions with Wave Hub in the United Kingdom which operates a comparable test center from which vital operational design requirements and lessons learned can be gleaned e.g. design flexibility requirements and strategies. Due diligence and outreach was performed on what will be required to subcontract Wave Hub personnel as benchmarking consultants per Federal contracting standards. Additionally, an analysis of Camp Rilea, OR wave energy program infrastructure design was undertaken and integrated into the CalWave[sm] II engineering perspective.

Finally, the Surveys and Wave Measurement subtask was progressed via the weekly team coordination meetings specifically regarding the subsea cable route desktop study subcontract scope and regional wave measurement survey requirements. The scope of work and subcontractor agreement with the University of San Diego Scripps Institution of Oceanography was drafted and is pending execution. Scope of work was refined for the Simulating Waves Nearshore (SWAN) Modeling requirement and scope was refined for the cost share that Pacific Gas & Electric is providing. All team members involved in the Surveys and Wave Measurement subtask have been actively involved in coordination discussions via conference call, phone calls with project management staff, and emails.

Task 12 CalWave[sm] Permitting Element (Q4-Q8)

The core project management team members including the Principal Investigator, Project Manager, Project Administrator, and Grants Analyst collaborated and coordinated scope of work review, refinement, and contracting/agreement administration for the key team members that are responsible for the Task 12 Permitting Element portion of the project. Specifically, the Permitting Element project team came under contract on March 4, 2016. Work since that time has consisted mostly of

administrative set up and participation in project coordination meetings and information exchanges with other members of the project team. The project team has continued to monitor ocean infrastructure regulatory and permitting issues and Virginia Tech has provided key permitting information for a potential Bureau of Ocean Energy Management (BOEM) research lease pathway that has been successfully implemented for a floating wind project in off the coast of Virginia.

Work has not yet begun on the following subtasks, however these tasks are expected to ramp up in the following quarter: Evaluation of Biological Resources Data, Consultation with Regulatory Agencies and Others, Regulatory Roadmap, Preparation of Environmental Baseline Summaries. The Project Coordination included team member attendance on several project team conference calls and active participation in e-mail and telephone exchanges with members of the engineering and project management team.

Task 13 CalWave[sm] Stakeholder Involvement and Public Participation Element(Q4-Q8)

The core project management team members including the Principal Investigator, Project Manager, Project Administrator, and Grants Analyst collaborated and coordinated scope of work collection, review, refinement and contracting/agreement administration for the key team members that are responsible for the Task 13 stakeholder involvement and public participation portion of the project. Work has yet to begin on the following Task 13 subtasks: Advisory Group, Regulatory Agency Group/Subgroup, Materials and Web Site Support. Project Team Coordination by Kearns & West has occurred as needed in order to support the aforementioned scope of work refinement and vendor agreement execution.

Section 3. Cost Status

Please see the following attachments in excel format:

Attachment B – "Spending Summary"

Attachment C – "Cost Share Contributions"

Attachment D – "Spend Plan Data"

Section 4. Schedule Status

Tasks to be focused on in the 6th quarter primarily include Task 11 and Task 12. These two tasks will fundamentally inform the permitting roadmap and draft NOI/PAD which is to be filed by the end of this project.

CalWave[sm] II – TASKS – 6th Quarter Emphasis	Quarter (from start of project)			
	5th	6th	7th	8th
Task 11: Develop Engineering Quantities, Cost and Schedule Estimates to Support Financing Plan, Select Preferred Location				
Task 12: Develop Permitting Roadmap to Populate Draft NOI/PAD				
Task 13: Develop List of Stakeholder Concerns and Develop Possible Solutions				

A major milestone schedule has been established by the core project team as follows:

CalWave[sm] II Milestone Tasks	Project Quarter	Est. Month of Completion	Year
Conceptual Design	6	June	2016
Present Conceptual Design to Agencies	7	July	2016
Preliminary Design	7	September	2016
Present Preliminary Design to Agencies	8	October	2016
Final Preliminary Design	8	October	2016
Draft NOI/PAD with Prelim. Design	8	November	2016
Present Draft NOI/PAD to Agencies	9	January	2017
Final Draft NOI/PAD	9	February	2017
Final Technical Report for DOE Submission	9	February	2017

Please also see attachment A – "Project Schedule and Milestone" in excel format.

Section 5. Changes to Scope and Project Approach

No changes to project scope or approach have occurred during this project reporting period.

Section 6. Problems/Delays

No significant delays have been observed other than the effect that a shortened quarter has had on the reportable progress for this quarter's reporting period.

Section 7. Key Personnel

Section 8. Products and Technology Transfer

Section 8.1 CalWave[sm] II Web Presence

The current website that reflects CalWave[sm] II can be visited at the following hyperlink.

http://www.iatpp.calpoly.edu/projects/energyinitiative.asp

Further updates and a future standalone website will be completed as a part of the Task 13 when stakeholder engagement and public participation engagements are facilitated and further data is gathered.

Section 8.2 Networks and Collaborations Fostered

The CalWave[sm] II Chief Engineer with Leidos Engineering, LLC joined the National Hydropower Association (NHA) Marine Energy Council (MEC) to enhance interaction with WEC developers.

Section 8.3 Technologies/Techniques

No substantial changes to technologies or techniques have been adopted to date.

Quarterly Technical Progress Report
(Sixth of Nine Quarters)
TITLE PAGE

Federal Agency to which Report is submitted:	DOE EERE – Wind & Water Power Program
Recipient:	Cal Poly Corporation; DUNS Number 02-932-6246
Recipient Type:	State University
Award Number:	DE-EE0006517.0005
Award Number:	Grant
Project Title:	California Wave Energy Test Center Phase II (CalWave[sm])
Project Period:	One year, February 19, 2016 to February 28, 2017.

Principal Investigator:	Sam Blakeslee; Director, Institute for Advanced Technology and Public Policy
Email:	sblakesl@calpoly.edu
Phone:	(805) 756-1694
Organization:	California Polytechnic State University, San Luis Obispo, California; (Cal Poly)

Report Submitted by:	William Toman; CalWave[sm] Project Manager
Email:	wtoman@calpoly.edu
Phone:	(707) 731-9261

Date of Report:	June 30, 2016
Covering Period:	April 30, 2016 to June 30, 2016 (6th of 9 Quarters)
DOE Funding Released:	February 19, 2016
Report Frequency:	Quarterly

Working Partners:

Vendors (F&A included as match)
Leidos (vendor); Rick Williams; richard.b.williams@leidos.com; (503) 484-4415
CH2M (vendor); Doug Davy; Doug.Davy@ch2m.com; (916) 286-0278
Kearns & West (vendor); Anna West; awest@kearnswest.com; (415) 391-7900
Omega Power Engineers, LLC (vendor); Randall M. Connett; randy.connett@omegapower.net; (303) 330 6920
UK Wave Hub (vendor); Stuart Herbert; stuart.herbert@wavehub.co.uk; 01736-800294

National Labs (F&A is not allowed)
National Renewable Energy Laboratory (NREL); Al LiVecchi; Al.LiVecchi@nrel.gov; (303) 384-7138
Sandia National Laboratories; Jesse Roberts; jdrober@sandia.gov; (505) 844-5730

Subrecipient (F&A included as match)
Electric Power Research Institute (EPRI) (subaward); Paul Jacobson; pjacobson@epri.com; (410) 489-3675
Humboldt State University (subaward); Arne Jacobson; Arne.Jacobson@humboldt.edu; (707) 826-4302
Virginia Tech (subaward); George Hagerman; hagerman@vt.edu; (757) 340-1921
Scripps Institution Of Oceanography, UC San Diego (subaward); Julie Thomas; jot@cdip.ucsd.edu; (858) 534-3034

State Government Agency and Utility
California Natural Resources Agency (government agency); Chris Potter; Chris.Potter@resources.ca.gov; (415) 740-9869
Pacific Gas and Electric (utility); Brendan Dooher; bxd6@pge.com; (925) 822-7716

Cost-Sharing Partners:

California Natural Resources Agency
Pacific Gas & Electric Company
Protean Wave Energy Ltd.

DOE Project Team: DOE HQ Program Manager – José Zayas
DOE Field Contract Officer – Pamela Brodie
DOE Field Financial Assistance Specialist – Jane Sanders
DOE Field Project Officer – Tim Ramsey
DOE/CNJV Project Monitor – Nicholas Massey

Signature of Submitting Official:

William Toman
CalWave[sm] Project Manager
California Polytechnic State University, San Luis Obispo, California

Section I. Project Accomplishment Narrative

The CalWave[sm] Phase II project award date began on February 19, 2016, such that there have been 133 calendar days over which work has progressed to this point. This quarterly report constitutes the 6th quarter of work on the CalWave[sm] project. This quarter represents the first quarter of substantial progress as the 5th quarter was truncated because the project start date and quarterly report submission date of March 30, 2016 were only 40 days (1.3 months) apart. The reporting period covered by this report encompasses April 1, 2016 through June 30, 2016. This quarterly report additionally articulates progress that occurred within the month of July, 2016 because 3 key events occurred within this timeframe:

- The California Department of California Governor's Office of Business and Economic Development (GO-Biz) issued a letter **(Appendix Attachment 1)** creating the Central Coast Wave Energy Hub – this designation formalizes an economic development and innovation strategy regarding wave energy technology in California and will also help to attract investment in this sector
- The first Permitting Agency Meeting was held on July 11th
- CalWave's[sm] international partner "UK Wave Hub", an existing wave energy test facility in the United Kingdom, made an initial trip to the Central Coast of California in order to provide consultancy on the lessons learned and critical elements for designing, building, and operating a wave energy test facility

These events represent substantive progress for the CalWave[sm] project and were reported on in the various tasks as outlined within the Statement of Project Objectives.

TASKS	Quarter (from start of project)				
	Feb. '16 – March	April – June	July – Sept.	Oct. – Dec.	Jan. '17 – Feb.
	5th	6th	7th	8th	9th
Task 11: Develop Engineering Quantities, Cost and Schedule Estimates to Support Financing Plan, Select Preferred Location					
Task 12: Develop Permitting Roadmap to Populate Draft NOI/PAD					
Task 13: Develop List of Stakeholder Concerns and Develop Possible Solutions					

**Dark grey means increased effort for a task, and light grey means decreased effort*

Major Progress of Objectives

Administrative

The project goals and objectives completed for this reporting period included final administration and execution of the agreements with CalWave[sm] II project partners, along with a primary focus on Tasks 11

and 13 with substantial progress being made on Task 12. The project partner contract administration succeeded in fully engaging the balance of the CalWave[sm] II project partners. Notably, the California Department of Natural Resources, via coordination by the California State Lands Commission (CSLC), issued a finalized cost share Memorandum of Understanding (MOU) with cosignatories including the following agencies: California Natural resources Agency, Ocean Protection Council, California Coastal Commission, and the Department of Fish and Wildlife. The CSLC has engaged consistently in project permitting discussions with representatives from the CSLC being the project lead. Points of contact were established for each of these agencies and a cost share tracking protocol has been established to fulfill agency position equivalent commitments to the project. The Pacific Gas & Electric Company (PGE) MOU was also finalized and an in-kind contribution documentation method has also been established. Finally, a consulting agreement was executed with representatives from UK Wave Hub and their travel plans to the United States for were finalized and execute.

Siting Down-Select, Site Visits, and Progression of Design

The site selection process narrowed the test berth siting to the South and Southeast test berth locations near the Vandenberg Dock which will utilize Vandenberg Air Force Base (VAFB) Substation "N".

An extreme events analysis was performed on the five proposed shore sites that included Tsunami modeling, historic weather modeling, and a seismic ground shaking assessment in order to inform the shore station down selection process.

The South Base Site was selected as the conceptual shore station and the site plan was refined based on a topographic field survey that was performed by a Cal Poly Team of students, professional surveyor instructor and Architectural Engineering Professor. This detailed land survey informed the conceptual civil, mechanical, and electrical engineering and architectural designs.

An extensive industry survey was conducted by the CalWave[sm] Subsea Cable Route Design Team. As a result, the preferred Horizontal Directional Drilling (HDD) launch site was selected as well as an alternate launch site. The selection was based on integrating the conceptual shore station design and location with the offshore test berth locations, topography, bathymetry, subsea cable capabilities and constraints, in conjunction with host facility requirements. The Team included:

- The CalWave II[sm] Project Manager
- The CalWave II[sm] Chief Engineer and Electrical Engineer
- Key VAFB personnel,
- The HDD Company a company that performs marine horizontal directional drilling services,
- The Fugro Pelagos marine geologist on the cable route desktop subcontractor team.
- The CalWave II[sm] environmental/permitting lead from CH2M who subcontracted to Fugro Pelagos,

This industry survey of the site, and subsequent meetings with marine construction industry members, further illuminated survey/data needs for the HDD bore and cable landing design.

The aforementioned work has led to the development and drafting of conceptual design drawings for the Civil, Electrical, and Architectural design drawings, with Mechanical and Auxiliary systems designs to follow.

A conceptual single line diagram and other electrical engineering elements were progressed including the evaluation/coordination of VAFB distribution infrastructure design and transmission equipment upgrade requirements. The technical specifications for the undersea cable are being iterated towards a practical solution for both electrical, horizontal directional drilling, and installation considerations. Project reliability and operability considerations are also under review with respect to repair times and off-design operation and to facilitate safety during maintenance activities.

Project Partner PG&E continued to review all aspects of the electrical engineering discipline and also began preparing data and models for a future PG&E grid interconnect study. PG&E also began preparing data and models for the wave modeling analysis.

The systems engineering boundary was further refined to include systems and sub-systems under the direct control of CalWave[sm] Team. Additionally, the boundary systems were further defined as systems or sub-systems that are a vital part of the design and are not under the direct control of the CalWave[sm] Team. Boundary systems include: The Wave Energy Convertor (WEC) systems; VAFB and PG&E electrical grids; and, VAFB facility infrastructure.

A conceptual “Oceanographic Station” buoy is under consideration This oceanographic buoy would perform wave resource and meteorological instrumentation/data collection to better monitor facility conditions and the buoy would also serve as a terminus for the spare cable and can be used to perform a systems check and calibration after the WEC has arrived on-site and prior to installing the WEC in a test berth.

Permitting

The permitting team continued to develop environmental baseline information and continues to consult with permitting agencies at a variety of venues. Key permitting and environmental personnel from VAFB and the CalWave[sm] team collaborated on-site to collect and disseminate previous VAFB environmental impact assessment documentation from projects within vicinity to the proposed site as it applies to both the marine and terrestrial elements of the project. The project team also began to collect historic information from the Coastal Data Information Program (CDIP) and their institutional partners such as the National Data Buoy Center, as well as US Coast Guard, on anchoring and mooring impacts on marine wildlife, and specifically cetaceans, as well as for other marine biological resource data. The permitting team also began coordination with California State Lands partners and other entities on acquiring the necessary geophysical data including seafloor and coastal mapping geographical information systems (GIS) data sets for permitting documentation and cable route design.

The first Permitting Agency Meeting was held on July 11and provided a project update to 15 different regulatory agencies and other institutional stakeholders. The intent of this meeting was to provide a general update on the CalWave[sm] latest site and conceptual design information, review the existing and expected data/information, and most importantly to seek preliminary feedback on the anticipated data needs that each regulatory agency will require during the permitting phase. Attendance to this meeting was robust and involved many key individuals from each of the agencies. The attendees also highlighted

points of emphasis and interest for future data collection for critical items like for example anchoring, mooring, and whale entanglement concerns.

Coordination/Collaboration and Benchmarking

12 weekly conference calls have been held so far with robust attendance of the CalWave[sm] team. Randy Connett of Omega Power Engineering, CalWave's[sm] electrical engineering team lead visited the Biscay Marine Energy Platform (BIMEP) ocean energy test site in Spain where technical engineering and infrastructure elements were investigated. In addition, representatives from the United Kingdom's "UK Wave Hub" visited the CalWave[sm] team headquarters as well as the conceptual wave energy test site location at VAFB over several days. UK Wave Hub presented information on a wide variety of aspects of their existing wave energy test facility in Cornwall, UK including permitting and technical design elements, operational and management strategies, and critical lessons learned based on their development, construction, and operational experiences over a twelve-year timeline. In addition to this, a consortium of Central and Southern California's marine/ocean industry representatives were convened to establish expertise and logistical capacity for the development of the CalWave[sm] wave energy test center as well as to establish a general industry interest in future marine renewable energy development in California.

Section 2. Details of Scope Accomplishments

The Project Manager coordinated the overall work efforts of the Engineering Element (Task 11), the Permitting and Environmental Element (Task 12) and Stakeholder Involvement and Public Participation Element (Task 13).

Task 11 Cal Wave[sm] II Engineering Element (Q4-Q8)

11.1 Engineering Project Management

The Project Manager coordinated the work efforts of the engineering team in collaboration with the engineering input from Chief Engineer Rick Williams with Leidos Inc. Leidos Inc. provided engineering input to the project management team and coordinated with the Cal Poly Principal Investigator, Project Developer, Project Manager, project management staff, and project team. Weekly project team conference calls continued; and, administrative tasks and reporting were accomplished. Preparation of the agenda for meetings during the week of July 11th was delegated to the Chief Engineer and executed.

Leidos Inc. provided engineering input to the project management team and coordinated with the Cal Poly Principal Investigator, Project Developer, Project Manager, project management staff, and project team. Weekly project team conference calls continued; and, administrative tasks and reporting were accomplished. Preparation of the agenda for meetings during the week of July 11th was delegated to the Chief Engineer and executed.

11.2 System Integration and Systems Engineering (SE&I)

Leidos executed systems integration and engineering (SE&I) activities, including review of the Feasibility Study from CalWave[sm] Phase I, with emphasis on maintaining design flexibility for infrastructure to

support testing out to the design life of 2050. This requires development of interfaces between major systems and sub-systems for Wave Energy Converters (WECs) that have yet to be invented as an input to the permitting process "book ends", also known as a "permitting envelope" and/or "permitting bounding box". This is discussed further in the Section 12 Permitting Element of this report.

The CalWave[sm] conceptual design endeavors to accommodate all WECs in the specified depth range by:

- allowing power conditioning onboard WEC, or ashore.
- providing instrumentation and load bank ashore for testing to demonstrate grid compliance.
- allowing AC or DC electrical output on export cable to shore station.
- providing flexibility in shape of seafloor footprint, vice constraining into squares.
- allowing WEC developer to use their own design for mooring and anchoring, vice a pre-installed (sub-optimized) anchor pattern.
- providing berths with a range of wave energy resource to enable WEC developers to populate data for a complete power matrix.
- providing an off-taker for power during reliability-phase of testing.
- CalWave[sm] can also accommodate shallow and mid-depth testing at Cal Poly Pier
- CalWave[sm] has also identified an adjacent near-shore site for testing WECs in the surf zone in a future phase.

Other progress included:

- Industry Marine Energy Council: Leidos participates in the National Hydropower Association (NHA) Marine Energy Council (MEC) to enhance interaction with WEC developers.

- Technical Standards: CalWave[sm] is considering emerging international standards in the design of infrastructure. The CalWave[sm] Chief Engineer served as Secretary of the international project team of eleven countries and US Delegate to the International Electrotechnical Commission Technical Committee 114 (IEC TC 114) in the multi-year effort to write the Marine Energy Design Technical Specification (62600-2) that will be issued in August/September. Our Chief Engineer will be the US Committee Chair for the follow-on technical specification Maintenance Team.

- Conformity Assessment: CalWave[sm] is considering emerging international movement toward conformity assessment, including component, and project certification, in the design of infrastructure. The CalWave[sm] Chief Engineer is a founding US Delegate to the International Electrotechnical Commission Renewable Energy (IECRE) organization and the Marine Energy Operations Management Committee (MEOMC).

Siting Down-Selection

During the 6th quarter, the CalWave[sm] System Design Concept was refined. Work included discussions of at-sea test berth site alternatives, shore station alternatives, and the potential use of offshore oil Platform Irene.

A spiral development approach was employed to iterate the design from a high state of uncertainty toward a consensus design. We started with the Feasibility Study baseline of five potential offshore sites and three potential shore sites; and, the "notional conceptual design" that was used for rough order of magnitude (ROM) construction estimates. The CalWave[sm] team reached consensus and down selected the offshore sites to those described by the BOEM lease blocks. The South and South East sites have been selected as illustrated per Figure 1.

Figure 1: Proposed CalWave[sm] II Siting Down Selection

Fishers from the ports North of the five originally proposed sites have indicated that the South and Southeast sites are rarely fished due to the distance from Central Coast ports in San Luis Obispo and Monterey counties, the Marine Protected Areas, Marine Reserves, and the rough waters that must be traversed in order to get as far down to Point Conception.

Fishers from the ports South of the site indicated they seldom go into the Point Arguello area due to sea conditions.

The South and Southeast sites are also closer to Port Hueneme which is a hub for Central and Southern California marine contractors, equipment, and capability that can be used for initial construction and long term operations and maintenance purposes. The South and Southeast sites are also still close enough to connect to and utilize Platform Irene as a "lilly pad" and/or existing electrical interconnection if that infrastructure becomes available at a future point in time.

An existing Scripps Buoy (CDIP 071) indicates that the South and Southeast test berth areas have an annual mean energy flux of more than 30 kW/m per data published in the CalWave[sm] I Feasibility Study Final Technical Report: APPENDIX 6-1.

CalWave[sm] I Feasibility Study Final Technical Report: APPENDIX 6-1

Wave Climate Characterization for VAFB Waters

Vicinity of CDIP Station 071 Annual Mean Energy Flux: 43.3 kW/m

South Test Site Area Annual Mean Energy Flux: 39.1 kW/m
South-by-Southeast Test Site Area Annual Mean Energy Flux: 30.4 kW/m

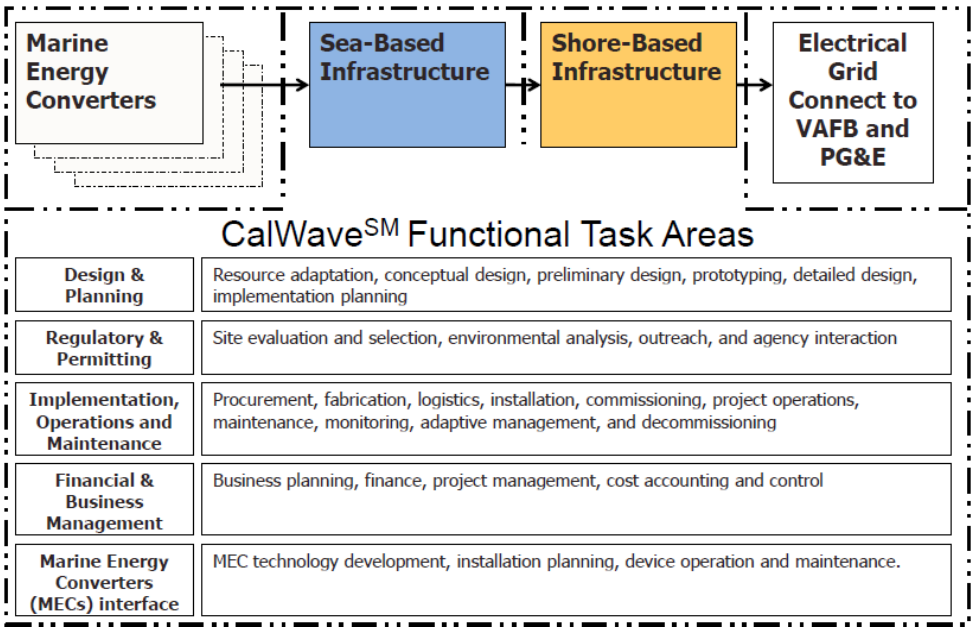
The shore site location was down selected to the South Base Site near the VAFB dock due to the proximity to the South and South East test births, the overall quality of the shore-side infrastructure and the benefit of being located outside of VAFB launch areas which come with significant operational restrictions/constraints, and as informed by the Extreme Events Study. In addition, fishers from Morrow Bay expressed a preference for the two most southerly sites as these represented the least overlap with their areas of commercial interest.

Figure 2: South Base Site (Source Leidos, Inc.)

The useable open space for power conditioning equipment and a substation yard, existing electrical transmission infrastructure for interconnection access (12kV line with a 70kV substation for upgrade capacity), access roads and staging areas, and the VAFB dock infrastructure itself are all critical for logistics/operational and engineering/design considerations which makes the South shore site the most viable in conjunction with the South and Southeast ocean test sites.

System Concept, System Boundary, and Boundary Systems

The system boundary was refined as consisting of Sea-Based Infrastructure, Shore-Based Infrastructure, and the functional task areas as shown below in Figure 3, the System Block Diagram developed by Leidos Inc. Boundary systems were identified as: WEC/MEC System; VAFB-PG&E Electrical Grids; and VAFB Base Facilities.



Leidos and the engineering team maintained an emphasis on establishing well defined boundaries between these system blocks.

The conceptual system design requires the WEC/MEC

Figure 3: System Block Diagram (Source Leidos, Inc.)

developers to provide their own: anchoring and mooring design and installation, umbilical/dynamic and riser cables with dry mate connectors, and either on-board or on-shore power conditioning capability.

This holistic system approach requires of the WEC Developer to provide a properly designed mooring and anchoring system for their specific WEC at the specific berth. The Test Berth concept has the following highlights:

- Provides flexibility in shape of seafloor footprint, vice constraining into squares
- Allow the WEC developer to use their own design for mooring and anchoring, vice a prescriptive, pre-installed, (sub-optimized), anchor pattern
- Provides berths with a range of wave energy resource to enable WEC developers to populate data for a complete power matrix

An important operational concept and system boundary will require the WEC/MEC developer to be responsible for the power conditioning and testing/checkout of their own device output before it is connected to the VAFB/PG&E grid infrastructure. The WEC/MEC developer will have the option of conditioning the power on-board the wave energy conversion device or via installation of equipment at the shore-side substation location.

A robust interconnection specification, modeled after UK WaveHub will be used to ensure protection of the export cable. The Test Berth concept has the following highlights:

- Provides instrumentation and load bank ashore for testing to demonstrate grid compliance.
- Provides an off-taker for power during reliability-phase of testing.
- Provides a grid-integration opportunity with CalWave[sm]'s partner utility PG&E.

The Conceptual Design Review conducted on July 13th included Vandenberg AFB representatives, UK WaveHub, and marine construction industry representatives from L3 Maripro (cable installers), Aqueous (diving and ROV services), Pacific Tug Services (vessels, cranes, barges, and landing craft), and Fugro Pelagos (marine survey services). Discussions were also held with Venoco (oil platform services) about recent cable installations.

Specific lessons learned included:

- The Vandenberg Grid is mission-critical so CalWave[sm] must take particular care to ensure grid integration standards and power quality requirements are satisfied before connection to the VAFB grid. This will drive instrumentation and test design.
    - WaveHub has the opportunity for prior testing at the European Marine Energy Center (EMEC).
- Regulations on vessel emissions, procedural restrictions, and industrial safety requirements are changing the availability of offshore services including vessels, barges, and diving.

- The waters off Vandenberg Dock are more challenging for cable installation than locations south of Point Conception.
- Many oil field vessels will require repowering to meet emission standards (Tier III), thus limiting choices going forward.
- Cable installation barges that previously used portable dynamic positioning systems are no longer authorized by the US Coast Guard, complicating selection of cable installation vessels.
- Divers are practically limited to 300 ft depth by US Coast Guard. Deeper depths require extensive waivers.

- Export cable protection requirements (armor package) vary along the length of the cable (HDD Bore Segment, Near-Shore Segment, Static Segment, Dynamic Cable Tail Segment).
  - Export cable tails, where the dry-mate connector is installed, have a limited number of lifts due to cable wear.
  - Connectors add complexity and are a typical failure point.

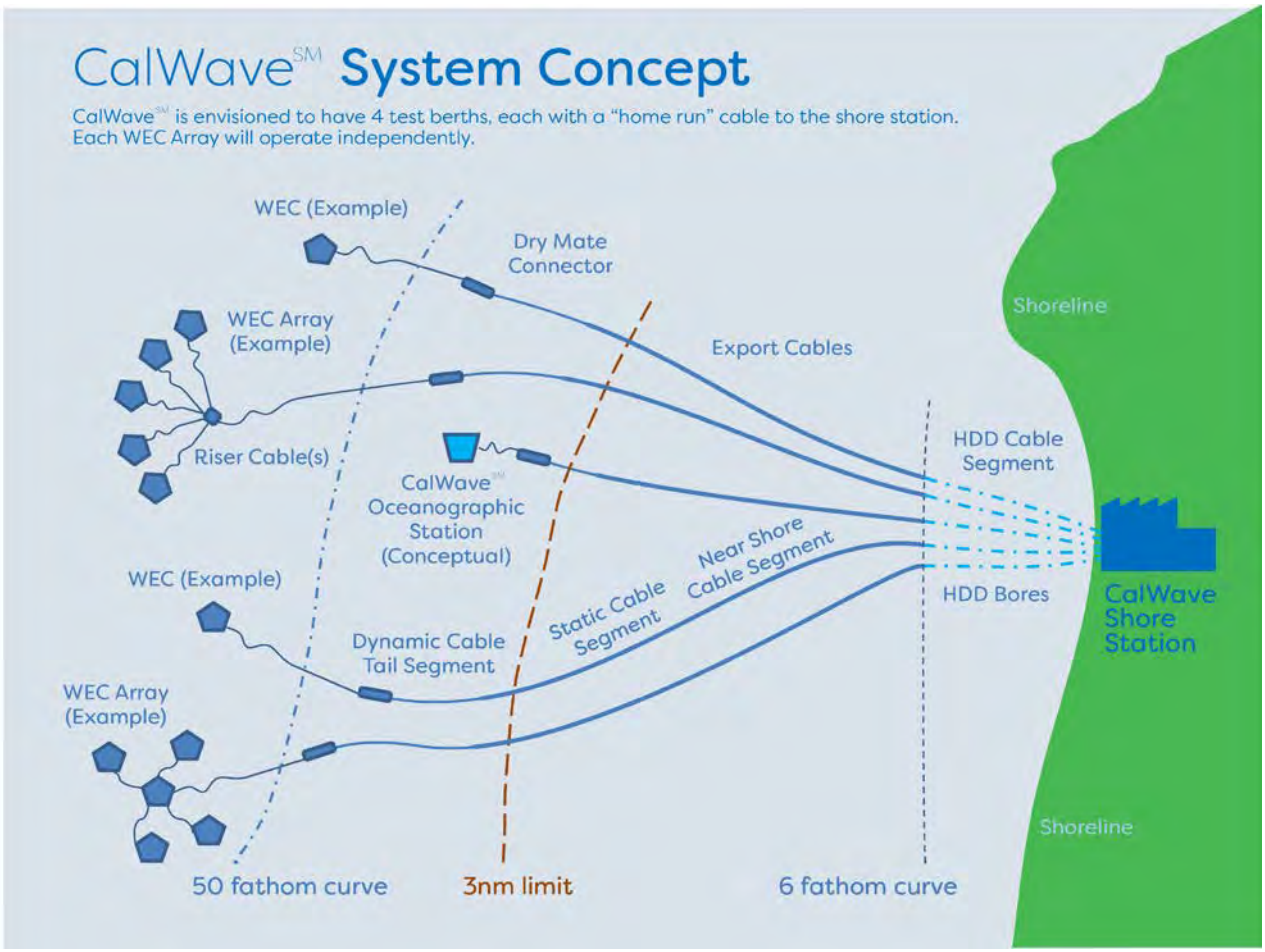


Figure 4: CalWave[sm] System Concept (Source: Leidos Inc./Kearns & West)

The evolving conceptual design reflects CalWave's[sm] emphasis on hosting mature WEC/MEC (TRL 7-9) devices while maintaining a requirements-driven, technology-neutral, vendor agnostic, and holistic design approach.

- The conceptual system includes four test berths on the Outer Continental Shelf (OCS).
- Export cables cross the California Territorial Sea (out to the three nautical mile limit
- Dry-mate connectors inside the 50 fathom (300 ft) curve.
- Surface lay cables, unless burial is required.
- HDD cable landing: five bores for four cables and spare.

Onsite meetings were held with the Vandenberg action officer in order to present and reach agreement on the conceptual baseline system design and location siting. A visit to the South Base Site identified additional constraints for conceptual shore-side infrastructure, such as: view shed considerations from the historic boat house and a base preference to use available excavated material rather than using engineered fill, which would need to be imported at significant expense and increased emissions from haul trucks.

This site visit also identified degrees of freedom, such as: the option of retaining excess excavation and Horizontal Directional Drilling (HDD) cuttings for the submarine cable launch on site in a berm in order to aid in mitigating view shed issues (blocking the view of the conceptual substation yard from the VAFB historic boat house); and, the option of HDD launch from the Vandenberg Dock area – or Dock HDD Launch. This site-walk, in conjunction with the Cable Route Study Team, resulted in a preferred Upland HDD Launch scenario and an alternative Dock HDD Launch scenario that have significant implications on the electrical and civil engineering designs.

Figure 5: South Base Site **(Source Leidos, Inc.)**

11.3 Design Engineering and Analyses: Progress toward Preliminary Design

Leidos Inc. provided Chief Engineer services to coordinate design across engineering disciplines and organizations, including review of scope of work for civil, electrical, construction and ocean engineering, using a systems engineering approach. The CalWave[sm] Project Manager also performed design coordination and review as necessary while PG&E personnel continued to review electrical engineering design development. Current design work products completed include the following conceptual design documents that are attached to this report in the appendix:

Appendix Attachment 2

- CalWave[sm] II Shore Station Concept Site Plan Civil Sheets - Revised 08, June 2016
  - G-1 – Cover Sheet
  - C-1 – Site Plan 1 (Site Location with Alternates)
  - C-2 - Site Plan 2 (VAFB 12kV & 70kV & Existing Substation Infrastructure)

- C-4 – Site Plan 3 (Site Layout Including HDD Bore Launch)

Appendix Attachment 3

- CalWave[sm] II Shore Station Concept Site Plan Architectural Sheets - Draft 07, June 2016
  - A-1 – Architecture (Vandenberg Architectural Influence)
  - A-2a – Architecture (3D View)
  - A-2b – Architecture (Elevation View)
  - A-3a – Architectural Floor Plans (North Modular)
  - A-4a – Architectural Floor Plans (South Modular)
  - A-4 – Architectural Sections

Appendix Attachment 4

- CalWave[sm] II Electrical Sheets - 23, June 2016
  - 16000578-0001-revA – General Arrangement (Layout for Substations and Power Cond.)
  - 16000578-0101 – One Line Diagram (Power Condition Yard and Substation)
  - 16000578-0102 – One Line Diagram (Submarine Cable Sectionalizing & Line Load Bank)

Civil Engineering and Extreme Event Analysis

A Cal Poly Survey Team performed a site investigation and executed a detailed topographic land survey of the conceptual onshore site location. This topographic information guided the civil, architectural, and shore-side infrastructure site layout aspects of the conceptual design. This topographic information was further developed by Cal Poly faculty and students and integrated into the conceptual project drawings.

Figure 6: Shore Station Topography

Cal Poly civil engineering department faculty performed an extreme event analysis for down selection and design consideration on each of the notional CalWave[sm] shore station sites and the HDD launch primary and alternative sites for tsunami inundation and seismic ground shaking based upon inundation maps and USGS Spectral Acceleration summary maps. This analysis will be peer reviewed by Calwave[sm] team partner PG&E. This review builds upon the Evaluation Matrix of the CalWave[sm] Final Technical Report and is categorized per the Construction Specification Institute MasterFormat of titles and numbers for reference. The full "CalWave[sm] Extreme Event Design Considerations with Appendix" dated June 25,

2016 report can be found in the **Appendix Attachment 5** of this report.[1] Below is an explanation and summary of the findings:

The Extreme Events Review was an input to shore site down-selection.

- The preferred CalWave[sm] Shore Station location alternative is the South Base.
- The South Base Shore Station was identified as the "notion conceptual shore location" in the Feasibility Study (Phase I).
- The South Base Shore Station will be included in the draft project description.

The Extreme Events Review was an input to horizontal directional drill (HDD) launch site down-selection.

- The preferred HDD Launch Site alternative is the Upland HDD Launch Site, adjacent to the power conditioning area, at a higher elevation.
- The Upland HDD Launch Site is intended to be included in the draft project description, subject to submarine cable design constraints.
- The alternative Dock HDD Launch Site, at the lower elevation, remains viable.

RESULTS (CSI 02 24 13 and CSI 02 31 13)

1. Southern Shore Station

No visible Inundation on the Southern Shore Station Site. (Appendix Attachment 5 Pg. 3)
Spectral Response Acceleration at the Southern Shore Station Site is SDS = 0.689g.
(Appendix Attachment 5 Pg. 9)

2. Vandenberg Air Force Base Dock (Tsunami and Seismic)

No Visible Inundation on the Vandenberg Dock however further research is recommended for Inundation effects at this location due to its visible low elevation. (Appendix Attachment 5 Pg. 3)
Spectral Response Acceleration at the South Central Shore Station Site is SDS = 0.689g.
(Appendix Attachment 5 Pg. 9)

3. South Central Shore Station Site

Visible Inundation at South Central Shore Station Site Vicinity. Visible Inundation along possible tsunami evacuation route from South Central Shore Station heading Northbound along Coast Rd. (Appendix Attachment 5 Pg. 4)
Spectral Response Acceleration at the South Central Shore Station Site is SDS = 0.700g.
(Appendix Attachment 5 Pg. 10)

4. North Central Shore Station Site

Visible Inundation at North Central Shore Station Site Vicinity. Visible Inundation along possible tsunami evacuation route from North Central Shore Station heading Northbound along Point Sal Rd and along Southbound Roads. (Appendix Attachment 5 Pg. 5)
Spectral Response Acceleration at the North Central Shore Station Site is SDS = 0.733g.
(Appendix Attachment 5 Pg. 11)

5. North Shore Station

Visible Inundation at North Central Shore Station Site Vicinity. Visible Inundation along possible tsunami evacuation route from North Central Shore Station heading Northbound along Point Sal Rd and along Southbound Roads. (Appendix Attachment 5 Pg. 6 and 7)
Spectral Response Acceleration at the South Central Shore Station Site is SDS = 0.772g.

[1] **Baltimore, Craig.** Extreme Events Review of CalWave[sm] Feasibility Report (Phase I) and Appendices, "Feasibility Study for the California Wave Energy Test Center", *for reference to* ***Extreme Events***

(Appendix Attachment 5 Pg. 12)

6. Directional Drill Launch Site Alternatives

a. Primary Location: No Visible Inundation. (Appendix Attachment 5 Pg. 2)

b. Boat Dock Alternative: No Visible Inundation per TsIM (Appendix Attachment 5 Pg.1-2).

- Further research is recommended for Inundation effects at this location due to its visible low elevation.

The Extreme Events Study also reviewed the Cal Poly Pier as a potential check-out site and shallow/mid-depth area:

Cal Poly Pier, Port San Luis

Significant Visible Inundation at the Cal Poly Pier Site. Significant Visible Inundation along Tsunami Evacuation Route Westbound on Avila Beach Dr. (Appendix Attachment 5 Pg. 8).

After the Conceptual Design Review observations are considered, and a proposed project description is written (estimate August 2016), the Extreme Events Study will be referred for peer review by our PG&E partner, who conducted a similar study for Diablo Canyon Nuclear Plant.

The referenced Extreme Events Review of the CalWave[sm] Feasibility Report (the Extreme Events Review) was considered during preparations for the Conceptual Design Review with permitting agencies and industry scheduled in July.

Ocean Engineering & Sea Based Infrastructure Survey/Planning

A Cable Route Industry Survey Team was organized and visited the South Base Site. The Team included: a subsea cable specialist (Center Marine/Harbor Offshore); HDD specialist (The HDD Company); marine geology specialist (Fugro Pelagos); and our CalWave[sm] Electrical Engineer, Permitting Lead, and Chief Engineer. This resulted in a preferred Upland HDD Launch scenario and HDD bore profiles that have significant implications on the electrical and civil engineering designs. This resulted in a preferred Upland HDD Launch scenario and HDD bore profiles that have significant implications on the electrical and civil engineering designs. The alternate HDD Launch Site near the Dock has a lower vertical profile, but requires additional infrastructure to route the cables up the hill to the shore station. As a result, the conceptual bore profiles identified the need to closely consider cable pull strength constraints.

The conceptual bore profiles also identified a need for detailed bathymetry to find the 30 ft and 40 ft depth contours in the vicinity where the HDD bores will “daylight”. The 30 ft curve is a ship safety consideration to avoid grounding. The 40 ft curve is a diver safety consideration to find a location outside the surf zone to avoid surges.

Engaging with the HDD consultant has also produced a conceptual layout of the equipment necessary to perform the HDD work at both the preferred HDD site as well as the alternate.

The CalWave[sm] team is considering a conceptual oceanographic station/buoy as a multi-function device that would provide a terminus for the 5th (spare) subsea power cable. The buoy would allow measurement of wave resource, meteorological instrumentation, and telemetry relay. It would also

allow for a pre-installation test and checkout station for a WEC device in route to a test berth. Figure 4, the System Concept Diagram provided by Leidos, shows the

Figure 7: Conceptual Shore Station Site Plan – Primary HDD Upland Launch Location **(Source Leidos, Inc.)**

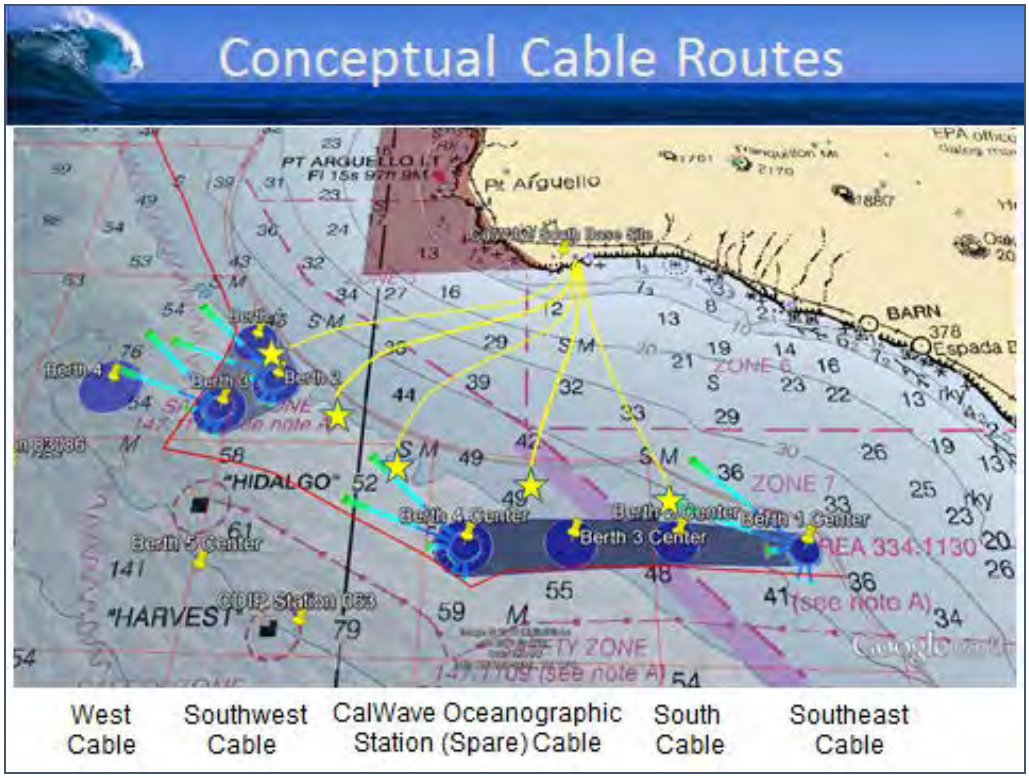


Figure 8: Conceptual Cable Routes (Source Leidos, Inc.)

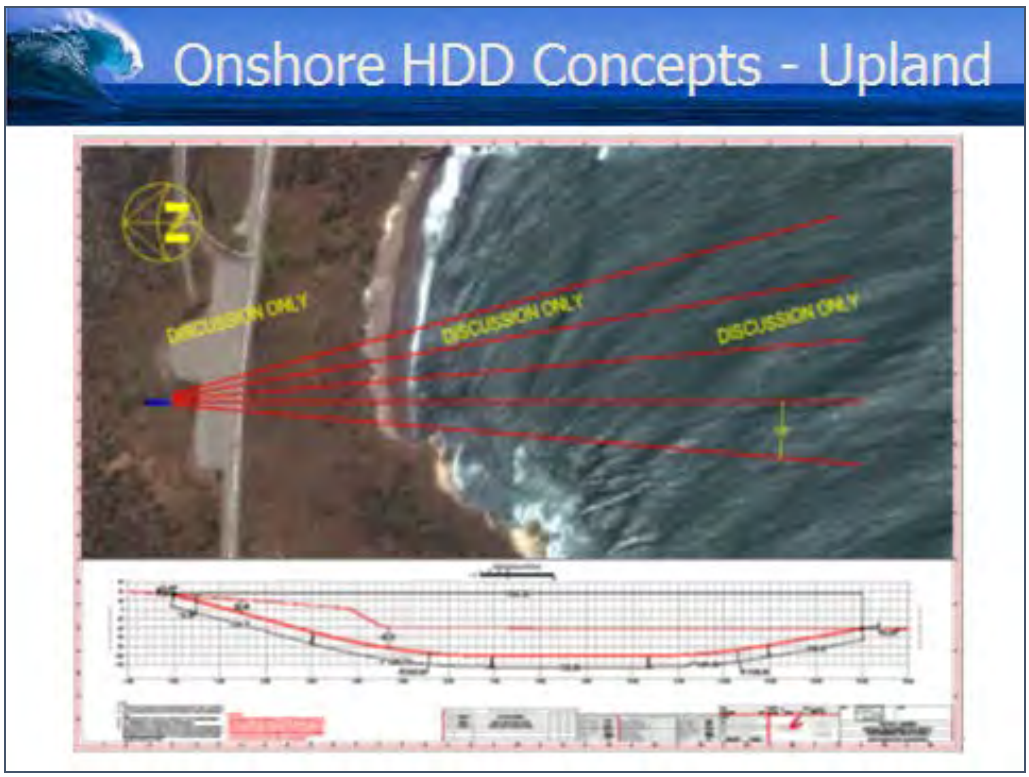


Figure 9: Onshore HDD Concepts – Upland (Source Leidos, Inc.)

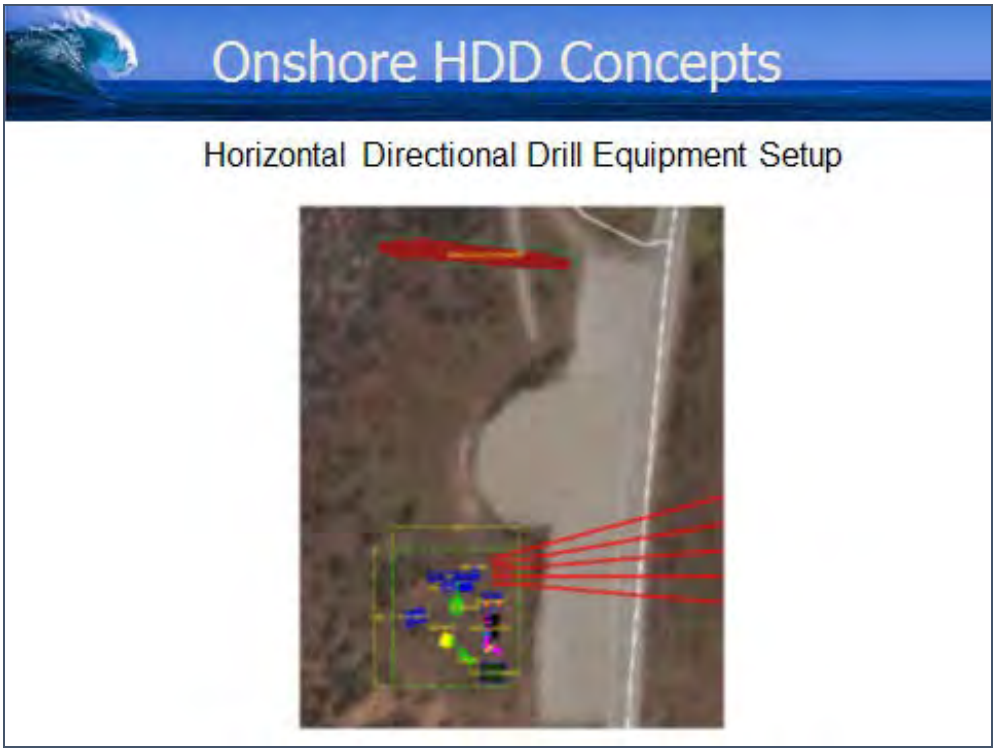


Figure 10: HDD Upland Launch - Equipment Setup (Source Leidos, Inc.)

The alternative Dock HDD Launch scenario and HDD bore profile remain viable.

Figure 11: Alternate HDD Dock Launch Location (Source Leidos, Inc.)

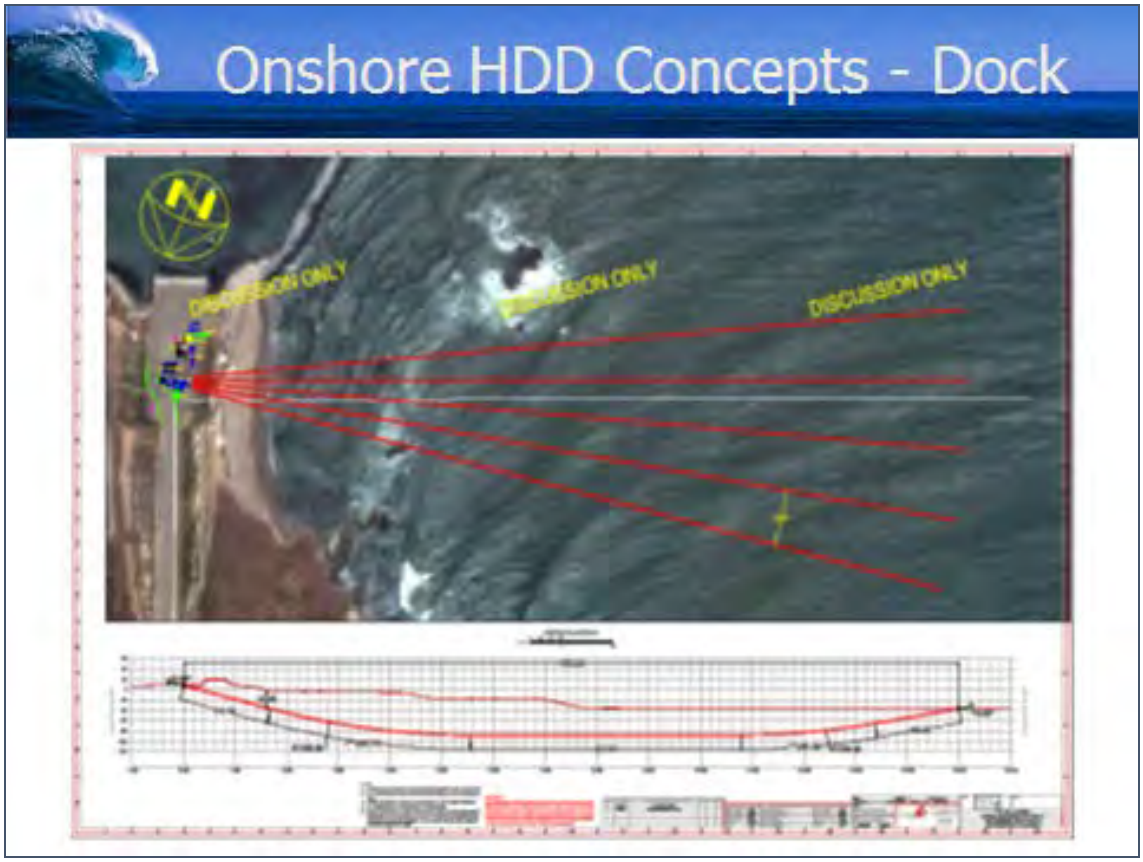


Figure 12: HDD Launch at Dock (Source Leidos, Inc.)

Electrical Engineering & VAFB Design Coordination

Work products for this portion of work included conceptual design briefing materials. Several Engineering Requests for Information (RFIs) were processed and the engineering disciplines then refined their inputs to the overall conceptual design.

Omega Power Engineers continued to refine the electrical engineering design for the conceptual design per design criteria inputs from site investigations, VAFB design requirements and coordination, and progress from the systems engineering and integration work. The electrical drawings as seen in **Appendix Attachment 4** incorporate much of the design progress to date.

Site Investigations: Two separate trips were taken to the site to investigate site conditions and meet with VAFB staff to coordinate. During these trips, existing substation, 70 kV transmission and 12 kV distribution facilities were investigated. The physical location of facilities and orientation was coordinated on site with other subject matter experts and preliminary arrangements agreed upon, with an eye toward practical and economical layouts. The 70 kV transmission line alignment was walked down to confirm alignment assumptions and identify issues for consideration during design.

Design Criteria: Significant attention and discussion was oriented around materials selection to resist corrosive salt fog, which causes severe corrosion of certain materials. VAFB has recommendations based on successful operating experience regarding material selection.

Design: Preliminary Single Line Diagrams **(Appendix Attachment 4)** were prepared articulating all new shore-based electrical facilities required to support the project. Electrical General Arrangements were prepared, revised per comments and submitted to provide for project functional requirements, and to facilitate future maintainability, operability, and reliability.

Request for Information: Seven Requests for Information (RFIs) were prepared and submitted, and information is in process of being returned for use by the client. These RFIs requested information from VAFB as well as PG&E, and will be the basis of the Design Concept for the project. Responses and design requirements from VAFB have been considered and incorporated into the conceptual design.

11.4 Benchmark Existing Test Centers: Coordination and Site Visits

The Chief Engineer with Leidos, Inc. was delegated coordination duties for the Wave Hub visit that occurred on the week of July 11th.

UK Wave Hub Visit (July 12th thru July 15)

The Commercial Director from the UK Wave Hub testing facility presented material on a variety of information regarding the Wave Hub facility including lessons learned, its historical timeline, permitting obstacles, technical design considerations and construction challenges, the operations and maintenance procedures of the facility, its WEC developer contracting/berthing lease and power purchase agreement models, and risk mitigation strategies and insurance structures. Much of this information is still being internalized and considered by the CalWave[sm] team and it is likely that future reports will incorporate further lesson's learned from this initial consultation visit. A follow up consultation is scheduled for this fall. **Attachment 9 UK Wave Hub Session 1 Slides for CalWave[sm]** was provided by the UK Wave Hub commercial director which highlights many, but not all, of the topics covered. Below is an outline of the presentation:

Presentation Topics

- Wave Hub History (2003 First Project Review – 2011 Site Open)
- Site Overview
- Original Drivers for Funding and Constructing the Facility
- Infrastructure and Installation Funding Sources
- Initial Installation Management
- The Business Case for the Facility/Economic Impact
- Current Ownership and Governance

A risk and insurance presentation was given by a UK firm Renewable Risk Advisors and Power Point content can be seen in **Appendix Attachment 10 UK Wave Hub Marine Energy Insurance and Associated Risks for Test Sites and Early State Technologies_July 2016.** This presentation covered a variety of risk mitigation and insurance issues including construction and operation issues, submarine cable issues, health and safety concerns, devices lost in transit, impacts from the fishing industry and pleasure craft, commissioning and reliability concerns, and many others; as well as how to reduce this uncertainty, mitigate the risk, and properly insure a project like CalWave[sm]. This presentation contained highly specialized risk management information for early state offshore renewable energy technologies which can be directly applied to the CalWave[sm] project.

Camp Rilea

Work also included comparative analysis of the Camp Rilea, Oregon wave energy program infrastructure design. The Camp Rilea situation requires a much more detailed analysis of tsunami inundation, including site-specific soil conditions and modeled water velocity and duration, as well as vertical displacement. The resulting "momentum flux", as an expression of mass and velocity, is used to evaluate scouring potential and informs the cable route design. The VAFB South Base Shore Station avoids these issues.

Camp Rilea is also a useful source of considerations for shallow and mid-depth WEC testing including near-shore devices in the surf zone. A potential shallow site near Vandenberg Dock has been identified for a future phase.

Biscay Marine Energy Platform (BIMEP)

CalWave's[sm] electrical engineer with Omega Power Engineers held meetings on May 19, 2016 with Yago Torre-Enciso, Director of Bimep (Biscay Marine Energy Platform, S.A.) and their outside electrical engineer regarding the Bimep project in Spain. This information has been considered while developing the conceptual CalWave[sm] design. BIMEP provided a power point with additional facility information per **Attachment 6 Bimep mayo 2016_CALWAVE**.

BACKGROUND:

- Bimep's mission appears very similar to CalWave's[sm] - i.e. as a demonstration facility for WEC devices. They are few years ahead of CalWave[sm], with a constructed facility.
- Their project is located in Armintza, a small coastal about town about 10 km from Bilbao, Spain. Bimep's staff gave a presentation (attached) to the CalWave[sm] electrical engineer and a tour of their shore facilities. The Google Earth *.kmz file attached is a link to their shore power substation location
- The attached presentation provides insight into Bimep's philosophy and capabilities which drove the configuration of the facility.
- Bimep project ultimate capacity is 20 MW.

FACILITY DEVELOPMENT:

- They began the process to develop the project about 12 years ago, and were subject to a lengthy permitting process. Construction was completed in 2013.
- The project was constructed by awarding two EPC (Engineer-Procure-Construct) contracts: one for the submarine cables and terminations and a second for the shore facilities.
- The submarine cables were installed by Pirelli (Editorial note: This is the same entity we have been communicating with about technical requirements for the submarine cables at CalWave[sm]).
- The first WEC device (a 40 kW device) is scheduled for installation Fall of 2016.

- The apparent lag between the completion date of the project and the installation of the first WEC device is due to the project having to deal with a 'chicken and egg' circumstance – WEC vendors needed to see the facility as a real project (i.e. in-service) before they risked investing in WEC device development.
- The Armintza site was chosen in part because of the proximity of transmission infrastructure as well as the wave resource. There is an abandoned ~1500 MW nuclear power plant (98% complete before abandonment) near the site, with robust unused transmission infrastructure installed. Interconnection is at 138 kV.
- The ownership of the Bimep project is ~92% EVE (Basque Energy Agency – the Regional Body) and IDEA (Spanish Energy Agency – the National Body).
- The project cost is listed at €20 MM ($22M). .

TECHNICAL DISCUSSION ITEMS Extensive discussion occurred with the Bimep EE about technical issues. Some specifics are as follows:

- Reviewed drawings of the Bimep facility. The electrical system configuration is very similar to what has been developed for CalWave[sm], except the Bimep substation transformers
- Bimep system is 13.2 kV. Submarine cables are 13.2 kV from WEC devices to shore. 4 cables with capacity for 5 MW each.
- Bimep does not have on-site generators – they feel islanded operation is difficult to achieve with the resource.
- Bimep has two main power transformers, each rated for 100% capacity. (Current CalWave[sm] configuration is 2 transformers each rated at 50% of ultimate capacity – this may need review/discussion).
- Bimep uses dry mate connectors for offshore connections – they see wet mate connector technology as not mature enough nor needed for the application. (The frequency of connection/disconnection is a factor). They noted that reliability of offshore was a substantial design criterion. Cost of repair of an offshore cable failure was less of a concern than the lead time required to arrange for equipment for such a repair.

OTHER:

- The power generated by the facility is physically delivered to Iberdrola (a private Spanish company – who also works in the US), who apparently markets the power.

11.5 Planning & Specifications: Surveys and Wave Measurement

Leidos reviewed requirements for the scope of work for subsea cable route desktop study and led the survey team that conducted a Vandenberg AFB site visit that included Fugro Pelagos. The emphasis is on determining accurate bathymetry to support horizontal directional drill (HDD) bore profile design. Additional meetings with Fugro Pelagos were held on the week of July 11th. This study will determine the follow-on surveys needed, including charting the kelp beds in the vicinity, and wave measurement instruments needed for CalWave[sm]. PG&E begin to preparing data and models for wave modeling effort.

Virginia Tech extracted hindcast wave data for five Wavewatch III coastal grid points encompassing the CalWave[sm] candidate test berth sites, together with measured wave data from two validation stations

operated by the Coastal Data Information Program (CDIP) at Scripps Institution of Oceanography. The hindcast time series is from a re-analysis that the National Centers for Environmental Prediction (NCEP) just completed in June, using a new swell physics package. The NCEP hindcast covers the period from 1980 through 2009, and the CDIP measurements to validate this hindcast are available for 1987-1998 from a submerged pressure gauge array on Harvest Platform, and for 1998- 2009 from a Waverider buoy 8 km southwest of Harvest Platform.

Task 12 CalWave[sm] Permitting Element (Q4-Q8)

12.1 Literature Review

The CalWave[sm] permitting team conducted literature search to obtain existing documentation regarding previously completed environmental permitting projects for infrastructure along the Central California Coast to evaluate regulatory issues and information sources. Key documents included the following (among others):

- Vandenberg Air Force Base Space Shuttle Program EIS and Supplemental EIS
- Vandenberg Delta Harbor Renovation
- Vandenberg Delta Harbor Dredging
- Vandenberg 12 kV feeder lines N-1 and N-3 upgrade
- PG&E Diablo Canyon Seafloor Seismometer Installation
- Exxon Santa Ynez Cable replacement

Progress continues on this subtask.

12.2 Evaluation of Biological Resources Data

The CalWave[sm] permitting team researched existing sources of biological resources data in the study area, including the following:

- California Cooperative Ocean Fishing Investigations (CalCOFI) data collection (sine 1949)
- California Data Information Program (since 1975)
- Southern California Coastal Ocean Observing System
- California Department of Fish and Wildlife commercial fish landings data
- NOAA Southwest Fisheries Science Center long-range gray whale studies
- Irvine, Mate, et al. long-range blue whale transmitter study
- CalCOFI bird surveys

Progress continues on this subtask.

12.3 Consultation with Regulatory Agencies and Others

A major milestone that was achieved in the permitting scope was the first Regulatory Agency Meeting as articulated in section *13.2 Regulatory Agency Group/Subgroup* of this report. This meeting has further

defined the need for additional environmental baseline data which includes points of emphasis for specific regulatory agency interests associated with this project. The meeting also served to demonstrate the substantial progress the engineering and environmental teams have completed in refining the project description and system design concept, and compiling existing environmental information.

The discussion focused on three areas: onshore infrastructure (the substation, transmission line, and other associated structures), the subsea cables, including horizontal directional drilling and avoidance of sensitive habitat, and the berths for the WEC arrays. The land-based elements and cables will be defined clearly enough to enable understanding of the potential environmental impacts.

One of the most important discussions at the July 11 Regulatory Agency meeting had to do with how CalWave[sm], as permit Applicant, will describe the project in permitting documents, given that the characteristics of the specific wave energy converter (WEC) devices to be tested there may not be known (or even invented) at the time the shore station and subsea cables and connectors are permitted. Taking this into consideration, the permitting documents will need to describe the different types of possible WECs and different types of anchoring, moorings, device characteristics, and ultimately their possible environmental effects as the 'bookends', 'envelope' or bounding box for the WECs and their mooring systems. WECs seeking to test at CalWave[sm] will need to fit within the 'envelope' described in the original permitting document in order to be automatically permitted or pre-qualified for testing. The more clearly the permitting documents can describe the variations possible within the 'envelope', the easier it will be to obtain authorizations to construct and begin operating the CalWave[sm] test center. The project team will be focusing on developing the 'envelope' description along with the detailed on land and cable route plans in the near-term efforts for this project so that the draft Preliminary Application Document completed in this project phase will have identified the project with specificity to inform efficient permitting in the next phase of this effort.

Permitting Lessons Learned from UK Wave Hub Visit (July 12 – 15)

UK Wave Hub staff indicated that they permitted the subsea cable and shore station with a definitive project description and permitted the test berths as an 'envelope' describing several generic types of WEC technologies. Individual clients of UK Wave Hub then are required to obtain their own Marine License "consent" from the UK Marine Management Organization which, because of the initial 'envelope' work, takes only 12 weeks. Also, UK Wave Hub's subsea cable could not be buried in seafloor sediment because of a lack of sediment thickness. The cable was instead laid on the seafloor and covered in rock for protection. At this time, it is unclear whether CalWave[sm] will be required to bury submarine power cables.

UK Wave Hub established a fund for compensation to the commercial fishing community in the project area, though it has not yet been established how the fund will be used or distributed. UK Wave Hub proposes that funds go to general improvements to infrastructure that would help all fishers, rather than in payments to individuals.

There have been no cases of whale entanglement in UK Wave Hub mooring cables to date, though total time of device testing so far is relatively small. UK Wave Hub will be consulted again in the future as more devices are installed there to monitor for cases of entanglement.

Permitting Process Plans

One of the challenges of permitting a testing center like CalWave[sm], or UK Wave Hub is, as mentioned above, that the WEC and WEC mooring project elements cannot be described precisely in the initial project description required for permit documents because test center occupants will not be known at the time of permitting and, in any case, may change from time to time. The consenting process for UK Wave Hub allowed for this by permitting the shore station and cabling and an 'envelope' describing various types of WECs and then allowing for a streamlined (12-week) consenting of individual WEC deployments. The advantage of this approach is that it reduces the uncertainty involved in permitting both the initial installation of the shore station and cabling and the deployment of the WECs at the test berths.

A parallel or similar process might be established in the United States by preparing the National Environmental Policy Act (NEPA) document for the shore station and cabling installation and basic WEC 'envelope' a Programmatic Environmental Impact Statement (PEIS) and then tiering off of this PEIS (incorporating it by reference) to authorize individual WEC deployments on an expedited basis at the time they are proposed. From a NEPA point of view, tiering from previous, more comprehensive, PEISs is an established procedure. As the WEC berths are in federal waters, it would not be necessary to develop a parallel process under the California Environmental Quality Act or California Coastal Act Coastal Development Permit process. WECs would need to meet basic criteria involving expected levels of effect to qualify for expedited permitting and would accept a standard set of environmental compliance conditions outlined in the PEIS.

The most challenging aspect of this approach and the aspect requiring the most discussion and negotiation with regulatory agencies, will be the aspect of obtaining authorizations under the Endangered Species Act (ESA) and Marine Mammal Protection Act (MMPA). The National Marine Fisheries Service (NMFS), will need to be able to make findings that it could issue limited 'take' or 'harassment' authorizations under these laws based on the project description and analysis in the PEIS. The NMFS would also have to agree that proposals to test individual WECs devices could be reviewed quickly to determine on an informal consultation basis, that they meet certain qualifications set forth in the master Incidental Take Authorization. Those meeting the qualifications would be approved in a matter of weeks with a letter of concurrence and would accept the conditions of compliance set forth in the master Incidental Take Authorization. Those not meeting the qualifications (for example, for a new technology that poses different permitting issues than those considered in the PEIS), would need to go through the 135-day formal consultation process under Section 7 of the ESA and/or a lengthier application and review under the MMPA.

The above is the general outline of a permitting approach that CalWave[sm] proposes to begin discussing with regulatory agencies such as Federal Energy Regulatory Commission, which will be the lead NEPA agency, and NMFS. It is our goal to have the outlines of this permitting approach more clearly developed to discuss at the next CalWave[sm] agency meeting.

Consultation and Coordination with California State Agencies and VAFB

The CalWave[sm] permitting team has also initiated preliminary discussions with the State Lands Commissions staff within the Commission's Geographic Information Systems (GIS) Division in order to for agency staff to share and develop the GIS data and resources needed to address the mapping needs of the project. Several CalWave[sm] team members attended and presented to the California Energy

Commission's Integrated Energy Planning Report (IEPR) Workshop on Offshore Renewable Energy held on May 24, 2016 and the CalWave[sm] Project Manager Bill Toman was invited to speak on behalf of the CalWave[sm] project. The purpose of this IEPR meeting was to begin establishing a preliminary understanding of regulatory pathways and stakeholder consultations for marine renewable energy deployment off of the coast of California. Dr. Doug Davy with CH2M was invited to present on permitting concepts and pathways for marine renewable energy in California.

The CalWave[sm] permitting team also performed a site visit and consulted with environmental staff of VAFB regarding environmental permitting of existing Air Force projects. This led to the collection of several environmental permitting studies done for projects performed in the recent past as listed in Section 12.1 of this report. VAFB environmental staff will be consulted as the project continues to develop. During the VAFB site visit, the CalWave[sm] permitting lead also conducted brief field reconnaissance assessments of the local environment adjacent to Vandenberg Dock, and along the 70 kV upgrade line, for example, to confirm the locations of archaeological sites identified in VAFB environmental documents and proximity of pinniped haul-out beaches, kelp beds, and other environmental resources.

On May 31, 2016 CalWavesm Project Manager Bill Toman was invited to the Offshore Wind Roundtable in San Francisco hosted by the Bureau of Ocean Energy Management Director, Abby Hopper, where he spoke about common siting, permitting and stakeholder issues between wave energy and offshore wind energy facilities.

12.4 Regulatory Roadmap

Through preliminary discussions at the July 11th Regulatory Agency Meeting, the CalWave[sm] team has been working with state and federal agencies to define an appropriate and effective permitting approach for CalWave[sm]. FERC maintains licensing authority for Marine Hydrokinetic Projects on the Outer Continental Shelf (OCS), while BOEM maintains lease authority for renewable energy projects located within BOEM's lease blocks on the OCS. BOEM representatives pointed the CalWave[sm] team to the Memorandum of Understand between FERC and BOEM on this permitting and lease pathway as well as the "BOEM / FERC Guidelines on Regulation of Marine and Hydrokinetic Energy Projects on the OCS". BOEM representatives also highlighted the basic requirements for holding a Research Lease with BOEM on the OCS and further detail was provide by BOEM personnel at a later time regarding the research lease application process.

Another important and notable step towards establishing the Regulatory Roadmap was the letter from California Governor Edmund G. "Jerry" Brown Jr. directed to the Department of the Interior/BOEM requesting that a State and Federal Marine Renewable Energy Task Force be formed in order to facilitate the permitting and stakeholder discussion process **(Appendix Attachment 7)**. It is also notable that this letter specifically mentions the possibility of the California Wave Energy Testing Center as a reason to quickly establish this task force. Since the issuance of this letter, BOEM has held a preliminary informational meeting about the fundamentals of the State/Federal Task Force, which was facilitated by one of the CalWave[sm] team members. The CalWave[sm] team can begin coordinating with state and federal agencies about permitting through this Task Force once the team files a research lease application with BOEM.

12.5 Preparation of Environmental Baseline Summaries

This task will begin after conceptual design phase is complete and will encompass an approximate time frame starting in July and ranging through the Fall of 2016.

12.6 Project Coordination

CH2M has executed an agreement with Fugro Pelagros to perform the cable route desktop study in order to perform a preliminary assessment of notional subsea cable routes, data gaps, and further surveys needed, as well as risk analysis per the International Cable Protection Committee Recommendation No. 9 – Minimum Technical Requirements for a Desktop Study (also known as Cable Route Study) Issue Date: 2 November, 2007. CH2M has also executed an agreement with Glosten to perform subcontract work on performing an anchoring and mooring lessons learned analysis as it pertains to CalWave[sm] infrastructure and possible future WEC developers and CalWave[sm] tenants in the context of permitting requirements and the regulatory roadmap.

Task 13 CalWave[sm] Stakeholder Involvement and Public Participation Element(Q4-Q8)

13.1 Advisory Group

The CalWave[sm] Advisory Group will serve as a multi-stakeholder forum to provide project information to representatives from all major stakeholder communities and solicit guidance and input on project parameters and studies/permitting efforts. Kearns & West will solicit interest in the Advisory Group and convene the members beginning in the third quarter of 2016. This group will be periodically engaged throughout the project to ensure that all stakeholder and community needs and potential concerns are addressed, to the extent feasible.

Collaboration between Kearns & West, Scripps Institution of Oceanography, CH2M, and State Lands produced conceptual stakeholder outreach materials that explain existing wave measurement buoys and their associated anchoring and mooring from the Coastal Data Information Program (CDIP). This outreach material has been used successfully in the past for stakeholder outreach specifically at Jalama Beach which is just Southeast of the CalWave[sm] South and Southeast test berths and the CalWave[sm] team is using it as a potential benchmark for future outreach material and strategies.

13.2 Regulatory Agency Group/Subgroup

The core project management team members including the Principal Investigator, Project Manager, Project Administrator, and Grants Analyst collaborated and coordinated scope of work collection, review, refinement and contracting/agreement administration for the key team members that are responsible for the Task 13 stakeholder involvement and public participation portion of the project. During Q6, the team worked towards organizing the first Regulatory Agency Meeting of this phase (held on July 11th in Camarillo, CA). Activities for this subtask included setting and distributing the meeting agenda, reaching out to and confirming participants by phone and email, updating the agency contact list, securing a meeting location, and developing presentations for the meeting. The list below shows who attended the Regulatory Agency Meeting:

Regulatory Organization	Name	Non Regulatory CalWave[sm] Team	Name
Bureau of Ocean Energy Management (BOEM)	Doug Boren	Cal Poly	Sam Blakelsee
Bureau of Ocean Energy Management (BOEM)	Jean Thurston	Cal Poly	Bill Toman
Bureau of Ocean Energy Management (BOEM)	Susan Zaleski	Cal Poly	Nick Osterbur
California Coastal Commission	Tom Luster (phone)	CH2M	Doug Davy
California Ocean Protection Council	Chris Potter (phone)	CH2M	Chris Rein
California State Lands Commission	Maren Farnum	Kearns & West	Anna West
California State Lands Commission	Cheryl Hudson (phone)	Kearns & West	Janet Thomson
California State Lands Commission	Pat Mulcahy	Leidos	Rick Williams
California State Water Resources Control Board	Joanne Jensen (phone)	PG&E	Brendan Dooher
California State Water Resources Control Board	Catherine Woody (phone)		
Federal Energy Regulatory Commission (FERC)	Jim Hastreiter (phone)		
NOAA Office of National Marine Sanctuaries	Lisa Wooninck		
NOAA Fisheries	Bill Foster		
Point Mugu Naval Air Warfare Center	John Burke		
United States Army Corps of Engineers (USACE)	Crystal Huerta (phone)		
United States Coast Guard (USCG)	Darryl Harvey		
United States Coast Guard (USCG)	James Morgia		
United States Fish and Wildlife Service (USFWS)	Lilian Carswell (phone)		
United States Fish and Wildlife Service (USFWS)	Dao Yang		
United States Navy	Walter Schobel (phone)		
Vandenberg Air Force Base	Ken Domako		
Vandenberg Air Force Base	Brad King		

The meeting objectives include providing an update on CalWave[sm], describing the latest site and conceptual design information, reviewing the existing and expected data/information, and seeking preliminary feedback on anticipated data needs during permitting. Topics on the Regulatory Agency Meeting Agenda include the following:

I. Introductions/Session Overview
II. CalWave[sm] Overview and Update
III. CalWave[sm] System Design Concept
IV. Draft CalWave[sm] Project Description
V. Existing Information; Anticipated Study Needs During Permitting
    - Brief presentations from BOEM and OPC regarding their existing and planned information/studies
    - Initial discussion of additional studies needed during permitting
VI. Next Steps and Anticipated Timeframes

Some of the key takeaways from this agency meeting included a general outline and follow-up for obtaining a BOEM research lease and a FERC license (with BOEM participating as a cooperating agency).

Key points from the regulatory agency meeting follow.

- There is extensive existing information available or underway for this project, including information on land-based resources, and marine resources. Detailed bathymetry for the entire California coastline is under development by USGS, funded by the State of California; upcoming coastal segments are directly applicable to the CalWave[sm] study area.
- Extensive marine mammal monitoring has occurred over many years so a very strong baseline of information is already established.
- The project is defined fairly well for the land-based and cable planned elements of the project. The "envelope" approach for the WEC devices and anchoring and mooring systems will be used to define the berths and their potential test installations by project developers.
- Strong relationships are established between the project team and the regulatory agencies given the almost two-year effort associated with CalWave[sm], as well as the previous WaveConnect project in both Humboldt and Central Coast. Also, given the co-funding efforts by the State of California, including State Lands Commission, the Natural Resources Agency (which includes the California Department of Fish and Wildlife and the Ocean Protection Council) has laid the groundwork to work closely through an efficient permitting process together with the state and federal agencies involved.
- Understanding the potential WEC device and associated mooring and anchoring plans will be the most important area of focus in permitting. Understanding the potential for entanglement and the monitoring/adaptive management and mitigation plans for entanglement will be a significant topic to address.
- The Coast Guard is ready to work with the project team to develop the specifics needed for this agency.
- US Fish and Wildlife has identified important species of concern associated with the land-based plans, including the 70kV transmission line. Specific contacts and next steps were identified to address these specifics efficiently and effectively.
- The project team plans close follow-up with FERC and BOEM to learn from previous experiences and apply lessons learned.
- The project team plans close follow-up with NMFS to assure that all relevant areas are involved early and throughout (general permitting, marine mammal, Essential Fish Habitat, etc.).
- A recent BOEM study has identified that cable experience across other projects have found no detectable effects for electromagnetic fields (EMF) associated with subsea cables. This study will be shared and reviewed in future regulatory agency meetings.
- The state agencies plan to closely coordinate amongst themselves and with federal agencies on this effort.

13.3 Materials and Web Site Support

Kearns & West will begin to create/collect information on this subtask beginning in late July with work progress continuing through the end of the project.

13.4 Project Team Coordination

Kearns & West has performed project team coordination as needed throughout the 6th quarter in order to organize and facilitate the first Regulatory Agency Meeting that was held on July 11, 2016. This subtask will be an ongoing process throughout the duration of the project.

Project Management and Reporting

The Principal Investigator, Project Manager and Project Administrator teamed to track workscope execution against schedule milestones and budget. The Quarterly Reports are drafted by the Project Administrator with specific inputs from all team members and then are reviewed by the Project Manager and Principal Investigator. The Final Report will follow a similar process.

Section 3. Cost Status

Please see the following attachments in excel format:

Attachment B – "Spending Summary"

Attachment C – "Cost Share Contributions"

Attachment D – "Spend Plan Data"

Section 4. Schedule Status

Tasks to be focused on in the 6th quarter primarily include Task 11 and Task 12. These two tasks will fundamentally inform the permitting roadmap and draft NOI/PAD which is to be filed by the end of this project.

TASKS	Quarter (from start of project)				
	Feb. '16 – March	April – June	July – Sept.	Oct. – Dec.	Jan. '17 – Feb.
	5th	6th	7th	8th	9th
Task 11: Develop Engineering Quantities, Cost and Schedule Estimates to Support Financing Plan, Select Preferred Location					
Task 12: Develop Permitting Roadmap to Populate Draft NOI/PAD					
Task 13: Develop List of Stakeholder Concerns and Develop Possible Solutions					

The major milestone schedule that has been established by the core project team is progressing as follows:

CalWave[sm] II Milestone Tasks	Project Quarter	Est. Month of Completion	Year
Conceptual Design (Complete)	6	June	2016
Present Conceptual Design to Agencies (Complete)	7	July	2016
Preliminary Design (In progress)	7	September	2016
Present Preliminary Design to Agencies	8	October	2016
Final Preliminary Design	8	October	2016
Draft NOI/PAD with Prelim. Design	8	November	2016
Present Draft NOI/PAD to Agencies	9	January	2017
Final Draft NOI/PAD	9	February	2017
Final Technical Report for DOE Submission	9	February	2017

Please also see **attachment A – "Project Schedule and Milestone"** in excel format.

Section 5. Changes to Scope and Project Approach

The major changes to the project approach thus far include:

- The conceptual oceanographic/instrumentation buoy as described in *Section 11.2 System Integration and Systems Engineering*
- WEC developers will be required to design and construct their own anchorage and mooring solutions
- The siting down selection to the South and Southeast test berths and the South Shore Station location near the VAFB dock as described in *Section 11.2 System Integration and Systems Engineering*

Section 6. Problems/Delays

No significant delays have been observed in this quarter.

Section 7. Key Personnel

No significant changes to key CalWave[sm] personnel has occurred since the beginning of Phase II.

Section 8. Products and Technology Transfer

Section 8.1 CalWave[sm] II Web Presence

The current website that reflects CalWave[sm] II can be visited at the following hyperlink. This site has not been updated since the last quarterly report.

http://www.iatpp.calpoly.edu/projects/energyinitiative.asp

or

www.calwave.us

Further updates and a future standalone website will be completed as a part of the Task 13 when stakeholder engagement and public participation engagements are facilitated and further data is gathered.

Section 8.2 Networks and Collaborations Fostered

Central Coast Wave Energy Hub Designation by State of CA

The California Department of California Governor's Office of Business and Economic Development (GO-Biz) has provided a letter **(Appendix Attachment #1)** which forms the Central Coast Wave Energy Hub which is connected to the existing IDEA iHUb which encompasses networks of innovation partners throughout Central and Southern California. This designation will provide the CalWave project with an overarching legal vehicle to form an economic and innovation development platform around the wave energy industry in California. The CalWave[sm] team will continue to develop this program and will update the Department of Energy as it unfolds. Below is an excerpt from the GO-Biz iHub website:

California's Innovation Hub for Defense, Energy and Aerospace (iDEA Hub) was founded in October 2013. Based in Ridgecrest the iDEA Hub's region encompasses California's Kern, Ventura, Orange, Los Angeles, San Luis Obispo, and San Diego Counties and provides an ideal backdrop to incubate and grow Defense, Energy and Aerospace technology and businesses. The iDEA Hub provides a focus both on small emerging technology companies and university research teams, as well as established high-tech businesses. With the Naval Air Warfare Center, Edwards Air Force Base, the AERO Institute and NASA Armstrong Flight Research Center as featured Federal laboratories, technology partners can benefit from the combined expertise of over 7,000 scientists, engineers, logisticians, prime government contractors, acquisition professionals and military operators. Additionally, participants can access vertically integrated RDT&E facilities and resources co-located with world class land, sea and air test ranges capable of simulating nearly any environment. With the recent inclusion of San Luis Obispo County, the Central Coast extension of iDEA Hub incorporates a developing Marine Renewable Energy cluster which includes public and private research partners. These research partnerships include Cal Poly - San Luis Obispo, Vandenberg Air Force Base, California Natural Resource Agency, Pacific Gas and Electric Company, National Renewable Energy Laboratory, Sandia National Laboratories, the Electric Power Research Institute, and the United Kingdom Wave Hub facility – a world class wave energy technology

test and deployment center, as well as corporate partners. Additional sectors that the Central Coast extension will focus on include San Luis Obispo County's emerging Cybersecurity and Water technology clusters with an emphasis on expanding public private partnerships, workforce development, and commercialization strategies. The California iDEA Hub provides unique access to a robust ecosystem addressing many of our Nation's most critical science and technology needs. Public and private partners in the iDEA Hub find mutual benefit by working collaboratively to foster innovation and create economic growth in surrounding communities. Harnessing the strengths of diverse organizations to leverage expertise in research, development, test and evaluation, we enable technology advancement to the industries we serve by:

- *Performing nationwide and worldwide promotion of the region's innovation ecosystem*
- *Facilitating partnerships between Government, Industry and Academia*
- *Providing business incubation services and facilities for entrepreneurs and start-up companies*
- *Connecting private sector capital with technology commercialization opportunities*
- *Pursuing funded research opportunities to strengthen the regional technology base*
- *Promoting, hosting and encouraging STEM outreach, programs and activities spanning the iDEA Hub's regions*
- *Supporting Federal retirees in entrepreneurship activities related to defense and aerospace*
- *Attracting and retaining a qualified workforce in the iDEA Hub geographies*
- *Hosting training and networking events to act as catalysts for idea exchange, collaboration, and knowledge sharing across Defense, Energy and Aerospace industries*

KEY PARTNERS:

Indian Wells Valley Economic Development Corporation
Los Angeles Economic Development Corporation
San Diego Regional Economic Development Corporation
Orange County Workforce Investment Board
Inland Empire Economic Partnership
County of Ventura
Greater Antelope Valley Economic Alliance
Santa Clarita Valley Economic Development Corporation

UNIVERSITY PARTNERS:

California State University, Los Angeles
University of California, Los Angeles

Cal Poly San Luis Obispo
Cal Poly Pomona

For more information about the IDEA iHub please visit the following hyperlink:

http://business.ca.gov/Programs/Innovation/iDEAiHub.aspx

California Energy Commission Integrated Energy Policy Report Workshop on Offshore Renewables

CalWave[sm] team members Bill Toman and Doug Davy made presentations before the California Energy Commission (CEC) Biennial Integrated Energy Policy Report (IEPR) workshop on offshore renewable energy. The IEPR process sets California's energy policy over a two-year period and 2016 is the first year that the CEC has held an IEPR workshop on offshore renewables. Bill Toman described CalWave[sm] and provided an update on CalWave[sm]'s project development progress. Doug Davy made a presentation on the challenges of permitting energy facilities in the marine environment, based on experience with CalWave[sm] and the Pacific Gas and Electric Company WaveConnect project. Representatives of each of the key regulatory agencies involved in permitting offshore renewable energy were present in person or by teleconference, including the U.S. Department of Energy, BOEM, FERC, National Marine Fisheries Service, US Fish and Wildlife Service, California State Lands Commission, California Coastal Commission, California Department of Fish and Game, and others.

State/Federal Marine Renewable Energy Task Force Formation

Key CalWave[sm] team members have participated in the preliminary discussions of the pending California/Federal Marine Renewable Energy Task Force. BOEM and the state agencies are anticipating a forthcoming CalWave[sm] research lease application to BOEM, which would formally enable CalWave[sm] to be discussed at the Task Force. However, given the high degree of coordination between the CalWave[sm] team and the state and federal regulatory agencies, it is possible that information-sharing about CalWave[sm] could occur at the Task Force prior to that research lease application. CalWave[sm] team members will maintain consistent contact and participation in this process as it unfolds especially considering that CalWave[sm] is one of only two marine renewable energy projects currently active in California.

UK Wave Hub

As discussed in depth in previous portions of this paper, the consultation visits with the Wave Hub wave energy test center in the United Kingdom led to very useful insights and transferrable lessons learned over Wave Hub's twelve-year existence. UK Wave Hub is likely to return in October to pick up where the consultation left off and to further explore pertinent technical topics that are high priority for CalWave[sm] to address.

Of note, Stuart Herbert, the Commercial Director of Wave Hub said at the conclusion of his July CalWave[sm] visit, that he was so impressed with the location, team, marine supply and support infrastructure, and the integral shoreside role of Vandenberg Air Force Base that he intends to enter into a Memorandum of Understanding (MOU) of collaboration with CalWave[sm] in the near future.

BIMEP

As discussed in previous sections of this report, Randy Connett of Omega Engineers, CalWave[sm]'s electrical engineer, visited the "BIMEP" marine energy test facility in Northern Spain on his own initiative while traveling in Europe. He retrieved useful benchmarking insights that can be considered for design comparison for the CalWave[sm] project.

Section 8.3 Technologies/Techniques

No substantial changes to technologies or techniques have been adopted to date that have not already been articulated in this report.

APPENDIX

Appendix Attachment 1

- Letter for GO-Biz Establishing the Central Coast Wave Energy Hub

Appendix Attachment 2

- CalWave[sm] II Shore Station Concept Site Plan Civil Sheets - Revised 08, June 2016

Appendix Attachment 3

- CalWave[sm] II Shore Station Concept Site Plan Architectural Sheets - Draft 07, June 2016

Appendix Attachment 4

- CalWave[sm] II Electrical Sheets - 23, June 2016

Appendix Attachment 5

- CalWave[sm] Extreme Event Design Considerations with Appendix - 24, June 2016

Appendix Attachment 6

- Attachment E Bimep mayo 2016_CALWAVE

Appendix Attachment 7

- Re: Request to Establish Federal-California Marine Renewable Energy Task Force – May 12, 2016

Appendix Attachment 8

- July 11 CalWave[sm] Agency Meeting Summary

Appendix Attachment 9

- UK Wave Hub Session 1 Slides for CalWave[sm]

Appendix Attachment 10

- UK Wave Hub Marine Energy Insurance and Associated Risks for Test Sites and Early State Technologies_July 2016

Quarterly Technical Progress Report
(Seventh of Nine Quarters)
TITLE PAGE

Federal Agency to which Report is submitted:	DOE EERE – Wind & Water Power Program
Recipient:	Cal Poly Corporation; DUNS Number 02-932-6246
Recipient Type:	State University
Award Number:	DE-EE0006517.0005
Award Number:	Grant
Project Title:	California Wave Energy Test Center Phase II (CalWave℠)
Project Period:	One year, February 19, 2016 to February 28, 2017.

Principal Investigator:	Dr. Sam Blakeslee; Director, Institute for Advanced Technology and Public Policy
Email:	sblakesl@calpoly.edu
Phone:	(805) 756-1694
Organization:	California Polytechnic State University, San Luis Obispo, California; (Cal Poly)

Report Submitted by:	William Toman; CalWave℠ Project Manager
Email:	wtoman@calpoly.edu
Phone:	(707) 731-9261

Date of Report:	October 31, 2016
Covering Period:	July 1, 2016 to September 30, 2016 (7th of 9 Quarters)
DOE Funding Released:	February 19, 2016
Report Frequency:	Quarterly

Working Partners:
Vendors (F&A included as match)
Leidos (vendor); Rick Williams; richard.b.williams@leidos.com; (503) 484-4415
CH2M (vendor); Doug Davy; Doug.Davy@ch2m.com; (916) 286-0278
Kearns & West (vendor); Anna West; awest@kearnswest.com; (415) 391-7900
Omega Power Engineers, LLC (vendor); Randall M. Connett; randy.connett@omegapower.net; (303) 330 6920
UK Wave Hub (vendor); Stuart Herbert; stuart.herbert@wavehub.co.uk; 01736-800294

National Labs (F&A is not allowed)
National Renewable Energy Laboratory (NREL); Al LiVecchi; Al.LiVecchi@nrel.gov; (303) 384-7138
Sandia National Laboratories; Jesse Roberts; jdrober@sandia.gov; (505) 844-5730

Subrecipient (F&A included as match)
Electric Power Research Institute (EPRI) (subaward); Paul Jacobson; pjacobson@epri.com; (410) 489-3675
Humboldt State University (subaward); Arne Jacobson; Arne.Jacobson@humboldt.edu; (707) 826-4302
Virginia Tech (subaward); George Hagerman; hagerman@vt.edu; (757) 340-1921
Scripps Institution Of Oceanography, UC San Diego (subaward); Julie Thomas; jot@cdip.ucsd.edu; (858) 534-3034

State Government Agency and Utility
California Natural Resources Agency (government agency); Chris Potter; Chris.Potter@resources.ca.gov; (415) 740-9869
Pacific Gas and Electric (utility); Brendan Dooher; bxd6@pge.com; (925) 822-7716

Cost-Sharing Partners:
California Natural Resources Agency
Pacific Gas & Electric Company
Protean Wave Energy Ltd., Steve Rogers, stephen.rogers@proteanwaveenergy.com.au, +61 (9481) 22771

DOE Project Team: DOE HQ Program Manager – Jim Ahlgrimm
DOE Field Contract Officer – Pamela Brodie
DOE Field Financial Assistance Specialist – Jane Sanders
DOE Field Project Officer – Tim Ramsey
DOE/CNJV Project Monitor – Nicholas Massey

Signature of Submitting Official:

William Toman

CalWave℠ Project Manager

Section I. Project Accomplishment Narrative

The CalWave℠ Phase II project award date began on February 19, 2016. The background of the CalWave Phase II project was provided in the CalWave I Report. The work performed on SOPO Tasks 1-10 was reported in the CalWave I Report.

The 5th Quarterly Report documented the startup of Phase II. The 6th Quarterly Report reiterated the background and SOPO Tasks 1-10, along with current progress on SOPO Tasks 11, 12, and 13 in April/May/June, and included the mid-July Conceptual Design Review.

This 7th Quarterly Report will address the following:

In Section 1:

- Overall Project Status at the start of the 7th quarter.
- Summary of key events in mid-July
- Summaries of progress in Tasks 11, 12 and 13

In Section 2:

- Progress from mid-July in the SOPO format for Tasks 11, 12, 13

In Section 3:

- Cost Data

In Section 4:

- Forecast activities planned during the next two quarters and the Final Report

This quarterly report constitutes the 7th quarter of work on the CalWave℠ project. The reporting period covered by this report encompasses July 1, 2016 through September 30, 2016.

1. Overall Project Status at the end of the 7th quarter:

To the extent that the Project Manager has visibility of cost and schedule, the CalWave℠ project is on track and within budget at the end of the 7th Quarter. The Project Manager does not have access to time/cost accounting of the Principal Investigator or of the Project Administrator. Twelve weekly conference calls had been held with robust attendance of the CalWave℠ team.

Task 11: Engineering Element:
The design had progressed during the Conceptual Stage. Multiple site visits and an industry survey had occurred with significant interaction with local industry on the design concept and operational aspects.

Task 12: Permitting Element:
The permitting effort proceeded with excellent support from the Vandenberg AFB and cooperation by the facilities, engineering, and permitting functional leads. The Permitting Lead was given access to sensitive data associated with archeological resources which informed the design in order to avoid sensitive areas as much as practicable. The Permitting Lead also participated in the industry site visit.

Task 13: Stakeholder Element:

The outreach and stakeholder engagement efforts proceeded with excellent participation from the agencies and regulators, and interest from diverse stakeholders in participating in the upcoming Stakeholder Advisory Group

2. Recap of key events in mid-July:

This 7th quarterly report reviews progress that occurred within the month of July, 2016 some of which was reported in the 6th quarterly report because 4 key events occurred within this timeframe:

- The California Department of California Governor's Office of Business and Economic Development issued a letter creating the Central Coast Wave Energy Hub. This designation formalizes an economic development and innovation strategy regarding marine renewable energy technology and development in California and will also help to attract investment in this sector
- The first Permitting Agency Meeting was held on July 11th
- Officials of CalWave's[sm] international partner Wave Hub Limited ("UK Wave Hub"), an existing wave energy test facility in the United Kingdom, made an initial trip to the Central Coast of California to provide consultancy on the lessons learned and critical elements for designing, building, and operating a wave energy test facility
- Conceptual Design Review was completed with the WaveHub and industry participants

During this period, the CalWave[sm] project team developed design concepts further to accommodate as many WECs as possible that could operate in the specified depth range by furthering concepts to:

- Provide berths with a range of wave energy resource
- Provide flexibility in seafloor footprint, rather than constraining into squares-shaped areas
- Provide instrumentation and load bank ashore for testing to demonstrate grid compliance.
- Provide a power purchaser for power during reliability-phase of testing.
- Allow power conditioning onboard the WEC, or ashore.
- Allow AC or DC electrical output on export cables to the shore station.
- Allow the WEC developer to use their own design for mooring and anchoring, rather than a pre-installed (sub-optimized) anchor pattern.

The operational aspects of the project (HDD, marine operations, cable installation, and cable terminations) were validated by industry participants as well-conceived and executable. These events represented substantive progress for the CalWave[sm] project and were reported on in the various tasks as outlined within the Statement of Project Objectives.

TASKS	Quarter (from start of project)				
	Feb. '16 – March	April – June	July – Sept.	Oct. – Dec.	Jan. '17 – Feb.
	5th	6th	7th	8th	9th
Task 11: Develop Engineering Quantities, Cost and Schedule Estimates to Support Financing Plan, Select Preferred Location					
Task 12: Develop Permitting Roadmap to Populate Draft Preliminary PAD					

Task 13: Develop List of Stakeholder Concerns and Develop Possible Solutions					

**Dark grey means increased effort for a task, and light grey means decreased effort*

Summary Engineering Element Progress (Task 11)

The Engineering Team led by **Leidos Maritime Solutions** continued the site selection process and narrowed the test berth siting to BOEM Lease Blocks that encompass the South and Southeast test berth locations near the Vandenberg Dock South Base Site.

The systems engineering boundary was further refined to include systems and sub-systems under the direct control of CalWave[sm] Team. Additionally, the boundary systems were further defined as systems or sub-systems that are a vital part of the design and are not under the direct control of the CalWave[sm] Team. Boundary systems include: The Wave Energy Convertor (WEC) systems; Vandenberg Air Force Base (VAFB) and PG&E electrical grids; and, VAFB facility infrastructure. As explained in more detail in Section 2 below, the System Block Diagram was shifted to a "Grid-Reference", vice "WEC-Reference" to acknowledge that the host facility and grid were more mature, and rigid. Boundary system and that the WECs were a less mature boundary system and subject to new product development.

An extreme events analysis, performed by **Cal Poly** on the five proposed shore sites, confirmed the selection of the South Base Site. The analysis included Tsunami modeling, historic weather modeling, and a seismic ground shaking assessment in order to inform the shore station down selection process.

The South Base Site topographic field survey by **Cal Poly** informed the conceptual civil, mechanical, and electrical engineering and architectural designs. The site surveys led to the development and drafting of conceptual design drawings for the Civil, Electrical, and Architectural design drawings, with Mechanical and Auxiliary systems designs to follow.

The conceptual single line diagram and electrical engineering by **Omega Power Engineers** progressed through increasing levels of detail including the evaluation/coordination of VAFB distribution infrastructure design and transmission equipment upgrade requirements.

The technical specifications for the undersea cable were iterated with input from **Center Marine** towards a practical solution for both electrical, horizontal directional drilling, and installation considerations. Project reliability and operability considerations are also under review with respect to repair times and to facilitate safety during maintenance activities.

PG&E continued to review all aspects of the electrical engineering design and also began preparing data and models for a future grid interconnect study. PG&E also began preparing wave resource data and for the wave modeling analysis with **Virginia Tech** and **Scripps Institution of Oceanography**.

The Cable Route Desktop Study by **Fugro Pelagos** alerted the Team to two situations affecting the horizontal direction drilling (HDD) and cable plans: the best available bathymetry indicates the required bore lengths will be 3,000 to 3,200 ft.; and, the best marine geological data indicates that drilling will be through hard rock found in the Monterey Formation. Two actions were taken: the rough order of magnitude estimates (ROMs) were updated; and, alternatives for onshore and offshore core sampling were explored.

Engineering input on mooring and anchoring, progressed with a draft study by **Glosten and Associates** that will inform the permitting envelope.

Feedback on the Conceptual Design has been provided by **UK Wave Hub.**

Summary of Permitting Progress (Task 12)

The permitting team continued to progress the CalWave[sm] permitting element while taking into consideration design inputs, field investigations, review of existing literature, and regulatory consultation. CH2M continued to perform literature search and review of existing Central Coast California coastal infrastructure projects that are germane to the CalWave[sm] project including oil platforms subsea cable installations. Additional research and review was performed on permitting methodologies specifically for marine hydrokinetic technologies. The CalWave[sm] permitting team further evaluated information on relevant biological resources for future incorporation into the "Environmental Baseline Studies". CH2M progressed the Cable Route Desktop Study to a draft format and began initial review of the Anchoring and Mooring Lessons Learned Analysis as well as the Cable Installation Lessons Learned Analysis as developed by CH2M's subcontractors. Finally, consultation and coordination took place with key VAFB personnel to further inform the design of the shore station site as well as the transmission line infrastructure upgrade for the purposes of avoiding sensitive biological and cultural resources located near the proposed development.

Summary of Stakeholder Progress (Task 13)

The Stakeholder Outreach team began assessment and planning for the kickoff of the CalWave[sm] Stakeholder Advisory Group which will include a variety of interested and potentially impacted stakeholders. This group will include representatives from the following industries/sectors: Academic, Economic/Business, Environmental, Fishing, Labor, Local/Regional Government, Recreation, Tribes, and representatives from the CalWave Operational Advisory Group. Kearns & West began the planning and coordination process for the first group meeting scheduled to be held on October 20, 2016 in San Luis Obispo, CA. Kearns & West also began planning and coordination for the 2nd Regulatory Agency meeting to be held in Camarillo on October 21, 2016. The focus and details of these upcoming meetings are further discussed in this report.

Section 2. Details of Scope Accomplishments

Major Progress of Objectives

Administrative

The Project Manager coordinated the overall work efforts of the Engineering Element (Task 11), the Permitting and Environmental Element (Task 12) and Stakeholder Involvement and Public Participation Element (Task 13).

Task 11 Cal Wave[sm] II Engineering Element (Q4-Q8)

The CalWave II (Phase 2.0) Engineering Element SOPO covers Task 11:

Task 11: Develop Engineering Quantities, Cost and Schedule Estimates to Support Financing Plan, Select Preferred Location

11.1 Engineering Project Management

Chief Engineer Rick Williams of **Leidos Maritime Solutions** provided engineering input to the project management team and coordinated with the Cal Poly Principal Investigator, Project Developer, Project Manager, project management staff, and project team. Weekly project team conference calls continued; and, administrative tasks and reporting were accomplished. Preparation of the agenda for meetings during the week of July 11th was delegated to the Chief Engineer and executed. The Conceptual Design Review was held. Follow-up from the Conceptual Design Review was accomplished and the Conceptual Design Stage was completed. The Preliminary Design stage was initiated.

11.2 System Integration and Systems Engineering (SE&I)

Leidos executed systems integration and engineering (SE&I) activities, including review of the WaveConnect Feasibility Study and Feasibility Study from CalWave[sm] Phase I, with emphasis on maintaining design flexibility for infrastructure to support testing out to the design life of 2050. This requires development of interfaces between major systems and sub-systems for Wave Energy Converters (WECs) that have yet to be invented as input to the permitting process known as the "permitting envelope" This is discussed further in the Section 12 Permitting Element of this report.

We continue to benefit from CalWave's[sm] electrical engineer Randy Connett of **Omega Power Engineering**, visit to the Biscay Marine Energy Platform (BIMEP) ocean energy test site in Spain where technical engineering and infrastructure elements were investigated.

In preparation for the Conceptual Design Review, an extensive industry survey was conducted by the CalWave[sm] Subsea Cable Route Design Team. As a result, the preferred Horizontal Directional Drilling (HDD) launch site was selected as well as an alternate launch site. The selection was based on integrating the conceptual shore station design and location with the offshore test berth locations,

topography, bathymetry, subsea cable capabilities and constraints, in conjunction with host facility requirements.

This industry survey of the site, and subsequent meetings with marine construction industry members, further illuminated survey/data needs for the HDD bore and cable landing design.

Representatives from the United Kingdom's "**UK Wave Hub**" visited the CalWave[sm] team headquarters as well as the conceptual wave energy test site location at VAFB over several days. UK Wave Hub presented information on a wide variety of aspects of their existing wave energy test facility in Cornwall, UK including permitting and technical design elements, operational and management strategies, and critical lessons learned based on their development, construction, and operational experiences over a twelve-year timeline. They represented that CalWave[sm]'s location, team, land operations host and wave energy resource made the proposed test center potentially one of the best in the world.

A working group of Central and Southern California's marine/ocean industry representatives were convened to provide expertise and as well as an operational and logistical knowledgebase for the development of the CalWave[sm] wave energy test center and to establish a general industry interest in future marine renewable energy development in California.

Conceptual Design Review Process

The Conceptual Design Review conducted on July 13th included **Vandenberg AFB** representatives, **UK Wave Hub**, and marine construction industry representatives from **L3 Maripro** (cable installers), **Aqueous** (diving and ROV services), **Pacific Tug Services** (vessels, cranes, barges, and landing craft), and **Fugro Pelagos** (marine survey services). Discussions were also held with **Venoco** (oil platform services) about recent cable installations and the **HDD Company** about recent cable installations.

The early-stage conceptual design, notional test sites, and notional shore site from the CalWave I Feasibility Study were validated in CalWave II.

A topographic field survey was performed by a **Cal Poly** Team of students, professional surveyor instructor and Architectural Engineering Professor. This detailed land survey informed the conceptual civil, mechanical, and electrical engineering and architectural designs.

The extensive industry survey that was conducted by the CalWave Subsea Cable Route Design Team was validated. The Team included:

- **VAFB** key personnel
- **Fugro**, the marine geologist on the cable route desktop subcontractor team
- **HDD Company**, that performs marine horizontal directional drilling services
- **Center Marine**, the subsea cable logistics
- CalWave II Project Manager
- CalWave II Chief Engineer from **Leidos**
- CalWave II Electrical Engineer from **Omega Power Engineers**

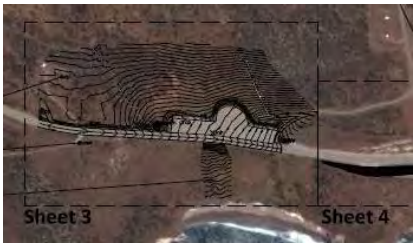


Figure 2-1: Topographic Survey

- CalWave II Environmental/Permitting Manager from **CH2M**

The preferred "Upland" Horizontal Directional Drilling (HDD) launch site adjacent to the Shore Station was confirmed. The alternate launch site near Vandenberg Dock was reviewed.

This industry survey of the site, and subsequent meetings with electrical engineers, marine construction industry members identified the bathymetric and geotechnical survey needs for the HDD bore, cable landing design and switchyard.

The refined site layout integrated the conceptual shore station design and location with the offshore test berth locations, topography, bathymetry, subsea cable capabilities and constraints, and host facility requirements. Electrical design work is provided by **Omega Power Engineers**, with support from **Atwell Engineering.**

This work led to the development and drafting of conceptual design drawings for the Civil, and Architectural design drawings by **Cal Poly Faculty**, with Mechanical and Auxiliary systems designs to follow.

As mitigation to view shed considerations from the historic US Coast Guard Boathouse, plans include landscape screening, a screening berm, and the architectural style of the historic buildings is reflected in CalWave buildings.

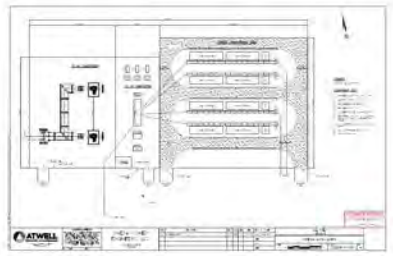


Figure 2-2: Electrical Switchyard Plan

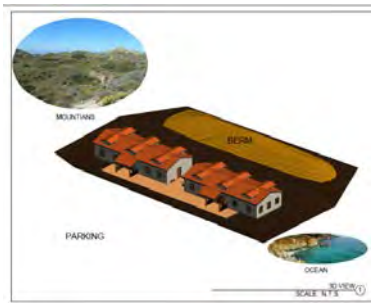


Figure 2-3: Architectural Plan

Specific lessons learned included:

- The Vandenberg Grid is mission-critical so CalWave[sm] must take particular care to ensure grid integration standards and power quality requirements are satisfied before connection to the VAFB grid. This will drive instrumentation and test design.
    - A "test bus" concept is being explored for connection of load banks and instrumentation.
    - WECs with lower maturity levels are typically tested at the European Marine Energy Center (EMEC) prior to WaveHub.

- Regulations on vessel emissions, procedural restrictions, and industrial safety requirements are changing the availability of offshore services including vessels, barges, and diving.
    - The waters off Vandenberg Dock are more challenging for cable installation than locations south of Point Conception such as Cojo Anchorage.
    - Cojo Anchorage may be used as a staging location during operations.
    - Many oil field vessels will require repowering to meet emission standards (Tier III), thus limiting choices going forward.

  - Cable installation barges that previously used portable dynamic positioning systems are no longer authorized by the US Coast Guard, complicating selection of cable installation vessels.
  - Divers are practically limited to 300 ft. depth by US Coast Guard regulations. Deeper depths require extensive waivers.
  - The CalWave[sm] cable terminations will be located in depths less than 300 ft.

- In theory, export cable protection requirements (armor package) would vary along the length of the cable (HDD Bore Segment, Near-Shore Segment, Static Segment, and Dynamic Cable Tail Segment). Telecom cables often vary the protection package. However, feedback to date is that this option is not available in power cables.
  - Dynamic Tails, where the dry-mate connector is installed, have a limited number of lifts due to cable wear.
  - Connectors add flexibility as well as complexity and are preferred to field splices. Both methods are potential failure points.

- Double armor protection may be the best option for the entire cable length.

- An alternative design is under consideration for double armor protection on the first 4,000 ft. to provide adequate strength for pull through the HDD conduit as well as protection near-shore. This Near Shore Segment would terminate in a connector.

- The Static Segment could use single armor, employ a connector to the first segment, proceed to approximately 3.2 nm and slightly shallower than 300 ft. depth, and terminate with a connector.

- The Dynamic Tail Segment can proceed from approximately 3.2nm to the berth location selected by the WEC Developer who can integrate the Dynamic Tail with the Riser Cable (Umbilical) that is designed in the WEC System.

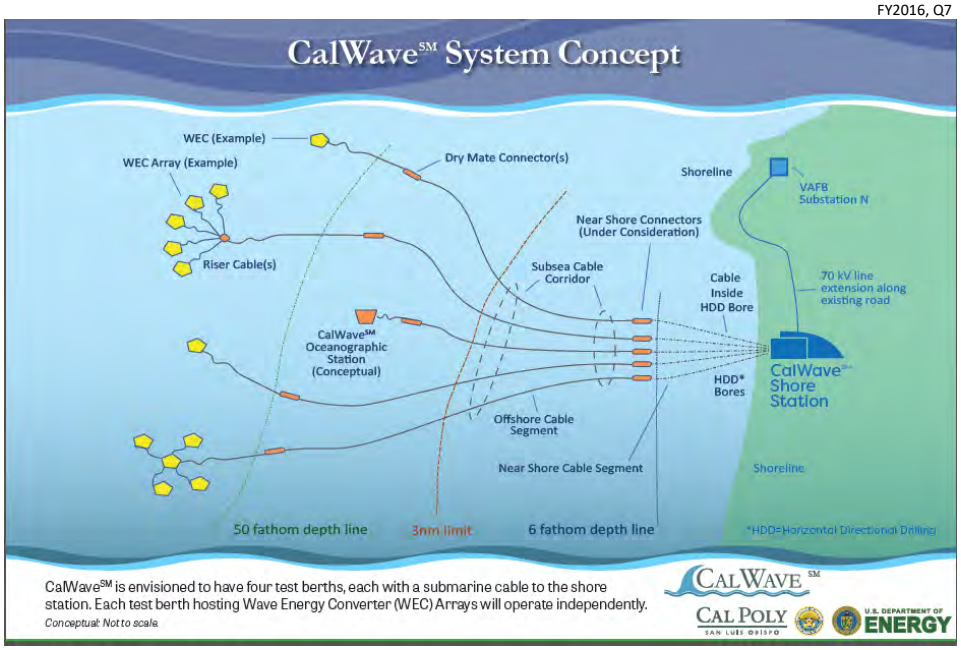


Figure 2-4: CalWavesm System Concept (Source: Leidos Inc./Kearns & West)

The evolving design reflects CalWave's[sm] emphasis on hosting mature WEC/MEC (TRL 7-9) devices while maintaining a requirements-driven, technology-neutral, vendor agnostic, and holistic design approach.

- The conceptual system includes four test berths on the Outer Continental Shelf (OCS).
- Export cables cross the California Territorial Sea (out to the three nautical mile limit)
- Dry-mate connectors inside the 50 fathom (300 ft.) curve.
- Surface lay cables, unless burial is required.
- HDD cable landing: five bores for four cables and spare.

The conceptual "Oceanographic Station" buoy that would leverage the spare cable was further discussed. This oceanographic buoy would perform wave resource and meteorological instrumentation/data collection to better monitor facility conditions and the buoy would also serve as a terminus for the spare cable and can be used to perform a systems check and calibration after the WEC has arrived on-site and prior to installing the WEC in a test berth.

Onsite meetings were held with the Vandenberg action officer in order to present and reach agreement on the conceptual location and baseline system design. A visit to the South Base Site reviewed additional constraints for conceptual shore-side infrastructure, such as: view shed considerations from the historic boat house and a base preference to retain excavated material, and HDD cuttings, in a berm rather than remove the material. This represents a significant savings and reduction in emissions from haul trucks.

Cal Poly completed a civil engineering study of drainage and runoff. See below.

Other progress included:

Industry engagement:

- CalWave's Chief Engineer participated in the National Hydropower Association (NHA) Hydrovision and presented the CalWave Test Center Design.
  - He was asked to serve as Co-Chair of next year's Marine Renewable Energy Track was CalWave Partner EPRI's Paul Jacobson.

- Industry Marine Energy Council: Leidos participates in the National Hydropower Association (NHA) Marine Energy Council (MEC) to enhance interaction with WEC developers.

- CalWave's Chief Engineer participated in the Oregon Wave Energy Trust (OWET) Ocean Renewable Energy Conference (OREC) XI events:
  - OWET Industry Summit
  - NHA Marine Energy Council meeting with DOE EERA Water Power Program
    Ocean Renewable Energy Conference (OREC) XI
    Participated on two panels: Test Sites and Technology Convergence

Technical Standards: CalWave[sm] is considering the emerging international standards in the design of infrastructure. The CalWave[sm] Chief Engineer served as Secretary of the international project team of eleven countries and US Delegate to the International Electrotechnical Commission Technical Committee 114 (IEC TC 114) in the multi-year effort to write the Marine Energy Design Technical Specification (62600-2) that will be issued in August/September.

- Our Chief Engineer is the US Committee Chair for the follow-on technical specification Maintenance Team.

Conformity Assessment: CalWave[sm] is considering emerging international movement toward conformity assessment, including component, and project certification, in the design of infrastructure. The CalWave[sm] Chief Engineer is a founding US Delegate to the International Electrotechnical Commission Renewable Energy (IECRE) organization and the Marine Energy Operations Management Committee (MEOMC).

CalWave[sm] Marine Industry Operational Advisory Group: the establishment of an advisory group made up of experienced marine operators was explored and socialized with industry members from Morro Bay, Santa Barbara, Carpenteria, Ventura, Oxnard, Port Hueneme, and Long Beach.

During the 7th quarter, the CalWave[sm] System Design Concept was further refined. Work included discussions of at-sea test berth site alternatives, shore station alternatives, and the potential use of offshore oil Platform Irene. Of note, the Bureau of Ocean Energy Management (BOEM) identified that the lease blocks shown on several external facing sites were based on different coordinate systems. BOEM is investigating.

Since much of the design has been in the marine engineering domain, the spiral design process of naval architecture was used as a reference model for iterative design in the face of multiple uncertainties. The system orientation of naval architecture was merged with the system engineering approach of "requirements-driven design".

As shown in Figures 2-5 and 2-6 spiral development approach was employed to iterate the design from a high state of uncertainty toward a consensus design.

The CalWave requirements-driven design process has three major iterations with associated reviews: Conceptual Design Review (CDR); Preliminary Design Review (PDR); and, Final Design Review (FDR).
In parallel, there are supporting processes that are more tightly coupled, such as:

- DOE Requirements
- Project Management
- Design Studies and Analyses
- Review and Oversight

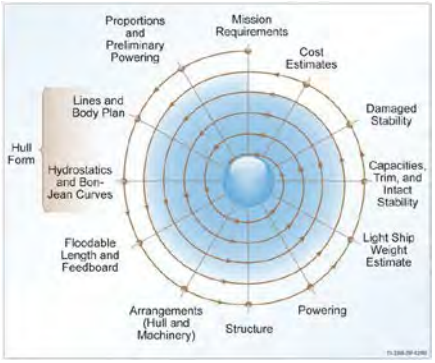
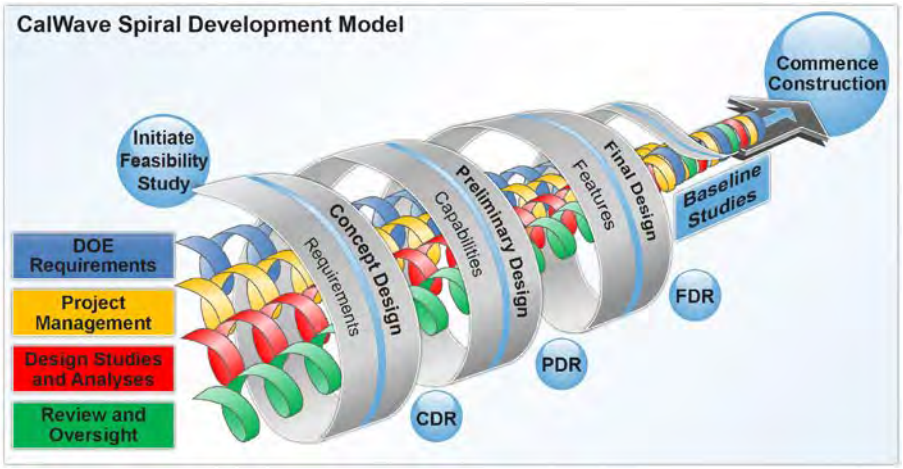


Figure 2-5: Naval Architecture Spiral Design Model



Phasing and milestones will leverage our existing spiral development process from Conceptual Design Review (CDR) through development of a Draft Preliminary Design adequate for the draft applications.

Systems engineering will continue to be used to ensure a requirements-driven design process. Requirements definition will progress from system level to capability level through functional allocation to feature level as shown below.

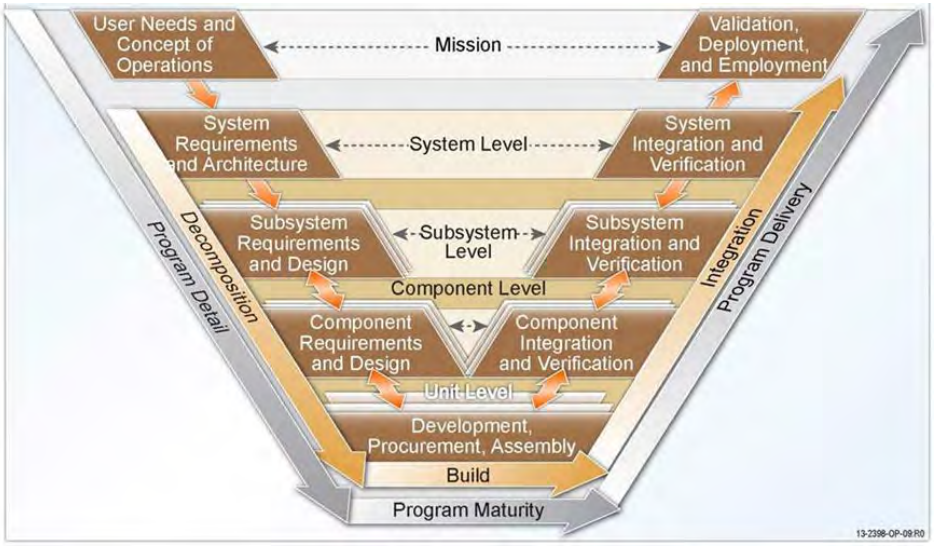


Figure 2-7

Each design spiral starts with requirements updates, maintains the requirements baseline, and ends with requirements tracking.

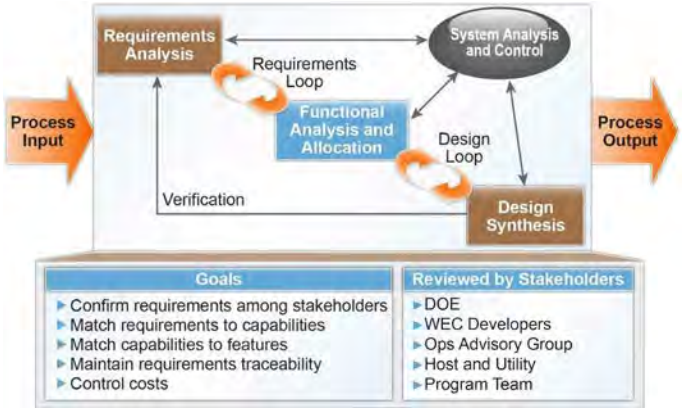


Figure 2-8 Requirements Process

The resulting system approach workflow supports the systems engineering process and the design spirals:

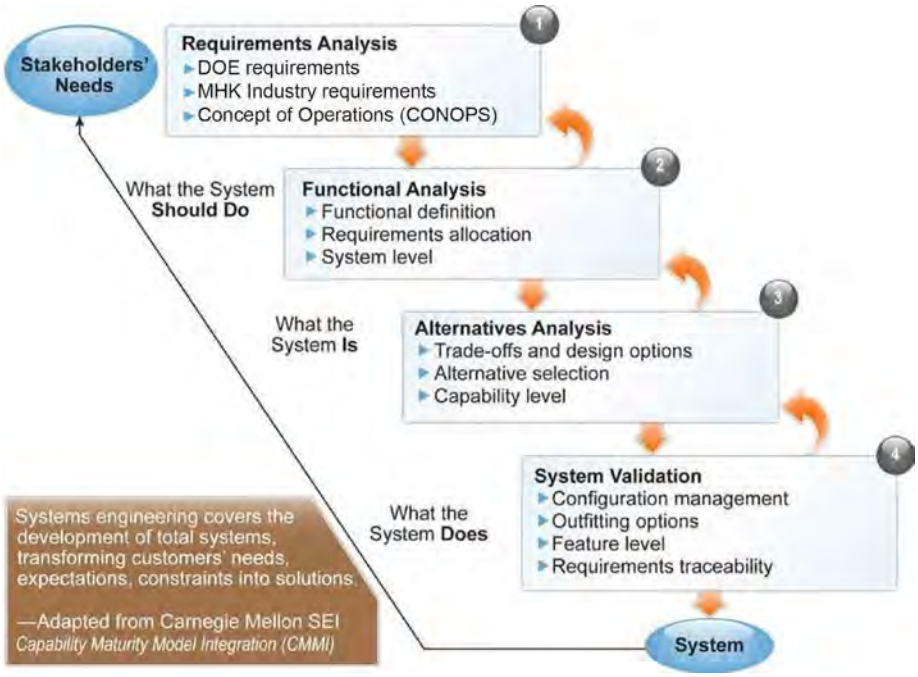


Figure 2-9 Systems Engineering Process

System Concept, System Boundary, and Boundary Systems

The system boundary was refined as consisting of Sea-Based Infrastructure, Shore-Based Infrastructure, and the functional task areas as shown below in, in the System Block Diagram Figure 2-10 developed by **Leidos** Inc. Boundary systems were identified as: WEC/MEC System; VAFB-PG&E Electrical Grids; and VAFB Base Facilities. Leidos and the engineering team maintained an emphasis on establishing well defined boundaries between these system blocks.

- The host facility, Vandenberg AFB, connects to CalWave. When considering the multiple interfaces, VAFB is a "system of systems" including: civil; architectural; mechanical; and electrical systems, and related sub-systems, such as electrical grid with connection to the PG&E utility grid, as well as the VAFB environment.
- CalWave interfaces to the host facility as a "boundary system" in that we must adhere to the interface requirements of the host.

- CalWave is also a "system of systems" including sea-based infrastructure and shore-based infrastructure as well as multiple supporting systems and sub-systems such as instrumentation and telemetry, data acquisition and management, and potentially the NREL Grid Emulator.
- The CalWave system interfaces to the WEC array(s) as another "boundary system." The WEC system(s) must adhere to the interface requirements of CalWave, in particular the design and operational limits of the submarine cable.
- Wave Energy Converter System(s) interface to the CalWave system and can be a number of "boundary systems" consisting of one or more WEC Arrays, each with multiple sub-systems such as mooring, anchoring, riser umbilical(s) and power conditioning.

There are two methods for describing CalWave, both emphasize the importance of interface definition and control, particularly at Designated Critical Interfaces:

WEC-References System Block Diagram: used during the Conceptual Design Stage. This method is "customer referenced" and addresses the primary mission of supporting the MHK industry and WEC developers. It starts with the WEC array(s) and progresses through the CalWave system to the host facility and connecting utility.

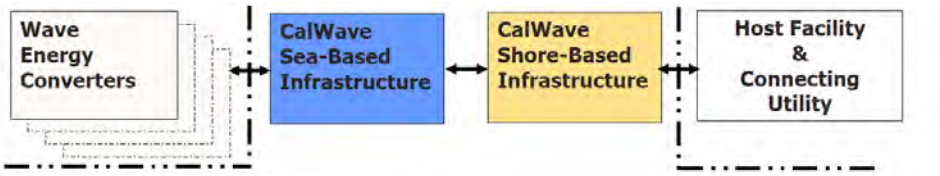


Figure 2-10: WEC-Referenced System Block Diagram (Source: Leidos)

Grid-Referenced System Block Diagram: used during Preliminary, Final, and Detailed Design Stages. This method is "power purchaser" and addresses the end goal of commercialization. It also acknowledges that the Grid is a mature Boundary System that CalWave and WECs must comply with. This method better represents the facility construction.

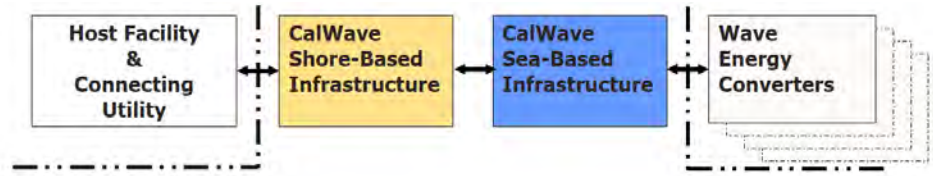


Figure 2-11: Grid-Referenced System Block Diagram (Source: Leidos)

While either frame of reference is correct, our design process focused on the CalWave system, and the interface to the grid, to maintain maximum flexibility for the WECs. We do not have control of the WECs that will be tested now or during the thirty-year design life of the test facility.

There is more certainty with the grid-connection and the order of construction will be from the shore base out to sea. The greatest complexity in the facility is in the shore-based infrastructure at the interface to the host facility and the interface to the sea-based infrastructure. Accordingly, we use the Grid-Referenced Block Diagram CalWave System Work Breakdown Structure (SWBS).

The system design requires the WEC/MEC developers to provide their own: mooring and anchoring design and installation, umbilical/dynamic and Riser cables integrated with Dynamic Tail(s) with dry mate connectors, and either on-board or on-shore power conditioning capability.

This holistic system approach requires of the WEC Developer to provide a properly designed mooring and anchoring system for their specific WEC at the specific berth. The Test Berth concept has the following highlights:

- Provides flexibility in shape of seafloor footprint, rather than constraining into squares
- Allow the WEC developer to use their own design for mooring and anchoring, rather than a prescriptive, pre-installed, (sub-optimized), anchor pattern
- Provides berths with a range of wave energy resource to enable WEC developers to populate data for a complete power matrix

An important operational concept and system boundary will require the WEC/MEC developer to be responsible for the power conditioning and testing/checkout of their own device output before it is connected to the VAFB/PG&E grid infrastructure. The WEC/MEC developer will have the option of conditioning the power on-board the wave energy conversion device or via installation of equipment at the shore-side substation location.

A robust interconnection specification, modeled after **UK WaveHub** will be used to ensure protection of the export cable.

The Shore Station and Test Berth concept has the following highlights:

- Provides instrumentation and load bank ashore for testing to demonstrate grid compliance.
- Provides an off-taker for power during reliability-phase of testing.
- Provides a grid-integration opportunity with CalWave℠'s partner utility **PG&E**.

System Work Breakdown Structure (SWBS): The SWBS is a product-oriented frame of reference for naval architecture and marine engineering design. It has been most useful during the design phases in highlighting the interfaces that must be carefully managed. A top-level summary of the SWBS is:

- System 100: Host Facility
- System 200: CalWave Shore-based Infrastructure

- System 300: CalWave Sea-based Infrastructure
  - System 310: Test Berth One
  - System 320: Test Berth Two
  - System 330: Test Berth Three
  - System 340: Test Berth Four
  - System 350: Fifth (spare) Cable and associated functions
- System 400: Wave Energy Converter System(s)
  - System 410: WEC in Test Berth One
  - System 420: WEC in Test Berth Two
  - System 430: WEC in Test Berth Three
  - System 440: WEC in Test Berth Four
  - System 450: WEC checkout function (also see System 800)
- System 500: CalWave Data Acquisition and Management System
- System 600: Test Instrumentation System
- System 700: Reserved for NREL Grid Emulator Equipment
- System 800: Reserved Ocean Observing System and CalWave Oceanographic Station
- System 900: Reserved for CalWave Informational Kiosks in the Region

Program Work Breakdown Structure (WBS): In contrast with the SWBS used in the design phases, the CalWave Program WBS activity-oriented and aligned with the anticipated Workplan, structured with a hierarchy of performance period (approximately annual), tasks and subtasks. The Task Description Summary provides an additional level of definition.

The WBS summary is an outline for Statement of Program Objectives (SOPO) in future phases. The SOPO will contain a more detailed description of the WBS and tasks.

CalWave Program WBS Summary – Post-CDR Technical Baseline

Level 0 – CalWave System Acquisition Program					
Level 1 – CalWave Facility Acquisition Program					
CalWave I Feasibility	CalWave II Draft NOI/PAD	Phase 3.0 Permitting	Phase 4.0 Construction	Phase 5.0 Test	Phase 6.0 Operations
Level 2 – CalWave Facility					
SOPO I-10	SOPO 11,12,13	SOPO III-1 to III-xx	SOPO IV-1 to IV-xx	SOPO V-1 to V-xx	SOPO VI-1 to VI-xx
1.0 Contracts & PM	2.0 Contracts & PM	3.0 Contracts & PM	4.0 Contracts & PM	5.0 Contracts & PM	6.0 Contracts & PM
1.1 Concept Dev	2.1 Engineering	3.1 Prelim Design	4.1 Final Design	5.1 Test Program	6.1 Transition to Ops
1.2 Permitting/Envr	2.1.1 Conceptual	3.1.1 Surveys	4.1.1 EPC or CM/GC	5.1.1 Certification	6.1.1 WEC Customers
1.3 Outreach	2.1.2 Marine/Cable	3.1.2 Decision Gates	4.1.2 Decision Gates	5.1.2 Decision Gates	6.1.2 Decision Gates
1.4 Feasibility	2.1.3 HDD	3.1.3 Risk Mgmt	4.1.3 Risk Mgmt	5.1.3 Risk Mgmt	6.1.3 Risk Mgmt
1.4.1 Wave Resource	2.2 Permitting/Envr	3.2 Permits/Licenses	4.2 Environ Support	5.2 Environ Support	6.2 Environ Support
1.4.2 Test Berth	2.2.1 Studies	3.2.1 Studies	4.2.1 Monitoring	5.2.1 Adaptive Mgmt	6.2.1 Adaptive Mgmt
1.4.3 Shore Sites	2.3 Outreach	3.3 Outreach	4.3 Outreach	5.3 Outreach	6.3 Outreach
1.4.4 Industry Base	2.3.1 Advisory Grps	3.3.1 Advisory Grps	4.3.1 Advisory Grps	5.3.1 Advisory Grps	6.3.1 Advisory Grps
1.4.5 Down-Select	2.4 Design Review	3.4 Design Review	4.4 Design Review	5.4 Test Review	5.4 Test Review
1.5 Notional Site	2.5 Baseline	3.5 Baseline	4.5 Config Mgmt	5.5 Config Mgmt	6.5 Config Mgmt
1.5.1 Estimating	2.5.1 Estimating	3.5.1 Estimating	4.5.1 Estimating	5.5.1 Estimating	6.5.1 Estimating
1.6 Change Mgmt	2.6 Change Mgmt	3.6 Change Mgmt	4.6 Change Mgmt	5.6 Refresh/Upgrade	6.6 Refresh/Upgrade
1.7 Reporting	2.7 Reporting	3.7 Reporting	4.7 Reporting	5.7 Reporting	6.7 Reporting
Level 3 – CalWave Test Center Support Tasks					

Figure 2-12: Program WBS (Work Breakdown Structure)

11.3 Design Engineering and Analyses: Progress toward Preliminary Design

Leidos Maritime Solutions provided Chief Engineer services to coordinate design across engineering disciplines and organizations, including review of scope of work for civil, electrical, construction and ocean engineering, using a systems engineering approach.

Progress on Preliminary Design

Preliminary Design activities are outcome-oriented and targeted toward eventual construction of the facility in subsequent phases.

- Systems Engineering and System Integration has progressed (**Leidos**)
- Review of input from engineering disciplines has progressed (**Leidos**)
- Preliminary 70kV transmission line extension route planning has progressed (**Omega**).
- Preliminary cost estimating has progressed (**Omega**)
- The Cable Route Desktop Study has progressed (**Fugro**).
- Subsea Cable Logistics Alternatives Review is in draft form (**Center Marine)**.
- Mooring and Anchoring Alternatives Review is in draft form (**Glosten and Associates**).

Electrical Engineering & VAFB Design Coordination

Work products for this portion of work included conceptual design briefing materials. Several Engineering Requests for Information (RFIs) were processed and the engineering disciplines then refined their inputs to the overall conceptual design.

Omega Power Engineers continued to refine the electrical engineering design for the conceptual design per design criteria inputs from site investigations, VAFB design requirements and coordination, and progress from the systems engineering and integration work.

70kV Line Extension:

As previously reported, two separate trips were taken to the site to investigate site conditions and meet with VAFB staff to coordinate. During these trips, existing substation, 70 kV transmission and 12 kV distribution facilities were investigated. The physical location of facilities and orientation was coordinated on-site with other subject matter experts and preliminary arrangements agreed upon, with an eye toward practical and economical layouts. The 70 kV transmission line alignment was walked down to confirm alignment assumptions and identify issues for consideration during design.

Additional 12kV Line Modification:

A new idea to add an additional circuit to the existing 12KV distribution poles was explored as a mitigation for expected delays in the 70kV approval process. Detailed engineering will be required to evaluate the alternatives.

Corrosion Design Criteria: Significant attention and discussion was oriented around materials selection to resist corrosive salt fog, which causes severe corrosion of certain materials. VAFB has recommendations based on successful operating experience regarding material selection.

Extensive discussions have been held between industry advisors representing the functional specialties: bathymetric and geotechnical survey; HDD operations; subsea cables; cable installation; electrical engineering; marine operations; and vessel services. The result was refinement of the proposed HDD profiles, launch location, and equipment layout.

Subsequent to the Conceptual Design Review, the Team conducted an analysis of alternatives with an effort to reduce the potential for release of Bentonite drilling mud, and the associated monitoring.

- 10" to 12" pilot holes, no boring, pull back 6" to 8" liner, pull in cable. Not practical with double armor.
- 14" bore with 8" liner. Not practical with double armor.
- Larger bores with triple liners. Not practical due to quantity of bentonite.
- One very large bore with five liners. Not desirable due to single point failure risk.

As a result, the Preliminary Design will proceed with five (5) 21" bores, single 14" liner, and double armored cable.

Figure 2-13: Conceptual HDD Bore Profiles Layout (Source: HDD Company)

Figure 2-14: Conceptual HDD Launch Site (Source: HDD Company)

Civil Engineering and Extreme Event Analysis

Cal Poly continues to provide Architectural and Civil Engineering support.

Hydrology Study: under review.

The Shore Station Site was analyzed for Hydrology to determine drainage infrastructure necessary to achieve no-flood requirements during 100-year storm events. The watershed is divided into three

individual areas of study – Area 1: Upper Watershed, Area 2: Lower Watershed, and Area 3: Shore Station.

The analysis indicates the following:

• Upper Watershed (Area 1) existing drainage is adequate and only requires restoration and maintenance of existing swales and culverts. Adequacy of drainage is based upon Union Pacific Railroad Design Standards for 100-year storms. Further analysis required to confirm.

• No improvements or recommendations made for Lower Watershed (Area 2). The watershed was analyzed for flow concentrations onto Shore Station (Area 3).

• Improvements for Shore Station Site (Area 3) include a drainage swale along northern the periphery of Shore Station Site with flow to existing culvert (Culvert A), see Figure 3 on page 10.

- Drainage from Area 3 flows to Existing Staging Area as Shallow Concentrated Flow and ties in to existing drainage infrastructure along Tow Rd.

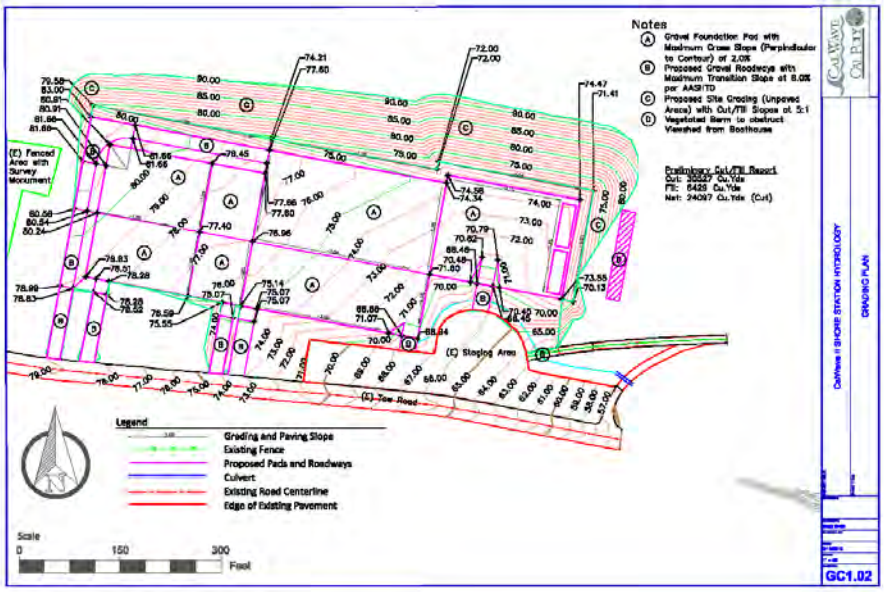


Figure 2-15: Grading Plan for 100 year Storm Drainage

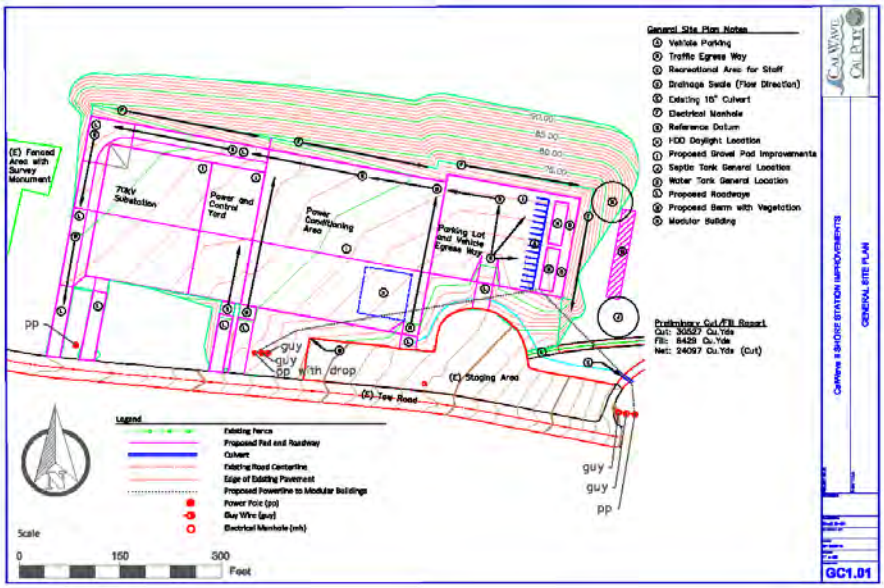


Figure 2-16: General Site Plan

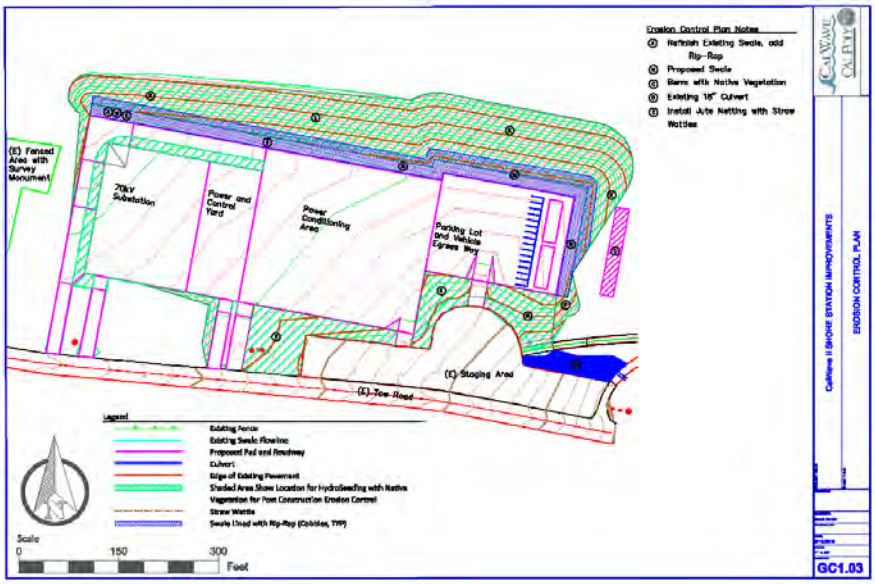


Figure 2-17: Erosion Control Plan

Ocean Engineering & Sea Based Infrastructure Survey/Planning

A Cable Route Industry Survey Team was organized and visited the South Base Site. The Team included: a subsea cable specialist (**Center Marine**); HDD specialist (**The HDD Company**); marine geology specialist (**Fugro Pelagos**); and our CalWave[sm] Electrical Engineer from **Omega**, Permitting Lead from **CH2M**, and Chief Engineer from **Leidos**. This resulted in a preferred Upland HDD Launch scenario and HDD bore profiles that have significant implications on the electrical and civil engineering designs. This resulted in a preferred Upland HDD Launch scenario and HDD bore profiles that have significant implications on the electrical and civil engineering designs. The alternate HDD Launch Site near the Dock has a lower vertical profile, but requires additional infrastructure to route the cables up the hill to the shore station. As a result, the conceptual bore profiles identified the need to closely consider cable pull strength constraints.

The conceptual bore profiles also identified a need for detailed bathymetry to find the 30 ft. and 40 ft. depth contours in the vicinity where the HDD bores will "daylight". The 30 ft. curve is a ship safety consideration to avoid grounding. The 40 ft. curve is a diver safety consideration to find a location outside the surf zone to avoid surges.

Engaging with the HDD consultant has also produced a conceptual layout of the equipment necessary to perform the HDD work at both the preferred HDD site as well as the alternate.

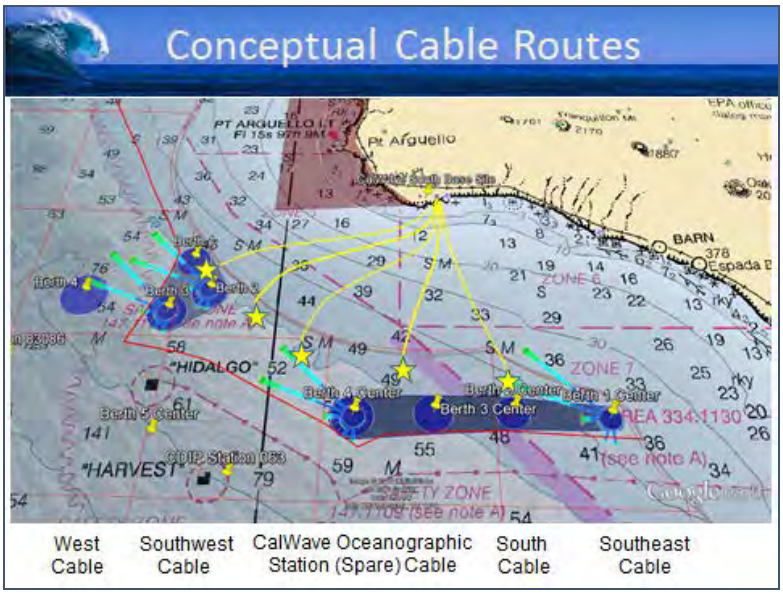


Figure 2-18: Conceptual Cable Routes (Source Leidos, Inc.)

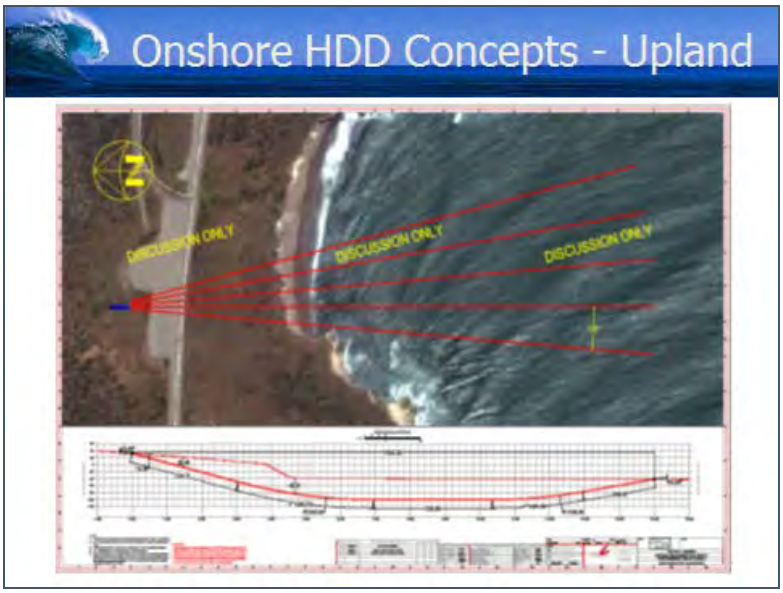


Figure 2-19: Onshore HDD Concepts – Upland (Source The HDD Company)

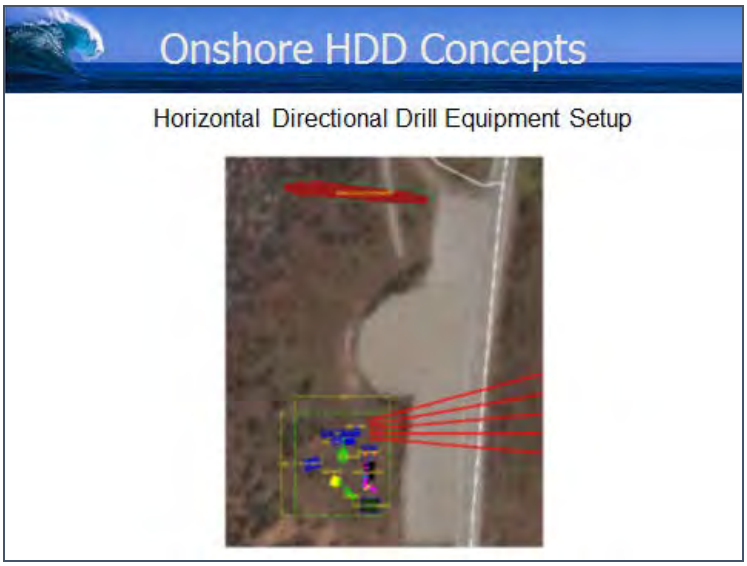


Figure 2-20: HDD Upland Launch - Equipment Setup (Source The HDD Company)

The alternative Dock HDD Launch scenario and HDD bore profile remain viable.

Figure 2-21: Alternate HDD Dock Launch Location (Source The HDD Company)

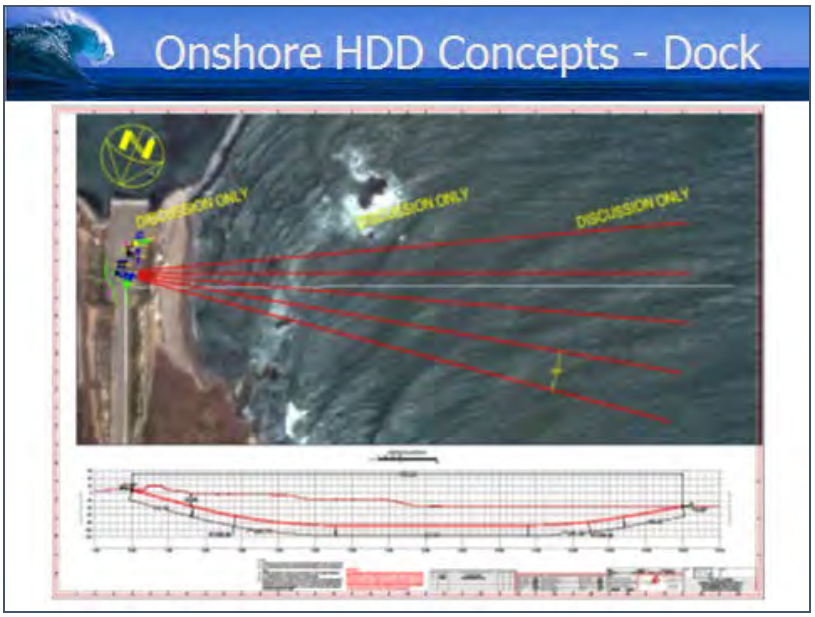


Figure 2-22: HDD Launch at Dock (Source The HDD Company)

Feeder Report Status:

Cable Route Desktop Study: Substantially complete with updates anticipated. **Fugro Pelagos**, CH2M's subcontractor submitted a draft report which has been reviewed by the team and commented upon. The report collects and analyses accurate bathymetry and subsea geological data to inform subsea cable design requirements and criteria.

Mooring and Anchoring Alternatives and Lessons Learned Report: Submitted and under review. **Glosten and Associates** submitted a draft report to **CH2M**. The report will inform the "permitting envelope".

Cable Logistics and Lessons Learned Report: Initial draft under review, additional content anticipated **Center Marine** submitted a draft report to **CH2M**. The report will inform the "permitting envelope"

11.4 Benchmark Existing Test Centers: Coordination and Site Visits

The Chief Engineer with **Leidos Maritime Solutions** was delegated coordination duties for the Wave Hub visit that occurred on the week of July 11th. Entries on WaveHub and BIMEP are restated below. As reported above CalWave presented on two panels at the OWET OREC XI conference in Portland.

UK Wave Hub Visit (July 12th thru July 15)

The Commercial Director from the **UK Wave Hub** testing facility presented material on a variety of information regarding the Wave Hub facility including lessons learned, its historical timeline, permitting obstacles, technical design considerations and construction challenges, the operations and maintenance procedures of the facility, its WEC developer contracting/berthing lease and power purchase agreement models, and risk mitigation strategies and insurance structures. Much of this information is still being internalized and considered by the CalWave[sm] team and it is likely that future reports will incorporate further lessons learned from this initial consultation visit. A follow up consultation is scheduled for this fall.

Presentation Topics

- Wave Hub History (2003 First Project Review – 2011 Site Open)
- Site Overview
- Original Drivers for Funding and Constructing the Facility
- Infrastructure and Installation Funding Sources
- Initial Installation Management
- The Business Case for the Facility/Economic Impact
- Current Ownership and Governance

A risk and insurance presentation was given by a UK firm **Renewable Risk Advisors**. This presentation covered a variety of risk mitigation and insurance issues including construction and operation issues, submarine cable issues, health and safety concerns, devices lost in transit, impacts from the fishing industry and pleasure craft, commissioning and reliability concerns, and many others; as well as how to reduce this uncertainty, mitigate the risk, and properly insure a project like CalWave[sm]. This

presentation contained highly specialized risk management information for early state offshore renewable energy technologies which can be directly applied to the CalWave[sm] project.

Camp Rilea

Work also included comparative analysis of the Camp Rilea, Oregon wave energy program infrastructure design. The Camp Rilea situation requires a much more detailed analysis of tsunami inundation, including site-specific soil conditions and modeled water velocity and duration, as well as vertical displacement. The resulting "momentum flux", as an expression of mass and velocity, is used to evaluate scouring potential and informs the cable route design. The VAFB South Base Shore Station avoids these issues.

Camp Rilea is also a useful source of considerations for shallow and mid-depth WEC testing including near-shore devices in the surf zone.

Biscay Marine Energy Platform (BIMEP)

CalWave's[sm] electrical engineer with **Omega Power Engineers** held meetings on May 19, 2016 with Yago Torre-Enciso, Director of Bimep (Biscay Marine Energy Platform, S.A.) and their outside electrical engineer regarding the Bimep project in Spain. This information has been considered while developing the conceptual CalWave[sm] design.

BACKGROUND:

- Bimep's mission appears very similar to CalWave[sm] - i.e. as a demonstration facility for WEC devices. They are few years ahead of CalWave[sm], with a constructed facility.
- Their project is located in Armintza, a small coastal about town about 10 km from Bilbao, Spain. Bimep's staff gave a presentation (attached) to the CalWave[sm] electrical engineer and a tour of their shore facilities.
- Bimep project ultimate capacity is 20 MW.

FACILITY DEVELOPMENT:

- They began the process to develop the project about 12 years ago, and were subject to a lengthy permitting process. Construction was completed in 2013.
- The project was constructed by awarding two EPC (Engineer-Procure-Construct) contracts: one for the submarine cables and terminations and a second for the shore facilities.
- The submarine cables were installed by Pirelli (Editorial note: This is the same entity we have been communicating with about technical requirements for the submarine cables at CalWave[sm]).
- The first WEC device (a 40 kW device) is scheduled for installation Fall of 2016.
- The apparent lag between the completion date of the project and the installation of the first WEC device is due to the project having to deal with a 'chicken and egg' circumstance – WEC vendors needed to see the facility as a real project (i.e. in-service) before they risked investing in WEC device development.

- The Armintza site was chosen in part because of the proximity of transmission infrastructure as well as the wave resource. There is an abandoned ~1500 MW nuclear power plant (98% complete before abandonment) near the site, with robust unused transmission infrastructure installed. Interconnection is at 138 kV.
- The ownership of the Bimep project is ~92% EVE (Basque Energy Agency – the Regional Body) and IDEA (Spanish Energy Agency – the National Body).
- The project cost is listed at €20 MM ($22M).

TECHNICAL DISCUSSION ITEMS Extensive discussion occurred with the Bimep EE about technical issues. Some specifics are as follows:

- Reviewed drawings of the Bimep facility. The electrical system configuration is very similar to what has been developed for CalWave[sm], except the Bimep substation transformers
- Bimep system is 13.2 kV. Submarine cables are 13.2 kV from WEC devices to shore. There are 4 cables with capacity for 5 MW each.
- Bimep does not have on-site generators – they feel islanded operation is difficult to achieve with the resource.
- Bimep has two main power transformers, each rated for 100% capacity. (Current CalWave[sm] configuration is 2 transformers each rated at 50% of ultimate capacity – this may need review/discussion).
- Bimep uses dry mate connectors for offshore connections – they see wet mate connector technology as not mature enough nor needed for the application. (The frequency of connection/disconnection is a factor). They noted that reliability of offshore was a substantial design criterion. Cost of repair of an offshore cable failure was less of a concern than the lead time required to arrange for equipment for such a repair.

OTHER:

- The power generated by the facility is physically delivered to Iberdrola (a private Spanish company – who also works in the US), who apparently markets the power.

11.5 Planning & Specifications: Surveys and Wave Measurement

Leidos Maritime Solutions coordinated with **CH2M, Fugro,** and **Tenera** to ensure the requirements for the scope of work for subsea cable route desktop study were implemented and led the survey team that conducted a Vandenberg AFB site visit that included Fugro Pelagos. The emphasis is on determining accurate bathymetry to support horizontal directional drill (HDD) bore profile design. Additional meetings with **Fugro Pelagos** were held on the week of July 11th. This study will determine the follow-on surveys needed, including charting the kelp beds in the vicinity, and wave measurement instruments needed for CalWave[sm].

PG&E continued to prepare data and models for wave modeling effort and **Virginia Tech** extracted hindcast wave data for five Wavewatch III coastal grid points encompassing the CalWave[sm] candidate test berth sites, together with measured wave data from two validation stations operated by the Coastal Data Information Program (CDIP) at **Scripps Institution of Oceanography**. The hindcast time series is

from a re-analysis that the National Centers for Environmental Prediction (NCEP) just completed in June, using a new swell physics package. The NCEP hindcast covers the period from 1980 through 2009, and the CDIP measurements to validate this hindcast are available for 1987-1998 from a submerged pressure gauge array on Harvest Platform, and from 1998- 2009 from a Waverider buoy 8 km southwest of Harvest Platform.

Task 12 CalWave[sm] Permitting Element (Q4-Q8)

12.1 Literature Review

The CalWave[sm] permitting team continued to conduct a literature search to obtain existing documentation regarding previously completed environmental permitting projects for infrastructure along the Central California Coast to evaluate regulatory issues and information sources. Key documents reviewed this quarter regarding permitting in the project region included the following (among others):

- Venoco Platform Holly Power Cable Replacement Permitting Studies
  - Geotechnical Desktop Study
  - Initial Study/Mitigated Negative Declaration
  - Air Quality and Greenhouse Gas Emissions Technical Report
  - Biological Resources Technical Report
- Geophysical Survey Permit Application Pre-survey Notification Form for Exxon Mobil Production Company and Vessel Cable Enterprise

Key documents reviewed this quarter regarding general permitting analysis methodologies for marine hydrokinetic technologies included the following:

- NOAA Technical Manual *Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing Underwater Acoustic Thresholds for Onset of Permanent and Temporary Threshold Shifts.* National Marine Fisheries Service, National Oceanic and Atmospheric Administration
- National Renewable Energy Laboratory. *A Review of the Environmental Impacts for Marine and Hydrokinetic Projects to Inform Regulatory Permitting: Summary Findings from the 2015 Workshop on Marine and Hydrokinetic Technologies, Washington, D.C.* Technical Report NREL/TP-5000-66688

Progress continues on this subtask.

12.2 Evaluation of Biological Resources Data

The CalWave[sm] permitting team continued researching existing sources of biological resources data in the study area, including as the following:

- California Cooperative Ocean Fishing Investigations (CalCOFI) fisheries data (since 1949)
- CalCOFI bird surveys
- California Data Information Program (since 1975)
- Southern California Coastal Ocean Observing System

• California Department of Fish and Wildlife commercial fish landings data

• NOAA Southwest Fisheries Science Center long-range gray whale studies

This information will be incorporated into the Environmental Baseline Studies prepared during Q8.

12.3 Consultation with Regulatory Agencies and Others

A major consultation task included preparation for and presentation to the first Regulatory Agency Meeting (see also Section *13.2 Regulatory Agency Group/Subgroup* of this report). This meeting helped in further defining the need for additional environmental baseline data. The meeting also served to demonstrate the substantial progress the engineering and environmental teams have completed in refining the project description and system design concept, and compiling existing environmental information.

The discussion focused on three areas: onshore infrastructure (the substation, transmission line, and other associated structures), the subsea cables, including horizontal directional drilling and avoidance of sensitive habitat, and the berths for the WEC arrays. The land-based elements and cables will be defined clearly enough to enable understanding of the potential environmental impacts.

One of the most important discussions at the July 11 Regulatory Agency meeting had to do with how CalWave[sm], as permit Applicant, will describe the project in permitting documents, given that the characteristics of the specific wave energy converter (WEC) devices to be tested there may not be known (or even invented) at the time the shore station and subsea cables and connectors are permitted. Taking this into consideration, the permitting documents will need to describe the different types of possible WECs and different types of anchoring, moorings, device characteristics, and ultimately their possible environmental effects as the 'bookends', 'envelope' or bounding box for the WECs and their mooring systems. WECs seeking to test at CalWave[sm] will need to fit within the 'envelope' described in the original permitting document in order to be automatically permitted or pre-qualified for testing. The more clearly the permitting documents can describe the variations possible within the 'envelope', the easier it will be to obtain authorizations to construct and begin operating the CalWave[sm] test center. The project team will be focusing on developing the 'envelope' description along with the detailed on land and cable route plans in the near-term efforts for this project so that the draft Preliminary Application Document completed in this project phase will have identified the project with specificity to inform efficient permitting in the next phase of this effort.

Permitting Lessons Learned from UK Wave Hub Visit (July 12 – 15)

UK Wave Hub staff indicated that they permitted the subsea cable and shore station with a definitive project description and permitted the test berths as an 'envelope' describing several generic types of WEC technologies. Individual clients of UK Wave Hub then are required to obtain their own Marine License "consent" from the UK Marine Management Organization which, because of the initial 'envelope' work, takes only 12 weeks. Also, UK Wave Hub's subsea cable could not be buried in seafloor sediment because of a lack of sediment thickness. The cable was instead laid on the seafloor and covered in rock for protection. At this time, it is unclear whether CalWave[sm] will be required to bury submarine power cables.

UK Wave Hub established a fund for compensation to the commercial fishing community in the project area, though it has not yet been established how the fund will be used or distributed. UK Wave Hub proposes that funds go to general improvements to infrastructure that would help all fishers, rather than in payments to individuals.

There have been no cases of whale entanglement in UK Wave Hub mooring cables to date, though total time of device testing so far is relatively small. UK Wave Hub will be consulted again in the future as more devices are installed there to monitor for cases of entanglement.

Consultation and Coordination with California State Agencies and VAFB

The CalWave[sm] permitting team also continued to consult with environmental staff of VAFB regarding environmental permitting of existing Air Force projects. VAFB had previously provided several environmental permitting studies done for projects performed in the recent past as listed in the previous quarterly report. During this quarter, Permitting Lead Doug Davy consulted with VAFB environmental permitting staff to request specific information about biological and cultural resources located near the proposed shore station site and 70 kV upgrade line routes. This information has informed the 70 kV upgrade routing and includes maps showing previous study results for the following species:

Plants:

Gaviota tarplant *(Dienandra increscens villosa)*

La Graciosa thistle *(Cirsium loncholepis)*

beach layia (*Layia carnosa*)

Lompoc yerba santa *(Eriodictyon capitatum)*

Vandenberg monkeyflower *(Diplacus vandenbergensis)*

Birds:

Western snowy plover *(Charadrius nivosus nivosus)*

California least tern *(Sternula antillarum browni)*

Southwestern willow flycatcher *(Empidonax trailii extimus)*

Southern sea otter *(Enhydra lutris nereis)* rafting areas

Mammals:

harbor seal (haulout locations)

Fish:

Unarmored threespine stickleback *(Gasterosteus aculeatus williamsoni)*

Tidewater goby *(Eucyclogobius newberryi)*

Southern steelhead *(Onchorhyncus mykiss)*

Amphibians:

California red-legged frog *(Rana draytonii)*

Invertebrates:

Black abalone (*Haliotus cracherodii*)

El Segundo blue butterfly *(Euphilotes battoides* near *allyni)*

Vernal pool fairy shrimp *(Branchinecta lynchi)*

Initial analysis shows that the CalWave[sm] shore station and generator tie-line will avoid disturbing habitat of these species as long as appropriate avoidance and mitigation measures are adopted, although field surveys will be required for the final generator-tie line route to confirm previous survey 7results as provided by VAFB.

California Natural Resources Engagement

California state agency partners are contributing staff resources to advance many aspects of the CalWave II project. The state is committed to increasing its supply of renewable energy resources and promoting clean energy innovation to ensure reliable alternatives to fossil fuels. Multiple California state agencies are part of the CalWave II team and will be responsible for reviewing and permitting various components of the project.

The State Lands Commission (SLC) has jurisdiction over the seafloor within State waters and, depending on the siting, will be responsible for issuing leases for any seafloor cables that pass through State waters. The ambulatory boundary of State Lands extends from the mean high tide line (MHTL) to approximately 3 nautical miles into the ocean. SLC staff expended 76.5 hours of work time during the third quarter of 2016 on the CalWave II project. Commission staff attended all weekly CalWave II team coordination and project update calls and participated in in-state and out-of-state offshore renewable energy interagency meetings and conferences, including the Oregon Wave Energy Trust conference in September and the BOEM permitting agency meeting in July. In addition, staff has prepared GIS map layers of bathymetry, existing infrastructure, and popular fishing grounds within and adjacent to the project area for the project developers.

The California Natural Resources Agency (CNRA) coordinates many divisions within the state tasked with managing and protecting California's natural, historic, and cultural resources. CNRA staff expended 40 hours of work time during the third quarter of 2016 on the CalWave II project. The majority of those hours were spent collaborating with federal and state partners to create the BOEM California Offshore Energy Task Force and draft its charter. The remaining hours were dedicated to CalWave II team coordination and project update calls.

The California Department of Fish and Wildlife (CDFW) is responsible for the management of the state's biological resources and regulates commercial and non-commercial activities that may impact those resources. The Department has additional responsibilities related to the protection of threatened and endangered species and species of special concern. CDFW staff has expended nearly 5 hours of work time during the 3rd quarter of 2016. Staff participated in some CalWave II team coordination and project update calls. Staff also attended a meeting of the NOAA Pacific Fisheries Management Council related to the interaction between different kinds of offshore renewable energy devices and commercial fish stocks and potential environmental impacts.

12.4 Regulatory Roadmap

The CalWave[sm] project team held conference calls with representatives of FERC and BOEM to discuss their experience with permitting previous offshore marine renewable energy projects, including offshore wind projects and marine hydrokinetic projects in the Pacific Northwest. These discussions were very informative regarding permitting procedure and timing. FERC maintains licensing authority for Marine Hydrokinetic Projects on the Outer Continental Shelf (OCS), while BOEM maintains lease authority for renewable energy projects located within BOEM's lease blocks on the OCS. BOEM and FERC conduct marine hydrokinetic permitting projects in accordance with the Memorandum of Understanding between FERC and BOEM on this permitting as well as the "BOEM / FERC Guidelines on Regulation of Marine and Hydrokinetic Energy Projects on the OCS".

12.5 Preparation of Environmental Baseline Summaries

This task will begin during Quarter #8, now that conceptual design phase is complete and will continue through early 2017.

12.6 Project Coordination

CH2M has obtained draft copies of the following reports from subconsultants:

- Cable Route Desktop Study, by Fugro Pelagros. This study provides a preliminary assessment of notional subsea cable routes, data gaps, and further surveys needed, as well as risk analysis per the International Cable Protection Committee Recommendation No. 9 – Minimum Technical Requirements for a Desktop Study (also known as Cable Route Study) Issue Date: 2 November, 2007. This study has been reviewed and is provided as an attachment to this report.
- Anchoring and Mooring Lessons Learned Analysis, by Glosten Associates, as it pertains to CalWave[sm] infrastructure and possible future WEC developers and CalWave[sm] tenants in the context of permitting requirements and the regulatory roadmap. This document is under review and will be provided in a subsequent quarterly report.
- Cable Installation Lessons Learned Analysis, by Center Marine. This document is under review and will be provided in a subsequent quarterly report.

Task 13 CalWave[sm] Stakeholder Involvement and Public Participation Element (Q4-Q8)

13.1 Stakeholder Advisory Group

In September, the CalWave[sm] Team launched the Stakeholder Advisory Group to provide project information to representatives from all major stakeholder communities and solicit guidance and input on project parameters and studies/permitting efforts. Invited organizations include the following:

Academic

- Cal State University Channels Islands
- Southern California Marine Institute
- U.C. Santa Barbara – Marine Science Institute, Bren School of Environmental Studies

Economic/Business

- City of Santa Barbara Harbor
- Port Hueneme
- Port San Luis Harbor District
- Morro Bay Harbor District
- Santa Barbara Region Chamber of Commerce
- Santa Maria Valley Chamber of Commerce

Environment & Recreation

- Community Environmental Council
- Environmental Defense Center
- Natural Resources Defense Council
- Sierra Club
- Surfrider Foundation
- The Nature Conservancy

Fishing

- California Sportfishing Association
- California Sportfishing Protection Alliance
- Central Coast Fisheries Conservation Coalition
- Commercial Fishermen of Santa Barbara
- Morro Bay Commercial Fisherman's Organization
- Southern CA Trawlers Association
- Port San Luis Commercial Fishermen's Association

Labor

- Coalition of Labor, Agriculture and Business
- International Brotherhood of Electrical Workers
- Tri-Counties Building and Trades Council

Local/Regional Government and Site Managers

- City of Lompoc
- Congresswoman Lois Capps' Office
- Santa Barbara County
- San Luis Obispo County
- Vandenberg Air Force Base

Representatives from CalWave[SM] Operational Advisory Group

- Associated Pacific Constructors
- Castagnolo Tug Service Inc.
- Trac Tide Marine Fuels
- Vessel operations, Morro Bay

Tribes and Tribal Governments

- Barbareño Chumash Council
- Chumash Maritime Association
- Coastal Band of the Chumash Nation
- Northern Chumash Tribal Council
- Santa Ynez Band of Chumash Indians
- Yak Tityu Tityu Northern Chumash

The first meeting of this group will occur on October 20th in San Luis Obispo. Participants have received a draft charter and will use the first meeting to discuss the Stakeholder Advisory Group purpose and charter, receive current information about the CalWave[SM] project including engineering and design specifications, and will begin discussing potential resource effects and information that will be needed for permitting. The meeting will be open to the public.

13.2 Regulatory Agency Group/Subgroup

The team has completed the first Regulatory Agency Meeting of this phase, which was held on July 11th in Camarillo, CA. We reported on this meeting during the 6th Quarterly Report. During that meeting, participants noted that they wanted to use the next meeting to discuss categories of WECs and their anchoring/mooring mechanisms in more detail, as well as to receive additional detailed information about potential environmental effects. The next meeting of the Regulatory Agency Group will be held on October 21st in Camarillo, CA, and will cover the following topics:

- Project updates, including updates to project engineering and design, information about the Cable routing desktop study, and Information about existing infrastructure
- Defining the envelope (range of potential WEC effects), including how the envelope works in the permitting process, and proposed groupings of wave energy converters (WECs) according to operating mechanism, along with anchoring and mooring mechanisms; this will also include an introduction to considering potential effects
- Recent research on electromagnetic fields (EMF), courtesy of BOEM
- A discussion of potential environmental effect risk profiles
- Review and discussion of draft risk profile matrices
- Update on State of CA Offshore Renewable Activities from the Ocean Protection Council (OPC)
- Next Steps and Anticipated Timeframes

A subsequent Regulatory Agency Meeting is scheduled for December 8, 2016.

13.3 Materials and Web Site Support

Kearns & West is updating the project website and associated communication materials during the 7th and 8th quarters of this project.

13.4 Project Team Coordination

Kearns & West has performed project team coordination as needed throughout the 7th quarter in order to organize and facilitate the October Stakeholder Advisory Group and Regulatory Agency Meetings. This subtask will be an ongoing process throughout the duration of the project.

Section 3. Cost Status

Please see the following attachments in excel format:

Attachment B – "Spending Summary"

Attachment C – "Cost Share Contributions"

Attachment D – "Spend Plan Data"

Section 4. Schedule Status

Project Management and Reporting

The Principal Investigator, Project Manager and Project Administrator teamed to track work scope

execution against schedule milestones and budget. The Quarterly Reports are drafted by the Project Administrator with specific inputs from all team members and then are reviewed by the Project Manager and Principal Investigator. The Final Report will follow a similar process.

Tasks to be focused on in the 6th quarter are Task 11, Task 12, and Task 13. These two tasks will fundamentally inform the permitting roadmap and draft NOI/PAD which is to be filed by the end of this project.

TASKS	Quarter (from start of project)				
	Feb. '16 – March	April – June	July – Sept.	Oct. – Dec.	Jan. '17 – Feb.
	5th	6th	7th	8th	9th
Task 11: Develop Engineering Quantities, Cost and Schedule Estimates to Support Financing Plan, Select Preferred Location					
Task 12: Develop Permitting Roadmap to Populate Draft Preliminary PAD					
Task 13: Develop List of Stakeholder Concerns and Develop Possible Solutions					

The major milestone schedule that has been established by the core project team is progressing as follows:

CalWave[sm] II Milestone Tasks	Project Quarter	Est. Month of Completion	Year
Conceptual Design (Complete)	6	June	2016
Present Conceptual Design to Agencies (Complete)	7	July	2016
Commence Preliminary Design (In progress)	7	September	2016
Present Preliminary Design to Agencies (In progress)	8	October	2016
Draft Preliminary Design (In progress)	8	October	2016
Draft PAD with Prelim. Design	8	November	2016
Present Draft PAD to Agencies	9	January	2017
Final Draft PAD	9	February	2017
Final Technical Report for DOE Submission	9	February	2017

Section 5. Changes to Scope and Project Approach

None at this time.

Section 6. Problems/Delays

None at this time.

Section 7. Key Personnel

No significant changes in personnel has occurred.

Section 8. Products and Technology Transfer

None at this time.

APPENDIX

Commented [WIT1]: Will there be an appendix? If not, please delete.

Quarterly Technical Progress Report
(Eighth of Nine Quarters)
TITLE PAGE

Federal Agency to which Report is submitted:	DOE EERE – Wind & Water Power Program
Recipient:	Cal Poly Corporation; DUNS Number 02-932-6246
Recipient Type:	State University
Award Number:	DE-EE0006517.0005
Award Number:	Grant
Project Title:	California Wave Energy Test Center Phase II (CalWave℠)
Project Period:	One year, February 19, 2016 to February 28, 2017.

Principal Investigator:	Dr. Sam Blakeslee; Director, Institute for Advanced Technology and Public Policy
Email:	sblakesl@calpoly.edu
Phone:	(805) 756-1694
Organization:	California Polytechnic State University, San Luis Obispo, California; (Cal Poly)

Report Submitted by:	William Toman; CalWave℠ Project Manager
Email:	wtoman@calpoly.edu
Phone:	(707) 731-9261
Organization:	California Polytechnic State University, San Luis Obispo, California; (Cal Poly)

Report Coordination by:	Nick Osterbur; CalWave℠ Project Administrator
Email:	nosterbu@calpoly.edu
Phone:	(805) 756-1693
Organization:	California Polytechnic State University, San Luis Obispo, California; (Cal Poly)

Date of Report:	January 31, 2017
Covering Period:	October 1, 2016 to December 30, 2016 (8th of 9 Quarters)
DOE Funding Released:	February 19, 2016
Report Frequency:	Quarterly

Working Partners:

Vendors (F&A included as match)
Leidos (vendor); Rick Williams; richard.b.williams@leidos.com; (503) 484-4415
CH2M (vendor); Dr. Doug Davy; Doug.Davy@ch2m.com; (916) 286-0278
Kearns & West (vendor); Anna West; awest@kearnswest.com; (415) 391-7900
Omega Power Engineers, LLC (vendor); Randall M. Connett; randy.connett@omegapower.net; (303) 330 6920
UK Wave Hub (vendor); Stuart Herbert; stuart.herbert@wavehub.co.uk; 01736-800294

National Labs (F&A is not allowed)
National Renewable Energy Laboratory (NREL); Al LiVecchi; Al.LiVecchi@nrel.gov; (303) 384-7138
Sandia National Laboratories; Jesse Roberts; jdrober@sandia.gov; (505) 844-5730

Subrecipient (F&A included as match)
Electric Power Research Institute (EPRI) (subaward); Dr. Paul Jacobson; pjacobson@epri.com; (410) 489-3675
Humboldt State University (subaward); Dr. Arne Jacobson; Arne.Jacobson@humboldt.edu; (707) 826-4302
Virginia Tech (subaward); Dr. George Hagerman; hagerman@vt.edu; (757) 340-1921
Scripps Institution Of Oceanography, UC San Diego (subaward); Julie Thomas; jot@cdip.ucsd.edu; (858) 534-3034

State Government Agency and Utility
California Natural Resources Agency (government agency); Chris Potter; Chris.Potter@resources.ca.gov; (415) 740-9869
Pacific Gas and Electric (utility); Dr. Brendan Dooher; bxd6@pge.com; (925) 822-7716

Cost-Sharing Partners:
California Natural Resources Agency
Pacific Gas & Electric Company
Protean Energy Ltd., Steve Rogers, stephen.rogers@proteanenergy.com.au, +61 (9481) 22771

DOE Project Team: DOE HQ Program Manager – Jim Ahlgrimm
DOE Field Contract Officer – Pamela Brodie
DOE Field Financial Assistance Specialist – Jane Sanders
DOE Field Project Officer – Tim Ramsey
DOE/CNJV Project Monitor – Nicholas Massey

Signature of Submitting Official:

_____

William Toman
CalWave℠ Project Manager

Section I. Project Accomplishment Narrative

This 8th quarterly report documents the work on the CalWave℠ project during the reporting period of October 1, 2016 through December 31, 2016 and will address the following:

In Section 1:

- Overall Project Status at the start of the 8th quarter.
- Summaries of progress in Tasks 11, 12 and 13

In Section 2:

- Progress from October to December in the SOPO format for Tasks 11, 12, 13

In Section 3:

- Cost Data

In Section 4:

- Forecast activities planned during the next (final) quarter and the Final Report

1. Overall Project Status at the end of the 8th quarter:

The CalWave℠ project is on track and within budget at the end of the 8th Quarter. Twelve weekly conference calls had been held with robust attendance of the CalWave℠ team.

Task 11: Engineering Element:
The design has progressed from the Conceptual Design Stage into the start of the Preliminary Design Stage. Additional meetings and significant interaction with agencies/regulators/host facility have occurred to evolve both the design and operational aspects.

Task 12: Permitting Element:
The permitting effort proceeded with the literature review work nearing completion and environmental baseline summaries initiated. A "potential issues" matrix representing potential permitting concerns was circulated to regulating agencies for consideration and input and, the final regulatory agency meeting was held. A draft Preliminary Application Document (PAD) project description was initiated and circulated for review and continues to be updated as the project progresses.

Task 13: Stakeholder Element:
The outreach and stakeholder engagement effort included two meetings of the CalWave℠ Regulatory Agency Group in October and December 2016, and the initial meeting of the CalWave℠ Stakeholder Advisory Group. Members of the Operational Advisory Group participated in the October stakeholder meeting. Additionally, the outreach team updated the project Fact Sheet and website with the most recent project information.

2. Recap of key events in the 8th Quarter:

This 8th quarterly report reviews progress that occurred in October, November, and December 2016.

During this period, the CalWave℠ project team refined the design concepts to accommodate diverse categories of WECs that could operate in the available depth range. We obtained input and letters of support from WEC Developers that expressed interest through our collaborative relationship with the UK Wave Hub. We incorporated US BOEM advice on lease blocks and fisherman input on existing uses and, in particular, we worked to:

- Recognize the constraints imposed by the BOEM lease block/aliquot system.
- Recognize the diversity of WECs anticipated during the Test Center operational lifespan and allow power conditioning onboard the WEC, or ashore, as well as either AC or DC electrical output on export cables to the shore station.
- Designate berths with a range of wave energy resources by combining the South and South-by-Southeast sites into our lease block plan
- Incorporate results of the cable route desktop study and input from fishermen and regulators.
- Incorporate results of mooring and anchoring report to ensure flexibility in seafloor footprint, rather than constraining into squares-shaped areas and obtain regulator input on plan to allow the WEC developer to use their own design for mooring and anchoring, rather than a pre-installed (sub-optimized) anchor pattern.
- Incorporate input from subsea cable manufacturer and subsea cable consultant to vary armor protection (near shore segment/static segment/dynamic tail segment) and eliminate the near-shore connectors.
- Incorporate input from NREL about instrumentation and load bank ashore for testing to demonstrate grid compliance.
- Explore alternatives for placement of the office buildings on Vandenberg AFB to improve access.
- Consider the "Conceptual Platform Configuration" alternatives for connection of WECs offshore, using the existing Platform Irene-to-Surf Substation 25MW subsea cable, and "wheel power" via PG&E grid to Vandenberg AFB.
- Continue discussions for power purchase during reliability-phase of testing.

The operational aspects of the project (HDD, marine operations, cable installation, and cable terminations) were routinely discussed and revalidated by industry participants as well-conceived and executable. These events represented substantive progress for the CalWave[sm] project and were reported on in the various tasks as outlined within the Statement of Project Objectives.

TASKS	Quarter (from start of project)				
	Feb. '16 – March	April – June	July – Sept.	Oct. – Dec.	Jan. '17 – Feb.
	5th	6th	7th	8th	9th
Task 11: Develop Engineering Quantities, Cost and Schedule Estimates to Support Financing Plan, Select Preferred Location					
Task 12: Develop Permitting Roadmap to Populate Draft Preliminary PAD					
Task 13: Develop List of Stakeholder Concerns and Develop Possible Solutions					

**Dark grey means increased effort for a task, and light grey means decreased effort*

Summary Engineering Element Progress (Task 11)

The Engineering Team led by **Leidos Maritime Solutions** refined the site selection process that had narrowed the test berth siting to BOEM Lease Blocks that encompass the South and Southeast test berth

locations near the Vandenberg Dock South Base Site. The focus was the "Conceptual South Base Configuration Baseline", with all facilities near Vandenberg Dock. That Baseline was finalized and carried into the Preliminary Design Stage as the "Preliminary South Base Configuration Baseline". Several options continue to be considered:

- The "Conceptual Platform Configuration" was evaluated and will require an expansion of the Surf Substation near the Surf Amtrak Station at the end of West Ocean Blvd.
- The review of the various platform-related alternatives resulted in an overall design improvement by exploring the option of "decoupling" the location of the buildings and the electrical infrastructure.
- The option to locate the CalWave[sm] Test Center buildings adjacent to the Surf Amtrak Station and the PG&E Surf Substation, with the option to redefine the VAFB security fence boundary would allow improved access and reduced construction and operational phase costs.

The Engineering Team supported the preparations for meetings and made presentations:

- October 20th , 2016: Stakeholder Advisory Group meeting with Operational Advisory Group representatives
- October 21st, 2016: Regulatory Agency Group meeting
- December 8th, 2016: Regulatory Agency Group meeting

As reported in the 7th Quarter Report, the systems engineering boundary was defined as the "systems and sub-systems under the direct control of the CalWave[sm] Team".

- The boundary systems were defined as "systems or sub-systems that are a vital part of the design and are not under the direct control of the CalWave[sm] Team". Boundary systems include: The Wave Energy Convertor (WEC) systems; Vandenberg Air Force Base (VAFB) and PG&E electrical grids; and, VAFB facility infrastructure.
- The System Block Diagram is now a "Grid-Reference", vice "WEC-Reference". This recognizes that the host facility and grid are more mature, and more rigid, boundary system and that the WECs are a less mature boundary system and subject to new product development.

The extreme events analysis, performed by **Cal Poly** on the five proposed shore sites, confirmed the selection of the South Base Site. The analysis included Tsunami modeling, historic weather modeling, and a seismic ground shaking assessment in order to inform the shore station down selection process.

- The extreme event implications of the alternative CalWave[sm] Test Center building location near the Surf Amtrak Station will be analyzed during the subsequent Phase III before making a decision on a formal configuration change.

Site construction estimates were progressed based on the South Base Site topographic field survey by **Cal Poly** that has informed the civil, mechanical, and electrical engineering and architectural designs to-date.

- The conceptual electrical engineering design by **Omega Power Engineers** progressed through increasing levels of detail.
- The site construction estimates are based on the electrical design for the Preliminary South Base Configuration Baseline.
- Input from the Cable Route Desktop Study by **Fugro Pelagos** indicates the required bore lengths will be 3,000 to 3,200 ft.; and, the best marine geological data indicates that drilling will be through hard rock found in the Monterey Formation.
    - The rough order of magnitude estimates (ROMs) were updated; and, alternatives for onshore and offshore core sampling were explored.
- Input from prospective horizontal directional drilling (HDD) contractor, **The HDD Company**, emphasized the pull strength considerations of the ~3,000 ft HDD profile that drives the cable design toward a double armor specification.
- Input from prospective cable installer, **L3 Maripro** raised the possibility of varying the armor protection along the length of 3.25nm cable versus two (or three) separate segments (near shore segment/static segment/dynamic tail segment) and could eliminate the near-shore connectors.
- Input from **Center Marine** enabled increased interaction with the prospective subsea cable manufacturer, **Prysmian**, that evolved the technical specifications for the undersea cables.
- Input from the cable route desktop study by **Fugro Pelagos** and discussions with fishermen reviewed the Preliminary Baseline Configuration cable routing (a fan of cables on shortest direct routes to the test berths) in contrast to a "cable corridor" that would require longer cables. The alternative of cable burial in some sections of the routes was also discussed.
- Input on mooring and anchoring by **Glosten and Associates** informed the briefing to agencies on the permitting envelope.

The integration of design, operations, and existing user considerations is essential in order to determine a practical solution for both electrical, horizontal directional drilling, and installation considerations.

- Project reliability and operability considerations are also under review, such as minimum cable separation (known as "route diversity"), with respect to repair times and to facilitate safety during maintenance activities.
- Risk mitigation and cost considerations are also under review comparing the cost of a direct route, surface lay versus the longer cable routes for a cable corridor and the cost of burial as options.

Omega Power Engineers worked through the application, and information security need-to-know requirements, of the Western Electricity Coordinating Council (WECC) and completed the preliminary grid integration study with positive results: the existing infrastructure at VAFB is adequate for the preliminary design.

- One potential overload scenario was identified on a short section of VAFB transmission grid if the PG&E grid failed + the VAFB loads were zero + the CalWave[sm] output was maximum. This scenario is highly unlikely and, for CalWave[sm] design purposes, can be dealt with by operational curtailment. Separately, VAFB is evaluating an upgrade to the line.

- The study data are limited distribution based on need-to-know definitions of WECC.

PG&E continued to review all aspects of the electrical engineering design and wave resource data and for the wave modeling analysis with **Virginia Tech** and **Scripps Institution of Oceanography**.

As reported in the 7th Quarterly Report, the **UK Wave Hub** provided feedback on the Conceptual Design. Continued input, and vital input from WEC Developers, has been valuable as the design progresses.

Summary of Permitting Progress (Task 12)

The permitting team continued to progress the CalWave[sm] permitting element and work on review of existing literature came to near completion as represented by the drafting of Environmental Baseline summaries which will be included as an attachment in the final report. Commercial fish catch data was collected and assessed for the area near the proposed CalWave[sm] test berths and information on marine biota with an emphasis on marine mammal entanglement and acoustics was collected and reviewed. The Cable Route Desktop Study was finalized as was the Anchoring and Mooring Lessons Learned Analysis while the Cable Installation Lessons Learned Analysis Is still in draft format. The draft permitting "envelope" and the draft project description were formalized in the draft (FERC formatted) Preliminary Application Document (PAD) which was circulated for to the CalWave[sm] team for review and comment. Consultation with the regulatory agencies and Vandenberg Air Force Base continued and an environmental permitting issues matrix was circulated for review and comment to permitting agencies.

The Permitting Team supported the preparations for meetings and made presentations:

- October 20th , 2016: Stakeholder Advisory Group meeting
- October 21st, 2016: Regulatory Agency Group meeting
- December 8th, 2016: Regulatory Agency Group meeting

Summary of Stakeholder Progress (Task 13)

In October 2016, the Stakeholder Outreach team held three meetings with CalWave[sm] project groups.

The Stakeholder Advisory Group, which first on October 20, 2016, in San Luis Obispo, CA, includes representatives from the following industries/sectors: Academic, Economic/Business, Environmental, Fishing, Labor, Local/Regional Government, Recreation, Tribes, and representatives from the CalWave[sm] Operational Advisory Group. The October 20th meeting saw participation from 20 of the 34 invited participants, as well as 12 members of the public, with highly engaged discussion.

During the 8th quarter, the Stakeholder Outreach team conducted two meetings of the CalWave[sm] Regulatory Agency Group, on October 21st and December 8th. The focus and details of these meetings are further discussed in this report.

Section 2. Details of Scope Accomplishments

Major Progress of Objectives

Administrative

The Project Manager coordinated the overall work efforts of the Engineering Element (Task 11), the Permitting and Environmental Element (Task 12) and Stakeholder Involvement and Public Participation Element (Task 13).

Task 11 CalWave[sm] II Engineering Element (Q4-Q8)

The CalWave II (Phase 2.0) Engineering Element SOPO covers Task 11:

Task 11: Develop Engineering Quantities, Cost and Schedule Estimates to Support Financing Plan, Select Preferred Location

11.1 Engineering Project Management

Chief Engineer Rick Williams of **Leidos Maritime Solutions** provided engineering input to the project management team and coordinated with the Cal Poly Principal Investigator, Project Developer, Project Manager, project management staff, and project team. Weekly project team conference calls continued; and, administrative tasks and reporting were accomplished. The Engineering Element is in the early part of the Preliminary Design Stage.

11.2 System Integration and Systems Engineering (SE&I)

Leidos continued systems integration and engineering (SE&I) activities as reported in the Summary above. The SE&I goal is to maintain design flexibility for infrastructure to support testing out to the design life of 2050.

- The SE&I objectives include interface definition between major systems and sub-systems for Wave Energy Converters (WECs) that have yet to be invented.
- Interface definition is a key component of the Project Description.
- The Project Description is a key input to the permitting process known as the “permitting envelope” This is discussed further in the Section 12 Permitting Element of this report.

We continue to benefit from CalWave[sm]’s electrical engineer, Randy Connett of **Omega Power Engineering**, visit to the Biscay Marine Energy Platform (BIMEP) ocean energy test site in Spain where technical engineering and infrastructure elements were investigated.

Operational Advisory Group (OAG)

As previously reported, a working group of Central and Southern California's marine/ocean industry representatives was convened to provide expertise and as well as an operational and logistical knowledgebase for the development of the CalWave[sm] wave energy test center and to establish a general industry interest in future marine renewable energy development in California.

A subset of the OAG attended the Stakeholder Advisory Group (SAG) meeting in San Luis Obispo.

Preliminary Design Process

The objective of the Phase II Preliminary Design Process is to evolve the design to a level of detail adequate for the Draft Preliminary Application Document (Draft PAD).

The preliminary site layout integrated the conceptual shore station design and location with the offshore test berth locations, topography, bathymetry, subsea cable capabilities and constraints, and host facility requirements. Electrical design work is provided by **Omega Power Engineers**, with support from **Atwell Engineering.**

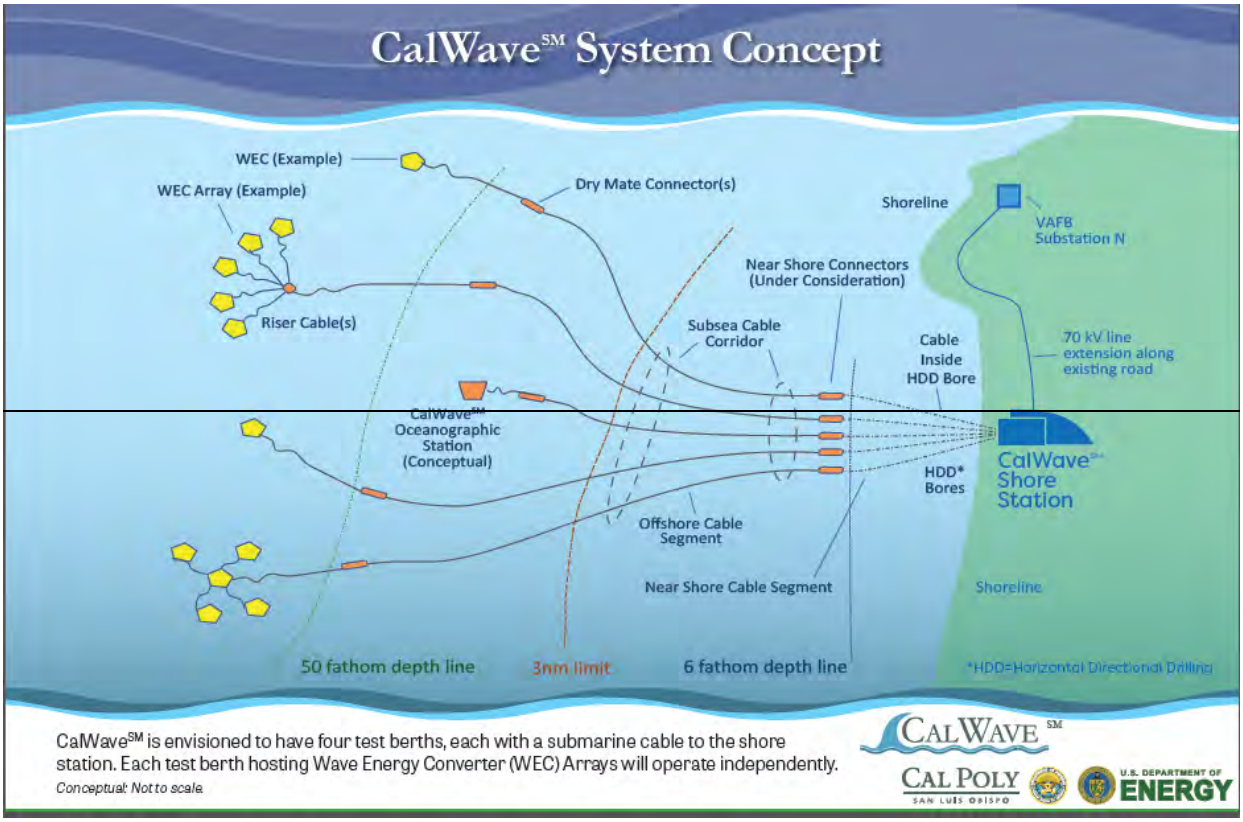


Figure 2-1: CalWave[sm] System Concept (Source: Leidos Inc./Kearns & West)

The evolving design reflects CalWave[sm]'s emphasis on hosting mature WEC/MEC (TRL 7-9) devices while maintaining a requirements-driven, technology-neutral, vendor agnostic, and holistic design approach.

- The preliminary design includes four test berths on the Outer Continental Shelf (OCS).
- Dry-mate subsea cable connectors inside the 50 fathom (300 ft.) curve.
- Surface lay cables, unless burial is required.
- Export cables cross the California Territorial Sea (from the three nautical mile limit to shore)
- HDD cable landing: five bores for four cables and spare.

In discussion with regulators about mooring and anchoring, the most probable WEC Developer designs will be multi-leg catenary moorings with drag-embedment anchors.

An alternative anchor technology is a "Suction Embedded Plate Anchor (SEPLA)". An opportunity to further explore the use of SEPLA technology at this site would be as the mooring and anchoring system for the conceptual "Oceanographic Station" buoy that would leverage the spare cable. This oceanographic buoy would perform wave resource and meteorological instrumentation/data collection to better monitor facility conditions and the buoy would also serve as a terminus for the spare cable and can be used to perform a systems check and calibration after the WEC has arrived on-site and prior to installing the WEC in a test berth.

Industry Engagement:

- CalWave[sm]'s Chief Engineer participated in the National Hydropower Association (NHA) Hydrovision and presented the CalWave Test Center Design.
  - He is serving as Co-Chair of next year's Marine Renewable Energy Track as was CalWave Partner EPRI's Paul Jacobson.
- Industry Marine Energy Council: Leidos participates in the National Hydropower Association (NHA) Marine Energy Council (MEC) to enhance interaction with WEC developers.
- CalWave[sm]'s Chief Engineer routinely participates in the Oregon Wave Energy Trust (OWET) Ocean Renewable Energy Conference (OREC) events and OWET Industry Summit.

Technical Standards: CalWave[sm] is closely tracking international standards in the design of infrastructure.

- The CalWave[sm] Chief Engineer served as Secretary of the international project team of eleven countries and US Delegate to the International Electrotechnical Commission Technical Committee 114 (IEC TC 114) in the multi-year effort to write the Marine Energy Design Technical Specification (62600-2).
- The CalWave[sm] Chief Engineer is the US Committee Chair for the follow-on technical specification Maintenance Team.
- He also serves as a US Delegate to the IEC Renewable Energy (IECRE) Marine Energy effort as well as the Operational Management Committee (ME-OMC).
- CalWave[sm] is budgeting for the purchase IEC standards in Phase III for use by the expanded team and will require the use of IEC standards in supporting subcontracts.

SE&I Process: The systems engineering and integration process continues as needed to progress and finalize the design of the facility and project description.

System Concept, System Boundary, and Boundary Systems

The system boundary was refined as including the Sea-Based Infrastructure, Shore-Based Infrastructure, and the functional task areas as shown below in, in the System Block Diagrams (Figures 2-7 and 2-8) developed by **Leidos** Inc. Boundary systems were identified as: WEC/MEC System; VAFB-PG&E Electrical Grids; and VAFB Base Facilities. Leidos and the engineering team maintained an emphasis on establishing well defined boundaries between these system blocks.

- The host facility, Vandenberg AFB, connects to CalWave. When considering the multiple interfaces, VAFB is a "system of systems" including: civil; architectural; mechanical; and electrical systems, and related sub-systems, such as electrical grid with connection to the PG&E utility grid, as well as the VAFB environment.
- CalWave interfaces to the host facility as a "boundary system" in that we must adhere to the interface requirements of the host.
- CalWave is also a "system of systems" including sea-based infrastructure and shore-based infrastructure as well as multiple supporting systems and sub-systems such as instrumentation and telemetry, data acquisition and management, and potentially the NREL Grid Emulator.
- The CalWave system interfaces to the WEC array(s) as another "boundary system." The WEC system(s) must adhere to the interface requirements of CalWave, in particular the design and operational limits of the submarine cable.
- Wave Energy Converter System(s) interface to the CalWave system and can be a number of "boundary systems" consisting of one or more WEC Arrays, each with multiple sub-systems such as mooring, anchoring, riser umbilical(s) and power conditioning.

There are two methods for describing CalWave, both emphasize the importance of interface definition and control, particularly at Designated Critical Interfaces:

WEC-References System Block Diagram: used during the Conceptual Design Stage. This method is "customer referenced" and addresses the primary mission of supporting the MHK industry and WEC developers. It starts with the WEC array(s) and progresses through the CalWave system to the host facility and connecting utility.

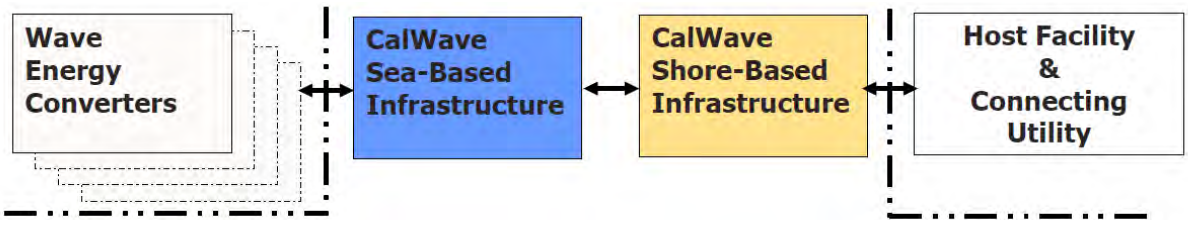


Figure 2-7: WEC-Referenced System Block Diagram (Source: Leidos)

Grid-Referenced System Block Diagram: used during Preliminary, Final, and Detailed Design Stages. This method is "power purchaser" and addresses the end goal of commercialization. It also acknowledges

that the Grid is a mature Boundary System that CalWave and WECs must comply with. This method better represents the facility construction.

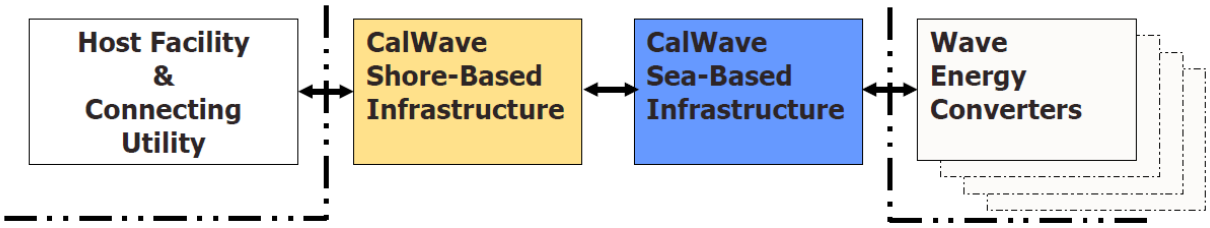


Figure 2-8: Grid-Referenced System Block Diagram (Source: Leidos)

While either frame of reference is correct, our design process focused on the CalWave system, and the interface to the grid, to maintain maximum flexibility for the WECs. We do not have control of the WECs that will be tested now or during the thirty-year design life of the test facility.

There is more certainty with the grid-connection and the order of construction will be from the shore base out to sea. The greatest complexity in the facility is in the shore-based infrastructure at the interface to the host facility and the interface to the sea-based infrastructure. Accordingly, we use the Grid-Referenced Block Diagram and the CalWave System Work Breakdown Structure (SWBS).

The system design requires the WEC/MEC developers to provide their own: mooring and anchoring design and installation, umbilical/dynamic and Riser cables integrated with Dynamic Tail(s) with dry mate connectors, and either on-board or on-shore power conditioning capability.

This holistic system approach requires of the WEC Developer to provide a properly designed mooring and anchoring system for their specific WEC at the specific berth. The Test Berth concept has the following highlights:

- Provides flexibility in shape of seafloor footprint, rather than constraining into squares
- Allow the WEC developer to use their own design for mooring and anchoring, rather than a prescriptive, pre-installed, (sub-optimized), anchor pattern
- Provides berths with a range of wave energy resource to enable WEC developers to populate data for a complete power matrix

An important operational concept and system boundary will require the WEC/MEC developer to be responsible for the power conditioning and testing/checkout of their own device output before it is connected to the VAFB/PG&E grid infrastructure. The WEC/MEC developer will have the option of conditioning the power on-board the wave energy conversion device or via installation of equipment at the shore-side substation location.

A robust interconnection specification, modeled after **UK WaveHub** will be used to ensure protection of the export cable.

The Shore Station and Test Berth concept has the following highlights:

- Provides instrumentation and load bank ashore for testing to demonstrate grid compliance.
- Provides an off-taker for power during reliability-phase of testing.
- Provides a grid-integration opportunity with CalWave[sm]'s partner utility **PG&E**.

System Work Breakdown Structure (SWBS): The SWBS is a product-oriented frame of reference for naval architecture and marine engineering design. It has been most useful during the design phases in highlighting the interfaces that must be carefully managed. A top-level summary of the SWBS is:

- System 100: Host Facility
- System 200: CalWave Shore-based Infrastructure
- System 300: CalWave Sea-based Infrastructure
  - System 310: Test Berth One
  - System 320: Test Berth Two
  - System 330: Test Berth Three
  - System 340: Test Berth Four
  - System 350: Fifth (spare) Cable and associated functions
- System 400: Wave Energy Converter System(s)
  - System 410: WEC in Test Berth One
  - System 420: WEC in Test Berth Two
  - System 430: WEC in Test Berth Three
  - System 440: WEC in Test Berth Four
  - System 450: WEC checkout function (also see System 800)
- System 500: CalWave Data Acquisition and Management System
- System 600: Test Instrumentation System
- System 700: Reserved for NREL Grid Emulator Equipment
- System 800: Reserved Ocean Observing System and CalWave Oceanographic Station
- System 900: Reserved for CalWave Informational Kiosks in the Region

Program Work Breakdown Structure (WBS): In contrast with the SWBS used in the design phases, the CalWave Program WBS activity-oriented and aligned with the anticipated Workplan, structured with a hierarchy of performance period (approximately annual), tasks and subtasks. The Task Description Summary provides an additional level of definition.

The WBS summary is an outline for Statement of Program Objectives (SOPO) in future phases. The SOPO will contain a more detailed description of the WBS and tasks.

CalWave Program WBS Summary – Post-CDR Technical Baseline

Level 0 – CalWave System Acquisition Program					
Level 1 – CalWave Facility Acquisition Program					
CalWave I Feasibility	CalWave II Draft NOI/PAD	Phase 3.0 Permitting	Phase 4.0 Construction	Phase 5.0 Test	Phase 6.0 Operations
Level 2 – CalWave Facility					
SOPO 1-10	SOPO 11,12,13	SOPO III-1 to III-xx	SOPO IV-1 to IV-xx	SOPO V-1 to V-xx	SOPO VI-1 to VI-xx
1.0 Contracts & PM	2.0 Contracts & PM	3.0 Contracts & PM	4.0 Contracts & PM	5.0 Contracts & PM	6.0 Contracts & PM
1.1 Concept Dev	2.1 Engineering	3.1 Prelim Design	4.1 Final Design	5.1 Test Program	6.1 Transition to Ops
1.2 Permitting/Envr	2.1.1 Conceptual	3.1.1 Surveys	4.1.1 EPC or CM/GC	5.1.1 Certification	6.1.1 WEC Customers
1.3 Outreach	2.1.2 Marine/Cable	3.1.2 Decision Gates	4.1.2 Decision Gates	5.1.2 Decision Gates	6.1.2 Decision Gates
1.4 Feasibility	2.1.3 HDD	3.1.3 Risk Mgmt	4.1.3 Risk Mgmt	5.1.3 Risk Mgmt	6.1.3 Risk Mgmt
1.4.1 Wave Resource	2.2 Permitting/Envr	3.2 Permits/Licenses	4.2 Environ Support	5.2 Environ Support	6.2 Environ Support
1.4.2 Test Berth	2.2.1 Studies	3.2.1 Studies	4.2.1 Monitoring	5.2.1 Adaptive Mgmt	6.2.1 Adaptive Mgmt
1.4.3 Shore Sites	2.3 Outreach	3.3 Outreach	4.3 Outreach	5.3 Outreach	6.3 Outreach
1.4.4 Industry Base	2.3.1 Advisory Grps	3.3.1 Advisory Grps	4.3.1 Advisory Grps	5.3.1 Advisory Grps	6.3.1 Advisory Grps
1.4.5 Down-Select	2.4 Design Review	3.4 Design Review	4.4 Design Review	5.4 Test Review	5.4 Test Review
1.5 Notional Site	2.5 Baseline	3.5 Baseline	4.5 Config Mgmt	5.5 Config Mgmt	6.5 Config Mgmt
1.5.1 Estimating	2.5.1 Estimating	3.5.1 Estimating	4.5.1 Estimating	5.5.1 Estimating	6.5.1 Estimating
1.6 Change Mgmt	2.6 Change Mgmt	3.6 Change Mgmt	4.6 Change Mgmt	5.6 Refresh/Upgrade	6.6 Refresh/Upgrade
1.7 Reporting	2.7 Reporting	3.7 Reporting	4.7 Reporting	5.7 Reporting	6.7 Reporting
Level 3 – CalWave Test Center Support Tasks					

Figure 0-9: Program WBS (Work Breakdown Structure)

11.3 Design Engineering and Analyses: Progress toward Preliminary Design

Leidos Maritime Solutions provided Chief Engineer services to coordinate design across engineering disciplines and organizations, including review of scope of work for civil, electrical, construction and ocean engineering, using a systems engineering approach.

The Engineering Team supported the preparations for meetings and made presentations:
- October 20th, 2016: Stakeholder Advisory Group meeting
- October 21st, 2016: Regulatory Agency Group meeting
- December 8th, 2016: Regulatory Agency Group meeting

The Engineering Team refined the site selection process that had narrowed the test berth siting to BOEM Lease Blocks that encompass the South and Southeast test berth locations near the Vandenberg Dock South Base Site. The "Conceptual South Base Configuration Baseline", with all facilities near Vandenberg Dock, was finalized and carried into the Preliminary Design Stage as the "Preliminary South Base Configuration Baseline".

- The "Conceptual Platform Configuration" was considered and will require an expansion of the Surf Substation near the Surf Amtrak Station at the end of West Ocean Blvd.
- The review of the various platform-related alternatives resulted in an overall design improvement by exploring the option of "decoupling" the location of the buildings and the electrical infrastructure.
- The option to locate the CalWave[sm] Test Center buildings adjacent to the Surf Amtrak Station and the PG&E Surf Substation, with the option to redefine the VAFB security fence boundary would allow improved access and reduced construction and operational phase costs.

Progress on Preliminary Design

Preliminary Design activities are outcome-oriented and targeted toward eventual construction of the facility in subsequent phases.

- Systems Engineering and System Integration has progressed (**Leidos**)
- Review of input from engineering disciplines has progressed (**Leidos**)
- Preliminary 70kV transmission line extension route planning has progressed (**Omega**).
- Preliminary cost estimating has progressed (**Omega and Cal Poly**)
- The Cable Route Desktop Study is complete. (**Fugro via CH2M**).
- Subsea Cable Logistics Alternatives Review is in draft form (**Center Marine via CH2M)**.
- Mooring and Anchoring Alternatives Review is complete. (**Glosten via CH2M**).

Electrical Engineering & VAFB Design Coordination

Omega Power Engineers continued work on authorized scope items during the 8th quarter of the project (fourth quarter of 2016).

Activities and progress against each SOPO item as follows:

SOPO WBS 11.3.1.1-1 – Conceptual Engineering: This task was completed in previous quarter. No activity.

SOPO WBS 11.3.3.3-2 Preliminary Engineering:

Preliminary Design of Shore Power Facilities was progressed to the level of detail appropriate for the Draft Preliminary Application Document (Draft PAD).

Single Line Diagrams and General Arrangements were evolved by picking up comments from project team and other stakeholders (including Vandenberg AFB – (VAFB)).

Preliminary Design of 70 kV Transmission Line design was developed to the level of detail appropriate for the Draft PAD. Coordination activities occurred to adjust 70 kV transmission line alignment to reflect potential impact of possible environmental and archeologically sensitive areas. Topographical information was acquired from public sources and Plan and profile drawings, including tower structure placements were prepared and submitted to project team (including permitting team) for coordination, review and comment. Comments were incorporated in November, to support agency meetings in early December.

Security approval was obtained from the Western Electric Coordinating Council (WECC) and the WECC database was released to Omega Power and our subcontractor, Atwell, LLC for preparation of the Transmission Impact Study. A summary Transmission Impact study was prepared which examined the impact of adding 50 MVA of WEC generators into the Vandenberg system. The primary focus of the task was to ensure that the installation would not require costly modifications to the PG&E transmission system to accommodate the installation. A secondary (and out of scope) task was to evaluate the impact of the facility on the VAFB system. The out of scope work was performed at no cost to the project. The net determination was that there is no material impact to the PG&E system as a result of installing the CalWave project. There was a determination that the project could negatively impact the VAFB system under certain occasional and brief operating conditions. It was agreed that this eventuality would be accommodated with administrative and operational controls, so no net additional cost to the project was envisioned as a result of the study.

SOPO11.3.1.3-3 Exploration of EPC alternatives:

A Draft Preliminary Cost Estimate was prepared for electrical shore facilities based on the status of the Draft Preliminary Design in the October 2016 timeframe.

Materials quotations were received during November, and installation labor applied to this and all other shore electrical facilities.

The draft estimates were submitted to the project team in at the end of the 8th quarter for collaborative review and comment by the Team during the 9th Project Quarter and inclusion in the Final Report.

In support of this estimate budgetary quotations were solicited for the following materials and equipment:

- Substation Transformers
- Substation 70 kV Circuit Breakers
- Substation Minor Material package (steel, insulators, buswork, connectors, jumpers, instrument transformers)
- 10 MW Resistive Load Bank (for WEC testing)
- Substation Power & Control building (includes relaying, control batteries, and 34.5 kV switchgear).
- 70 kV spun concrete Transmission poles (matches current VAFB design standards)
- Transmission line materials package (wire, fiber optics, insulators, anchors, hardware, connectors, etc) (Materials match current VAFB design standards).

Civil Engineering and Extreme Event Analysis

Cal Poly has provided input on civil and construction engineering elements to the cost estimate and has also conducted an independent cost estimate for the shore station.

Ocean Engineering & Sea Based Infrastructure Survey/Planning

The "Conceptual South Base Configuration Baseline", with all facilities near Vandenberg Dock, was finalized and carried into the Preliminary Design Stage as the "Preliminary South Base Configuration Baseline".

The "Conceptual Platform Configuration" was considered and will require significant ocean engineering review relative to working on offshore platforms.

11.4 Benchmark Existing Test Centers: Coordination and Site Visits

Leidos Maritime Solutions provided Chief Engineer services to benchmark other test sites when possible. Our Chief Engineer was delegated coordination duties for the Wave Hub visit that occurred during the 7th Quarter and continues to interact with WaveHub. Integration of lessons learned from WaveHub, BIMEP, and Camp Rilea continues to inform the iterative design and systems integration process.

11.5 Planning & Specifications: Surveys and Wave Measurement

Leidos Maritime Solutions continues to coordinate with **CH2M, Fugro,** and **Tenera** to ensure the requirements for the scope of work for subsea cable route desktop study were implemented and led the survey team that conducted a Vandenberg AFB site visit that included Fugro Pelagos. The emphasis is on determining accurate bathymetry to support horizontal directional drill (HDD) bore profile design.

PG&E continues to prepare data and models for wave modeling effort and **Virginia Tech** extracted hindcast wave data for five Wavewatch III coastal grid points encompassing the CalWave℠ candidate test berth sites, together with measured wave data from two validation stations operated by the Coastal Data Information Program (CDIP) at **Scripps Institution of Oceanography**.

Task 12 CalWave℠ Permitting Element (Q4-Q8)

12.1 Literature Review

The CalWave℠ permitting literature review task is mostly complete as the permitting team moves forward to prepare written summaries of the information reviewed (per Task 12.5, Prepare Environmental Baseline Summaries, below). The Literature Review task is to obtain existing documentation regarding previously completed environmental permitting projects for infrastructure along the Central California Coast to evaluate regulatory issues and information sources. The written summaries of the literature search material will be included in an attachment to the final report that will be prepared in the format of a draft Federal Energy Regulatory Commission (FERC) Preliminary Application Document (PAD). Additional data and information obtained this period included:

- Commercial fish catch data (pounds and dollar value) by species within 10-minute square blocks for fishing blocks located near the project tests berths (blocks 643, 644, 645, 658, 659, and 660) was obtained from the California Department of Fish and Wildlife.
- Information on project area geology and geomorphology as summarized in the Cable Route Desktop Study, prepared under Task 11 by Fugro Pelagos.
- Information on project area soil types and their characteristics as provided in various reports of the U.S. Department of Agriculture Soil Conservation Service and University of California College of Agriculture, Soil Survey, Inventory of Soil Resources (1950).
- Information on marine biota including the following key sources in marine mammal entanglement and acoustics:
    - Harnois, V. et al. 2015. Assessment of entanglement risk to marine megafauna due to offshore renewable mooring systems. *International Journal of Marine Energy* 11:27-49.
    - Kaikonen, K, J. Sundberg, and M. Leijon. 2013. Characteristics of the operational noise from full scale wave energy converters and the Lysekil Project: Estimation of potential environmental impacts. *Energies* 6:2562-2582.
    - Krop, R. 2013. Biological and existing data analysis to inform risk of collision and entanglement hypotheses. Prepared for U.S. Department of Energy. Prepared by Pacific Northwest National Laboratory, Richland, Washington, under Contract DE-AC05-76RL01830.
    - Wilson, B. et al. 2007. Collision risks between marine renewable energy devices and mammals, fish and diving birds. Report to the Scottish Executive. Scottish Association for Marine Science, Oban, Scotland. PA37 1QA.
    - Thomsen, F. et al. 2016. MaRVEN – Environmental impacts of noise, vibrations, and electromagnetic emissions from marine renewable energy. Prepared for the European Commission, Directorate General for Research and Innovation. RTD-KI-NA-27-738-EN-N.

- Parvin, S.J. R. Workman, and A. Booker. 2007. Assessment of underwater noise impact from the Wave Dragon device construction and operation. Subacoustech Report No. 674R0205. Subacoutech Ltd. Prepared for PMSS Ltd, Bath, UK.

- Information on recreational facilities and activities in the project area from recreation-oriented internet sites and other sources including information on:
  - Charter fishing and whale watching services operating out of Morro Bay, Port San Luis, and Santa Barbara, distance traveled, species taken (for recreational fishing charters), seasonal fishing requirements of CDFW.
  - Surfing, wind sailing, and diving sites located in the VAFB vicinity and their popularity and characteristics, as indicated by surfing and diving guide sites such as wannaSurf.com, wannaDive.com, and SurfLine.com, among others.

12.2 Evaluation of Biological Resources Data

The CalWave[sm] permitting team continued researching existing sources of biological resources data in the study area, including the following:

- California Cooperative Ocean Fishing Investigations (CalCOFI) fisheries data (since 1949)
- CalCOFI bird surveys
- California Data Information Program (since 1975)
- Southern California Coastal Ocean Observing System
- California Department of Fish and Wildlife commercial fish landings data
- NOAA Southwest Fisheries Science Center long-range gray whale studies

This information is being incorporated into the Environmental Baseline Studies that are under preparation in the format of a FERC PAD.

12.3 Consultation with Regulatory Agencies and Others

A major consultation task this period included preparation for and presentations to the Stakeholder Advisory Group Meeting October 20 and Regulatory Agency Meetings held on October 21 and December 8 (see also Section *13.2 Regulatory Agency Group/Subgroup* of this report for a more detailed account of the meeting). At these meetings, the permitting team shared a matrix listing possible environmental permitting issues by project "zone" (shore station, cable run, and test berths) with the regulatory agencies and asked them to comment on or add to the list from the perspective of their particular agency. The consolidated list of issues was discussed at the December meeting, with the goal of trying to define studies that could be conducted during a later permitting phase to address the issues.

The meetings also focused on refining a description of the CalWave[sm] permitting "envelope" as a description of the project elements that are fixed and known, such as the shore station elements and 70 kV upgrade line and cable routes, but also a description of the limits of the test berth elements that are unknown due to the nature of the project as a test center that will host several types of wave energy converters (WECs). The CalWave[sm] presentation focused in particular on the generic types of WECs that could be hosted for testing at CalWave[sm] and also on setting limits of scale to the types of devices and ancillary equipment that would be included within the permitted "envelope". That is, the presentation focused on what is included in the project description, but also and very importantly, on what is not included. Reducing the uncertainty in the project description will reduce the uncertainty involved in analyzing environmental effects and possibly help to expedite permitting.

Agency personnel gave useful presentations on recent studies on the effects of electro-magnetic frequency (EMF) emissions from subsea power cables (Ann Bull of the Bureau of Ocean Energy Management [BOEM]) and whale entanglement and acoustics issues (Greg Sanders of BOEM).

Permitting team staff attended the Offshore Renewable Energy Conference at the University of California, Davis, on November 3, 2016. Although focused more on offshore wind energy projects than MHK, most of the presentations related to both sets of technologies.

The CalWave[sm] permitting team also continued to consult with environmental staff of VAFB regarding environmental permitting of existing Air Force projects and environmental conditions on VAFB and potential constraints to siting the 70 kV upgrade line. Initial results are that the 70 kV upgrade line would not encounter significant habitat for listed species or other sensitive biological resources, as long as the line is designed to span water courses and wetlands, which appears feasible. Field surveys will be required for the final 70 kV upgrade route to confirm previous survey results as provided by VAFB.

The permitting and stakeholder involvement teams met with the staff of the California State Lands Commission (SLC) to discuss the SLC's role in the CalWave[sm] project. Permitting staff held additional discussions regarding a joint California Environmental Quality Act (CEQA)/National Environmental Policy Act (NEPA) process with SLC as the lead agency for CEQA and the FERC as lead for NEPA. SLC confirmed that the joint CEQA/NEPA document would likely be a CEQA Mitigated Negative Declaration/NEPA Environmental Assessment (assuming no unmitigated adverse environmental impacts).

California State Regulatory Agencies Progress Report

California state agency partners facilitated interagency coordination, contributed environmental impact research and evaluation, and outlined technical permitting considerations for the CalWave II project in the fourth quarter of 2016. The state is committed to increasing its supply of renewable energy resources and promoting clean energy innovation to ensure reliable alternatives to fossil fuels. The state has a diverse and expansive energy portfolio that strives to incorporate advanced technologies compatible with high environmental quality while serving the needs of its businesses and communities.

The State Lands Commission (SLC) has jurisdiction over the seafloor within State waters and, depending on the siting, will be responsible for issuing leases for any seafloor cables that pass through State waters. The ambulatory boundary of State Lands extends from the mean high tide line (MHTL) to approximately 3 nautical miles into the ocean. SLC staff expended 202.75 hours of work time during the fourth quarter of 2016 on the CalWave II project. Commission staff attended weekly CalWave II team coordination and project update calls and participated in offshore renewable energy interagency meetings and conferences, including the BOEM California Offshore Renewable Task Force meeting in October, the CalWave Permitting Agencies meeting in October, the BOEM California Offshore Renewable Energy (CORE) Conference in November, and the CalWave Regulatory Agencies meeting in December. The team program manager at the State Lands Commission, Science Policy Advisor Jennifer Mattox, represents the Executive Officer of the State Lands Commission on the BOEM Intergovernmental Renewable Energy Task Force, and was instrumental in developing the memorandum of understanding signed by the U.S. Department of Interior and the State of California in December, 2016 to expedite offshore renewable energy plans for the West Coast. State Lands staff, including engineers, environmental scientists, and land management specialists, evaluated potential environmental impacts resulting from the offshore and onshore components of the CalWave renewable

wave energy project. In addition, staff provided the CalWave team with resources and research contributions for the draft Preliminary Application Document prepared for the Department of Energy throughout the latter half of the fourth quarter. Resources and research included a summary of acoustic impacts resulting from geophysical surveys, permitting and environmental review considerations related to seafloor cables and offshore energy infrastructure, and historic cultural resource information. Finally, State Lands' geographic information specialists coordinated data management and collection with USGS staff, as well as researched, reviewed, and processed bathymetric data in anticipation of future project needs.

The California Natural Resources Agency (CNRA) coordinates many divisions within the state tasked with managing and protecting California's natural, historic, and cultural resources. CNRA staff expended 57 hours both coordinating interagency meetings as well as participating in those meetings. CNRA staff was a key organizer of the BOEM California Offshore Renewable Energy Task Force meeting held in October, as well as the BOEM Offshore Renewable Energy Conference in November. Additionally, CNRA staff participated in CalWave II project update calls, the aforementioned BOEM meeting and conference, as well as the CalWave Permitting Agencies meeting in October and the CalWave Regulatory Agencies meeting in December.

The California Coastal Commission (CCC) is an independent, quasi-judicial state agency that regulates land use and planning within the coastal zone, according to the policies outlined in the California Coastal Act of 1976. Along with the Bay Conservation and Development Commission and the Coastal Conservancy, the CCC also administers the federal Coastal Zone Management Act in California state waters. CCC staff expended 29 work hours during the fourth quarter reviewing the potential environmental impacts resulting from the offshore and onshore components of the CalWave renewable wave energy project, reviewing research and materials for the CalWave permitting and regulatory agency meetings, and presenting information at the CalWave regulatory agency meeting.

The California Department of Fish and Wildlife (CDFW) is responsible for the management of the state's biological resources and regulates commercial and non-commercial activities that may impact those resources. The Department has additional responsibilities related to the protection of threatened and endangered species and species of special concern. CDFW staff expended 46.5 work hours during the fourth quarter attending meetings and conferences related to the project. CDFW staff participated in the BOEM California Offshore Renewable Task Force meeting in October, the CalWave Permitting Agencies meeting in October, the BOEM California Offshore Renewable Energy Conference held at UC Davis in November, and the CalWave Regulatory Agencies meeting in December. In addition, CDFW staff attended a BOEM presentation at the Pacific Fisheries Management Council meeting to learn more about the evaluated impacts to fisheries from offshore renewable energy projects.

12.4 Regulatory Roadmap

The CalWave[sm] project team has continued discussions with regulatory agencies, including the SLC, as discussed immediately above to inform the preparation of the regulatory road map. Preparation of the Regulatory Roadmap report will begin during the final quarter.

12.5 Preparation of Environmental Baseline Summaries

This task has begun, based on the results of Task 12.1 Literature Review and 12.2 Review of Marine Biological Data. A draft Project Description, including statement of project objectives and permitting "envelope" project description, has been prepared for the draft PAD and circulated for review. Preparation of the written environmental baseline discussion sections has begun and several sections are completed in draft. The sections (per FERC PAD outline) are:

- Geology and soils resources
- Water resources
- Fish and aquatic resources
- Wildlife and botanical resources
- Wetlands, riparian, and littoral habitat
- Rare, threatened, and endangered species
- Recreation and land use
- Aesthetic resources
- Cultural resources
- Socioeconomic resources
- Tribal resources
- River basin description – (note: this section is not applicable for an MHK project)

12.6 Project Coordination

CH2M has obtained final copies of the following reports from subconsultants:

- Cable Route Desktop Study, by Fugro Pelagros. This study provides a preliminary assessment of notional subsea cable routes, data gaps, and further surveys needed. See **Appendix Attachment A**.
- Anchoring and Mooring Lessons Learned Analysis, by Glosten, as it pertains to CalWave[sm] infrastructure and possible future WEC developers and CalWave[sm] tenants in the context of permitting requirements and the regulatory roadmap. See **Appendix Attachment B**.

The following report is in draft:

- Cable Installation Lessons Learned Analysis, by Center Marine Services. This document is under final review and will be provided in a subsequent quarterly report.

Task 13 CalWave[sm] Stakeholder Involvement and Public Participation Element (Q4-Q8)

13.1 Stakeholder Advisory Group

As we reported in the 7th Quarterly Report, the CalWave[sm] Team launched the Stakeholder Advisory Group to provide project information to representatives from all major stakeholder communities and solicit guidance and input on project parameters and studies/permitting efforts.

The first meeting of this group occurred on October 20th in San Luis Obispo. Participants received a draft charter and used the first meeting to discuss the Stakeholder Advisory Group purpose and charter, receive information about the CalWave[SM] project including engineering and design specifications, and began discussing potential resource effects and information that will be needed for permitting. The meeting was open to the public.

The discussion was focused on understanding the scope of the project (footprint of the devices, parameters of the cable lay), potential interactions between fishing gear and the project, project location in reference to existing fishing grounds, decommissioning, and potential environmental studies. Participants were very involved, and asked for additional meetings in 2017. The meeting summary can be found in **Appendix Attachment C.**

13.2 Regulatory Agency Group/Subgroup

The second and third Regulatory Agency Meetings of this phase were held on October 21st and December 8th in Camarillo and Oxnard, CA, respectively. The October 21st meeting covered the following topics:

- Project updates, including updates to project engineering and design, information about the Cable Route Desktop Study, and information about existing infrastructure
- Defining the envelope (range of potential WEC effects), including how the envelope works in the permitting process, and proposed groupings of wave energy converters (WECs) according to operating mechanism, along with anchoring and mooring mechanisms; this will also include an introduction to considering potential effects
- Recent research on electromagnetic fields (EMF), courtesy of BOEM
- A discussion of potential environmental effect risk profiles
- Review and discussion of draft risk profile matrices
- Update on State of CA Offshore Renewable Activities from the Ocean Protection Council (OPC)
- Next Steps and Anticipated Timeframes

Participants were particularly interested in the recent work on EMF and agreed that presentations describing scientific research on potential environmental effects would be useful for future meetings of this group. The agencies agreed to review the draft risk profile matrices prior to the December 8th agency meeting. This meeting saw attendance from 23 agency members; the summary is attached as **Appendix Attachment D**.

A subsequent Regulatory Agency Meeting occurred on December 8, 2016, with participation from 29 agency members, the summary of which can be found in **Appendix Attachment E**. This meeting covered the following topics:

- Updates on CalWave[sm]
- Review of the updated project description
- Initial feedback on environmental effect matrices
- Presentations on recent research on interactions with marine mammals & acoustics

At this meeting, the Stakeholder Outreach team provided a summary of the feedback received by the agencies on the environmental effect matrices. This information will be used to inform what studies are needed in order to permit CalWave[sm] and what studies may be appropriate during the adaptive management and monitoring phase. These matrices can be found in **Appendix Attachments F, G, & H**.

13.3 Materials and Web Site Support

Kearns & West finished updating the project website and fact sheet during the 8th quarter.

13.4 Project Team Coordination

Kearns & West has performed project team coordination as needed throughout the 8th quarter in order to organize and facilitate the October Stakeholder Advisory Group and October and December Regulatory Agency Meetings. This subtask will be an ongoing process throughout the duration of the project.

Section 3. Cost Status

Please see the following attachments in excel format:

Attachment B – "Spending Summary"

Attachment C – "Cost Share Contributions"

Attachment D – "Spend Plan Data"

Section 4. Schedule Status

Project Management and Reporting

The Principal Investigator, Project Manager and Project Administrator teamed to track work scope execution against schedule milestones and budget. The Quarterly Reports are drafted by the Project Administrator with specific inputs from all team members and then are reviewed by the Project Manager and Principal Investigator. The Final Report will follow a similar process.

Tasks to be focused on in the 9th quarter include finalizing Tasks 11 and Task 13 in order to inform Task 12 which is the primary effort in this quarter. These two tasks will fundamentally inform the permitting roadmap and draft NOI/PAD which is to be filed by the end of this project.

TASKS	Quarter (from start of project)				
	Feb. '16 – March	April – June	July – Sept.	Oct. – Dec.	Jan. '17 – Feb.
	5th	6th	7th	8th	9th
Task 11: Develop Engineering Quantities, Cost and Schedule Estimates to Support Financing Plan, Select Preferred Location					
Task 12: Develop Permitting Roadmap to Populate Draft Preliminary PAD					
Task 13: Develop List of Stakeholder Concerns and Develop Possible Solutions					

The major milestone schedule that has been established by the core project team is progressing as follows:

CalWave℠ II Milestone Tasks	**Project Quarter**	**Est. Month of Completion**	**Year**
Conceptual Design (Complete)	6	June	2016
Present Conceptual Design to Agencies (Complete)	7	July	2016
Commence Preliminary Design (Complete)	7	September	2016
Present Preliminary Design to Agencies (Complete)	8	October	2016
Draft Preliminary Design (Complete)	8	October	2016
Draft PAD with Prelim. Design (Complete)	8	November	2016
Present Draft PAD to Agencies (Complete)	9	January	2017
Final Draft PAD (In Progress)	9	February	2017
Final Technical Report for DOE Submission (In Progress)	9	February	2017

Section 5. Changes to Scope and Project Approach

None at this time.

Section 6. Problems/Delays

None at this time.

Section 7. Key Personnel

No significant changes in personnel has occurred.

Section 8. Products and Technology Transfer

None at this time.

APPENDIX

Attachment A: Cable Route Desktop Study

Attachment B: Anchoring and Mooring Lessons Learned Analysis

Attachment C: 1st Stakeholder Advisory Group Meeting Summary – October 20, 2016

Attachment D: 2nd Regulatory Agency Meeting Summary – October 21, 2016

Attachment E: 3rd Regulatory Agency Meeting Summary – December 8, 2016

Attachment F: Environmental Effect Matrices Summary – Onshore Landing

Attachment G: Environmental Effect Matrices Summary – Cable routes

Attachment H: Environmental Effect Matrices Summary – Test Berths

Quarterly Technical Progress Report
(Nine of Eleven Quarters)
TITLE PAGE

Federal Agency to which Report is submitted:	DOE EERE – Wind & Water Power Program
Recipient:	Cal Poly Corporation; DUNS Number 02-932-6246
Recipient Type:	State University
Award Number:	DE-EE0006517.0005
Award Number:	Grant
Project Title:	California Wave Energy Test Center Phase II (CalWave[sm])
Project Period:	One year, February 19, 2016 to June 30, 2017.

Principal Investigator:	Dr. Sam Blakeslee; Director, Institute for Advanced Technology and Public Policy
Email:	sblakesl@calpoly.edu
Phone:	(805) 756-1694
Organization:	California Polytechnic State University, San Luis Obispo, California; (Cal Poly)

Report Submitted by:	Nicholas Osterbur; Project Administrator
Email:	nosterbu@calpoly.edu
Phone:	(805) 756-1694
Organization:	California Polytechnic State University, San Luis Obispo, California; (Cal Poly)

Date of Report:	March 31st, 2017
Covering Period:	January 1, 2017 to March 31, 2017 (9th of 10 Quarters)
DOE Funding Released:	February 19, 2016
Report Frequency:	Quarterly

Working Partners:

Vendors (F&A included as match)
Leidos (vendor); Rick Williams; richard.b.williams@leidos.com; (503) 484-4415
CH2M (vendor); Dr. Doug Davy; Doug.Davy@ch2m.com; (916) 286-0278
Kearns & West (vendor); Anna West; awest@kearnswest.com; (415) 391-7900
Omega Power Engineers, LLC (vendor); Randall M. Connett; randy.connett@omegapower.net; (303) 330 6920
UK Wave Hub (vendor); Stuart Herbert; stuart.herbert@wavehub.co.uk; 01736-800294

National Labs (F&A is not allowed)
National Renewable Energy Laboratory (NREL); Al LiVecchi; Al.LiVecchi@nrel.gov; (303) 384-7138
Sandia National Laboratories; Jesse Roberts; jdrober@sandia.gov; (505) 844-5730

Subrecipient (F&A included as match)
Electric Power Research Institute (EPRI) (subaward); Dr. Paul Jacobson; pjacobson@epri.com; (410) 489-3675
Humboldt State University (subaward); Dr. Arne Jacobson; Arne.Jacobson@humboldt.edu; (707) 826-4302
Virginia Tech (subaward); Dr. George Hagerman; hagerman@vt.edu; (757) 340-1921
Scripps Institution Of Oceanography, UC San Diego (subaward); Julie Thomas; jot@cdip.ucsd.edu; (858) 534-3034

State Government Agency and Utility
California Natural Resources Agency (government agency); Chris Potter; Chris.Potter@resources.ca.gov; (415) 740-9869
Pacific Gas and Electric (utility); Dr. Brendan Dooher; bxd6@pge.com; (925) 822-7716

Cost-Sharing Partners:
California Natural Resources Agency
Pacific Gas & Electric Company
Protean Energy Ltd., Steve Rogers, stephen.rogers@proteanenergy.com.au, +61 (9481) 22771

DOE Project Team: DOE HQ Program Manager – Jim Ahlgrimm
DOE Field Contract Officer – Pamela Brodie
DOE Field Financial Assistance Specialist – Jane Sanders
DOE Field Project Officer – Tim Ramsey
DOE/CNJV Project Monitor – Nicholas Massey

Signature of Submitting Officials:

Sam Blakeslee
CalWave℠ Project Director

Bill Toman
CalWave℠ Project Manager

Section I. Project Accomplishment Narrative

1. Overall Project Status at the end of the 9th quarter:

The CalWave[sm] project requested and received a four-month Period of Performance (POP) extension extending the project's end date to June 30, 2017. This cost extension was requested in principle to provide Pacific Gas & Electric (PG&E) and California State Agencies enough time to complete the required scope and cost share obligations for the CalWave[sm] project.

The core CalWave[sm] project team completed the remainder of their contractual scope and proceeded to synthesize and complete the relevant portions of the Final Technical Report to a 95% completion level. The CalWave[sm] project team subsequently performed a final review of the 95% complete Final Technical Report including the relevant supplementary documents. Members of California State Agencies reviewed and commented on the Regulatory Roadmap document and continue to develop a refined Regulatory Roadmap deliverable that is consistent with prior efforts and format. Cal Poly Staff and Faculty continue to review the Final Technical Report and supplementary documents.

The Electric Power Research Institute (EPRI) was granted a POP extension to perform a final review of the Final Technical Report. The UK Wave Hub was granted a POP extension to produce the final write-ups providing a description/explanation of the UK Wave Hub test program per the required contractual scope. This information will be provided as an appendix to the Final Technical Report. Finally, Pacific Gas & Electric (PG&E) continues to work on a variety of cost share deliverables including literature review on various topics, data collection for wave analysis, grid interconnection analysis, and engaged a subcontractor to perform a supplementary literature review on existing environmental data for the notional CalWave[sm] export cable run areas.

TASKS	Quarter (from start of project)					
	Feb. '16 – March	April – June	July – Sept.	Oct. – Dec.	Jan. '17 – March.	April – June '17
	5th	6th	7th	8th	9th	
Task 11: Develop Engineering Quantities, Cost and Schedule Estimates to Support Financing Plan, Select Preferred Location						
Task 12: Develop Permitting Roadmap to Populate Draft Preliminary PAD						
Task 13: Develop List of Stakeholder Concerns and Develop Possible Solutions						
**Dark grey means increased effort for a task, and light grey means decreased effort*						

Section 2. Details of Scope Accomplishments

Administrative

The Project Manager coordinated the overall work efforts of the Engineering Element (Task 11), the Permitting and Environmental Element (Task 12) and Stakeholder Involvement and Public Participation Element (Task 13). Review of the Final Technical Report continues by various CalWave[sm] team members.

Task 11 CalWave[sm] II Engineering Element (Q4-Q8)

The following final deliverables were provided from Leidos, Omega, CH2m and Cal Poly and are currently under review by various CalWave team members:

- Attachment 11-1: Top- Level Requirements and Site Selection Criteria
- Attachment 11-2: Project Objectives, Alternatives and Top-Level Concept
- Attachment 11-3: System Block Diagrams and Interface Definition List
- Attachment 11-4: Cable Route Desktop Study
- Attachment 11-5: Horizontal Directional Drill (HDD) Profiles
- Attachment 11-6: Civil/Architectural Engineering and Extreme Events Analysis
- Attachment 11-7: Electrical Design and Interconnect Study
- Attachment 11-8: Cable Logistics Lessons Learned
- Attachment 11-9: Mooring and Anchoring Study
- Attachment 11-10: Benchmarking: UK Wave Hub, Camp Rilea, BIMEP
- Attachment 11-11: Risk Management Plan
- Attachment 11-12: Cost Estimating

Under the direction and final review of Leidos, Omega and Cal Poly issued the final Preliminary Design Documents for internal review and review by Vandenberg Airforce Base for evaluation of sensitive information. The design documents are as follows:

- Architectural Shore Station Concept Site Plan
- Civil Shore Station Concept Site Plan
- Electrical Shore Facilities
- System Impact Study
- Transmission Line Report

Additionally, cost share partner Pacific Gas & Electric Company (PG&E) continued to work toward completion of deliverables and made progress on the following scoping items:

- PG&E performed and completed a literature search on the Mathworks platform SimPowerSystems™ for the purposes of substation design and are currently working to compile information into report format.
- PG&E performed and completed data collection for wave analysis work.
- PG&E performed and completed relevant literature search on neural net wave analysis and prediction, and are currently working on report.
- Developing paper on cost effective locales for grid interconnection.
- PG&E Subcontractor Tenera Environmental performed literature search on environmental conditions in the subsea export cable approaches for the CalWave test berths.

Permitting Progress (Task 12)

The following final deliverables were provided from CH2m and are currently under review by various CalWave team members:

- Attachment 12-1: Biological Resources Data Evaluation Report
- Attachment 12-2: Regulatory Roadmap
- Attachment 12-3: Draft Federal Energy Regulatory Commission Pre-Application Document

California State Regulatory Agencies Progress Report

The State Lands Commission (SLC) manages and leases submerged and intertidal public lands for the state of California. The ambulatory boundary of State Lands extends from the mean high tide line (MHTL) to approximately 3 nautical miles into the ocean. SLC staff expended 46 hours of work time during the first quarter of 2017 on the CalWave II project. Commission staff attended weekly CalWave II team coordination and project update calls. Science Policy Advisor Jennifer Mattox and staff reviewed the regulatory permitting roadmap document, as well as the Preliminary Application Document (PAD) and revised project description. In addition, the staff conducted research and began drafting a revised regulatory permitting roadmap document that will offer future offshore renewable energy project applicants a more comprehensive overview of permitting considerations and process guidance.

The California Natural Resources Agency (CNRA) coordinates many divisions within the state tasked with managing and protecting California's natural, historic, and cultural resources. In the first quarter of 2017, CNRA staff conducted stakeholder outreach and engagement throughout the state for the Marine Renewable Energy Task Force and facilitated discussions about marine hydrokinetic energy siting, feasibility, financing, and environmental impacts. CNRA staff also contributed to the regulatory permitting roadmap document under development and will continue to work with other CalWave II agency cost-share partners to complete it. CNRA staff expended 80 hours of work time during this quarter.

The California Coastal Commission (CCC) is an independent, quasi-judicial state agency that regulates land use and planning within the coastal zone, according to the policies outlined in the California Coastal Act of 1976. Along with the Bay Conservation and Development Commission and the Coastal Conservancy, the CCC also administers the federal Coastal Zone Management Act in California state waters. CCC staff expended 4 work hours during the first quarter of 2017 reviewing research documents and attending the final CalWave II team meeting on February 22, 2017.

The California Department of Fish and Wildlife (CDFW) is responsible for the management of the state's biological resources and regulates commercial and non-commercial activities that may impact those resources. The Department has additional responsibilities related to the protection of threatened and endangered species and species of special concern. CDFW staff expended 1 hour of work time attending the final CalWave II team meeting on February 22, 2017.

Stakeholder Progress (Task 13)

Statement of Project Objectives, Task 13, has been completed and the following supplementary documents have submitted for final review:

- Attachment 13-1: July 2016 Regulatory Agency Meeting Summary
- Attachment 13-2: July 2016 Regulatory Agency Meeting Presentation
- Attachment 13-3: October 2016 Stakeholder Advisory Group Meeting Summary
- Attachment 13-4: October 2016 Regulatory Agency Meeting Summary
- Attachment 13-5: December 2016 Regulatory Agency Meeting Summary
- Attachment 13-6: December 2016 Regulatory Agency Meeting Presentation
- Attachment 13-7: December 2016 Regulatory Agency Meeting Presentation (Greg Sanders)
- Attachment 13-8: Stakeholder Advisory Group Members
- Attachment 13-9: Regulatory Agency Group Members
- Attachment 13-10: Matrix of Onshore Landing Topics of Interest
- Attachment 13-11: Matrix of Cable Route Topics of Interest
- Attachment 13-12: Matrix of WEC Test Berth Topics of Interest
- Attachment 13-13: CalWave Fact Sheet

Section 3. Cost Status

Please see the following attachments in excel format:

Attachment B – "Spending Summary"

Attachment C – "Cost Share Contributions"

Attachment D – "Spend Plan Data"

Section 4. Schedule Status

Project Management and Reporting

The core project team substantially completed SOPO tasks 11, 12, & 13 less the ongoing work detailed previously in this report. The Project Manager facilitated the completion of these tasks and provided review and direction on the Final Technical Report. The Project Administrator provided format direction and ongoing review of the Final Technical Report as well as coordination and tracking of the remaining deliverables and cost share obligations.

The final quarter will be used principally to finalize review of the Final Technical Report while tracking and collecting the remaining supplementary deliverables and cost share obligations.

TASKS	Quarter (from start of project)					
	Feb. '16 – March	April – June	July – Sept.	Oct. – Dec.	Jan. '17 – March.	April – June '17
	5th	6th	7th	8th	9th	
Task 11: Develop Engineering Quantities, Cost and Schedule Estimates to Support Financing Plan, Select Preferred Location						
Task 12: Develop Permitting Roadmap to Populate Draft Preliminary PAD						
Task 13: Develop List of Stakeholder Concerns and Develop Possible Solutions						
**Dark grey means increased effort for a task, and light grey means decreased effort*						

The major milestone schedule that has been established by the core project team is progressing as follows:

CalWave[sm] II Milestone Tasks	Project Quarter	Est. Month of Completion	Year
Conceptual Design (Complete)	6	June	2016
Present Conceptual Design to Agencies (Complete)	7	July	2016
Commence Preliminary Design (Complete)	7	September	2016
Present Preliminary Design to Agencies (Complete)	8	October	2016
Draft Preliminary Design (Complete)	8	October	2016
Draft PAD with Prelim. Design (Complete)	8	November	2016
Present Draft PAD to Agencies (Complete)	9	January	2017
Final Draft PAD (Complete)	9	February	2017
Final Technical Report for DOE Submission (Review Continues	9	June	2017

Section 5. Changes to Scope and Project Approach

None at this time.

Section 6. Problems/Delays

Cal Poly, the prime contractor on the CalWave[sm] project requested and received a period of performance (POP) extension for the purposes of providing two key cost share partners the time necessary to complete cost share and scope obligations.

Section 7. Key Personnel

No significant changes in personnel has occurred.

Section 8. Products and Technology Transfer

None at this time.

APPENDIX 11: CalWave ENGINEERING ELEMENT

The CalWave Engineering Element was summarized at a high level in the Executive Summary (Section C).

The Project Overview was summarized in Section D and Engineering Element was summarized in Section D.11.

For continuity, and so this Appendix stands alone, portions of the Executive Summary are restated below and the longer version of the Project Overview is provided.

11.0 Executive Summary

The California Wave Energy Test Center (CalWave) Feasibility Study, sponsored by a U.S. Department of Energy (DOE) funding award (DE-EE0006517), was a program to identify and evaluate a primary offshore site along the California coast for a national wave energy testing facility appropriate for Technical Readiness Level 8-9 (TRL) Wave Energy Converters (WECs). Leveraging prior work by EPRI and PG&E's WaveConnect Program, the CalWave project team concentrated its efforts on two locations along the California coastline: (1) offshore of Humboldt Bay in the California North Coast area, and (2) offshore of Vandenberg Air Force Base (VAFB) in the Central Coast area (Figure 1-1). Throughout the CalWave Program, we employ a tailored mix of techniques from Program and Project Management, Systems Engineering (requirements-driven design) and System Integration (spiral development).

Site selection leveraged an extensive history of resource and site characterization by the core development team as documented in the CalWave Phase I Final Report. Prior studies and development include multiple studies on ocean energy by CalWave Partners Electric Power Research Institute (EPRI) starting in 2004 and Pacific Gas & Electric Co (PG&E) WaveConnect Program in 2007. VAFB was added in 2009. In 2010, PG&E submitted a Draft Pilot License Application to the Federal Energy Regulatory Commission (FERC) for the Humboldt site. These events were reported in December 2011.

In CalWave I, site selection was reevaluated at Humboldt and Vandenberg Air Force Base (VAFB) and VAFB was selected as the primary site. Alternatives were further down-selected to a notional conceptual site at VAFB South Base with Test Site off Pt Arguello. During CalWave II, macro-siting was further developed and micro-siting was progressed and VAFB South Base was designated as the primary site. An alternative site in the VAFB area at Platform Irene was also identified and evaluated.

The VAFB Site is well-suited for wave energy development. The Central California Region presents market opportunities for marine renewable energy that are unmatched in the United States, and perhaps the world.

Our study included participation and benchmarking from the United Kingdom's Wave Hub, that is currently largest and most advanced wave energy test center in the world.

The CalWave System Concept is centered on "home run" cables and features that allow WEC Developers to field their mature pre-commercial system designs with a minimum of test facility-induced constraints, a significant lesson-learned from other wave energy test centers. The design goals and objectives enable precise measurement of performance from each test berth hosting individual WECs or arrays:

- Requirements-driven, modular design of an open-ocean, fully energetic Test Center.
- Grid-connected Test Berths with excellent wave resource and deep water depths.
- Design features (mooring/anchoring flexibility, electrical system, power conditioning options, and test instrumentation) that remove barriers to entry for WEC developers.
- Integrate with host facility (VAFB) grid infrastructure (12kV & 70kV) and connecting utility.
- Integrate with host facility (VAFB) civil facilities and environmental guidelines.
- Integrate with local marine industry support with decades of experience at this site.
- Integrate input from stakeholders, agencies, and regulators in Draft Project Description.

11.0.1 Project Overview

The initial one-year feasibility study of cost, schedule, regulatory and stakeholder issues of establishing a national wave energy testing center in California was executed in 2014 and 2015 and called CalWave I.

After a comprehensive siting area evaluation down-selection process, the Vandenberg site was chosen for additional intensive study and the development of Conceptual Stage plans and designs. The VAFB South Base with associated Test Berths was designated as the "Notional Conceptual Baseline" to acknowledge the several degrees of freedom available at the end of CalWave I.

A second year of work was executed in 2016 and 2017 and was called CalWave II. The Notional Conceptual Baseline at Vandenberg South Base was confirmed and further developed through industry site visits and the Conceptual Design Review (CDR).

The CDR was attended by marine industry representatives, the VAFB host facility representative, and the UK Wave Hub.

In addition to the Primary Site at Vandenberg South Base, the Alternate Site associated with Platform Irene was progressed using the concept of repurposing oil & gas infrastructure as offshore substations. Substantive discussions were held with the platform owners/operators and regulators.

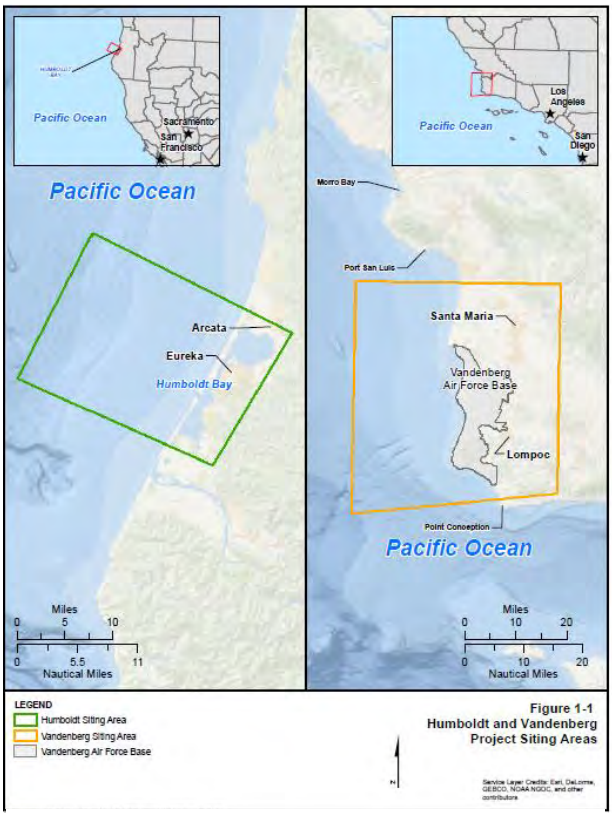


Figure 11-1: CalWave Candidate Siting Areas

Development continued from Feasibility, to Conceptual, and into the Preliminary Design Stage with Engineering, Permitting and Stakeholder efforts developed to sufficient detail to produce the Draft Pre-Application Document, Regulatory Roadmap, and Stakeholder Engagement Plan for the Primary Site: **the Vandenberg South Base Configuration Baseline**. Primary Site designs and cost estimates were leveraged and adapted to the Alternate Site: **Platform Irene Configuration**.

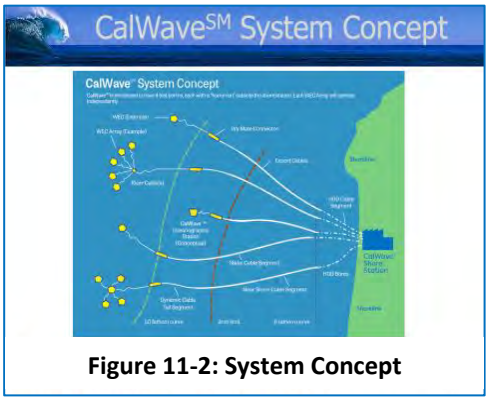


Figure 11-2: System Concept

Four (4) test berths off the coast of Vandenberg AFB on the South Base that leverages significant base infrastructure.

Test berth sites will be in BOEM lease blocks on the Outer Continental Shelf (OCS). Subsea cables would transit through State of California Territorial waters to a shore landing near Vandenberg Dock.

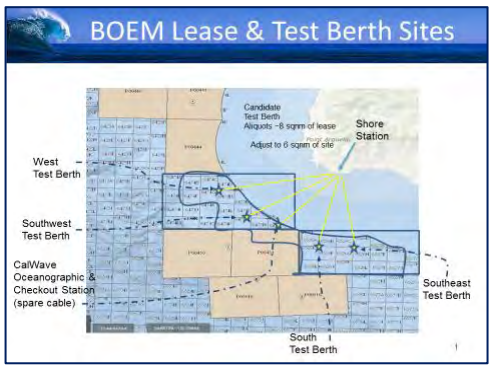


Figure 11-3: BOEM Lease Blocks

11.0.2 Project Objectives

The CalWave studies focused on the Statement of Project Objectives (SOPO):

• **Developing and using criteria to rank and finalize the choice for the candidate ocean test site (SOPO Task #1).** Comparison of the two candidate siting areas, Humboldt and Vandenberg Air Force Base.

• **Understanding the shore-side support infrastructure (SOPO Task #2).** Analysis of facilities, transportation infrastructure, harbor navigation, project operational resources and assets.

• **Exploring utility grid interconnection (SOPO Task #3).** Analysis of the capacities of specific substations and any required upgrades. Additionally, the task included determining the spare transmission capacity of existing submarine power cables and compiling anticipated costs for grid interconnection.

• **Identifying known environmental constraints and progress on permitting (SOPO Task #4)**. Literature reviews, desktop studies, and siting investigations to determine whether critical project development and environmental permitting issues or fatal flaws exist for prospective CalWave siting locations.

• **Public acceptance (SOPO Task #5).** Contact with key stakeholders and holding public and regulatory agency meetings to understand stakeholder issues that CalWave will encounter during development and permitting, including a summary of discussions with conclusions about expected public acceptance.

• **Top-Level Requirements and Device-Testing Criteria (SOPO Task #6)**. Develop top-level requirements and associated listing of specific test site design and a detailed analysis of the wave climate at each potential berth location for the CalWave project using a ten-year hindcast of wave conditions.

• **Develop Preliminary Design Drawings (SOPO Task #7).** Develop preliminary drawings for the baseline conceptual designs for the cables and shore station at the notional South Base location, including considerations for electrical, civil and ocean engineering as well as architecture.

• **Develop estimates of construction quantities and costs (SOPO Task #8).** Prepare general estimates of construction quantities and costs, based on inputs from conceptual design studies and preliminary bids from industry (such as offshore cable installers, etc.).

• **Develop operating, maintenance, and testing cost estimates (SOPO Task #9)**. Benchmark similar renewable energy testing centers to establish conceptual business and operational models for the test center and to develop preliminary estimates of operating, maintenance, and testing costs.

• **Develop Schedule for Site Development and Facility Construction (SOPO Task #10).** Develop a preliminary permitting, engineering design, procurement, and construction schedule for execution.

• **Develop Engineering Quantities, Cost and Schedule Estimates to Support Financing Plan, Select Preferred Location (SOPO Task #11).** Progress the design from the Conceptual Stage into the start of the Preliminary Stage. Incorporate inputs from additional meetings and initiate significant interactions with agencies/regulators/host facility to evolve both the design and operational aspects.

• **Develop Permitting Roadmap to Populate Draft Preliminary PAD (SOPO Task #12).** Progress the literature review work and environmental baseline summaries to a “potential issues” matrix. Develop a draft Preliminary Application Document or Pre-Application Document (Draft PAD) with draft project description for review.

• **Develop List of Stakeholder Concerns and Develop Possible Solutions (SOPO Task #13).** Progress the outreach and stakeholder engagement effort of the CalWave Regulatory Agency and Stakeholder Advisory Group. Develop the Operational Advisory Group. Maintain the project Fact Sheet and website with the most recent project information.

11.0.3 Programmatic Approach

CalWave program execution concept must balance Scope, Cost, and Schedule with Quality across Engineering, Permitting and Stakeholder elements.

The CalWave programmatic approach implements the technical, management, procurement, and administrative activities necessary for all phases of the CalWave In particular, the Triple Constraint Model of the Project Management Institute (PMI), Figure 11-2, that guides the balance between conflicting forces and also guide our Risk Management, Contingency Management, and Configuration Control methods.

The CalWave program envisions use of a Program Execution Plan (PEP) to employ industry best practices including: Program/project execution methods from the Project Management Institute (PMI), the stage gate methods of new product development from the Product Development and Management Association (PDMA) and the systems approach of the International Council on Systems Engineering (INCOSE).

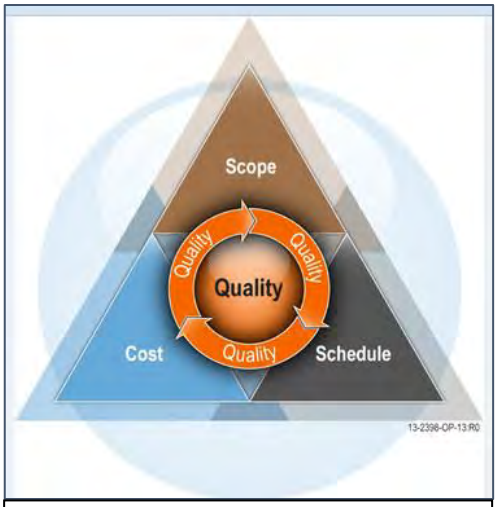


Figure 11-4: Triple Constraint PM Model

11.0.4 Design Approach

CalWave required a multi-disciplinary design approach that leveraged techniques from naval architecture and marine engineering for the sea-based infrastructure, terrestrial techniques for the shore-based infrastructure, techniques from New Product Development such as Stage Gate to anticipate the interfaces with the Wave Energy Converter (WEC) systems yet to be invented.

As discussed more below, a spiral development model was adapted for CalWave to implement the cross-checks of major acquisition programs while maintaining lean project management. Phasing and milestones were used to prepare for Conceptual Design Review (CDR) and will be employed through the major milestones Preliminary Design Review (PDR) and Final Design Review (FDR) yielding a Construction Design Baseline.

Working with wave energy test centers in the UK (European Marine Energy Center and UK Wave Hub), we learned that wave energy developers need to understand the unique electrical characteristics of their WEC device and can only do so effectively from the shore station if the test berths each have a dedicated subsea cable. This innovation results in a higher cost to install cables, but may be the key to a test center that successfully reduces time-to-market and allows real-time understanding of WEC generation characteristics.

Another innovation is to design test berths so that each WEC developer provides their own anchoring and mooring systems and umbilical, that uses our standard connector. This allows WEC developers to install the mooring that best fits their own device configuration and also avoids legal liabilities for the test center.

These design flexibility features remove barriers to entry for WEC Developers by allowing them to field their mature designs with a minimum of test facility-induced constraints. It will also avoid artificialities, like square test berths, or pre-determined anchoring patterns, and will enable the WEC Developer to demonstrate and prove their pre-commercial system design.

Other examples of the facility's innovative design flexibility include that the shore station voltage of 35 kV will allow a range of WEC outputs and inputs, including AC or DC, which provides maximum design flexibility to WEC developers, fostering innovative WEC designs and lowering barriers to entry. Unlike other approaches requiring offshore power conditioning, the power conditioning at CalWave can be configured offshore or on-shore, minimizing constraints and lowering costs to WEC developers. Further, our shore station test bus provides flexibility in testing WEC devices, which reduces the risk of future obsolescence or costly retrofits due to evolving test protocols.

11.0.5 Site Down-Selection Process

The feasibility-stage project design envisioned a long-duration (25-30 year design life), fully energetic, open ocean facility, designed for evaluation of mature WECs at advanced TRLs. The Conceptual Baseline Design called for a phased implementation to a fully-capable test center rated at 25-30 MW, with an upgrade path to 50 MW. The comparison criteria included WEC design flexibility, cable lay cost, manufacturing/shipbuilding and infrastructure support ports, variability of sea states and wave energy resource, mooring costs, accessibility for maintenance, cost for grid interconnect and existing infrastructure, regulatory and licensing processes and prospects, potential public acceptance, and long-term growth potential. The CalWave site selection process was conducted in two phases:

11.0.5.1 Down-selection Phase 2: Humboldt or Multiple Options at Vandenberg

The formal multi-criteria review and down-selection process, considered Humboldt and Vandenberg as documented in the Feasibility Study Final Report, (Appendix 1-1).

TABLE 11-1
Site Selection Criteria, SOPO Task #1

No.	Site Selection Criterion
1	Wave energy resource for a test center, P_{min} 30 KW/m, months per year
2	Variability of sea states for a test center
3a	Flexibility to accommodate different WEC designs, compactness for a range of depths >75m
3b	Sea bottom terrain
4	Extreme event design environment
5	Operations port suitability/capability and affordability of ocean engineering equipment
6	Operations port proximity and ability to accomplish tasks in a day charter
7	Construction accessibility for both sea-based and shore-based infrastructure
8	Regional heavy manufacturing / marine supply chain capability
9	Regional industrial marine support operations capability
10	Certainty / length of regulatory and permitting pathway
11	Ease of interconnection for 30 MW
12	Power sales potential for 30 MW
13	Academic/research community proximity
14	Existing infrastructure for co-use, substation
15	Existing infrastructure for co-use, submarine cable
16	Stakeholder support
17	Site commercial buildout potential
18	Ease of interconnection for 300 MW
19	Proximity to shipbuilding facility for WEC fabrication

Siting area selection for the facility was driven by the test site criteria. Test site criteria development leveraged the significant efforts of the Oregon Wave Energy Trust (OWET) and the OWET Industry Advisory Council during the Territorial Sea Plan process employed by the State of Oregon to select wave energy test sites. The test site selection criteria were further refined by the CalWave Team during interviews with Marine Energy Converter (MEC) developers (focus on WECs), and benchmarking of existing wave energy test sites in the United Kingdom and evolving sites in the United States. Figure 11-1 showed the general siting areas considered in the north coast (Humboldt) and central coast (Vandenberg) regions.

During the siting evaluation process, the project team initially looked at five siting regions: (1) nearshore Humboldt, (2) offshore Humboldt, (3) nearshore Vandenberg, (4) offshore Vandenberg, and (5) Offshore Vandenberg using existing transmission from oil and gas Platform Irene. Initial analysis confirmed quickly that

the nearshore sites (territorial waters) would be infeasible because of inadequate depth and relatively low available wave energy.

After identifying candidate sites and developing 19 scoring criteria, project team members worked together to develop scores for the criteria, recognizing that some should have more relative importance than others. In this process, each scoring participant (Cal Poly, Humboldt State University, Virginia Polytechnic Institute and State University, Leidos Maritime Solutions, Columbia Power, and CH2M) contributed a weighting score and these were averaged, with final weightings ranging from 2.0 for Criterion #4, "Extreme Event Design Environment" to 7.9 for Criterion #1 "Wave energy resource for a test center, Pmin 30 KW/m, months per year".

The project team then developed scoring guidelines for each criterion. For example, for criterion #2, "Variability of Sea States for a Test Center," scoring focused on the number of days per year that significant wave height would be less than 1.5 m for more than 2 days in a row, with <20 scoring 0 to 2 points, 20 to 40 scoring 3-6 points, and >40 scoring 7-10 points.

Finally, the project team assigning responsibility for analyzing and scoring particular criteria and documenting the scoring process and findings to particular team members best qualified by their assigned roles on the project to conduct the scoring for a particular criterion. The final evaluation of the candidate siting areas was determined by multiplying the site scores by the weightings for the criteria and adding up total scores by site. The result was then submitted to a review committee made up of project team members from the National Renewable Energy Laboratory and Sandia National Laboratory. The review committee provided comment on and endorsed the finding of the site evaluation exercise.

TABLE 11-2
Siting Area Site Selection Scores

Site	Composite, Weighted Final [a]
Humboldt Area, Offshore Federal Waters, new cable from shore	5.4
Vandenberg Area, Offshore Federal Waters, existing cable from Platform Irene	7.7
Vandenberg area, Offshore Federal Waters, new cable from shore	6.8

[a] Composite of scores along 19 different criteria, each weighted by relative importance.

• **Host Facility**—Vandenberg Air Force Base (AFB) offered secure sites for a shore station and demand for test facility power. The goals of CalWave are consistent with the DOD's and VAFB's goals o develop more self-sufficient energy supplies, including renewables, and Vandenberg is a cooperative host and project partner. The base offers robust transportation and industrial facilities.

• **Shore Station**—the notional design is based on the "South Base" location near Vandenberg Dock. Vandenberg Dock was constructed for offloading rocket boosters and the Space Shuttle and is served by a well-constructed tow road to other parts of the base. Shore-station facilities would include electrical substations (12 kV and 70 kV), a switchgear building, gravel pad space to hold WEC-Developer power conditioning equipment, and operations buildings with offices for CalWave and WEC developer staff.

• **Co-Use of Existing Marine Infrastructure**— While it is conceptually feasible to co-use the existing offshore infrastructure at Platform Irene (platform, submarine power cable and shore substation),there are many engineering unknowns about platform system integration that need to be resolved via technical exchanges with the infrastructure owner. The study team has identified a potential $7 million cost savings to CalWave if we can have access to this infrastructure versus installing new cables.

• **Permitting Issues**—A critical issues analysis of environmental permitting issues in the Vandenberg area did not result in the identification of issues that could prevent project development or cause significant cost increases or schedule delays beyond what would be expected for a project of this nature.

• **Test Berth Sites**—Test berth sites are available within 3 to 7 nm from the Vandenberg dock in the desired depth range of 70 to 110 m and in BOEM-defined lease blocks not currently leased for oil and gas purposes. The South

Base location has the advantage of offering shore station facilities close to test berth locations, reducing the length and cost of the cable runs. The sites are located on sandy bottom and the prospective cable route can avoid rocky bottom near the shore using horizontal directional drilling (HDD). Note: test berth definition will be driven by BOEM Lease Block descriptions.

• **Wave Energy Resource**—the five prospective sites offer average annual energy flux ranging from 30.4 kW/m (South by Southeast) to 40.5 kW/m (South Central). The sites offer a wide variety of seasonal and year-to-year wave configurations that will be useful testing under a variety of wave height and period conditions.

• **Shore Side Infrastructure**— the shore side infrastructure is highly developed for marine engineering and marine logistics services in support of the offshore oil industry. CalWave is located within a few nm of four offshore oil platforms and a number of additional platforms are located further east in the Santa Barbara Channel area. The platforms have been in operation for nearly thirty years and an oil services construction and operations industry has developed in the region. Capable shore side infrastructure is therefore readily available very near the project area. Infrastructure available includes port facilities at deep water Port Hueneme, Santa Barbara, Port San Luis, and Morro Bay, all within a reasonable distance of the project site, and Vandenberg Dock, at the project shore station site. Facilities include heavy lift floating (offshore rated) and dockside cranes, and a variety of work boats and other vessels, including large work vessels and cable lay vessels, remotely operated vehicles, and automated underwater vehicles.

• **Marine Operations Support—**In addition to port facilities and equipment, the offshore oil industry has fostered the development of an experienced marine operations workforce with first-hand experience supporting complex offshore industrial facilities in the project area. Local mariners have experienced a wide range of operational conditions in the area and understand marine industrial support operations.

• **Ocean Use—**Initial contacts with the local fishing communities of Morro Bay and Santa Barbara have indicated that commercial fishing concerns about a wave energy test site in the Vandenberg area are few. The project site is not considered a productive fishing area, possibly because of the distance from port and associated transit costs, location near a restricted Vandenberg Launch Area, and also because it is adjacent to a very large State Marine Reserve area where fishing is prohibited and also a federal Essential Fish Habitat Fishing Conservation Area where fishing for ground fish is prohibited.

• **Shoreside Land Use**—shore facilities located on Vandenberg AFB do not conflict with land uses on the base. The base extends across 42 miles of shoreline up to the adjacent ridge tops. There are few residential, resort, or recreational areas near the project site that could be a potential source of complaints regarding impacts to scenic viewsheds along this scenic stretch of the coast. In addition, the WECs would be located relatively near oil platforms, compared with which they would not have a large visual profile seen from land.

11.0.5.2 Down-selection Phase 2: Vandenberg

Phase 1 found that the Vandenberg was better-suited for a Test Center. Additionally, VAFB had demand for the power output, the market conditions on the Central Coast could support wave energy commercialization, and the Central Coast industrial base was more capable. The subsequent phase of down-selection was focused on Vandenberg, converged on the South Base, and narrowed the test berth siting to the South and Southeast test berth locations near the Vandenberg Dock that use Vandenberg Air Force Base (VAFB) Substation “N”.

The South Base Site was selected as the conceptual shore station and the site plan was refined based on a topographic field survey that was performed by a Cal Poly Team of students, professional surveyor instructor and Architectural Engineering Professor. This detailed land survey informed the conceptual civil, mechanical, and electrical engineering and architectural designs. An extreme events analysis was performed on the five proposed shore sites that included Tsunami modeling, historic weather modeling, and a seismic ground shaking assessment in order to inform the shore station down selection process.

An extensive industry survey was conducted by the CalWave Subsea Cable Route Design Team. As a result, the preferred Horizontal Directional Drilling (HDD) launch site was selected as well as an alternate launch site. The selection was based on integrating the conceptual shore station design and location with the offshore test berth locations, topography, bathymetry, subsea cable capabilities and constraints, in conjunction with host facility requirements. An industry survey of the site, and subsequent meetings with marine construction industry members, further illuminated survey/data needs for the HDD bore and cable landing design. The survey work led to

the development and drafting of conceptual design drawings for the Civil, Electrical, and Architectural design drawings.

11.0.6 Systems Approach

CalWave is envisioned as a permanent (25-30 year design life), fully energetic, open ocean test center that is designed for evaluation of WECs at mature TRLs (levels 7/8/9). The Conceptual Baseline Design is for a phased implementation to a fully-capable test center, rated at 25-30 MW, with an upgrade path to 50 MW.

A systems engineering approach to requirements-driven design is shown in Figure 11-3. Modular design practices and the use of proven components from related industries concepts were emphasized.

This approach was a key factor in collaboration across CalWave Program Elements:

- Engineering
- Permitting and Environmental
- Stakeholder and Outreach

11.0.7 CalWave II Engineering Element

The Sea-Based Infrastructure and Shore-Based Infrastructure as well as Wave Energy Converters and the VAFB and PG&E Grid are described in more detail in CalWave I Final Report (Appendix 1-1).

The CalWave II SOPO Task 11 is intended to advance the engineering of CalWave to support submission of the Draft Pre-Application Document (Draft PAD). The Subtasks are:

- 11.1 Engineering Program Management
- 11.2 System Integration and Systems Engineering
- 11.3 Design Engineering and Analyses: Progress toward Preliminary Design
- 11.4 Benchmark Existing Test Centers: Coordination and Site Visits
- 11.5 Planning & Specifications: Surveys and Wave Measurement

The Shore Station design and electrical, civil, and architectural engineering analyses are described in more detail below in the Appendix 11 attachments:

- Attachment 11-1: Final Report – Task 11
- Attachment 11-2: Top- Level Requirements and Site Selection Criteria
- Attachment 11-3: Project Objectives, Alternatives and Top-Level Concept
- Attachment 11-4: System Block Diagrams and Interface Definition List
- Attachment 11-5: Cable Route Desktop Study Summary
- Attachment 11-5-1: Cable Route Desktop Study
- Attachment 11-6: Horizontal Directional Drill (HDD) Profiles
- Attachment 11-7: Civil/Architectural Engineering and Extreme Events Analysis Summary
- Attachment 11-7-1: Civil/Architectural Engineering Drawings
- Attachment 11-7-2: Extreme Events Analysis
- Attachment 11-8: Electrical Design and Interconnect Study Memo
- Attachment 11-8-1: Electrical Shore Facilities
- Attachment 11-8-2: Transmission Line Report Volume 1
- Attachment 11-8-3: System Impact Study Letter
- Attachment 11-9: Cable Logistics Lessons Learned Memo
- Attachment 11-9-1: Cable Logistics Lessons Learned Final Report
- Attachment 11-10: Mooring and Anchoring Study Memo
- Attachment 11-10-1: Mooring and Anchoring Study
- Attachment 11-11: Benchmarking: UK Wave Hub, Camp Rilea, BIMEP Memo
- Attachment 11-11-1: Marine Energy Insurance and Associated Risks for Test Sites Presentation

- Attachment 11-12: Risk Management Plan
- Attachment 11-13: Cost Estimating Summary
- Attachment 11-13-1: Comparison Table - Preliminary Cost Estimates
- Attachment 11-13-2: Basis of Estimate Cost Workbook – Rough Order of Magnitude (ROM)
- Attachment 11-13-3: Electrical Facilities Cost Estimate – Preliminary Design
- Attachment 11-13-4: Marine Operations Planning Estimate
- Attachment 11-14: 3rd Marine Hydrokinetic Instrumentation Workshop Report
- Attachment 11-15: OWET - Wave Energy Electrical Infrastructure Planning Presentation

11.1 Engineering Project Management

The CalWave Chief Engineer of **Leidos Maritime Solutions** provided engineering input to the project management team and coordinated with the Cal Poly Principal Investigator, Project Developer, Project Manager, project management staff, and project team. Weekly project team conference calls continued; and, administrative tasks and reporting were accomplished. The Engineering Element is in the early part of the Preliminary Design Stage.

11.2 Systems Engineering & Systems Integration

The CalWave project concept and design are "requirements-driven", in that we determined user needs and top level requirements first and then carried these through the Feasibility Study, Conceptual Design, and into Preliminary Design Stages. In addition, we employed a system engineering approach defined by the International Council on Systems Engineering (INCOSE) that translates user needs into requirements; develops, analyzes, and selects from the best alternatives; and considers the total life-cycle of the design including environmental, regulatory, outreach, and permitting.

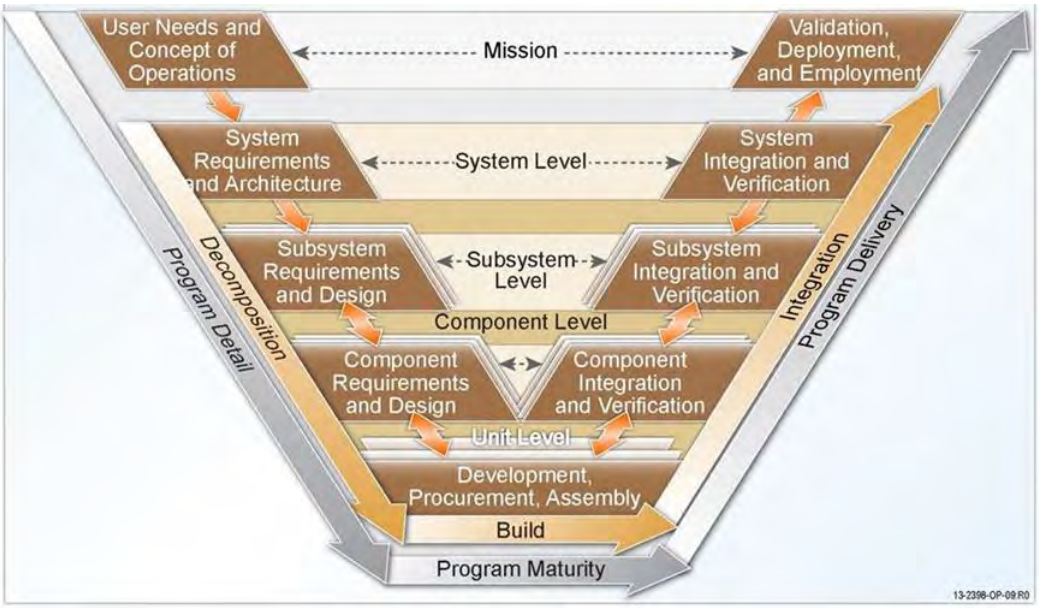


Figure 11-5: Systems Engineering Process

11.2.1 Requirements Definition

The CalWave requirements-driven design process and the systems engineering approach was used for requirements definition that starts with user needs, and site selection criteria and translated those user needs into Top Level Requirements. The Top Level Requirements carried through the Feasibility Study, Conceptual and Preliminary Design Stages. Requirements definition progressed from system level to capability level through functional allocation to feature level as shown above.

11.2.2 Functional Allocation

Requirements analysis is ongoing as the design progresses into more detail. As alternatives are down-selected and degrees of freedom in design are reduced, the design can iteratively develop into preliminary and detailed design stages while minimizing rework. The goal is to make progress towards final design for a fully-capable facility, designed for evaluation of mature WECs at TRLs 7/8/9, defined as:

- TRL 7 – Full-scale prototype demonstrated in relevant environment (open ocean)
- TRL 8 – Actual system, tested, and qualified under expected conditions
- TRL 9 – Actual system operated under full range of operational conditions

11.2.3 Requirements Baseline

CalWave is envisioned as a permanent (25-30 year), fully energetic, open ocean test center designed for evaluation of WECs at mature TRLs (levels 7/8/9). The Conceptual Baseline Design is for a phased implementation to a fully-capable test center, with four (4) test berths serviced by 10MW home run cables to a shore station rated at 25-40 MW, with an upgrade path to 50 MW. The site selection criteria also informed the Top-Level Requirements.

Initial installations of subsea cables will extend to deep water test berths. Shallower, mid-depth, and deeper sites are available as alternatives for expansion. The primary focus on wave energy converters, with consideration given to possible future addition of floating wind, and wave-wind hybrid designs.
Our approach is to acknowledge the multi-disciplinary engineering tasks involved including systems engineering and ocean engineering tasks as well as civil/electrical/mechanical engineering and architecture.

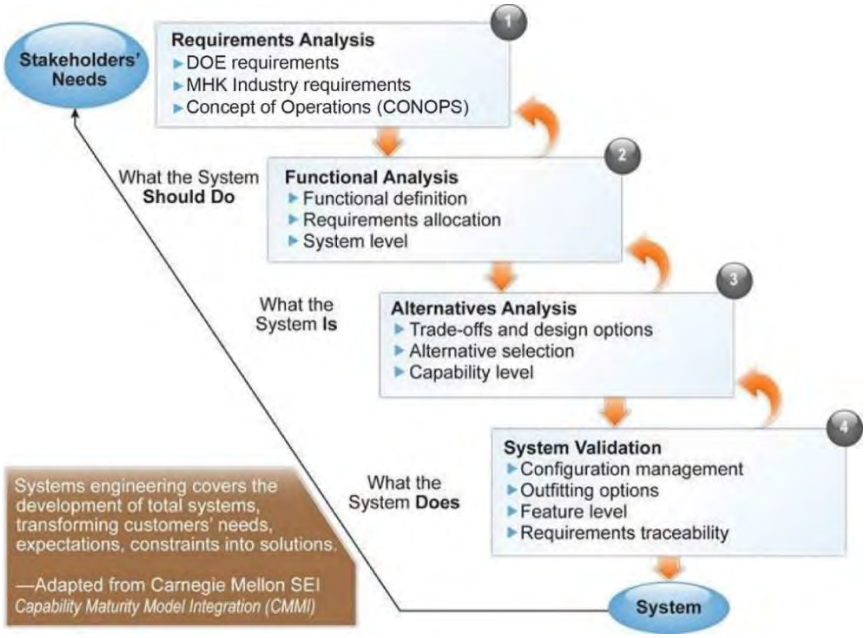


Figure 11-6: Requirements Definition Process

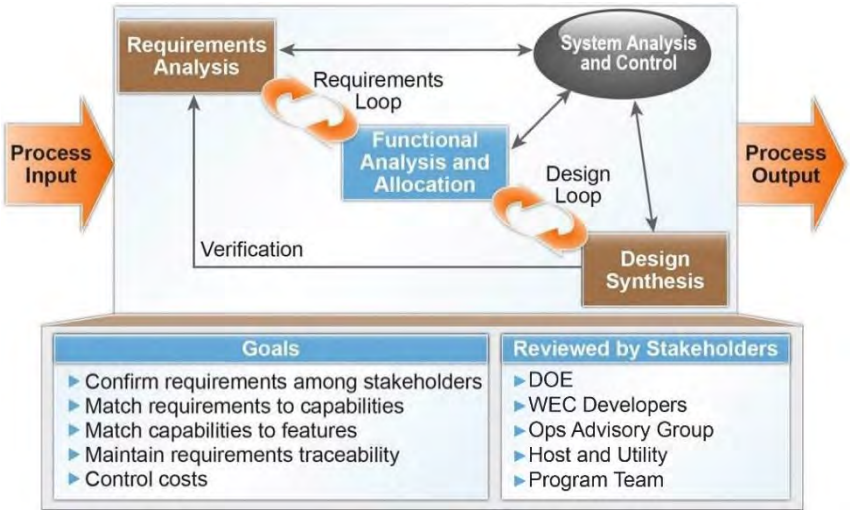


Figure 11-7: Requirements Review Process

The resulting system approach workflow supports the systems engineering process and the three major iterations with associated reviews: Conceptual Design Review (CDR); Preliminary Design Review (PDR); and, Final Design Review (FDR).

11.2.4 Spiral Development

Since much of the design has been in the marine engineering domain, the spiral design process of naval architecture was used as a reference model for iterative design in the face of multiple uncertainties.

The system orientation of naval architecture was merged with the system engineering approach of “requirements-driven design”.

Spiral development approach was employed to iterate the design from a high state of uncertainty toward a consensus design.
In parallel, there are supporting processes that are more tightly coupled, such as:

- DOE Requirements
- Project Management
- Design Studies and Analyses
- Review and Oversight

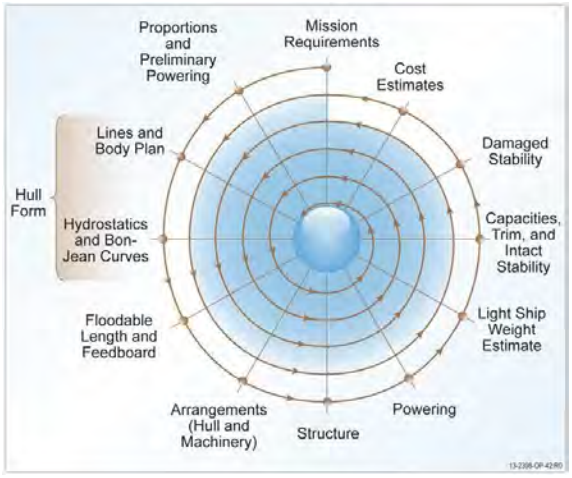


Figure 11-8: Naval Architecture Spiral Design

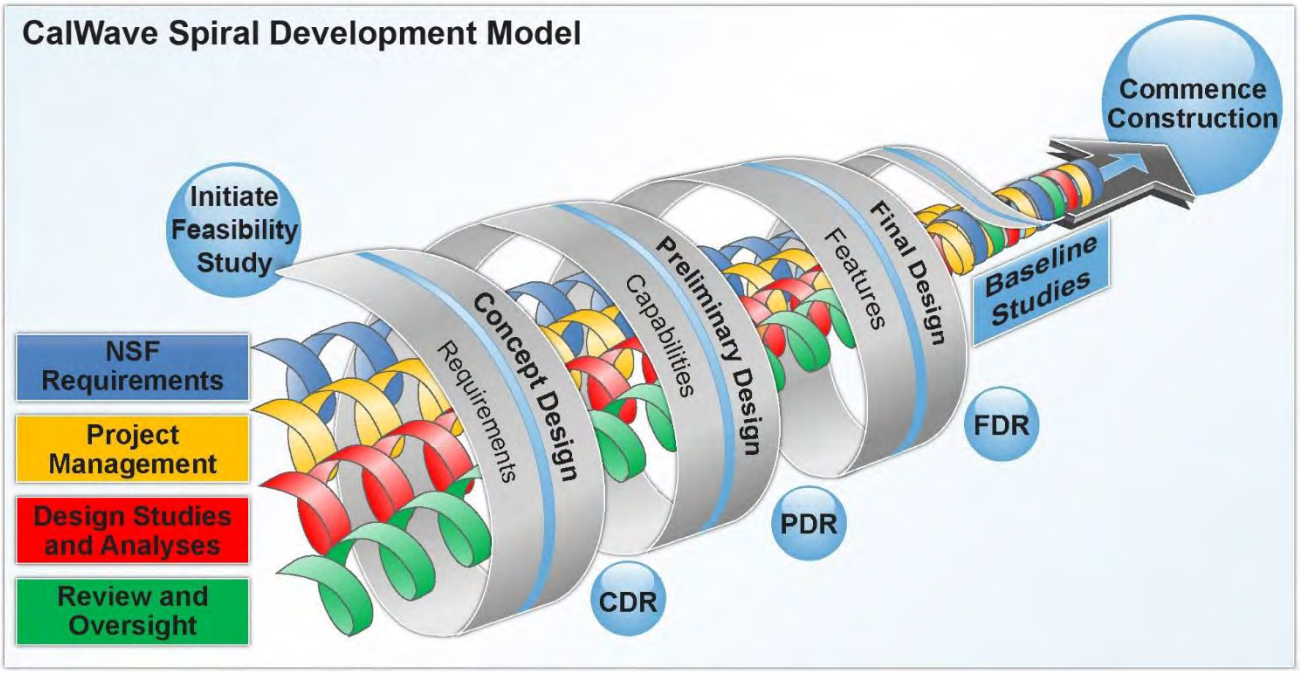


Figure 11-9: CalWave Spiral Development Model

Phasing and milestones will leverage our existing spiral development process from Conceptual Design Review (CDR) through development of a Draft Preliminary Design adequate for the draft applications.

Systems engineering will continue to be used to ensure a requirements-driven design process. Requirements definition will progress from system level to capability level through functional allocation to feature level as shown below.

11.2.5 System Concept

Based on benchmarking international test sites, the CalWave System Concept is centered on “home run” cables and features that allow WEC Developers to field their mature pre-commercial system designs with a minimum of test facility-induced constraints, a significant lesson-learned from other wave energy test centers. Implement design goals and objectives that enable precise measurement of performance from each test berth hosting individual WECs or arrays.

Given the costs of tooling, mobilization and demobilization and ocean operations, a spare cable is a major benefit with reasonable cost.

The system concept is shown in the diagram below.

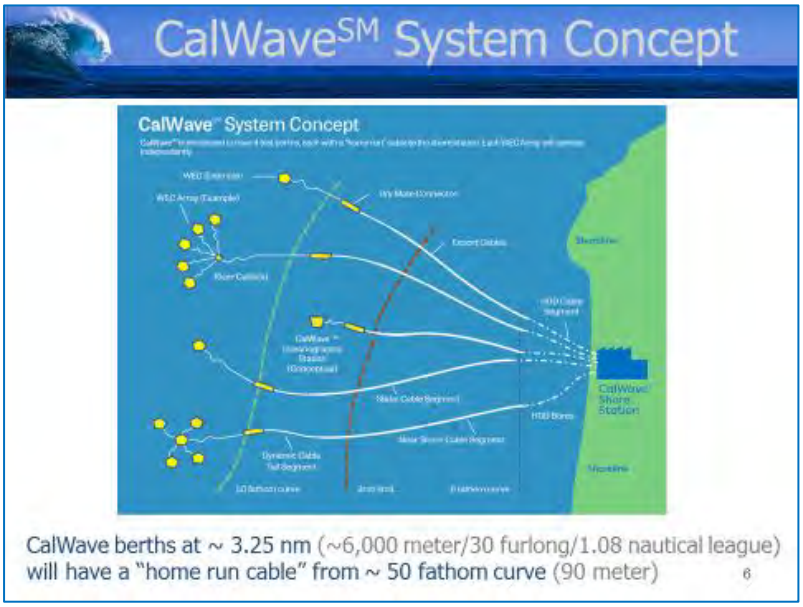


Figure 11-10: CalWave System Concept

11.2.6 System Block Diagrams

The design implements the system concept, starting with system block diagrams that show major interfaces:

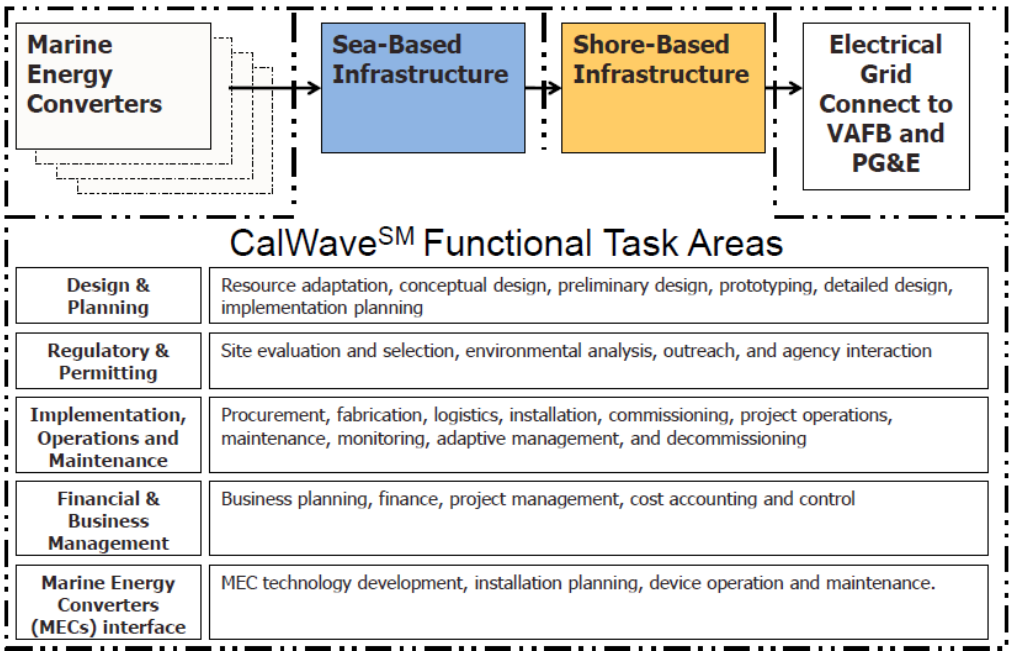


Figure 11-11: CalWave System Block Diagram – Conceptual Stage

The term “Marine Energy Converter (MEC)” was narrowed for CalWave to :”Wave Energy Converter (WEC)”. There are two system block diagram methods for describing CalWave, both emphasize the importance of interface definition and control, particularly at Designated Critical Interfaces:

11.2.6.1 WEC-References System Block Diagram: used during the Conceptual Design Stage. This method is “customer-centered” and addresses the primary mission of supporting the MHK industry and WEC developers. It starts with the WEC array(s) and progresses through the CalWave system to the host facility and connecting utility.

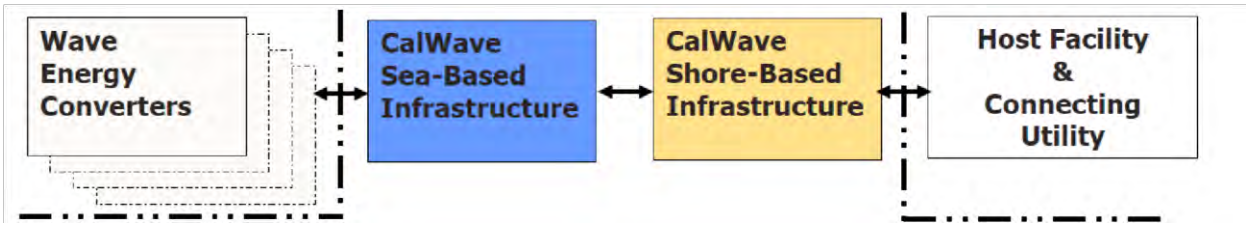


Figure 11-12: WEC-Referenced System Block Diagram (Source: Leidos)

11.2.6.2 Grid-Referenced System Block Diagram: used during Preliminary, Final, and Detailed Design Stages. This method is “power purchaser-centered” and addresses the end goal of commercialization. It also acknowledges that the Grid is a mature Boundary System that CalWave and WECs must comply with. This method better represents the facility construction.

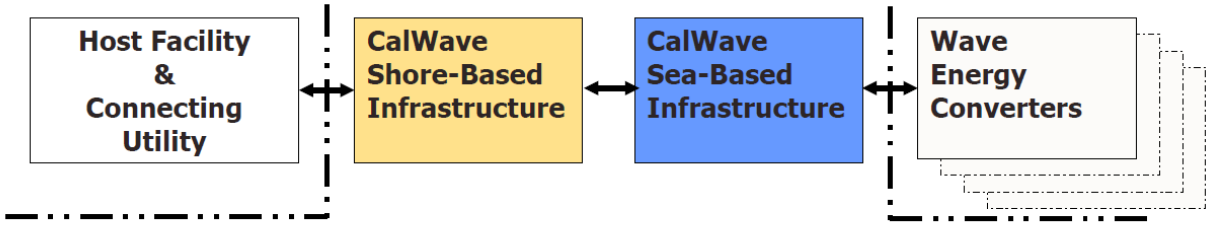


Figure 11-13: Grid-Referenced System Block Diagram (Source: Leidos)

11.2.7 System Boundaries

The system boundary was defined as including the Sea-Based Infrastructure and Shore-Based Infrastructure are summarized below in the System Block Diagrams developed by **Leidos** Inc. A more detailed discussion, including functional task areas, is in D.11 Engineering Element. Boundary systems were identified as: WEC/MEC System; VAFB-PG&E Electrical Grids; and VAFB Base Facilities.

- CalWave is also a system of systems including sea-based infrastructure and shore-based infrastructure as well as multiple supporting systems and sub-systems such as instrumentation and telemetry, data acquisition and management.
- CalWave interfaces to the host facility as a boundary system” in that we must adhere to the interface requirements of the host. The host facility, Vandenberg AFB, is also a system of systems including: civil; architectural; mechanical; and electrical systems, and related sub-systems, such as electrical grid with connection to the PG&E utility grid, and the environment.
- The CalWave system interfaces to WEC(s) and WEC array(s) as another boundary system. The WEC system(s) must adhere to the interface requirements of CalWave, in particular the design and operational limits of the submarine cable and grid compliant power.
- Wave Energy Converter System(s) also interface to the ocean environment with multiple sub-systems such as mooring, anchoring, riser umbilical(s) and power conditioning.

11.2.8 Engineering and Operational Criteria

The CalWave conceptual design balances user needs, engineering, and operations as well as expected TLRs and the findings from a preliminary Failure Modes and Effects Criticality Analysis (FMECA) that identified the requirement to accommodate a wide range of WECS out to the year 2050, with designs that are most likely not anticipated at present, and a range of potential failure modes.
One goal of the CalWave design was to incorporate features that ensure "graceful degradation" in the event of material failures in one Test Berth and enable continued operations of CalWave's other Test Berths.

Translating systems into design disciplines was accomplished with the goal to maintain design flexibility for infrastructure to support testing out to the design life of 2050.

- The SE&I objectives include interface definition between major systems and sub-systems for Wave Energy Converters (WECs) that have yet to be invented.
- Interface definition is a key component of the Project Description.
- The Draft Project Description is a key input to the permitting process known as the "permitting envelope" This is discussed further in the Section 12 Permitting Element of this report.

11.2.8.1 Engineering Concept of Operations

A key engineering design consideration is "how will the end-users employ the system"? This question drives the Top Level Requirements development (SOPO Task #6) for developing test center operational criteria. The outline of the Concept of Operations (CONOPS) below was derived from discussions with wave energy developers and reference to experience operating surface ship engineering and submarine reactor plants. The CalWave Shore Station design is envisioned to enable the following operational modes to support device testing.

Secured (Abnormal Condition)

No station power,
No staff on site
Indications remoted

Standby

Station power, no staff on site, condition monitoring
Indications remoted

- Monitoring condition of shore-based infrastructure
- Monitoring condition of sea-based infrastructure
- Monitoring condition of any installed WECs

Ready

Station power, with staff on-site, condition monitoring
Shore station is controlling, with indications remoted

- Monitoring condition of shore-based infrastructure
- Monitoring condition of sea-based infrastructure
- Monitoring condition of any installed WECs

Testing

Station power, with staff on-site, performance monitoring Shore station is controlling, with indications remoted Monitoring performance of shore-based infrastructure

- Monitoring performance of sea-based infrastructure
- Monitoring performance of any installed WECs
- Monitoring grid interface
- Coordinating with VAFB and PG&E
- Generating to load bank
- Installing or removing WECs
- Conducting maintenance, refresh, or upgrades

Operating: Non-Grid Connected

Station power, with staff on-site, performance monitoring Shore station is controlling, with indications remoted

- Monitoring performance of shore-based infrastructure
- Monitoring performance of sea-based infrastructure
- Monitoring performance of any installed WEC
- Monitoring grid interface
- Coordinating with VAFB and PG&E
- Generating to Load Bank

Operating: Grid Connected

Station power, with staff on-site, performance monitoring Shore station is controlling, with indications remoted

- Monitoring performance of shore-based infrastructure
- Monitoring performance of sea-based infrastructure
- Monitoring performance of any installed WECs
- Monitoring grid interface
- Coordinating with VAFB and PG&E

The CalWave Shore Station design will accommodate either the Primary Site (South Base Configuration), with all equipment collocated and/or remote capabilities, such as the Surf Station option; or, the Alternate Site (Platform Configuration) needed for Platform Irene. The design will support the following operational modes.

Berth Tagged-out For Safety:

- All power secured, all breakers open and racked-out
- Submarine cable circuits grounded to prevent induced voltage problems

Berth Shutdown:

- Main power secured, with breakers open
- Auxiliary circuits secured with breakers open
- Fiber channels in-use for wave measurement and meteorology and oceanography (METOC)

Berth Monitoring:

- Fiber data channels in-use for wave measurement, METOC, and WEC monitoring
- Auxiliary Circuit #1 powering berth condition monitoring
- Auxiliary Circuit #1 powering WEC instrumentation and WEC condition monitoring

Berth Ready:

- Fiber data channels in-use for wave measurement, METOC, and WEC monitoring
- Auxiliary Circuit #1 powering berth condition monitoring
- Auxiliary Circuit #1 powering WEC instrumentation and WEC condition monitoring
- Auxiliary Circuit #2, powering WEC system and breaker controls and performance

Berth Startup:

- Fiber data channels in-use for wave measurement, METOC, and WEC monitoring
- Auxiliary Circuit #1 powering berth condition monitoring
- Auxiliary Circuit #1 powering WEC instrumentation and condition monitoring
- Auxiliary Circuit #2, powering WEC system and breaker controls and performance
- Main Power Circuit powering berth, WEC and Power Conditioning

Berth Testing:

- Fiber data channels in-use for wave measurement, METOC, and WEC monitoring
- Auxiliary Circuit #1 powering berth condition monitoring
- Auxiliary Circuit #1 powering WEC instrumentation and condition monitoring
- Auxiliary Circuit #2, powering WEC system and breaker controls and performance
- Main Power Circuit powering berth, WEC and Power Conditioning
- Main Power Circuit generating into Load Bank

Berth Operating – Non-Grid Connected:

- Fiber data channels in-use for wave measurement, METOC, and WEC monitoring
- Auxiliary Circuit #1 powering berth condition monitoring
- Auxiliary Circuit #1 powering WEC instrumentation and condition monitoring
- Auxiliary Circuit #2, powering WEC system and breaker controls and performance
- Main Power Circuit powering berth, WEC and Power Conditioning
- Main Power Circuit generating into Load Bank: grid emulation

Berth Operating –Grid Connected:

- Fiber data channels in-use for wave measurement, METOC, and WEC monitoring.
- Auxiliary Circuit #1 powering berth condition monitoring
- Auxiliary Circuit #1 powering WEC instrumentation and condition monitoring
- Auxiliary Circuit #2, powering WEC system and breaker controls and performance
- Main Power Circuit powering berth, WEC and Power Conditioning
- Main Power Circuit generating into CalWave Sub-Station

Berth Fault Detect

Berth Emergency Shutdown

11.2.9.1 CalWave Operational Model

The Concept of Operations (CONOPS) drives the CalWave operational, maintenance, and testing costs that will be dominated by labor expenses for the first four to five years until reaching capacity with all test berths operating. Labor costs over the second five years will be reduced, by comparison, while monitoring and maintenance costs will rise, then stabilize over the long- term.

The CalWave Operational Model will have three major priorities:

- Ensure safe operations
- Implement effective procedures for efficient operation
- Ensure regulatory compliance

CalWave staffing will be determined from the operational, technical, and safety requirements, and supported by the fees collected from client WEC developers. The total staffing level that can be supported depends on the mix of personnel and percentage of time devoted to CalWave per employee.

The primary driver of CalWave's operational success, however, will be the caliber of people chosen to staff the facility. Early staffing with the best-qualified people and positive retention will be the enablers of test center success.

A key factor in designing cost-effective operations, maintenance, and testing budgets is to ensure that all Operational Procedures (OPs), Test Procedures (TPs), and Berth Test Protocols (BTPs) are completed and validated during construction and commissioning.

- Installation of a WEC(s) in one berth to achieve Initial Operating Capability (IOC) during Commissioning.
- All Berths tested during Commissioning.
- Full Operating Capability (FOC) will be achieved when WECs are installed in all berths.

Another key factor will be the enterprise model and business organization to ensure that legal, risk management, contracts and procurement functions are staffed to support the CalWave Test Center as an operational site.

11.2.9 Interface development

The approach to interface definition is to use the system block diagram. Where there is a line between the blocks that is an interface.

The block diagrams are taken to further detail in later stages of design.

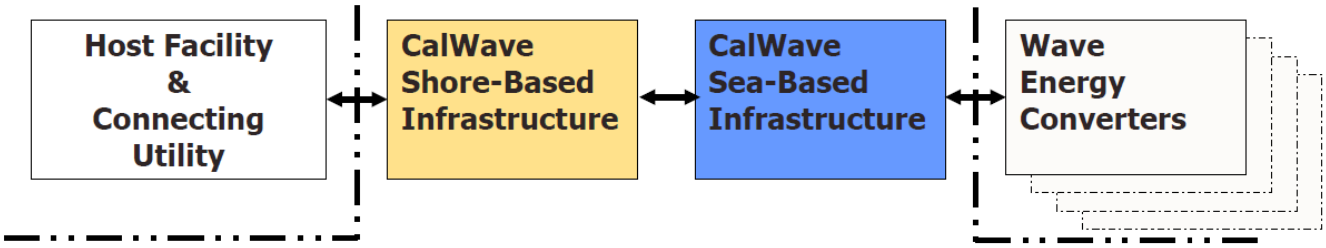


Figure 11-14: Grid-Referenced System Block Diagram (Source: Leidos)

Proceeding to more detail, the next consideration is criticality, to either life of system function, and designate critical interfaces.

Then considered complexity, particularly where coordination is required across functional or organizational lines and designated controlled interfaces.

One of the benefits of this approach is to use as much detail as needed, and no more. This resulted in the following Preliminary Interface List:

Critical Interfaces

1. Subsea Connectors at CalWave System Boundary to WEC Subsea Connector
2. Subsea Cables to CalWave Transition Switchgear Grounding Scheme
3. 12kV Connection at CalWave System Boundary to VAFB Distribution Grid
4. 70kV Connection at CalWave System Boundary to VAFB Transmission Grid
5. WEC Onboard Monitoring and Telemetry to CalWave Control System

Controlled Interfaces

1. Subsea Cable Specification to HDD Bore Specification
2. Subsea Cable Connections to CalWave Switchgear and Instrumentation
3. CalWave Switchgear and Instrumentation to WEC Power Conditioning (inbound)
4. WEC Power Conditioning to CalWave Switchgear and Instrumentation (outbound)
5. WEC Mooring and Anchoring interface to sea floor
6. WEC interface to ocean environment
7. CalWave Shore Station to VAFB physical site (Air, Water, Ground)
8. CalWave Shore Station to VAFB environment and wildlife
9. CalWave Shore Station to VAFB cultural and historic resources

See **Attachment 11-4: System Block Diagrams and Interfaces**

11.3 Design Engineering and Analysis – Preliminary Design Status Overview

The Conceptual Design Stage was continued through Conceptual Design Review (CDR). The Preliminary Design Stage was initiated with the goal of refining the Draft Project Description through permitting and stakeholder review meetings and to a level of detail adequate for the Draft Pre-Application Document (Draft PAD).

The shore station is intended to meet the minimum requirements expressed by DOE and the Host Facility. The footprint for the phased implementation and anticipated expansion are included in the Draft Project Description.

Design Criteria: Significant attention and discussion was oriented around materials selection to resist corrosive salt fog, which causes severe corrosion of certain materials. VAFB has recommendations based on successful operating experience regarding material selection.

Design: Preliminary Single Line Diagrams were prepared articulating all new shore-based electrical facilities required to support the project. Electrical General Arrangements were prepared, revised per comments and submitted to provide for project functional requirements, and to facilitate future maintainability, operability, and reliability.

Requests for Information: Seven Requests for Information (RFIs) were prepared and submitted for use by the team. These RFIs requested information from VAFB as well as PG&E, and formed the basis of the Design Concept for the project. Responses and design requirements were considered and incorporated into the conceptual design.

The Engineering Team refined the site selection process that had narrowed the test berth siting to BOEM Lease Blocks that encompass the South and Southeast test berth locations near the Vandenberg Dock South Base Site. The "Conceptual South Base Configuration Baseline", with all facilities near Vandenberg Dock, was finalized and carried into the Preliminary Design Stage as the "Preliminary South Base Configuration Baseline".

- The "Conceptual Platform Configuration" was considered and will require an expansion of the Surf Substation near the Surf Amtrak Station at the end of West Ocean Blvd.
- The review of the various platform-related alternatives resulted in an overall design improvement by exploring the option of "decoupling" the location of the buildings and the electrical infrastructure.
- The option to locate the CalWave Test Center buildings adjacent to the Surf Amtrak Station and the PG&E Surf Substation, with the option to redefine the VAFB security fence boundary would allow improved access and reduced construction and operational phase costs.

The Conceptual Design Review conducted on July 13th included Vandenberg AFB representatives, UK WaveHub, and marine construction industry representatives from L3 Maripro (cable installers), Aqueous (diving and ROV services), Pacific Tug Services (vessels, cranes, barges, and landing craft), and Fugro Pelagos (marine survey services). Discussions were also held with Venoco (oil platform services) about recent cable installations.

Specific lessons learned included:

- The Vandenberg Grid is mission-critical so CalWave must take particular care to ensure grid integration standards and power quality requirements are satisfied before connection to the VAFB grid. This will drive instrumentation and test design.
    - WaveHub has the opportunity for prior testing at the European Marine Energy Center (EMEC).
- Regulations on vessel emissions, procedural restrictions, and industrial safety requirements are changing the availability of offshore services including vessels, barges, and diving.
    - The waters off Vandenberg are more challenging for cable installation than south of Point Conception.
    - Many oil field vessels will require repowering to meet emission standards (Tier III), thus limiting choices.
    - Cable installation barges that previously used portable dynamic positioning systems are no longer authorized by the US Coast Guard, complicating selection of cable installation vessels.
    - Divers are limited to 300 ft depth by US Coast Guard. Deeper depths require extensive waivers.
- Export cable protection requirements (armor package) vary along the length of the cable (HDD Bore Segment, Near-Shore Segment, Static Segment, Dynamic Cable Tail Segment).
    - Export cable tails, where the dry-mate connector is installed, have a limited number of lifts due to cable wear.
    - Connectors add complexity and are a typical failure point.

11.3.1 System Work Breakdown Structure (SWBS): The SWBS is a product-oriented frame of reference for naval architecture and marine engineering design. It is used during the design phases in highlighting the interfaces that must be carefully managed. A top-level summary of the SWBS, based on the System Block Diagram, is:

- System 100: Host Facility
- System 200: CalWave Shore-based Infrastructure
- System 300: CalWave Sea-based Infrastructure
- System 310: Test Berth One and Cable
- System 320: Test Berth Two and Cable
- System 330: Test Berth Three and Cable
- System 340: Test Berth Four and Cable
- System 350: Fifth (spare) Cable and associated functions
- System 400: Wave Energy Converter System(s)
- System 410: WEC in Test Berth One
- System 420: WEC in Test Berth Two
- System 430: WEC in Test Berth Three
- System 440: WEC in Test Berth Four
- System 450: WEC Checkout Station functions (also see System 800)
- System 500: CalWave Data Acquisition and Management System
- System 600: Test Instrumentation System
- System 700: Reserved for NREL Grid Emulator Equipment
- System 800: Reserved Ocean Observing System & CalWave Oceanographic Station
- System 900: Reserved for CalWave Informational Kiosks in the Region

11.3.2 Program Work Breakdown Structure (WBS): In contrast with the SWBS used in the design phases, the CalWave Program WBS activity-oriented and aligned with the anticipated Workplan, structured with a hierarchy of performance period (approximately annual), tasks and subtasks. The Task Description Summary provides an additional level of definition.

The WBS summary is an outline for Statement of Program Objectives (SOPO) in future phases. The SOPO will contain a more detailed description of the WBS and tasks.

CalWave Program WBS Summary – Post-CDR Technical Baseline					
Level 0 – CalWave System Acquisition Program					
Level 1 – CalWave Facility Acquisition Program					
CalWave I Feasibility	CalWave II Draft NOI/PAD	Phase 3.0 Permitting	Phase 4.0 Construction	Phase 5.0 Test	Phase 6.0 Operations
Level 2 – CalWave Facility					
SOPO I-10	SOPO II,12,13	SOPO III-I to III-xx	SOPO IV-1 to IV-xx	SOPO V-1 to V-xx	SOPO VI-1 to VI-xx
1.0 Contracts & PM	2.0 Contracts & PM	3.0 Contracts & PM	4.0 Contracts & PM	5.0 Contracts & PM	6.0 Contracts & PM
1.1 Concept Dev	2.1 Engineering	3.1 Prelim Design	4.1 Final Design	5.1 Test Program	6.1 Transition to Ops
1.2 Permitting/Envr	2.1.1 Conceptual	3.1.1 Surveys	4.1.1 EPC or CM/GC	5.1.1 Certification	6.1.1 WEC Customers
1.3 Outreach	2.1.2 Marine/Cable	3.1.2 Decision Gates	4.1.2 Decision Gates	5.1.2 Decision Gates	6.1.2 Decision Gates
1.4 Feasibility	2.1.3 HDD	3.1.3 Risk Mgmt	4.1.3 Risk Mgmt	5.1.3 Risk Mgmt	6.1.3 Risk Mgmt
1.4.1 Wave Resource	2.2 Permitting/Envr	3.2 Permits/Licenses	4.2 Environ Support	5.2 Environ Support	6.2 Environ Support
1.4.2 Test Berth	2.2.1 Studies	3.2.1 Studies	4.2.1 Monitoring	5.2.1 Adaptive Mgmt	6.2.1 Adaptive Mgmt
1.4.3 Shore Sites	2.3 Outreach	3.3 Outreach	4.3 Outreach	5.3 Outreach	6.3 Outreach
1.4.4 Industry Base	2.3.1 Advisory Grps	3.3.1 Advisory Grps	4.3.1 Advisory Grps	5.3.1 Advisory Grps	6.3.1 Advisory Grps
1.4.5 Down-Select	2.4 Design Review	3.4 Design Review	4.4 Design Review	5.4 Test Review	6.4 Test Review
1.5 Notional Site	2.5 Baseline	3.5 Baseline	4.5 Config Mgmt	5.5 Config Mgmt	6.5 Config Mgmt
1.5.1 Estimating	2.5.1 Estimating	3.5.1 Estimating	4.5.1 Estimating	5.5.1 Estimating	6.5.1 Estimating
1.6 Change Mgmt	2.6 Change Mgmt	3.6 Change Mgmt	4.6 Change Mgmt	5.6 Refresh/Upgrade	6.6 Refresh/Upgrade
1.7 Reporting	2.7 Reporting	3.7 Reporting	4.7 Reporting	5.7 Reporting	6.7 Reporting
Level 3 – CalWave Test Center Support Tasks					

Figure 11-15: Program WBS (Work Breakdown Structure) (Source Leidos, Inc.)

11.3.3 Ocean Engineering Summary

Ocean engineering is, by definition, multi-disciplinary engineering effort that is closely aligned with systems engineering and system integration and, as a result interface engineering. By its nature, ocean engineering is also closely aligned with marine operations and meteorology to understand the "weather windows" when work can be safely accomplished.

The CalWave design is modular in nature, so that key work tasks can be "decomposed" and staged to reduce the impact event of weather delays. Given the goal of accomplishing work tasks in the hostile open ocean, key ocean engineering support activities include:

- Risk Management, and associated Configuration Management and Contingency Management (see Section 11.3.15).
- Benchmarking (see Section 11.4: Benchmark Existing Test Centers Overview),
- Participation in WEC Developer forums and international standards development (see Section11.3.14: International WEC Testing and Certification Summary), and
    - Industry Marine Energy Council: Leidos participates in the National Hydropower Association (NHA) Marine Energy Council (MEC) to enhance interaction with WEC developers.
    - CalWave's Chief Engineer participated in the National Hydropower Association (NHA) Hydrovision and presented the CalWave Test Center Design.
        - He is serving as Co-Chair of next year's Marine Renewable Energy Track as was CalWave Partner EPRI's Paul Jacobson.
    - Industry Marine Energy Council: Leidos participates in the National Hydropower Association (NHA) Marine Energy Council (MEC) to enhance interaction with WEC developers.
    - CalWave's Chief Engineer routinely participates in the Oregon Wave Energy Trust (OWET) Ocean Renewable Energy Conference (OREC) events and OWET Industry Summit.
- Industry engagement, such as the Operational Advisory Group (OAG).

11.3.3.1 CalWave Operational Advisory Group (OAG)

The OAG is composed of local mariners and marine operators, and those who employ marine services in the CalWave area. The purpose of the OAG is for CalWave to benefit from the decades of ocean engineering projects associated with oil & gas and experience and collaboration with fishermen.

The OAG was conceived by our Chief Engineer and is structured like an Integrated Product Team (IPT) in major defense acquisition programs.

> An **Integrated Product Team** (**IPT**) is a multidisciplinary group of people who are collectively responsible for delivering a defined product or process.[1]
> IPTs are used in complex development programs/projects for review and decision making. The emphasis of the IPT is on involvement of all stakeholders (users, customers, management, developers, contractors) in a collaborative forum. IPTs are created most often as part of structured systems engineering methodologies, focusing attention on understanding the needs and desires of each stakeholder.

As the first step, we worked in collaboration with Scripps Oceanographic Institution who maintains wave measurement buoys in the area. Scripps had a longstanding relationship with Captain Jon Belchere of TracTide Marine who stages operations out of Port Hueneme. Captain Belchere supports marine operations at Vandenberg Dock.

CalWave reviewed our design and Concept of Operations (CONOPS) with Captain Belchere and networked to other key players. Then, our Chief Engineer made calls and paid visits to the recommended network of marine professionals, and added skill sets to cover all design aspects.

The OAG spans a range of geography and industry from Los Angeles /Long Beach Basin to Morro Bay. We started small with about eight people with a focus on marine operations and expanded to twelve. Meeting facilities for Phase 3 have been offered by platform owner/operator Venoco in a central location of Carpenteria. As the program matures, we will expand the OAG to gain access to a specific skill set:

- from shore side (ports, cranes, land transportation, rail)
- to water side (vessels, barges, landing craft, divers, ROVs)
- and those in the middle (marine operations, marine constructors, HDD, cable installers, and geotech/bathymetric surveyors).

The Co-Chairs are located such that they span the geographic catchment for marine services and attended the Stakeholder Advisory Group (SAG) meeting to provide valuable marine operations input.

The Conceptual Design was shared with all members of the OAG and found to be realistic and executable and four members of the OAG attended the Conceptual Design Review (CDR).

The Operations Director of UK's WaveHub, the world's most advanced and operational wave energy test center also attended the CDR. The WaveHub representative stated that the mix of talent and experience that CalWave has fielded for the OAG is world-class.

OAG MEMBERS

Co-Chair (South):	Captain Jon Belcher	TracTide Marine	Port Hueneme
Co-Chair (North):	Captain Frank Loving	M/V Surveyor	Morro Bay
Meeting Host (Central):	Larry Huskins	Venoco	Carpenteria
Marine Operations/Construction:	Paul Gillian	Associated Pacific	Morro Bay/LA
Marine Operations/Vessels:	Ralph Botticelli	Pacific Tug Boats	Long Beach
Marine Operations/Divers-ROVs:	Dan Holmes	Aqueous	Ventura
Geotechnical/Geophysical:	Todd Mitchell	Fugro Pelagos	Ventura
Horizontal Direction Drilling	Rick Evans	The HDD Co	Sacramento
SubSea Cable Installation:	Chuck Ebner	L3 Maripro	Goleta
Subsea Cable Logistics:	Cliff Center	Center Marine	Seattle
Naval Architecture/Marine Engineering:	Jay Edgar	Glosten Associates	Seattle
Naval Architecture/Landing Craft:	Ralph Duncan	BMT Engineering	Seattle

11.3.3.2 Sea-Shore Interface: CalWave Shore Station

The Shore Station location is on the high ground above Vandenberg Dock as shown below.

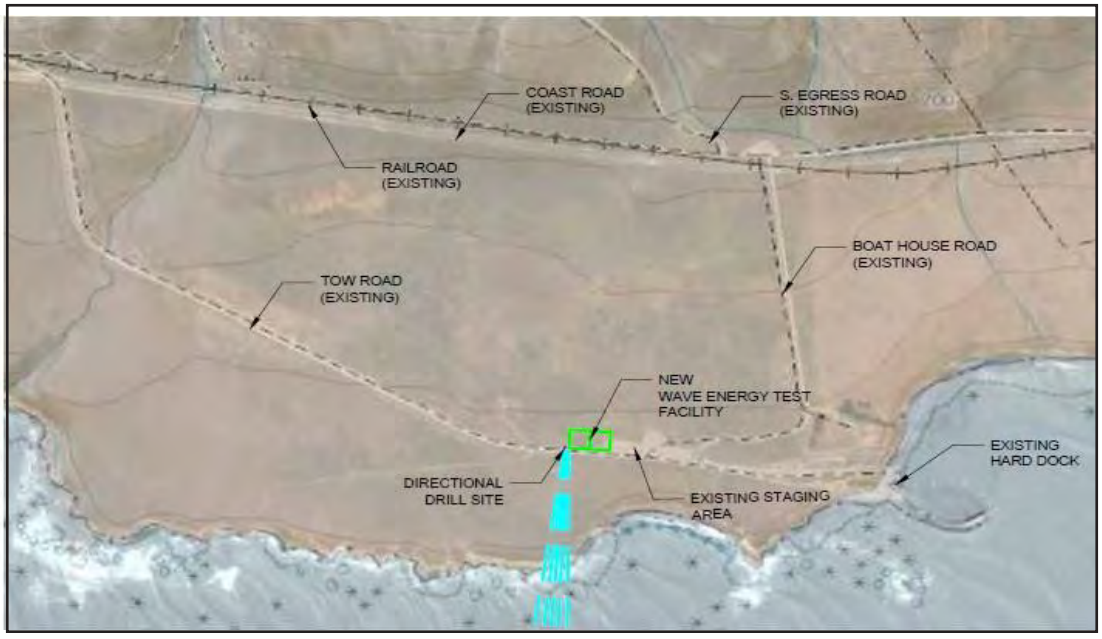


Figure 11-16: South Base Site (Source Leidos,

Figure 11-17: Conceptual Shore Station– Primary HDD Upland Launch Location
(Source Leidos, Inc.)

This "Upland Site" is planned as the site of two modular buildings and space for modular power conditioning equipment to be provided by the WEC developers. An adjacent 12 kV switchyard has been designed to connect with local distribution at 12 kV as well as a 70 kV Substation

11.3.4 Sub-Sea Cables

The cables from test berths will come to the shore outboard of Vandenberg Dock. The cables will be rated for 35kV and 10MW. Grounding and isolation are significant design factors. A vital consideration is the cable route.

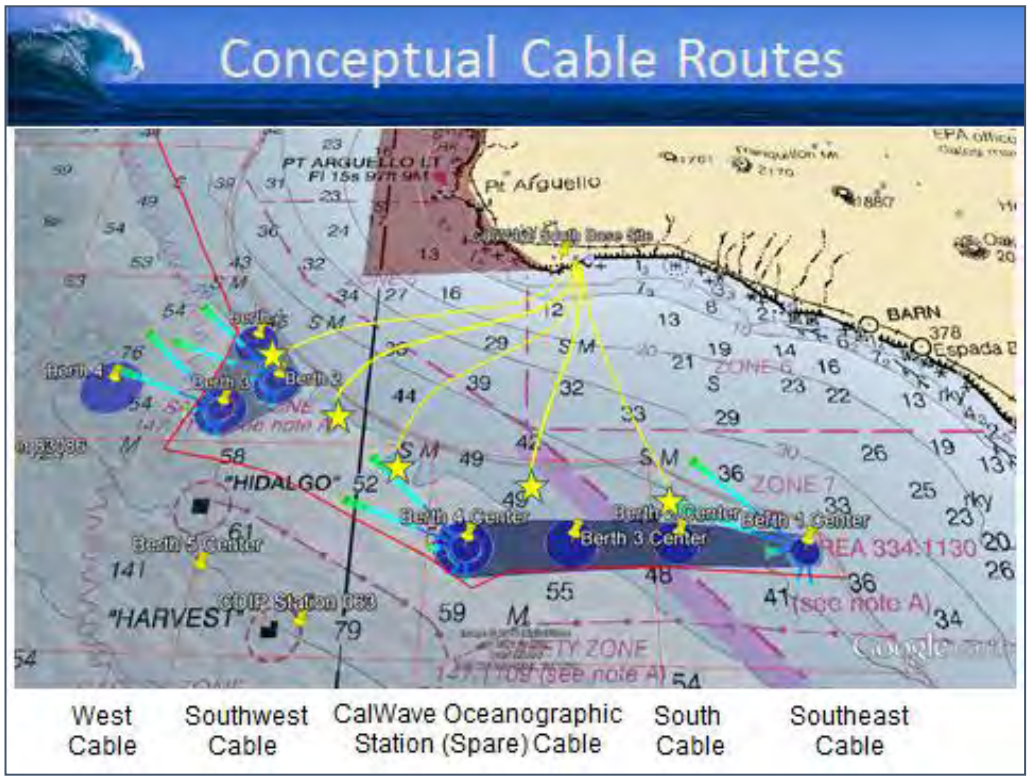


Figure 11-18: Conceptual Cable Routes **(Source Leidos, Inc.)**

11.3.4.1 Cable Route Desktop Study

The subsea cable route desktop study was completed. The survey team that conducted a Vandenberg AFB site visit included Fugro Pelagos, the cable logistics consultant, the HDD industry representative and CalWave's PM, Chief Engineer, Electrical Engineer and VAFB Host.

See **Attachment 115-1: Cable Route Desktop Study**

The emphasis of future surveys will be to determine accurate bathymetry to support horizontal directional drill (HDD) bore profile design.

11.3.5 Horizontal Directional Drilling (HDD)

An extensive industry survey was conducted by the CalWave Subsea Cable Route Design Team. As a result, the preferred Horizontal Directional Drilling (HDD) launch site was selected as well as an alternate launch site. The selection was based on integrating the conceptual shore station design and location with the offshore test berth locations, topography, bathymetry, subsea cable capabilities and constraints, in conjunction with host facility requirements

See **Attachment 11-6: Horizontal Directional Drilling (HDD) Profiles**

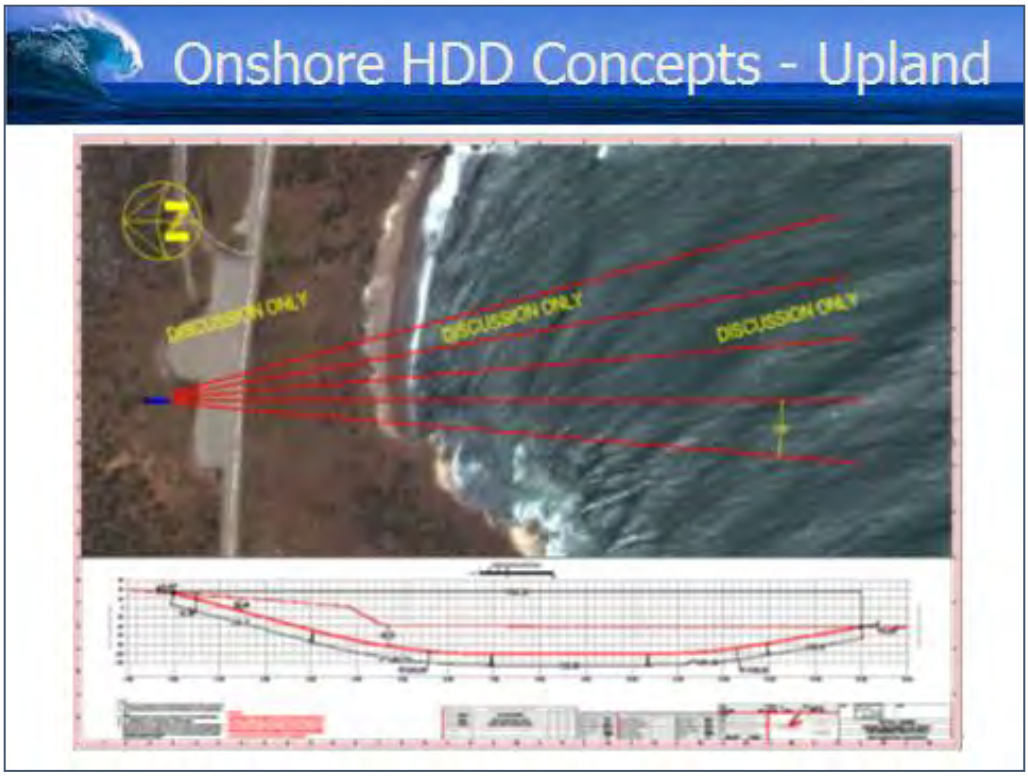


Figure 11-19: Onshore HDD Concepts – Upland (Source Leidos, Inc.)

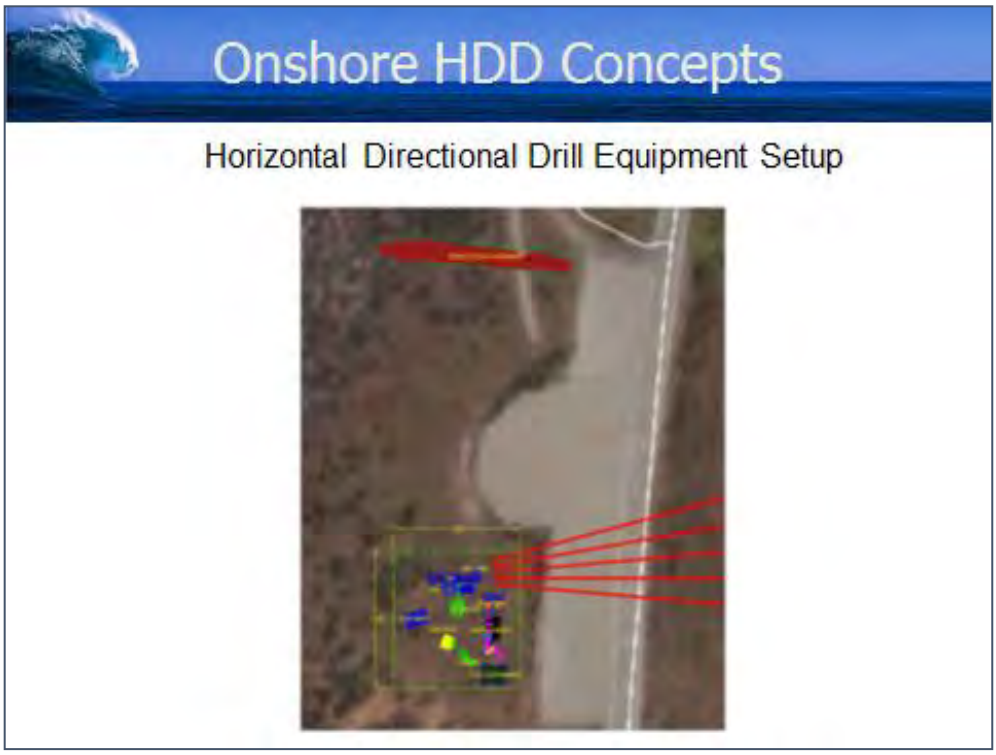


Figure 11-20: HDD Upland Launch - Equipment Setup (Source Leidos, Inc.)

The alternative Dock HDD Launch scenario and HDD bore profiles remain viable.

Figure 11-21: Alternate HDD Dock Launch Location (Source Leidos, Inc.)

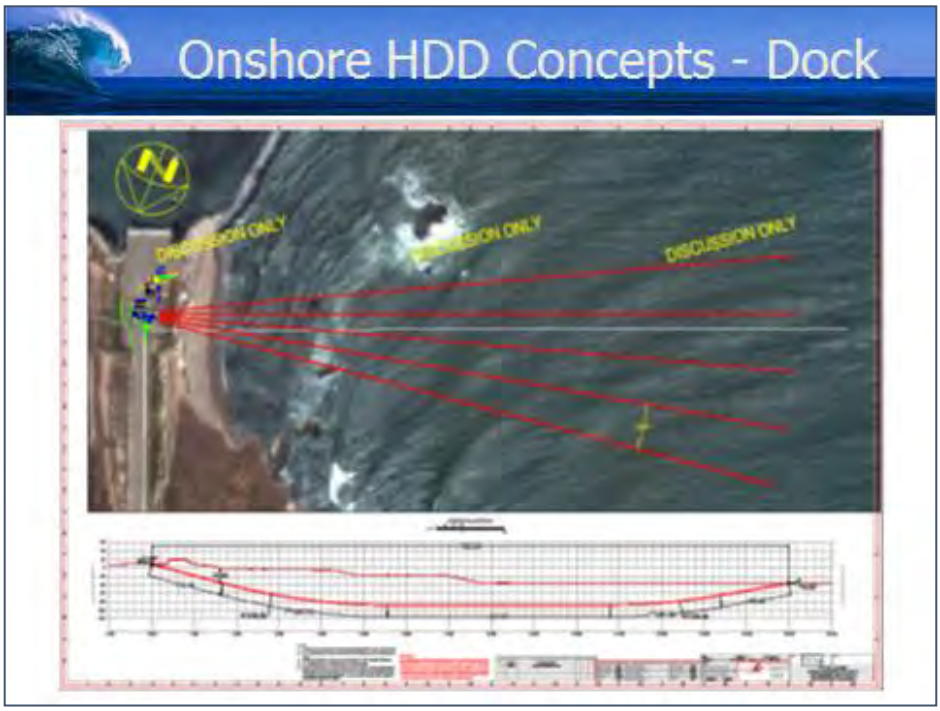


Figure 11-22: HDD Launch at Dock (Source Leidos, Inc.)

11.3.6 Civil/Architectural Engineering Overview

The CalWave Shore Station will support the electrical infrastructure and the Operations Buildings that will host key site personnel and WEC developer staff during test center operations.

Conference rooms, guest offices, and internet connectivity are included. The Vandenberg Dock area is located at the former US Coast Guard Surf Station, which may be available for office functions on a not-to-interfere basis.

The top level architectural requirement could be satisfied with two standard construction job site trailers for the shore station building. Given the historical nature of the site, and the expected constraints to use of jobsite trailers at the location, the Cal Poly Architectural Engineering group has designed two affordable pre-manufactured, mobile, modular buildings as an alternative operations building that are architecturally consistent with the historical design of the remaining Coast Guard structure.

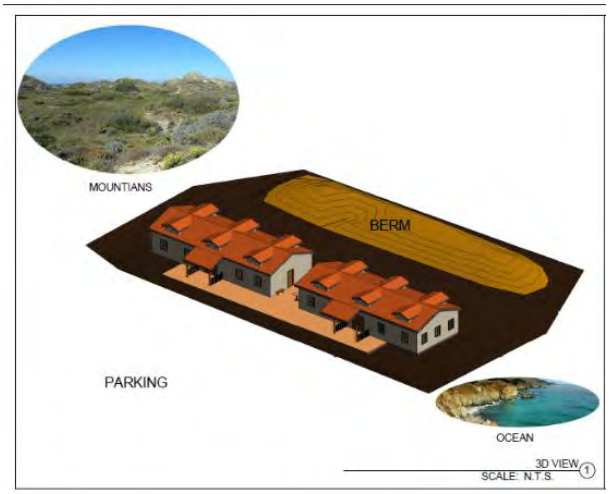
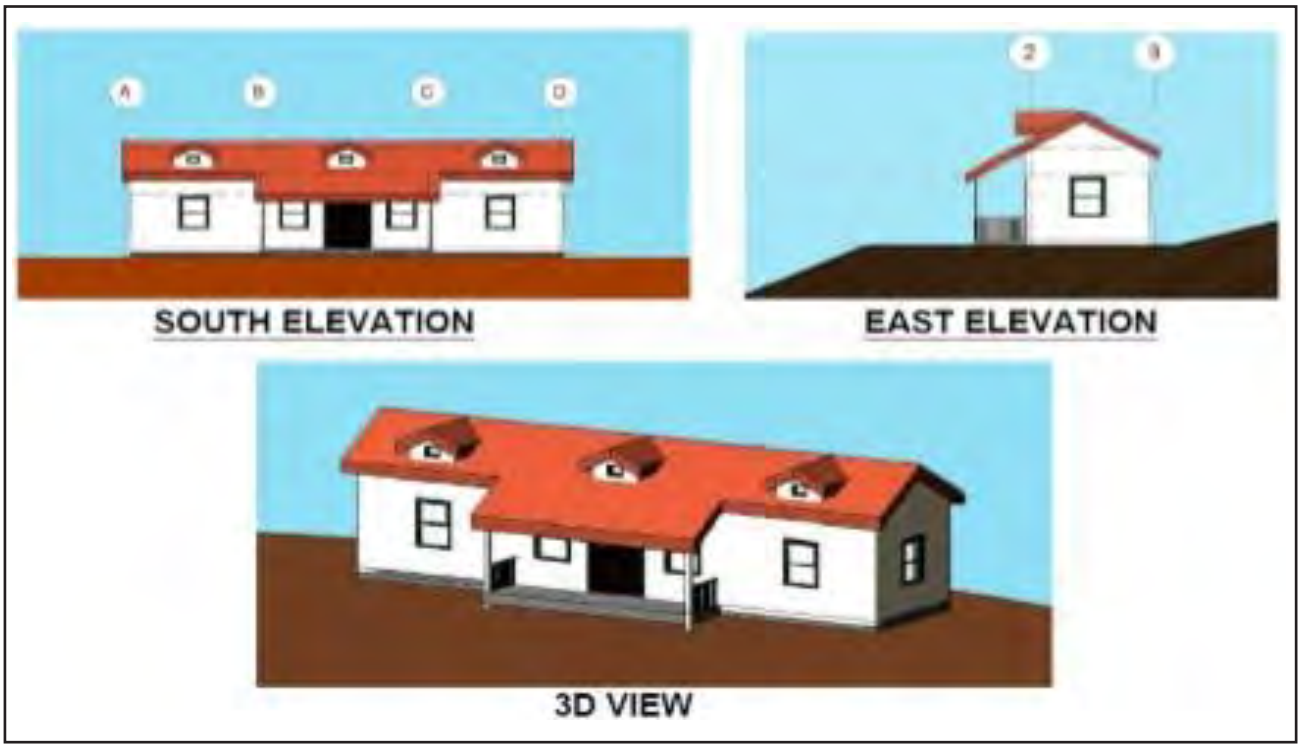


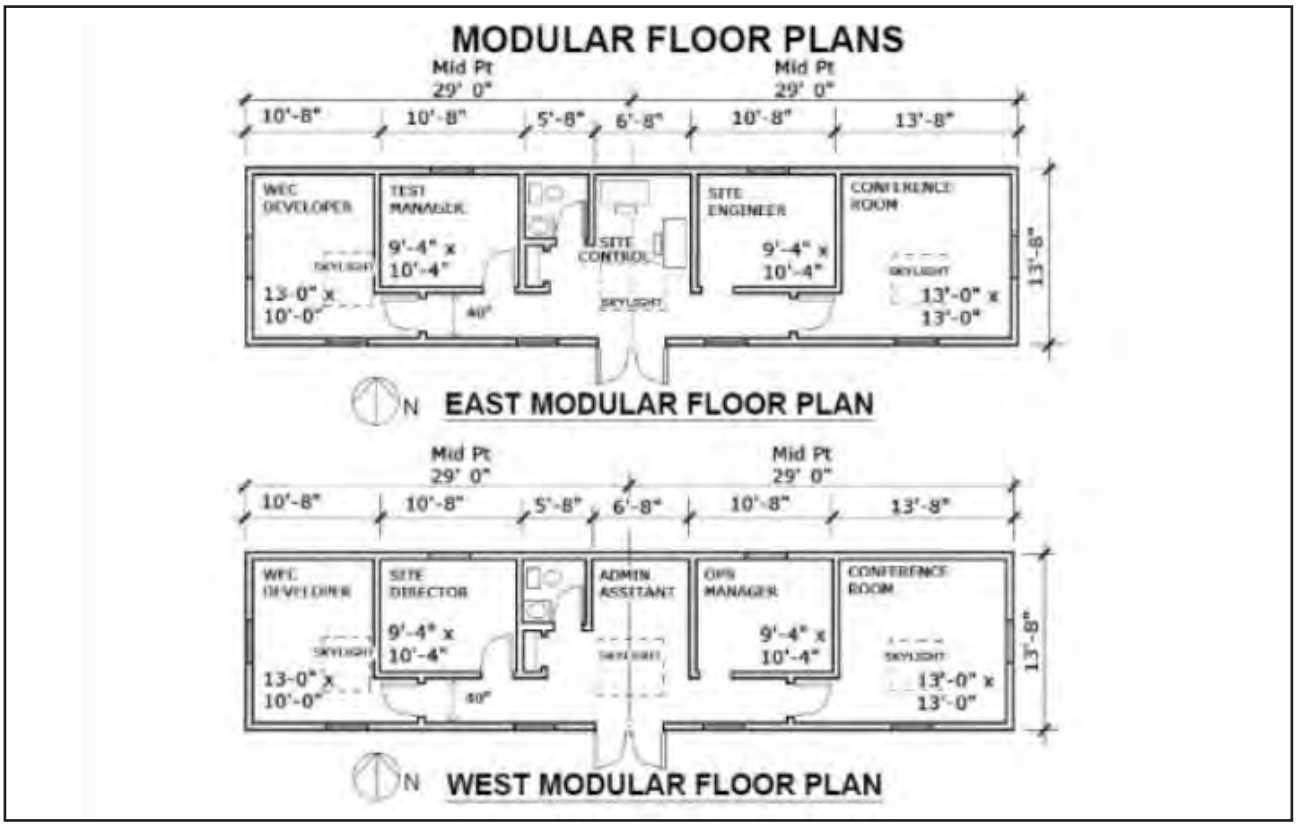
Figure 11-23: Conceptual Architectural Plan

A Cal Poly Survey Team performed a site investigation and executed a detailed topographic land survey of the conceptual onshore site location. This topographic information guided the civil, architectural, and shore-side infrastructure site layout aspects of the conceptual design.

This topographic information was further developed by Cal Poly faculty and students and integrated into the conceptual project drawings. Based on preliminary site assessment for site excavation, cut and fill quantities can be balanced on-site and HDD tailings can be used for a visual berm and retained on-site, further reducing cost.

Figure 11-24: Shore Station Topography





Figures 11-25 A and B: Shore Station Architectural Drawings

11.3.6.1 Extreme Events Analysis Summary

An extreme events analysis was performed on the five proposed shore sites that included Tsunami modeling, historic weather modeling, and a seismic ground shaking assessment The South Base Shore Station is outside the inundation zone. A subsequent update of the extreme events analysis for the office building option at Surf Station location was also completed.

Cal Poly Civil Engineering Department faculty performed the extreme event analysis for down selection and design consideration on each of the notional CalWave shore station sites and the HDD launch primary and alternative sites for tsunami inundation and seismic ground shaking based upon inundation maps and USGS Spectral Acceleration summary maps in order to inform the shore station down selection process.

This analysis was peer reviewed by CalWave team partner PG&E who conducted a similar study for Diablo Canyon Nuclear Plant. This review builds upon the Evaluation Matrix of the CalWave Final Technical Report and is categorized per the Construction Specification Institute MasterFormat of titles and numbers for reference.

Below is an explanation and summary of the findings:

The Extreme Events Review was an input to shore site down-selection.

- The preferred CalWave Shore Station location alternative is the South Base.
- The South Base Shore Station was identified as the “notion conceptual shore location” in the Feasibility Study (Phase I).
- The South Base Shore Station will be included in the draft project description.

The Extreme Events Review was an input to horizontal directional drill (HDD) launch site down-selection.

- The preferred HDD Launch Site alternative is the Upland HDD Launch Site, adjacent to the power conditioning area, at a higher elevation.
- The Upland HDD Launch Site is intended to be included in the draft project description, subject to submarine cable design constraints.
- The alternative Dock HDD Launch Site, at the lower elevation, remains viable.

The referenced Extreme Events Review of the CalWave Feasibility Report (the Extreme Events Review) was considered during preparations for the Conceptual Design Review (CDR) industry in July 2017 and subsequently with permitting agencies. After the CDR observations were considered, a Draft Project Description was written.

Summary: For the locations planned at VAFB (South Base and Surf), no visible Inundation is expected.

The full “CalWave Extreme Event Design Considerations with Appendix” dated June 25, 2016 report can be found in the **Appendix 11 Attachment 7** of this report.

11.3.7 Electrical Engineering Overview

The electrical design is modular in concept and uses readily available components from commercial and utility construction. The VAFB approved material list was also referenced for compliance to base regulations. This industry survey of the site, and subsequent meetings with electrical engineers, marine construction industry members identified the bathymetric and geotechnical survey needs for the HDD bore, cable landing design and switchyard.

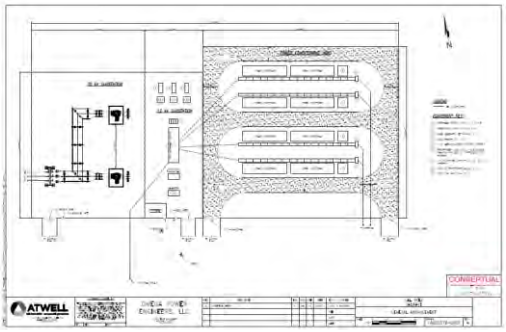


Figure 11-26: Electrical Switchyard Plan

The refined site layout integrated the conceptual shore station design and location with the offshore test berth locations, topography, bathymetry, subsea cable capabilities and constraints, in conjunction with host facility requirements.

This work led to the development and drafting of conceptual design drawings for the Civil, Electrical, and Architectural design drawings, with Mechanical and Auxiliary systems designs to follow in the next phase.

As mitigation to view shed considerations from the historic US Coast Guard Boathouse, plans include landscape screening, a screening berm, and the architectural style of the historic buildings is reflected in CalWave buildings.

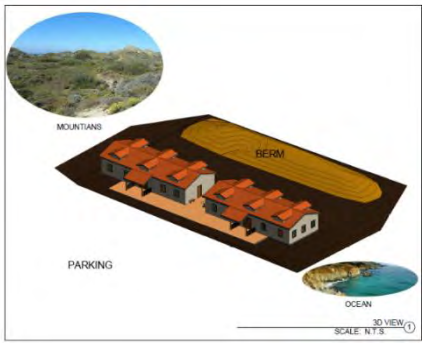


Figure 11-27: Berm

The basis of design is to interconnect the WECs, to shore, then to the grid, with proper isolation and instrumentation. The design is place-based and focused on the shore site location that was selected to the South Base Site near the VAFB dock due to the proximity to the test berths, the overall quality of the shore-side infrastructure and the benefit of being located outside of VAFB launch areas which come with significant operational restrictions/constraints, as informed by the Extreme Events Study.

Figure 11-28: South Base Site (Source Leidos, Inc.)

The useable open space for power conditioning equipment and a substation yard, existing electrical transmission infrastructure for interconnection access (12kV line with a 70kV substation for upgrade capacity), access roads and staging areas, and the VAFB dock infrastructure itself are all critical for logistics/operational and engineering/design considerations which makes the South shore site the most viable in conjunction with the South and Southeast ocean test sites.

Design features:

- Subsea cable rating and grounding scheme are key design factors
- The connection to the 12kV distribution grid will be underground to the existing pole line.
- The connection from the CalWave 70kV Substation will be above ground with a new pole line. Conceptual route review (historic and wildlife resources) was conducted with favorable results.
- Single Line Diagrams and General Arrangements were evolved by picking up comments from project team and other stakeholders (including Vandenberg AFB – (VAFB)).
- Preliminary Design of 70 kV Transmission Line design was developed to the level of detail appropriate for the Draft PAD. Coordination activities occurred to adjust 70 kV transmission line alignment to reflect potential impact of possible environmental and archeologically sensitive areas. Topographical information was acquired from public sources and Plan and profile drawings, including tower structure placements were prepared and submitted to project team (including permitting team) for coordination, review and comment.

11.3.7.1 Grid interconnection impact study summary

Security approval was obtained from the Western Electric Coordinating Council (WECC) and the WECC database was released to Omega Power and our subcontractor, Atwell, LLC for preparation of the Transmission Impact Study. A summary Transmission Impact study was prepared which examined the impact of adding 50 MVA of WEC generators into the Vandenberg system. The primary focus of the task was to ensure that the installation would not require costly modifications to the PG&E transmission system to accommodate the installation. A secondary (and out of scope) task was to evaluate the impact of the facility on the VAFB system. The out of scope work was performed at no cost to the project. The net determination was that there is no material impact to the PG&E system as a result of installing the CalWave project. There was a determination that the project could negatively impact the VAFB system under certain occasional and brief operating conditions. It was agreed that this eventuality would be accommodated with administrative and operational controls, so no net additional cost to the project was envisioned as a result of the study.

11.3.7.2 Platform Irene Engineering Considerations

Use of an offshore platform as a substation is very attractive.That said, the platform structures are weight-limited and the electrical systems are “mission-critical” for safety.

Repurposing of Platform Irene will require decommissioning from oil and gas operations and adaptation of the South Base Configuration design. CalWave cables will be installed using “J-Tubes” and extend approximately 1nm south of the platform to the Test Berths. Switchgear and limited test instrumentation will be installed on the platform. This will also include “decoupling” the Shore Station and separating the Operations Building from the Switchyard and Substation. From an operations perspective crew boats and/or helicopters will be used for personnel transfers.

Conversely, shared use of an operational oil and gas platform with the CalWave functions will be more complex. Electrical designs will require additional safety considerations and pose constraints and increase cost.

See Appendix 8: Electrical Engineering and Interconnect Study.

11.3.8 Subsea Cable Lessons Learned Report Summary

With a decade or more of submarine cables installed worldwide, especially in the wind farm market, there are some very good “lessons learned” papers published. Center Marine Services, Inc was engaged to prepare a lessons learned report.

After contacting sales people, cable masters and deck superintendents, Center Marine researched company files for lessons learned, and reviewed published lessons learned on the web, the best use of our time is to consolidate this information and reinforce the lessons learned from personal experience. Some of the documents are copy right protected, some are published, other are vessel logs. A list of the documents reviewed is in the report.

The evaluation included:

- Consider lessons learned from cable installations on the Pacific, Atlantic, and Gulf coasts
- Evaluate lessons learned from recent cable installations near the Los Angeles/Long Beach Basin
- Evaluate lessons learned in dynamic umbilicals and array interconnections
- Evaluate lessons learned in subsea connections, to include dry-mate and wet-mate
- Discuss progress on CalWave 25 kV, 10 MW cable design to-date with CalWave team
- Provide input on cable route desktop study specifications and future in-water surveys
- Leverage lessons learned in cable specification, procurement, logistics and installation to provide recommendations
- Lessons learned in deployment of subsea cables and electrical interconnections

See Attachment 11-9: Cable Logistics Study

11.3.9 Anchoring & Mooring Study Summary

Glosten and Associates provided a study of mooring and anchoring design considerations and lessons learned for wave energy converters.

In summary: In discussion with naval architects, WEC developers, and regulators about mooring and anchoring, the most probable WEC Developer designs will be multi-leg catenary moorings with drag-embedment anchors.

An alternative anchor technology is a “Suction Embedded Plate Anchor (SEPLA)”. An opportunity to further explore the use of SEPLA technology at this site would be as the mooring and anchoring system for the conceptual “Oceanographic Station” buoy that would leverage the spare cable. This oceanographic buoy would perform wave resource and meteorological instrumentation/data collection to better monitor facility conditions and the buoy would also serve as a terminus for the spare cable and can be used to perform a systems check and calibration after the WEC has arrived on-site and prior to installing the WEC in a test berth.

The basis of the Glosten analysis was that the CalWave Energy Test Center concept can be considered a second generation test facility for ocean renewable devices. The evolution of the ocean renewable technology and the experiences of earlier demonstration sites provide direction and efficiency in defining the interfaces between Test Center operators, prospective developers and permitting agencies.

Key efforts in the development of the Test Center include:

- Understanding the range and complexities of possible devices and how they may be accommodated and cultivated as a growing Test Center client base.
- Understanding the level and content of Test Center input required by developers to tailor energy generation for site conditions and provide design input for sound mooring and structural systems.
- Developing vetting programs for tenant developer designs and plans to manage risks to other tenants, Test Center infrastructure, future permitting efforts, and the wider health of the ocean renewable sector.
- This report will discuss each of these Test Center efforts in detail. Section 1 describes the potential devices, moorings, and export lines that could be installed at the test site.
- Section 2 describes the engineering and design codes and practices for permanent installations and temporary installation works.
- Section 3 discuss the risks for system developers, and how to mitigate them.
- Bottom-founded devices are excluded from this review, and while some moored ocean current generators may be categorized within the reviewed typologies, they are given light treatment due to the relatively low current speeds expected at the site.

See Attachment 11-10-1: Mooring and Anchoring Study

11.3.10 Navigation review with US Coast Guard summary

The WEC devices will be moored and anchored within the designated Test Berths and connected to by undersea cables that come ashore to the Upland Shore Station near Vandenberg Dock.

The United State Coast Guard (USCG) will conduct a navigation safety review as an advisory input to the Federal Energy Regulatory Commission (FERC), the Bureau of Ocean Energy Management (BOEM) for areas on the Outer Continental Shelf (OCS) outside of 3nm from shore and to the California State Lands Commission for the cables crossing the territorial sea.

The off-shore infrastructure must comply with all USCG regulations for navigation lighting and marking and those requirements are based on international treaties and standards. Current and future vessel traffic patterns will be considered as shown in the chart below.

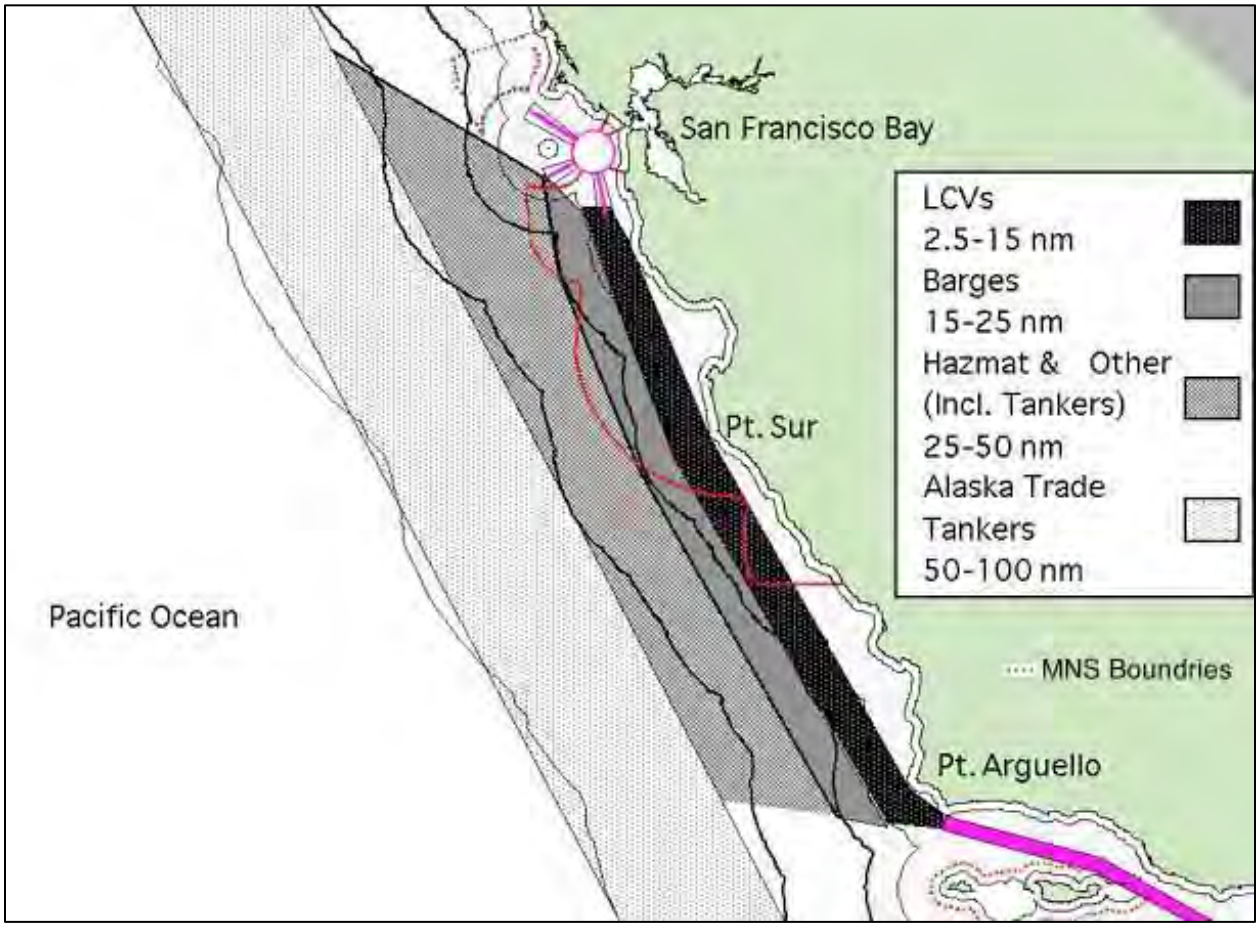


Figure 11-29: Previous Patterns of Vessel Traffic http://montereybay.noaa.gov/vt/vtexec.html

The site must be identified on navigation charts using USCG Notice to Mariners and its boundaries designated and marked on charts as an Area to be Avoided (ATBA). US Code or Federal Regulations 33 CFR Part 148.5. CalWave will propose a “Mandatory ATBA” for tug and tow, deep draft vessels, and trawl operations; and, will propose a “Recommended ATBA” for shallow draft and fishing vessels who enter the Test Berths at their own risk.

§ 148.5: *Area to be avoided* or *ATBA* means a routing measure comprising an area within defined limits in which either navigation is particularly hazardous or it is exceptionally important to avoid casualties and should be avoided by all ships or certain classes of vessels.

An ATBA may be either recommended ("recommendatory") or mandatory. An ATBA is recommendatory when ships are advised to navigate with caution in light of especially hazardous conditions.

An ATBA is mandatory when navigation is prohibited or subject to a competent authority's conditions.

§ 150.905: Why are safety zones, no anchoring areas, and areas to be avoided established?
(a) Safety zones, no anchoring areas (NAAs) and areas to be avoided (ATBAs) under this subchapter are established to promote safety of life and property, marine environmental protection, and navigational safety at deepwater ports and adjacent waters.
(b) Safety zones are the only federally regulated navigation areas. They accomplish these objectives by preventing or controlling specific activities, limiting access by vessels or persons, and by protecting the living resources of the sea from harmful agents.
(c) The NAAs and ATBAs are established via the International Maritime Organization (IMO). An NAA, specifically established to protect vessels in transit and sub-surface deepwater port components, will be mandatory. An ATBA will be a recommendatory routing measure.
(d) The sizes of restricted areas will be the minimum size needed to ensure safety, while at the same time considering potential impacts on other activities, including recreational boating, fishing, and Outer Continental Shelf activity.

The necessary inputs for the navigation safety review will start with a review of Automated Information System (AIS) tracks at the time of application, as well as a review of the prior year. Purchase of AIS viewer software will be required in the next phase.

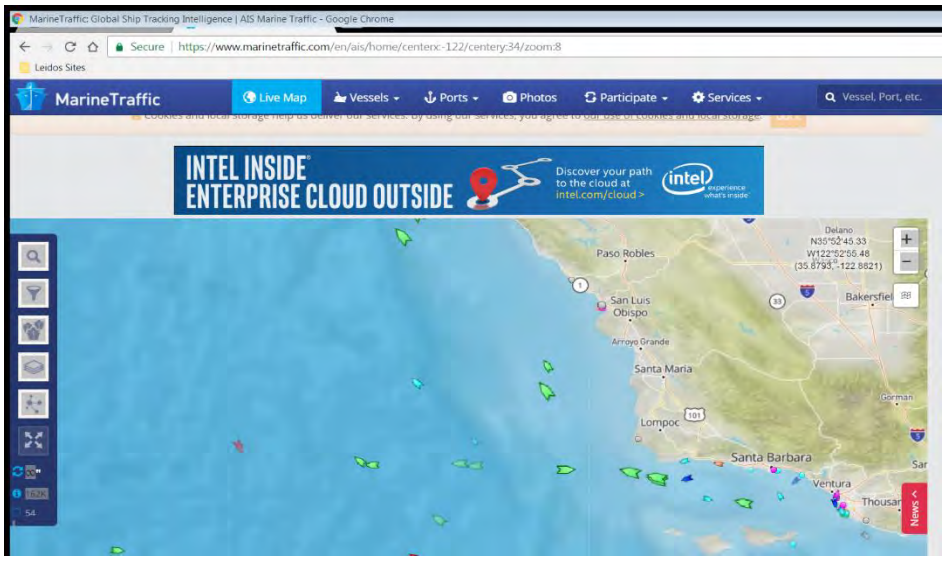


Figure 11-30: AIS Viewer: https://www.marinetraffic.com/en/ais/home/centerx:-122/centery:34/zoom:8

Given that fishing vessels are not typically equipped with AIS transponders, radar track data will be a valuable input. The method used at Camp Rilea in Oregon is recommended for data collection and analysis.

The coastal monitoring system consists with a Furuno radar and Nobletec software. Areas of analysis can be designated as shown in the screenshot below at Camp Rilea.

The designated areas are:

- Marine Danger Zone
- Project Datum Circle
- Cable Corridor rectangle

In the case of CalWave, Platform Hidalgo is equipped with an appropriate Furuno radar.

Figure 11-31: Example Coastal Monitoring System Area Analysis

As an example, the database stored tracks of AIS targets and radar targets entering the designated areas. Below is a picture of January 7th 2017 at about 9AM:

Figure 11-32: AIS and Radar Area Analysis

The data acquisition feature noted tracks by area, AIS and Automated Radar Piloting Aid (ARPA) radar tracks. Note: an AIS equipped vessel will show as both an AIS track and an ARPA track.

Baseline data collection started in mid-December, prior to commercial crab season. Almost no traffic was detected in the areas of interest until January 7.

Then, starting at about 7AM on January 7, crab season opened resulting in lots of contact (mainly in the Marine Danger Area).

Very few are crossing the Cable Corridor. Below are the statistics per day:

	Marine Danger		Project Datum		Cable Corridor	
Date	***AIS***	***ARPA***	***AIS***	***ARPA***	***AIS***	***ARPA***
12/19/2016	0	0	0	0	0	0
12/20/2016	0	0	0	0	0	0
12/21/2016	0	0	0	0	0	0
12/22/2016	0	1	0	0	0	0
12/23/2016	0	0	0	0	0	0
12/24/2016	0	0	0	0	0	0
12/25/2016	0	0	0	0	0	0
12/26/2016	0	0	0	0	0	0
12/27/2016	0	0	0	0	0	0
12/28/2016	0	0	0	0	0	0
12/29/2016	0	1	0	0	0	0
12/30/2016	0	0	0	0	0	0
12/31/2016	0	0	0	0	0	0
1/1/2017	0	0	0	0	0	0
1/2/2017	0	0	0	0	0	0
1/3/2017	0	0	0	0	0	0
1/4/2017	0	0	0	0	0	0
1/5/2017	0	0	0	0	0	0
1/6/2017	0	2	0	0	0	0
1/7/2017	8	41	4	8	0	2
1/8/2017	7	5	2	3	0	0
1/10/2017	3	40	0	15	0	2
1/11/2017	1	36	1	11	0	2
1/12/2017	5	39	1	8	1	3
1/13/2017	2	33	0	10	0	5
1/14/2017	1	30	0	12	0	6
1/15/2017	0	29	0	10	0	1
1/16/2017	2	12	0	4	0	2

Table 11-3: AIS Area Analysis Statistics Output

11.3.11 Risk Management Procedures Summary

Leidos provided the CalWave risk management approach that integrates risk, configuration control and contingency management. The approach is a foundation of complex acquisition programs.

Effective risk management will be critical to the success of the CalWave Program and the facility to be constructed. This planning will require close attention to current risk, vigilance to emerging risk, constant monitoring of risk, and the contingency against that risk.

The CalWave Program Team intends to use recognized and accepted techniques and analyses in our approach to risk management. The CalWave Program Risk Management Plan (RMP) will be fully developed during Phase III and will be based on a critical process approach to identify, assess, analyze, and track risk throughout the project.

The CalWave Program Team has made an initial effort to link identified risk elements to the WBS (see CalWave Program Risk Register). The Team intends to conduct a risk workshop early in Phase III to review and refine this preliminary Risk Register and lay the groundwork to complete the final RMP.

Risk Management Plan

The final RMP will build on this preliminary register and will include the following:

- Methodology
- Roles and Responsibilities
- Budgeting for Identified Risks
- Timing
- Risk Categories
- Definitions of Risk Probabilities and Impact
- Probability and Impact Matrix
- Stakeholders' Risk Tolerances
- Risk Reporting Processes
- Risk Tracking Processes.

Change Control and the associated Configuration Control will be vital. Changes will be managed in accordance accepted program and project management practices and DOE guidelines. The CalWave Program team will implement Change Control supports Configuration Management, Contingency Management, Risk Management and Quality Control.

See **Attachment 11-12: Risk Management**

11.3.12 Construction Estimates

Cost estimating efforts focused on the Primary Site, and the Conceptual Design of the South Base Configuration Baseline, near Vandenberg Dock. Refinements were made as the Preliminary Design Stage was initiated. Cost comparisons were used to estimate the alternatives.

The draft estimates were submitted to the project team in at the end of the 8th quarter for collaborative review and comment by the Team during the 9th Project Quarter and inclusion in the Final Report.

In support of this estimate budget quotations were solicited for the following materials and equipment:

- Substation Transformers
- Substation 70 kV Circuit Breakers
- Substation Minor Material package (steel, insulators, buswork, connectors, jumpers, instrument transformers)
- 10 MW Resistive Load Bank (for WEC testing)
- Substation Power & Control building (includes relaying, control batteries, and 34.5 kV switchgear).
- 70 kV spun concrete Transmission poles (matches current VAFB design standards)
- Transmission line materials package (wire, fiber optics, insulators, anchors, hardware, connectors, etc) (Materials match current VAFB design standards).

Primary Site – South Base (40MW)
The CalWave Team preliminary cost estimate is $82M with four (4) years from initiation of Phase 3 (Permitting) through Construction, Test and Certification.

Primary Site – South Base with Shore Station at Surf (40MW)
The CalWave Team preliminary cost estimate is $79M, with the same schedule.

Alternate Site – Platform Irene with Shore Station at Surf
The CalWave Team preliminary cost estimate is $75M. Scheduled to be determined.

See **Attachment 11-13: Cost Estimates**

11.4 Benchmarking

The CalWave Program has benefited from benchmarking activities that go back almost a decade and include two visits to EMEC, GalWay Bay, and UK WaveHub, and routine interaction with WETS, NNMREC, and Camp Rilea. Additional benchmarking was possible when UK WaveHuib joined the CalWave Team. CalWave's Electrical Engineer visited BIMEP in Spain and the CalWve Chief Engineer will visit in March 2017.

11.4.1 International WEC Testing and Certification Summary

CalWave benefited from participation in the US Marine Energy Council for industry engagement through the National Hydropower Association as well as international standards efforts.

- The CalWave Chief Engineer served as Secretary of the international project team of eleven countries and US Delegate to the International Electrotechnical Commission Technical Committee 114 (IEC TC 114) in the multi-year effort to write the Marine Energy Design Technical Specification (62600-2).
- The CalWave Chief Engineer is the US Committee Chair for the follow-on technical specification Maintenance Team.
- He also serves as a US Delegate to the IEC Renewable Energy (IECRE) Marine Energy effort as well as the Operational Management Committee (ME-OMC).
- CalWave is budgeting for the purchase IEC standards in Phase III for use by the expanded team and will require the use of IEC standards in supporting subcontracts.

11.4.2 Lessons learned, design, and operational considerations from UK Wave Hub

The Commercial Director from the UK Wave Hub testing facility presented material on a variety of information regarding the Wave Hub facility including lessons learned, its historical timeline, permitting obstacles, technical design considerations and construction challenges, the operations and maintenance procedures of the facility, its WEC developer contracting/berthing lease and power purchase agreement models, and risk mitigation strategies and insurance structures. Much of this information is still being internalized and considered by the CalWave team and it is likely that future reports will incorporate further lessons learned from this initial consultation visit. The UK Wave Hub commercial director which highlights many, but not all, of the topics covered. Below is an outline of the presentation:

<u>Presentation Topics</u>

- Wave Hub History (2003 First Project Review – 2011 Site Open)
- Site Overview
- Original Drivers for Funding and Constructing the Facility
- Infrastructure and Installation Funding Sources
- Initial Installation Management
- The Business Case for the Facility/Economic Impact
- Current Ownership and Governance

A risk and insurance presentation was given by a UK firm Renewable Risk Advisors and Power Point content can be seen in **Appendix Attachment 11-11-1 UK Wave Hub Marine Energy Insurance and Associated Risks for Test Sites and Early State Technologies July 2016.**

11.4.3 Lessons learned, design, and operational considerations from Camp Rilea

Camp Rilea

Work also included comparative analysis of the Camp Rilea, Oregon wave energy program infrastructure design. The Camp Rilea situation requires a much more detailed analysis of tsunami inundation, including site-specific soil conditions and modeled water velocity and duration, as well as vertical displacement. The resulting "momentum flux", as an expression of mass and velocity, is used to evaluate scouring potential and informs the cable route design. The VAFB South Base Shore Station avoids these issues.

Camp Rilea is also a useful source of considerations for shallow and mid-depth WEC testing including near-shore devices in the surf zone. A potential shallow site near Vandenberg Dock has been identified for a future phase.

11.4.4 Lessons learned, design, and operational considerations from BIMEP

Biscay Marine Energy Platform (BIMEP)

CalWave's electrical engineer with Omega Power Engineers held meetings on May 19, 2016 with Yago Torre-Enciso, Director of Bimep (Biscay Marine Energy Platform, S.A.) and their outside electrical engineer regarding the Bimep project in Spain. This information has been considered while developing the conceptual CalWave design. BIMEP provided a power point with additional facility information.

BACKGROUND:

- Bimep's mission appears very similar to CalWave's - i.e. as a demonstration facility for WEC devices. They are few years ahead of CalWave, with a constructed facility.
- Their project is located in Armintza, a small coastal about town about 10 km from Bilbao, Spain. Bimep's staff gave a presentation (attached) to the CalWave electrical engineer and a tour of their shore facilities. The Google Earth *.kmz file attached is a link to their shore power substation location
- The attached presentation provides insight into Bimep's philosophy and capabilities which drove the configuration of the facility.
- Bimep project ultimate capacity is 20 MW.

FACILITY DEVELOPMENT:

- They began the process to develop the project about 12 years ago, and were subject to a lengthy permitting process. Construction was completed in 2013.
- The project was constructed by awarding two EPC (Engineer-Procure-Construct) contracts: one for the submarine cables and terminations and a second for the shore facilities.
- The submarine cables were installed by Pirelli (Editorial note: This is the same entity we have been communicating with about technical requirements for the submarine cables at CalWave).
- The first WEC device (a 40 kW device) is scheduled for installation Fall of 2016.
- The apparent lag between the completion date of the project and the installation of the first WEC device is due to the project having to deal with a 'chicken and egg' circumstance – WEC

vendors needed to see the facility as a real project (i.e. in-service) before they risked investing in WEC device development.
- The Armintza site was chosen in part because of the proximity of transmission infrastructure as well as the wave resource. There is an abandoned ~1500 MW nuclear power plant (98% complete before abandonment) near the site, with robust unused transmission infrastructure installed. Interconnection is at 138 kV.
- The ownership of the Bimep project is ~92% EVE (Basque Energy Agency – the Regional Body) and IDEA (Spanish Energy Agency – the National Body).
- The project cost is listed at €20 MM ($22M). .

TECHNICAL DISCUSSION ITEMS Extensive discussion occurred with the Bimep EE about technical issues. Some specifics are as follows:

- Reviewed drawings of the Bimep facility. The electrical system configuration is very similar to what has been developed for CalWave, except the Bimep substation transformers
- Bimep system is 13.2 kV. Submarine cables are 13.2 kV from WEC devices to shore. 4 cables with capacity for 5 MW each.
- Bimep does not have on-site generators – they feel islanded operation is difficult to achieve with the resource.
- Bimep has two main power transformers, each rated for 100% capacity. (Current CalWave configuration is 2 transformers each rated at 50% of ultimate capacity – this may need review/discussion).
- Bimep uses dry mate connectors for offshore connections – they see wet mate connector technology as not mature enough nor needed for the application. (The frequency of connection/disconnection is a factor). They noted that reliability of offshore was a substantial design criterion. Cost of repair of an offshore cable failure was less of a concern than the lead time required to arrange for equipment for such a repair.

OTHER:

- The power generated by the facility is physically delivered to Iberdrola (a private Spanish company – who also works in the US), who apparently markets the power.

11.4.5 Design and Operational Input from NREL, Sandia, & EPRI

CalWave's collaboration with National Laboratories (NREL and Sandia) and the utility industry research organization (EPRI), as well as the UK WaveHub, shaped how the Test Center will support provide mature WECs (TRL 7-9) the opportunity to demonstrate readiness of their pre-commercial configuration without artificialities imposed by the test center, with instrumentation and data collection capabilities, and in a manner that documents performance and reliability, with certification support available, and in a location that is near market opportunities for commercialization.

When completed, CalWave will advance the state of the art and provide the testing infrastructure that will be the key to enabling a successful MHK industry. CalWave's infrastructure will be available to test designs across the span of technology readiness levels, and meet the MHK Industry needs, including open-water test berths and affordable access to world-class test facilities for emerging wave energy components and systems

Protection of proprietary data belonging to users of the test sites is of paramount importance.

The CalWave Conceptual Design implements a balanced system of data acquisition, data Management, physical security, personnel security, and cybersecurity. The design will implement lessons learned from WaveHub and NREL. The CalWave Supervisory Control and Data Acquisition (SCADA) System that monitors instrumentation will have password protection to ensure the separation of proprietary performance data. SCADA data, offshore electricity meter data and other performance data collected from test articles will be transmitted back to the substation using high speed high bandwidth fiber optic connections located within the main export cables. Each technology developer will have their own export cable and fiber optic connections to transmit and receive data. At the Shore Station, data will be routed through a switch to a secure communications cabinet. The conceptual design includes cabinets for each WEC developer who will have a key to gain exclusive access to their own cabinet. Each cabinet will have an Uninterruptable Power Supply to protect data in the event of a power failure.

The CalWave Shore Station will be provisioned with sufficient bandwidth to allow each WEC Developer to employ a Virtual Private Network (VPN) for proprietary communications. WEC performance data will be able to be accessed remotely by each technology developer using a secure internet link. A CalWave SharePoint server, with password protection, will be provisioned for shared documents, permitting, environmental, and test procedures. CalWave Staff will conduct periodic training on security measures and ethics. All personnel will be tasked with being observant for security risks and report any concerns to the Site Director. The Site Engineer/Quality Assurance Officer will monitor the system.

The installed infrastructure will provide the following minimum capability for each WEC Developer;

- Direct and tested multiple fiber connectivity to off-shore WEC or WEC Array
- LAN connectivity, for the installation of their server and network attached equipment
- Fire detection systems to give early warning of any smoke and/or fire.
- Separate guest wireless internet access for visiting WEC providers
- Optional secure remote access to network attached equipment.
- Optional site-to-site VPN service provision for upload of telemetry data
- Optional cloud data backup facilities

The CalWave development team is committed to providing WEC Developers with the capabilities needed to achieve commissioning and accreditation, starting with the commissioning and accreditation of the CalWave facility, procedures and people.

CalWave planning implements lessons learned from our partner, the UK Wave Hub. All procedure writing, and the testing of all berths and cables, will be completed as a condition of delivery. CalWave and NREL test engineering personnel to support this outcome will be included in Construction (Phase 4.0) and Test (Phase 5.0) staffing. The Test Phase will reflect the same concepts and responsibilities that will be employed during Operations (Phase 6.0) and the 30-year design life of CalWave.

The CalWave core development team will provide continuity to ensure that specifications and contracts support the end goals of commissioning and accreditation. They will monitor construction and progressive testing at key milestones, as well as provide independent witnesses in key integration, test and validation procedures.

- In addition to the on-site staff, the extended team of on-call personnel will provide additional utility industry expertise.
- The planned personnel assignments (detachments) from the Electric Power Research Institute (EPRI), National Renewable Energy Laboratory (NREL), and Sandia National Laboratories will provide utility industry and national laboratory experience in commissioning procedures and proven Test Engineers and Test Technicians, with additional services that include calibration, analytics and independent certification personnel from NREL.
- Additional independence and oversight is planned for in services from a third party certification society, such as DNV-GL.

The impact of CalWave will be significant. We will achieve each one of the DOE FOA objectives and target specifications and metrics. The design is based on providing the developers of mature (TRL7/9) WECs the optimum conditions to achieve both the MHK industry stakeholders and DOE objectives. The key is enabling WEC Developers to prove that their pre-commercial configuration delivers both utility-scale generation and utility-grade reliability.

Of particular importance is the removal of barriers to entry for the WEC Developer's pre-commercial configuration. Mature WECs are expected to have implemented a total system approach with a properly designed WEC; mooring and anchoring system; riser umbilical; and a practical method of deployment, maintenance and recovery using the readily available marine industry capabilities. Further, the WEC Developer is responsible to ensure their power conditioning for grid compliance, either onboard the individual WEC, in the WEC Array, or ashore in the Power Conditioning Area. CalWave will be provisioned with measurement and data acquisition capabilities. The CalWave System will include connection features for WEC Developers to demonstrate grid-compliance using load banks.

CalWave's core development team has worked together for almost a decade and combines practical project development and engineering experience with the financial acumen necessary to bring a test center into successful operation. The team intends to provide design, permitting, outreach, and operational services past the completion of the FOA's five-year period of performance and well into the future.

11.5 Planning & Specifications – Surveys and Wave Measurements

Existing geophysical, bathymetric and wave resource data were employed during the CalWave I and II Studies.

CalWave II included a Cable Route Desktop Study by Fugro-Pelagos. Leidos reviewed requirements for the scope of work for subsea cable route desktop study and led the survey team that conducted a Vandenberg AFB site visit that included Fugro Pelagos. The emphasis is on determining accurate bathymetry to support horizontal directional drill (HDD) bore profile design. Additional meetings with Fugro Pelagos were held on the week of July 11th. This study determined the follow-on surveys needed, including charting the kelp beds in the vicinity, and wave measurement instruments needed for CalWave.

Fugro Pelagros performed the cable route desktop study in order to develop a preliminary assessment of notional subsea cable routes, data gaps, and further surveys needed, as well as risk analysis per the International Cable Protection Committee Recommendation No. 9 – Minimum Technical Requirements for a Desktop Study (also known as Cable Route Study) Issue Date: 2 November, 2007.

The subsea cable route desktop study was initiated with a site survey The survey team that conducted a Vandenberg AFB site visit included Fugro Pelagos, the cable logistics consultant, the HDD industry representative and CalWave's PM, Chief Engineer, Electrical Engineer and VAFB Host. This resulted in a preferred Upland HDD Launch scenario and HDD bore profiles that have significant implications on the electrical and civil engineering designs. The alternate HDD Launch Site near the Dock has a lower vertical profile, but requires additional infrastructure to route the cables up the hill to the shore station. As a result, the conceptual bore profiles identified the need to closely consider cable pull strength constraints.

The conceptual bore profiles also identified a need for detailed bathymetry to find the 30 ft and 40 ft depth contours in the vicinity where the HDD bores will "daylight". The 30 ft curve is a ship safety consideration to avoid grounding. The 40 ft curve is a diver safety consideration to find a location outside the surf zone to avoid surges.

11.5.1 Follow on study/survey plan and needs assessment

The critical path in the next phase will be detailed bathymetric and geotechnical/geophysical surveys.

A cable route survey should be conducted along the selected route in advance of the cable installation in order to finalize an engineered route.
The surveys should be adequate to:

a. ascertain the presence of shallow geological anomalies or hazards and gather other information to be used as an aid in designing a safe cable route,
b. determine the presence and location of any significant man-made obstructions,
c. determine the position of existing in-service cables and pipelines in the approach to the landings,
d. enable an accurate profiling of the seafloor and cable engineering plan
e. assess burial feasibility along the route to the end of burial (EOB), if the cables are to be buried.

See **Attachment 11-5-1: Cable Route Desktop Study**

11.5.2 Wave energy resource assessment and findings summary

PG&E continues to prepare data and models for wave modeling effort and **Virginia Tech** extracted hindcast wave data for five Wavewatch III coastal grid points encompassing the CalWave candidate test berth sites, together with measured wave data from two validation stations operated by the Coastal Data Information Program (CDIP) at **Scripps Institution of Oceanography**.

See **Appendix 14: Wave Resource**

11.6 Engineering Progress Summary

The CalWave Engineering Element progressed efficiently through program stages: Feasibility Study; Geographic Site Down-Selection; Conceptual Design; Macro-Siting; Micro-Siting. Engineering, Permitting, and Stakeholder activities. Phase 1 progress was reported in the CalWave I Final Report.

The Engineering Element followed a Systems Engineering and System Integration Approach that was based on the guideless: Requirements-Driven; Technology-Neutral; and, Vendor-Agnostic. These guidelines were necessary to design a test center that will become operational in 2020-2022 and have a 30 year design life, support Wave Energy Converters that have not yet been invented.

Given the complexity of the design task, and the marine domain, a Spiral Development Model was employed for iterative approach

A viable Primary Site was identified and developed to sufficient detail to produce the Draft Pre-Application Document (Draft PAD), Regulatory Roadmap, and Stakeholder Engagement Plan for the Primary Site: the South Base Configuration Baseline.

Additionally, a viable Alternate Site was identified and developed for comparative estimating.

11.7 Primary Project Site Conclusion

The CalWave Primary Site (the Vandenberg South Base Site) will support full-scale, multi-unit array, grid-connected wave energy technology demonstrations and research in an area with market demand for wave energy, including 25MW demand from the onshore host, Vandenberg Air Force Base (VAFB). CalWave is designed with four (4) 10MW Test Berths in fully-energetic wave resource conditions with average annual power densities exceeding 30 kW/m, in water depths greater than 60 meters but still close to shore. The Primary Site design is rated at 40MW, with a path to 50MW, and has been developed into Preliminary Design Stage with adequate detail for a Draft pre-Application Document (Draft PAD).

The Vandenberg South Base Configuration Baseline leverages a decade of work, supported by U.S. DOE funding, by a dedicated core development team. Based on the work performed by EPRI, the PG&E WaveConnect Team, and CalWave, it is reasonable to state: The CalWave site off Vandenberg is the best wave energy site in the United States.

The CalWave System Concept is centered on “home run” cables and features that allow WEC Developers to field their mature pre-commercial system designs with a minimum of test facility-induced constraints. The dedicated cables enable precise measurement of performance and power quality from each test berth hosting individual devices or arrays. This design captures a significant lesson-learned from European wave energy test centers.

Additionally, and based on input during our Conceptual Design Review from the United Kingdom’s Wave Hub, that is currently largest and most advanced wave energy test center in the world, ***The CalWave Primary Site will be the most capable and most flexible wave energy test center in the world.***

11.8 Alternate Project Site Conclusion

The CalWave Alternate Site (Platform Irene Site) will also support full-scale, multi-unit array, grid-connected wave energy technology demonstrations and research in an area with market demand for wave energy, including 25MW demand from the onshore host, Vandenberg Air Force Base (VAFB). The CalWave Alternate Site is also designed with four (4) 10MW Test Berths in fully-energetic wave resource conditions with average annual power densities exceeding 30 kW/m, in water depths greater than 60 meters and connected to an offshore platform. The Alternate Site design is based upon the Primary Site and has been developed through Feasibility Stage into Conceptual Design Stage. The Alternate Site is rated at 25MW, with a path to 50MW.

The trade-space between the two sites includes: projected cost saving in cabling and horizontal directional drilling at Platform Irene and the elimination of permitting for new cable landings in the 25MW configuration, versus higher engineering complexity, more complicated access requirements for boats and helicopters, and higher operating costs.

11.9 Cost, Schedule, and Economics Recap

The CalWave Primary Site, in the South Base Configuration Baseline, is estimated (Preliminary) at $82M with a schedule to become operational in 2021-22 with a design life of 30 years.

11.9.1 Cost Summary

The CalWave Primary Site, in the South Base Configuration Baseline, is estimated (Preliminary) to include approximately $60M in construction costs and $22M in Non-Construction Costs, for a total of $82M. These estimates include conceptual-level quotations from key vendors

The CalWave Primary Site, in the South Base Configuration Baseline, is estimated (Preliminary) to include approximately $40M in construction costs, associated with less subsea cabling and no horizontal directional drilling, and $35M in Non-Construction Costs to include platform engineering, increased marine operations, and access constraints, for a total of $75M.

See **Attachment 11-13: Cost Estimating**

11.9.2 Schedule Summary

The conceptual schedule is shown in Figure 11-33: Conceptual CalWave Acquisition Timeline.

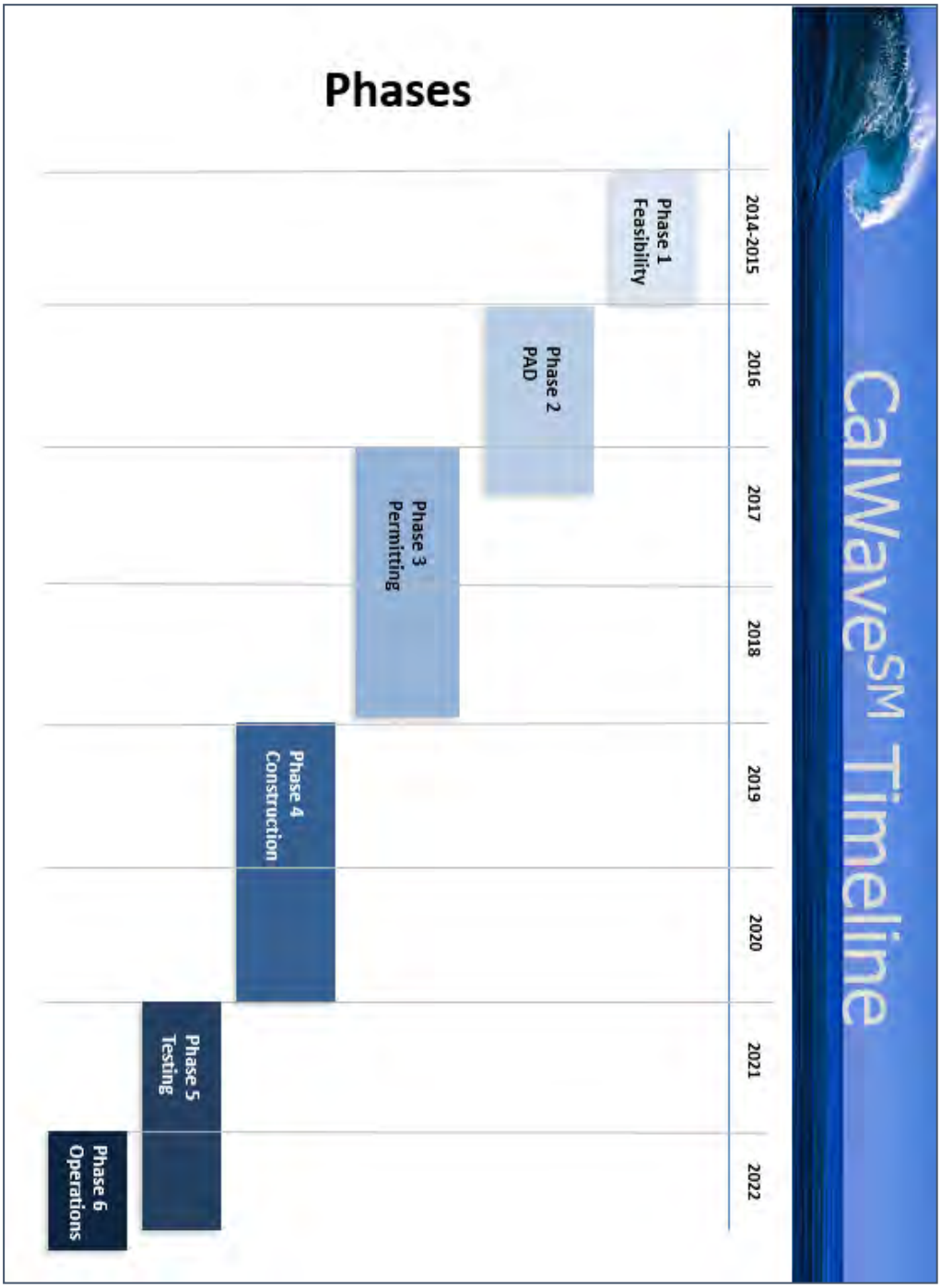


Figure 11-33: Conceptual CalWave Acquisition Timeline

The schedule is shown in more detail per Figure 11-34: Detailed Conceptual Timeline below:

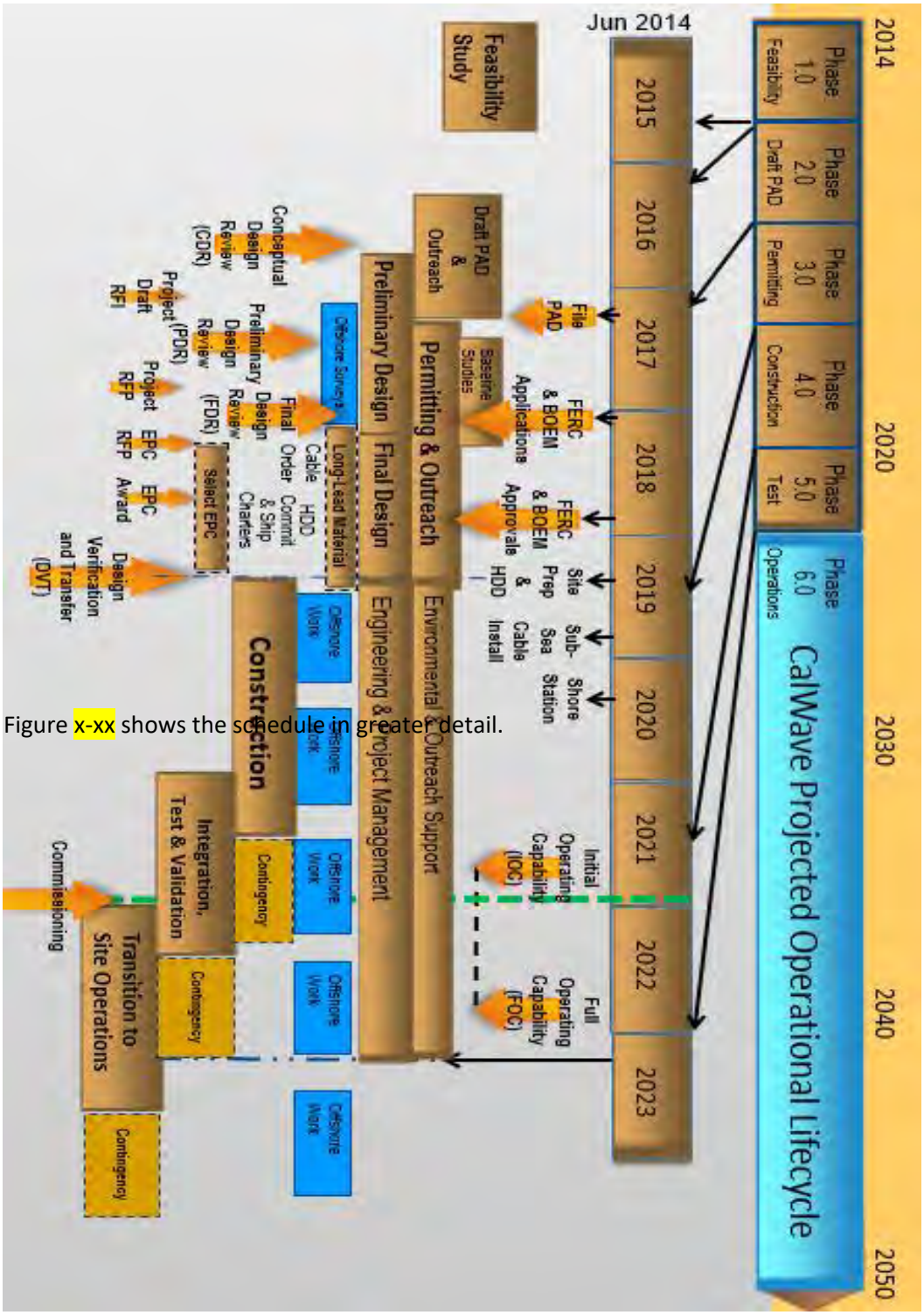


Figure x-xx shows the schedule in greater detail.

Figure 11-34: Detailed Conceptual Timeline

The Work Plan is based on the CalWave Program Phases (Projects) proposed timeline, summarized here:

Table 11-4 – CalWave Program Phases and Proposed Timeline					
SOPO	**Phase**	**WBS**	**Task Name**	**Start**	**Finish**
	Phase 0	0	WaveConnect (WaveConnect Completed)		
	Phase 1.0	1	Feasibility Study (CalWave I Completed)	5/7/14	10/7/15
	Phase 2.0	2	Draft PAD (CalWave II In Progress)	2/1/16	2/28/17
III	**Phase 3.0**	**3**	**Permitting (2017-2018)**	**3/1/17**	**12/31/18**
III-0		3	Contracts and PM	3/1/17	12/31/18
III-1		3.1	Engineering	3/1/17	12/31/18
III-2		3.2	Permitting/Environmental	3/1/17	7/31/18
III-3		3.3	Outreach	3/1/17	
III-4		3.4	In-Process Design Review	6/20/17	1/8/19
III-5		3.5	Initial Contracting Baseline	8/1/18	11/6/18
III-6		3.6	Change Management	9/7/17	12/17/18
III-7		3.7	Reporting	3/1/17	12/31/18
IV	**Phase 4.0**	**4**	**Construction (2019-2020)**	**10/1/18**	**12/31/20**
IV-0		4	Contracts and PM	10/1/18	12/31/20
IV-1		4.1	Engineering and Final Design	10/1/18	12/31/20
IV-2		4.2	Permitting/Environmental	10/1/18	12/31/20
IV-3		4.3	Outreach	10/1/18	12/31/20
IV-4		4.4	In-Process Design Review	3/18/19	9/4/19
IV-5		4.5	Configuration Management	10/1/18	12/31/20
IV-6		4.6	Change Management	10/1/18	12/31/20
IV-7		4.7	Reporting	10/1/18	12/31/20
V	**Phase 5.0**	**5**	**Test (2020-2021)**	**10/1/20**	**12/31/21**
V-0		5	Contracts and PM	10/1/20	12/31/21
V-1		5.1	Engineering	10/1/20	11/23/21
V-2		5.2	Permitting/Environmental	10/1/20	12/31/21
V-3		5.3	Outreach	10/1/20	12/31/21
V-4		5.4	Test Readiness Review	2/4/21	2/9/21
V-5		5.5	Configuration Management	10/1/20	12/31/21
V-6		5.6	Change Management	10/1/20	12/31/21
V-7		5.7	Reporting	10/1/20	12/31/21
VI	**Phase 6.0**	**6**	**Operations (2021-2022 plus 30 years)**	**10/1/21**	**12/30/22**
VI-0		6	Contracts and PM	10/1/21	12/30/22
VI-1		6.1	Engineering	10/1/21	10/13/22
VI-2		6.2	Permitting/Environmental	10/1/21	12/30/22
VI-3		6.3	Outreach	10/1/21	12/30/22
VI-4		6.4	Operational Readiness Review	2/4/22	2/9/22
VI-5		6.5	Configuration Management	10/1/21	12/30/22
VI-6		6.6	Change Management	10/1/21	12/30/22

11.10 Recommendations and Further Study Needs

We recommend that the CalWave Team continue to evolve the Preliminary Design from the Draft Pre-Application Document (Draft PAD) to Final Design Stage and into Construction, Test and Operation.

The critical path in the next phase will be detailed bathymetric and geotechnical/geophysical surveys.

In the next phase of work, we will review responses from agencies and regulators and incorporate inputs, update the Preliminary Design, and submit the Preliminary Application Document (PAD).

The responses and conditions associated with approval of the PAD will be incorporated into the design and we will conduct a Preliminary Design Review (PDR). After PDR actions are incorporated, we complete the Preliminary Design.

At that point, we proceed into the Final Design Stage to support selection of an Engineering, Procurement and Construction (EPC) contractor. The EPC RFP will include a Value Engineering Review, a Final Design Review (FDR), and a Design Verification and Transfer (DVT).

After Value Engineering inputs are considered and FDR actions are incorporated, we will complete the Final Design and then conduct the DVT. After the EPC completes DVT, they will commence the Detailed Engineering Stage at the level of specificity needed for construction drawings.

These steps are consistent with the Spiral Design Model and needed in the marine construction domain for risk reduction.

Attachment 11-2: Top- Level Requirements and Site Selection Criteria

Top-Level Requirements:

- Requirements-driven, modular design of an open-ocean, fully energetic Test Center.
- Grid-connected Test Berths with excellent wave resource and deep water depths.
- Design features (mooring/anchoring flexibility, electrical system, power conditioning options, and test instrumentation) that remove barriers to entry for WEC developers.
- Integrate with host facility grid infrastructure and connecting utility.
- Integrate with host facility civil facilities and environmental guidelines.
- Integrate with local marine industry support with decades of experience at this site.
- Integrate input from stakeholders, agencies, and regulators in Draft Project Description.

Site Selection Criteria:

Site Selection Criteria, SOPO Task #1

No.	Site Selection Criterion
1	Wave energy resource for a test center, P_{min} 30 KW/m, months per year
2	Variability of sea states for a test center
3a	Flexibility to accommodate different WEC designs, compactness for a range of depths >75m
3b	Sea bottom terrain
4	Extreme event design environment
5	Operations port suitability/capability and affordability of ocean engineering equipment
6	Operations port proximity and ability to accomplish tasks in a day charter
7	Construction accessibility for both sea-based and shore-based infrastructure
8	Regional heavy manufacturing / marine supply chain capability
9	Regional industrial marine support operations capability
10	Certainty / length of regulatory and permitting pathway
11	Ease of interconnection for 30 MW
12	Power sales potential for 30 MW
13	Academic/research community proximity
14	Existing infrastructure for co-use, substation
15	Existing infrastructure for co-use, submarine cable
16	Stakeholder support
17	Site commercial buildout potential
18	Ease of interconnection for 300 MW
19	Proximity to shipbuilding facility for WEC fabrication

Attachment 11-3: Project Objectives, Alternatives and Top-Level Concept

Project Objectives:

- Candidate test site areas, comparing a siting area in off Humboldt Bay in northern California and one off Vandenberg Air Force Base (AFB), Central California
- Availability of shore-side infrastructure to support the test center
- Availability and suitability of co-using existing offshore energy infrastructure
- Capacity of the local electrical grid system to accept test center power and on-shore power facilities
- Site area environmental permitting issues and agencies and available baseline data
- Potential for public and agency stakeholder acceptance of the project and siting area
- Top-Level Requirements and testing device design criteria
- Approach to preparing preliminary design drawings
- Potential costs of constructing the test center
- Potential costs of operating and maintaining the test center
- A schedule for project development and facility construction

Range of Alternatives:

- Two potential regional locations (Eureka/Humboldt Bay and Vandenberg/Central Coast)
- Five test site alternatives at Vandenberg
- Potential co-use of an existing offshore oil platform, its 25 MW capacity submarine power cable going ashore, and the associated shore substation with its existing interconnection with the incumbent utility
- Three potential new cable landings with shore stations at Vandenberg

Top-Level Concept:

Based on benchmarking international test sites, the CalWave System Concept is centered on “home run” cables and features that allow WEC Developers to field their mature pre-commercial system designs with a minimum of test facility-induced constraints, a significant lesson-learned from other wave energy test centers. Implement design goals and objectives that enable precise measurement of performance from each test berth hosting individual WECs or arrays.

Given the costs of tooling, mobilization and demobilization and ocean operations, a spare cable is a major benefit with reasonable cost.

Attachment 11-4: System Block Diagrams and Interface Definition List

The design implements the system concept, starting with system block diagrams that show major interfaces:

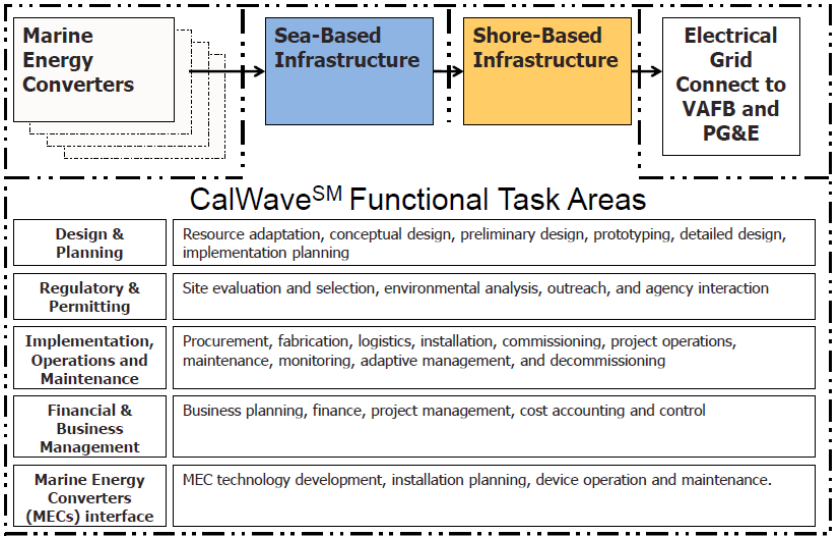


Figure 11-4-1: CalWave System Block Diagram – Conceptual

The term "Marine Energy Converter (MEC)" was narrowed for CalWave to:"Wave Energy Converter (WEC)". There are two system block diagram methods for describing CalWave, both emphasize the importance of interface definition and control, particularly at Designated Critical Interfaces:

WEC-References System Block Diagram: used during the Conceptual Design Stage. This method is "customer-centered" and addresses the primary mission of supporting the MHK industry and WEC developers. It starts with the WEC array(s) and progresses through the CalWave system to the host facility and connecting utility.

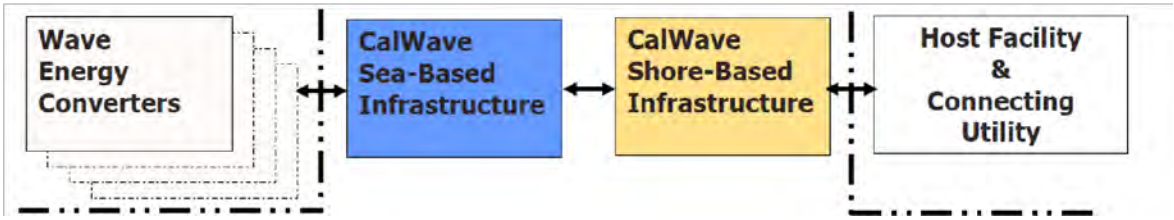


Figure 11-4-2: WEC-Referenced System Block Diagram (Source: Leidos)

Grid-Referenced System Block Diagram: used during Preliminary, Final, and Detailed Design Stages. This method is "power purchaser-centered" and addresses the end goal of commercialization. It also acknowledges that the Grid is a mature Boundary System that CalWave and WECs must comply with. This method better represents the facility construction.

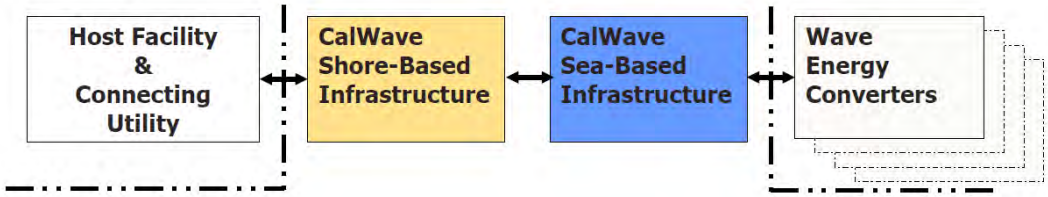


Figure 11-4-3: Grid-Referenced System Block Diagram (Source: Leidos)

System Boundaries

The system boundary was defined as including the Sea-Based Infrastructure and Shore-Based Infrastructure are summarized below in the System Block Diagrams developed by **Leidos** Inc. A more detailed discussion, including functional task areas, is in D.11 Engineering Element. Boundary systems were identified as: WEC/MEC System; VAFB-PG&E Electrical Grids; and VAFB Base Facilities.

- CalWave is also a system of systems including sea-based infrastructure and shore-based infrastructure as well as multiple supporting systems and sub-systems such as instrumentation and telemetry, data acquisition and management.
- CalWave interfaces to the host facility as a boundary system" in that we must adhere to the interface requirements of the host. The host facility, Vandenberg AFB, is also a system of systems including: civil; architectural; mechanical; and electrical systems, and related sub-systems, such as electrical grid with connection to the PG&E utility grid, and the environment.
- The CalWave system interfaces to WEC(s) and WEC array(s) as another boundary system. The WEC system(s) must adhere to the interface requirements of CalWave, in particular the design and operational limits of the submarine cable and grid compliant power.
- Wave Energy Converter System(s) also interface to the ocean environment with multiple sub-systems such as mooring, anchoring, riser umbilical(s) and power conditioning.

Interface development

The approach to interface definition is to use the system block diagram. Where there is a line between the blocks that is an interface.

Proceeding to more detail, the next consideration is criticality, to either life of system function, and designate critical interfaces. The next consideration is complexity, particularly where coordination is required across functional or organizational lines and designated controlled interfaces.

One of the benefits of this approach is to use as much detail as needed, and no more. This resulted in the following Preliminary Interface List:

Critical Interfaces

1. Subsea Connectors at CalWave System Boundary to WEC Subsea Connector
2. Subsea Cables to CalWave Transition Switchgear Grounding Scheme
3. 12kV Connection at CalWave System Boundary to VAFB Distribution Grid
4. 70kV Connection at CalWave System Boundary to VAFB Transmission Grid
5. WEC Onboard Monitoring and Telemetry to CalWave Control System

Controlled Interfaces

1. Subsea Cable Specification to HDD Bore Specification
2. Subsea Cable Connections to CalWave Switchgear and Instrumentation
3. CalWave Switchgear and Instrumentation to WEC Power Conditioning (inbound)
4. WEC Power Conditioning to CalWave Switchgear and Instrumentation (outbound)
5. WEC Mooring and Anchoring interface to sea floor
6. WEC interface to ocean environment
7. CalWave Shore Station to VAFB physical site (Air, Water, Ground)
8. CalWave Shore Station to VAFB environment and wildlife
9. CalWave Shore Station to VAFB cultural and historic resources

Attachment 11-5: Cable Route Desktop Study

CalWave II included a Cable Route Desktop Study by Fugro-Pelagos. Leidos reviewed requirements for the scope of work for subsea cable route desktop study and led the survey team that conducted a Vandenberg AFB site visit that included Fugro Pelagos. The emphasis is on determining accurate bathymetry to support horizontal directional drill (HDD) bore profile design. Additional meetings with Fugro Pelagos were held on the week of July 11th. This study determined the follow-on surveys needed, including charting the kelp beds in the vicinity, and wave measurement instruments needed for CalWave.

Fugro Pelagros performed the cable route desktop study in order to develop a preliminary assessment of notional subsea cable routes, data gaps, and further surveys needed, as well as risk analysis per the International Cable Protection Committee Recommendation No. 9 – Minimum Technical Requirements for a Desktop Study (also known as Cable Route Study) Issue Date: 2 November, 2007.

The subsea cable route desktop study was initiated with a site survey The survey team that conducted a Vandenberg AFB site visit included Fugro Pelagos, the cable logistics consultant, the HDD industry representative and CalWave's PM, Chief Engineer, Electrical Engineer and VAFB Host. This resulted in a preferred Upland HDD Launch scenario and HDD bore profiles that have significant implications on the electrical and civil engineering designs. The alternate HDD Launch Site near the Dock has a lower vertical profile, but requires additional infrastructure to route the cables up the hill to the shore station. As a result, the conceptual bore profiles identified the need to closely consider cable pull strength constraints.

The conceptual bore profiles also identified a need for detailed bathymetry to find the 30 ft and 40 ft depth contours in the vicinity where the HDD bores will "daylight". The 30 ft curve is a ship safety consideration to avoid grounding. The 40 ft curve is a diver safety consideration to find a location outside the surf zone to avoid surges.

SURVEY RECOMMENDATIONS

A cable route survey should be conducted along the selected route in advance of the cable installation in order to finalize an engineered route.
The surveys should be adequate to:

a. ascertain the presence of shallow geological anomalies or hazards and gather other information to be used as an aid in designing a safe cable route,
b. determine the presence and location of any significant man-made obstructions,
c. determine the position of existing in-service cables and pipelines in the approach to the landings,
d. enable an accurate profiling of the seafloor and cable engineering plan
e. assess burial feasibility along the route to the end of burial (EOB), if the cables are to be buried.

Based on the above criteria, it is essential to have facilities on site that allow immediate routing decisions to be made in case unfavorable seabed conditions are discovered along the route during the survey. In addition, the most complex survey operations will occur within the burial areas. These are areas where the most amount of survey data will have to be collected and analyzed.

The following survey specifications are provided as general recommendations and guidelines for acquiring the data required to engineer and install the cable routes.

Table 11.5.1: General Survey Recommendations for the CalWave Submarine Power Cable Routes			
Survey Phase	**Survey Sensor**	**Description**	**Survey Corridor**
Geophysical Survey	Multibeam Echo Sounder (MBES)	Bathymetric contours to ascertain water depth along the route	250 m corridor (minimum) centered over each submarine power cable route
	Side Scan Sonar (SSS)	SSS mosaics – imagery of the seabed, interpreted for geologic features and sediment classification	250 m corridor (minimum) centered over each submarine power cable route
	Sub-bottom Profiler (SBP)	Sub-bottom profile of the upper 10 m+ of seabed for interpretation of sediment coverage, buried geologic features, etc.	Centerline (minimum) along each submarine power cable route
Geotechnical	Gravity Core	Sediment samples of upper 1 m of seabed for aid in ground-truthing sediment classification from SSS data	1 core / kilometer centered over in-field selected route, conducted after geophysical survey.
	Cone Penetration Tests (CPTs)	Sediment classification at-depth below the seabed to aid burial feasibility and sub- bottom conditions	1 CPT / kilometer centered over in-field selected route, conducted after geophysical survey

Typically the CPT's and the Sub-bottom Profile data would only be collected if there was a possibility the cables would be buried. If the cables are to be surface-laid, a survey including MBES, SSS and Coring would be adequate for a submarine power cable installation, except for areas of planned HDD. Sub-bottom and CPT information would be useful in order to characterize the conditions of the HDD operation.

In addition to a marine route survey which include the geophysical and geotechnical components outlined above, a marine environmental survey will likely be required by the State of California and includes assessment of the benthic habitat and an archaeological assessment. In addition, Marine Mammal Observers (MMOs) will have to be onboard to observe all vessel related activities including survey and installation operations.

CALWAVE DESKTOP STUDY

For the

Submarine Export Power Cables

FINAL REPORT
Revision 1

Volume 1 of 1

Prepared for

CALWAVE

Submitted by

Fugro Pelagos, Inc
3574 Ruffin Road
San Diego, CA 92123
www.fugro-pelagos.com
Tel: +1 858 292-8922

* * *

7 November 2016

CALWAVE DESKTOP STUDY

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Submarine Export Power Cables

FINAL REPORT
Revision 1

Volume 1 of 1

Prepared for: **CH2M HILL**

Mr. Doug Davy
Technical Point of Contact
2485 Natomas Park Drive, Suite 600
Sacramento, CA 95833
Tel: +1 916.286.0278
Email: doug.davy@ch2m.com

Rev	Description	Prepared	Date
0	CALWAVE DRAFT DTS REPORT	Ryan Wopschall / Chuck Chamberlain	29 July 2016
1	CALWAVE FINAL DTS REPORT	Ryan Wopschall / Chuck Chamberlain	7 November 2016

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EXECUTIVE SUMMARY

Fugro Pelagos, Inc. (FPI) is pleased to submit to CH2M Hill and the CalWave Project Team this FINAL Desktop Study (DTS) report for the evaluation and design of the HVAC export power cables, intended to connect future wave energy facilities offshore Vandenberg Air Force Base (VAFB). The planned cable configuration includes the allowance for five (5) power cables to be installed from a landing point at VAFB via Horizontal Direction Drilling (HDD) and extending approximately 7 km (4.3 miles) offshore where they reach a terminus point roughly centered within the areas proposed to accept the future installation of wave energy facilities.

This FINAL DTS report has been prepared to incorporate comments provided by Leidos and CH2M Hill based upon the review of the draft version. Further follow-on work, particularly with the design of the cables, consideration of a “cable corridor” and other cable-specific requirements will be provided to the CalWave team on an on-going basis through email and phone communication as the project develops.

This desktop study has utilized the International Cable Protection Committee’s (ICPC) Recommendation No. 9, Issue 3 – Minimum Technical Requirements for a Desktop Study, as a guideline for the study and design of the submarine power cables. This DTS report was prepared for planning purposes based on the evaluation and assessment of the main risks and hazards associated with the planned cable routes.

This report highlights the main issues and considerations with regard to pertinent information on seabed depths, geological conditions and hazards along the proposed cable alignments. Where available and/or researched, this report also summarizes weather conditions, general permitting considerations, and information on existing cables and other seabed infrastructure, and fisheries considerations offshore each landing. Also provided with this report are the routes designed at the time of this DTS, which are subject to modification when a marine route survey is conducted.

To achieve feasible cable alignments for the CalWave submarine power cables, several steps were taken specific to this study. These steps included:

- Conducting a site visit with the CalWave Project Team to assess a Primary and Alternate landing site location
- Liaison with The HDD Company and Leidos regarding orientation and extent of directional drilling from the landing points to a distance offshore and the determination of the HDD entry and exit points for each cable
- Optimization of each cable route for both the Primary and Alternate landings based on offshore conditions and hazards
- Gap analysis to provide recommendation on stakeholder outreach, permitting, and marine route survey requirements including environmental, geophysical and geotechnical investigations.

A list of the cable segments designed during the DTS project are provided in the tables below. The tables delineate the cable segments designed for the Primary and Alternate landing points selected throughout the course of the study. The coordinates for the HDD bore entry and exit points are listed, as well as the terminus point for each cable. Summarized also are the overall route lengths of each cable, and the total cable length to for all five segments. It is noted that the lengths provided in this study are “route” lengths and do not include any extra cable slack, as may be applied during installation.

Below is a summary of the segments designed for this study, including the scenarios for the HDD borehole exiting at the 5m contour and the 10m contour:

CalWave *Primary* Cable Segments (WGS84), 5m Contour Bore Exit					
Cable Segment	**Bore No.**	**Bore Entry Coordinates**	**Bore Exit Coordinates (5m Contour)**	**Cable Terminus**	**Route Length (km) / (mi)**
Segment 1 – West	01	34° 33' 20.3552" N	34° 33' 05.5665" N	34° 33' 20.3552" N	7.630 / 4.741
		120° 36' 51.9475" W	120° 36' 53.4111" W	120° 36' 51.9475" W	
Segment 2 – Southwest	02	34° 33' 20.3506" N	34° 33' 05.5151" N	34° 33' 20.3506" N	7.460 / 4.635
		120° 36' 51.8796" W	120° 36' 51.7798" W	120° 36' 51.8796" W	
Segment 3 – Anchorage (Spare)	03	34° 33' 20.3558" N	34° 33' 05.5816" N	34° 33' 20.3558" N	5.767 / 3.583
		120° 36' 51.8117" W	120° 36' 50.1493" W	120° 36' 51.8117" W	
Segment 4 – South	04	34° 33' 20.3635" N	34° 33' 05.7653" N	34° 33' 20.3635" N	7.122 / 4.425
		120° 36' 51.7443" W	120° 36' 48.5319" W	120° 36' 51.7443" W	
Segment 5 – Southeast	05	34° 33' 20.3760" N	34° 33' 06.0650" N	34° 33' 20.3760" N	7.525 / 4.676
		120° 36' 51.6780" W	120° 36' 46.9400" W	120° 36' 51.6780" W	
				Total	**35.504 / 22.060**

CalWave *Primary* Cable Segments (WGS84), 10m Contour Bore Exit					
Cable Segment	**Bore No.**	**Bore Entry Coordinates**	**Bore Exit Coordinates (10m Contour)**	**Cable Terminus**	**Route Length (km) / (mi)**
Segment 1 – West	01	34° 33' 20.3552" N	34° 32' 55.5000" N	34° 33' 20.3552" N	7.630 / 4.741
		120° 36' 51.9475" W	120° 36' 54.3600" W	120° 36' 51.9475" W	
Segment 2 – Southwest	02	34° 33' 20.3506" N	34° 32' 54.7200" N	34° 33' 20.3506" N	7.460 / 4.635
		120° 36' 51.8796" W	120° 36' 51.8400" W	120° 36' 51.8796" W	
Segment 3 – Anchorage (Spare)	03	34° 33' 20.3558" N	34° 32' 54.6000" N	34° 33' 20.3558" N	5.767 / 3.583
		120° 36' 51.8117" W	120° 36' 48.9600" W	120° 36' 51.8117" W	
Segment 4 – South	04	34° 33' 20.3635" N	34° 32' 55.7400" N	34° 33' 20.3635" N	7.122 / 4.425
		120° 36' 51.7443" W	120° 36' 46.2600" W	120° 36' 51.7443" W	
Segment 5 – Southeast	05	34° 33' 20.3760" N	34° 32' 56.2200" N	34° 33' 20.3760" N	7.525 / 4.676
		120° 36' 51.6780" W	120° 36' 43.5000" W	120° 36' 51.6780" W	
				Total	**35.504 / 22.060**

CalWave *Alternate* Cable Segments (WGS84), 5m Contour Bore Exit					
Cable Segment	**Bore No.**	**Bore Entry Coordinates**	**Bore Exit Coordinates (5m Contour)**	**Cable Terminus**	**Route Length (km) / (mi)**
Segment 1 – West	01	34° 33' 17.7742" N	34° 33' 03.4205" N	34° 33' 20.3552" N	7.832 / 4.867
		120° 36' 37.7615" W	120° 36' 42.3070" W	120° 36' 51.9475" W	
Segment 2 – Southwest	02	34° 33' 17.7623" N	34° 33' 03.1355" N	34° 33' 20.3506" N	7.606 / 4.726
		120° 36' 37.6950" W	120° 36' 40.7113" W	120° 36' 51.8796" W	
Segment 3 – Anchorage (Spare)	03	34° 33' 17.7553" N	34° 33' 02.9666" N	34° 33' 20.3558" N	5.838 / 3.628
		120° 36' 37.6276" W	120° 36' 39.0916" W	120° 36' 51.8117" W	
Segment 4 – South	04	34° 33' 17.7531" N	34° 33' 02.9152" N	34° 33' 20.3635" N	7.076 / 4.397
		120° 36' 37.5596" W	120° 36' 37.4602" W	120° 36' 51.7443" W	
Segment 5 – Southeast	05	34° 33' 17.7531" N	34° 33' 02.9816" N	34° 33' 20.3760" N	7.350 / 4.567
		120° 36' 37.5596" W	120° 36' 35.8297" W	120° 36' 51.6780" W	
				Total	**35.702 / 22.185**

CalWave *Alternate* Cable Segments (WGS84), 10m Contour Bore Exit					
Cable Segment	**Bore No.**	**Bore Entry Coordinates**	**Bore Exit Coordinates (10m Contour)**	**Cable Terminus**	**Route Length (km) / (mi)**
Segment 1 – West	01	34° 33' 17.7742" N	34° 32' 55.9800" N	34° 33' 20.3552" N	7.832 / 4.867
		120° 36' 37.7615" W	120° 36' 44.8200" W	120° 36' 51.9475" W	
Segment 2 – Southwest	02	34° 33' 17.7623" N	34° 32' 57.6600" N	34° 33' 20.3506" N	7.606 / 4.726
		120° 36' 37.6950" W	120° 36' 41.8200" W	120° 36' 51.8796" W	
Segment 3 – Anchorage (Spare)	03	34° 33' 17.7553" N	34° 32' 59.1000" N	34° 33' 20.3558" N	5.838 / 3.628
		120° 36' 37.6276" W	120° 36' 39.3600" W	120° 36' 51.8117" W	
Segment 4 – South	04	34° 33' 17.7531" N	34° 32' 59.4600" N	34° 33' 20.3635" N	7.076 / 4.397
		120° 36' 37.5596" W	120° 36' 37.2600" W	120° 36' 51.7443" W	
Segment 5 – Southeast	05	34° 33' 17.7531" N	34° 32' 59.1000" N	34° 33' 20.3760" N	7.350 / 4.567
		120° 36' 37.5596" W	120° 36' 35.7000" W	120° 36' 51.6780" W	
				Total	**35.702 / 22.185**

In addition to the above information, below are the approximate distances (for reference) of the primary and alternate segments to get straight out to the 10 m contour and past the anticipated outcropped Monterey formation. To get these distances, the currently planned HDD routing was projected in a straight-line measurement to the end of the interpreted rock areas.

PRIMARY (10 m contour)
Seg 1: 3,048 ft
Seg 2: 3,171 ft
Seg 3: 3,172 ft
Seg 4: 3,051 ft
Seg 5: 3,031 ft

ALTERNATE (10 m contour)
Seg 1: 2,751 ft
Seg 2: 2,509 ft
Seg 3: 2,280 ft
Seg 4: 2,238 ft
Seg 5: 2,269 ft

Also shown below are the bore lengths (approximate) to the 5 m contour:

PRIMARY (5 m contour)
Seg 1: 1,488 ft
Seg 2: 1,495 ft
Seg 3: 1,493 ft
Seg 4: 1,497 ft
Seg 5: 1,507 ft

ALTERNATE (5 m contour)
Seg 1: 1,491 ft
Seg 2: 1,487 ft
Seg 3: 1,488 ft
Seg 4: 1,513 ft
Seg 5: 1,498 ft

At the time of this study, it is not yet clear if cable burial will be required either as a regulatory factor or as a cable protection measure to guard against potential damages caused by possible bottom trawl fishing (if any) or vessel anchorages.

A summary of the significant results of this feasibility study includes:

General Results:

- The CalWave cables transit through charted Military Practice Areas. All vessel related activity such as survey and installation operations will have to be coordinated with the relevant authorities at Vandenberg Air Force Base.
- The CalWave cables exit the HDD boreholes in approximately 5 m water depth and have to run along areas of interpreted hard rock to approximately the 10 m contour until softer sediments are reached, posing less risk to the submarine cable. Cable protection measures such as rock dumping, pinning or others should be considered in areas where the cables may be surface laid on hard rock to prevent currents from moving the cable and risking abrasion and damage.

- Further investigations will need to take place in the form of stakeholder engagement with the State of California and the Fisheries groups to understand the risk and requirements necessitating cable burial as either a regulatory measure or a cable protection measure.
- The submarine power cable routes terminate in water depths ranging from 70 to 80 m deep. It is anticipated that from the 10 m contour to these terminus locations, soft sediments including sand, silt and clay will be present. Aside from the immediate area offshore to the 10 m contour where hard rock exists, all other areas of interpreted rock have been avoided by the cable routes.
- There are no charted hazards, restricted areas or obstructions affecting the design of the submarine power cables.
- The submarine cable routes do not transit any designated Marine Protected Areas (MPAs) managed by NOAA. However for reference, two MPA's exist in the vicinity of the project site and include the Vandenberg State Marine Reserve located off west off Point Arguello and VAFB, and the Point Conception Essential Fish Habitat Conservation Area located offshore beyond the terminus of each planned power cable.
- Shipping density maps show a variety of shipping activity in the project area. Much of the shipping activity is constrained to shipping lanes further offshore from the project site; however, vessel activity does occur throughout the area. It is unknown at the time of this report if anchorages occur within the project site that could pose risk to the cables. Further discussions with relevant authorities at VAFB should take place to better understand the type and frequency of vessel activity off Point Arguello.
- The CalWave segments terminate in the United States Territorial Sea past the California State Waters Limit.
- Past seismic centers including charted earthquake faults are located off Point Arguello and in the vicinity of the project site. Analysis of USGS seismicity data and literature suggest the risk to the submarine power cables due to seismic events is relatively low.
- All vessel related activities should be coordinated with VAFB. A Notice to Mariners should also be sent out to notify of offshore vessel activity related to the survey and installation of the CalWave submarine power cables.

1. INTRODUCTION

On 15 June 2016, CH2M Hill and Fugro Pelagos, Inc. entered into a contract for desktop study services to support the planning of the CalWave export power cables.

Site visits were conducted by Fugro's Charles Chamberlain on June 14, 2016 in coordination with the CalWave project team. The purpose of the site visits was to evaluate and select a suitable Primary and Alternate landing point from which to base the planned HDD operations around. Final landing points for each of the five planned cables at the Primary and Alternate sites were provided by The HDD Company for use in this study.

Subsequent to the site visits, Fugro undertook research of existing public and proprietary data sets to further assess site conditions, the results of which are contained in each section of this report. Furthermore, the design of the HVAC export power cable routes was performed including five routes to the Primary HDD bore locations and five routes to the Alternate HDD bore locations. Each cable route was designed up to a terminus location provided by Leidos at the start of the study.

A summary of the cable segments included in this desktop study are provided in Table 1.1 and Table 1.2 below.

Table 1.1: CalWave *Primary* Cable Segments (WGS84)

Cable Segment	Bore No.	Bore Entry Coordinates	Bore Exit Coordinates	Cable Terminus	Route Length (km) / (mi)
Segment 1 – West	01	34° 33' 20.3552" N	34° 33' 05.5665" N	34° 33' 20.3552" N	7.630 / 4.741
		120° 36' 51.9475" W	120° 36' 53.4111" W	120° 36' 51.9475" W	
Segment 2 – Southwest	02	34° 33' 20.3506" N	34° 33' 05.5151" N	34° 33' 20.3506" N	7.460 / 4.635
		120° 36' 51.8796" W	120° 36' 51.7798" W	120° 36' 51.8796" W	
Segment 3 – Anchorage (Spare)	03	34° 33' 20.3558" N	34° 33' 05.5816" N	34° 33' 20.3558" N	5.767 / 3.583
		120° 36' 51.8117" W	120° 36' 50.1493" W	120° 36' 51.8117" W	
Segment 4 – South	04	34° 33' 20.3635" N	34° 33' 05.7653" N	34° 33' 20.3635" N	7.122 / 4.425
		120° 36' 51.7443" W	120° 36' 48.5319" W	120° 36' 51.7443" W	
Segment 5 – Southeast	05	34° 33' 20.3760" N	34° 33' 06.0650" N	34° 33' 20.3760" N	7.525 / 4.676
		120° 36' 51.6780" W	120° 36' 46.9400" W	120° 36' 51.6780" W	
				Total	**35.504 / 22.060**

Table 1.2: CalWave *Alternate* Cable Segments (WGS84)

Cable Segment	Bore No.	Bore Entry Coordinates	Bore Exit Coordinates	Cable Terminus	Route Length (km) / (mi)
Segment 1 – West	01	34° 33' 17.7742" N	34° 33' 03.4205" N	34° 33' 20.3552" N	7.832 / 4.867
		120° 36' 37.7615" W	120° 36' 42.3070" W	120° 36' 51.9475" W	
Segment 2 – Southwest	02	34° 33' 17.7623" N	34° 33' 03.1355" N	34° 33' 20.3506" N	7.606 / 4.726
		120° 36' 37.6950" W	120° 36' 40.7113" W	120° 36' 51.8796" W	
Segment 3 – Anchorage (Spare)	03	34° 33' 17.7553" N	34° 33' 02.9666" N	34° 33' 20.3558" N	5.838 / 3.628
		120° 36' 37.6276" W	120° 36' 39.0916" W	120° 36' 51.8117" W	
Segment 4 – South	04	34° 33' 17.7531" N	34° 33' 02.9152" N	34° 33' 20.3635" N	7.076 / 4.397
		120° 36' 37.5596" W	120° 36' 37.4602" W	120° 36' 51.7443" W	
Segment 5 – Southeast	05	34° 33' 17.7531" N	34° 33' 02.9816" N	34° 33' 20.3760" N	7.350 / 4.567
		120° 36' 37.5596" W	120° 36' 35.8297" W	120° 36' 51.6780" W	
				Total	**35.702 / 22.185**

An overview of the Primary and Alternate cable segments are displayed in Figure 1.1 and 1.2. More detailed planning charts are provided separately as part of this study, the details of which are presented in Section 2.1 of this study.

Route Position Lists (RPL) are presented in Appendix A of this document. The routes have also been provided in Google Earth .kml format.

This DTS provides pertinent information on seabed depths, geological conditions and hazards along the proposed route alignments, as well as weather conditions, permitting information, information on existing cable and other seabed infrastructure, oil and gas activities and fisheries consideration offshore the proposed landing site. The route design of each cable has been based upon hydrographic charts published by NOAA, as well as other data currently available to FPI at the time of the study including C-MAP electronic nautical charts, SRTM 30+ bathymetric data and other public data sources.

All data pertinent to the evaluation and design of the cable system was analysed using ESRI ArcGIS software. Cable design was performed using FPI's Cable Analyst II software, which is an extension within ArcGIS.

A summary of datasets collected and analysed in this study, as well as their source are provided in the table below.

Table 1.3: Data Sources for the CALWAVE Desktop Study

Data	Source
Geodesy	Project geodesy for all electronic deliverables is WGS 84, suitable for a marine route survey.
Cables	Fugro Cable Database, ICPC cable listings (Telegeography cable map (in-service cables only))
Bathymetry and Topography	SRTM 30+, C-Map Electronic Nautical Charts
Hazards and Obstructions	In-house database, digitized from paper and electronic nautical charts (ENC or C-Map), and/or downloaded from NOAA including: for example - danger areas, fishing/FAD's, floating buoys, obstructions, restricted areas, sanctuaries, shipping lanes, wrecks, pipelines, cables
Maritime Boundaries	General Dynamics database (GMBD 2008 Spring edition), crosschecked again NOAA published boundaries.
Marine Protected Areas	Downloaded from NOAA (for US Territories only), crosschecked on published nautical charts and C-Map Electronic Nautical Charts
Coastline	Digitized from C-Map Electronic Nautical Charts
Fisheries	Public information, where available
Permitting	In-house database, if information is available
Meteorology and Oceanography	Web search, published literature
Geology and Marine Physiography	Web search, published literature, in-house information
Seismicity and Fault Activity	Web search, published literature. Data provided by USGS

Satellite Imagery	Google Earth imagery
Aerial Photography	See Satellite Imagery
Nautical Charts	Downloaded from NOAA
Existing Side Scan Sonar Data	Downloaded from Seafloor Mapping Lab, CSU Monterey Bay. Imagery provided by CSMP (Southern CAL: H11953)
California State Boundary 3nm limit, Active Leases and Offshore Oil and Gas Pipelines	Provided by BOEM online sources.

In addition to the data and sources outlined in the table above, nautical charts published by NOAA were used to cross check all electronic data used in this study.

The table below summarizes the published nautical charts that cover the project area.

Table 1.4: Nautical Charts

Chart Number	Agency	Description	Scale
18720	NOAA	Point Dume to Purisima Point	1:232,188
18721	NOAA	Santa Cruz Island to Purisima Point	1: 100,000

Although FPI has made every effort to verify the information collected in this study, FPI cannot guarantee that this study can be completely conclusive or all encompassing. This information should be used for its intended purposes, i.e. for initial planning and as a guide to assist in site visits, collecting verifiable survey data, and as a basis for complete pre-installation cable engineering.

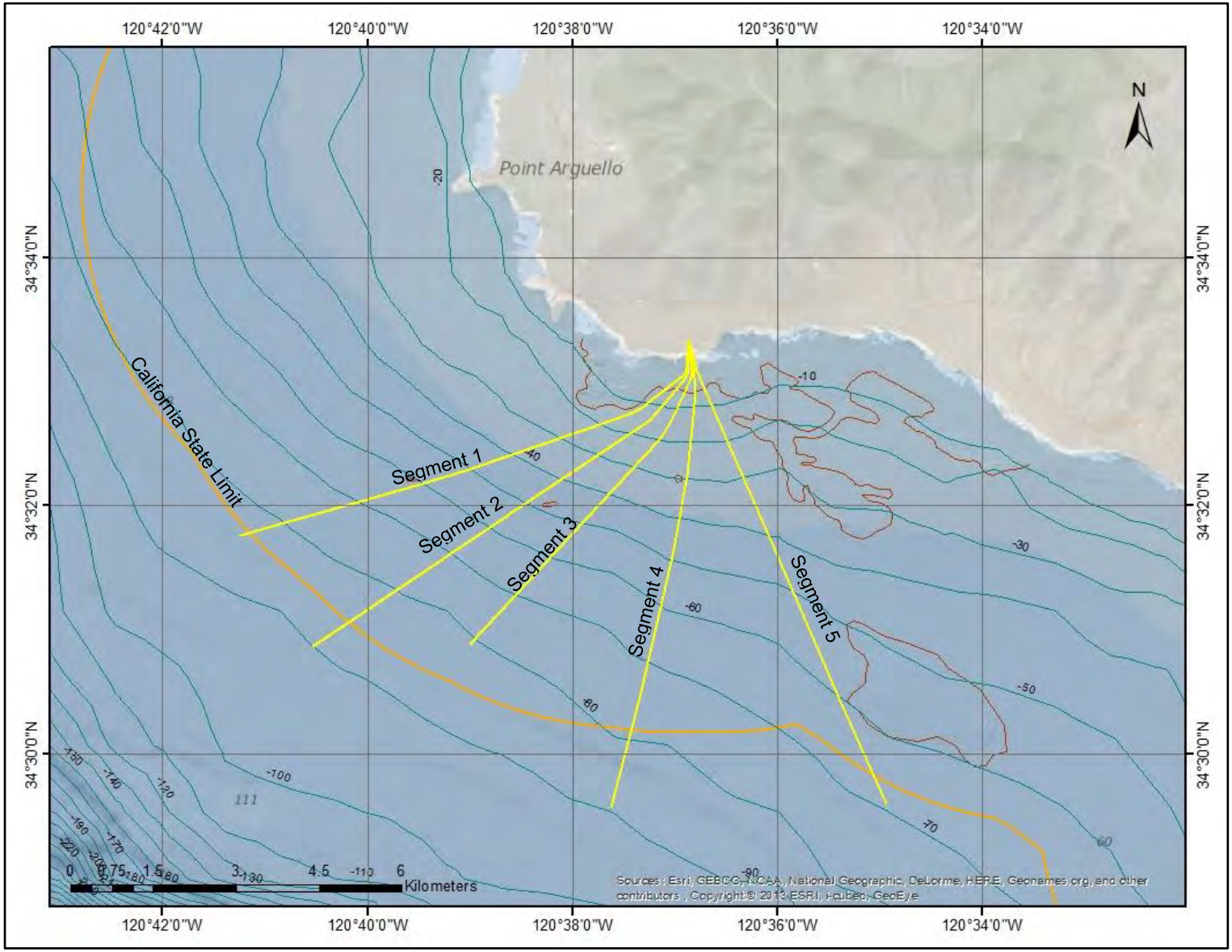

Figure 1.1: Overview of CalWave Primary Landing Site and Cable Routes (contours in meters)

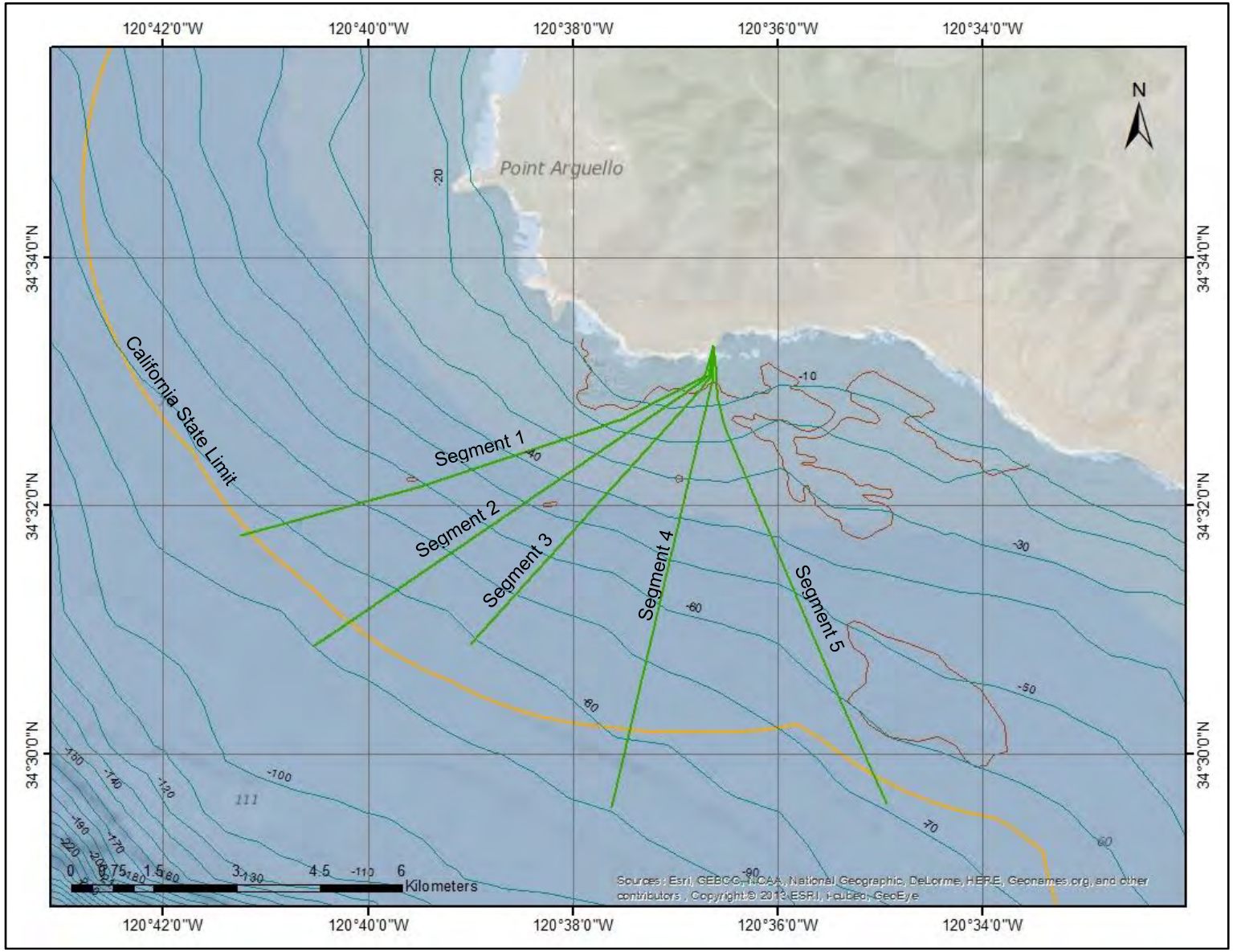

Figure 1.2: Overview of CalWave Alternate Landing Site and Cable Routes (contours in meters)

1.1 Scope of Work

In order to provide necessary, accurate and timely information for use in the planning and design of the CalWave cable routes, the primary objectives of this DTS were to:

- understand and assess the proposed landing sites and their implications for the shallow water approaches for the cable system;
- assess the potential natural and man-made hazards and obstructions, which may affect the cable safety and protection, as well as cable installation and maintenance;
- examine and review all hydrographic charts (published paper charts and electronic nautical chart information) and data covering the route;
- provide information on permitting (where available);
- collect information on existing and planned cable systems, pipelines, and offshore resource activities;
- assess the weather and oceanographic conditions that may impact the route survey and cable installation and maintenance;
- delineate all national and state boundaries;
- provide general guidelines to quantities of cables that will be required for the system, and
- provide recommendations on environmental, geophysical and geotechnical survey operations.

1.2 Summary of Landing Site Information

A Primary (Upland) launch location (landing site) and an Alternate (Dock) launch location (landing site) were selected during a site visit conducted on 14 June 2016 by team members (Table 1.4) that included:

Table 1.5: CalWave Landing Site Visit Team

Name	Responsibility	Affiliation
Doug Davy	Client	CH2M
Richard B. Williams	Chief Engineer	Leidos Maritime Solutions
Cliff Center	Cable Supplier	Center Marine Services
Randy Connett	Electrical Engineering	Omega Power Engineers
Rick Evans	Directional Driller	The HDD Company
C. F. Chamberlain	Site Survey	Fugro Pelagos, Inc.

During the site visit, horizontal directional drilling constraints, options for substation and other ancillary building placement and general site conditions were assessed before the selection of the landing points was made.

The two notional landing points and a project base station were identified:

- Base Station (0+00): 34° 33’ 20.05” N, 120° 36’ 53.55” W
- Primary Upland Landing Point: 34° 33’ 20.80” N, 120° 36’ 51.81” W
- Alternate Dock Landing Point: 34° 33’ 17.52” N, 120° 36’ 37.86” W

The landing sites were evaluated by Fugro on the basis of the following criteria:

- Discussions with The HDD Company, Leidos Maritime Solutions, Center Marine Services and Omega Power Engineers;
- beach topography and geomorphology;
- shallow water bathymetric and geologic conditions, as well as charted hazards, obstructions, and restricted areas;
- presence of existing cables, particularly active cables at each location;
- assessment of launch point conditions, i.e. road access, open land in the immediate vicinity, suitable launch point conditions, and an apparent offshore approach to the landing site; and,
- feasibility of installation operations and requirements.

The landing point positions proposed in this study are considered preliminary and were used only for initial planning purposes. Utilizing the above preliminary locations as a starting point, The HDD Company provided HDD launch points for each of the five bores at each of the landing points in NAD83 (California South HPGN). These were subsequently converted to a WGS84 datum as presented below in Tables 1.5 and 1.6.

Table 1.6: Primary Launch (Landing) Site (WGS84)

Bore No.	Cable	Latitude	Longitude	Bore Length (ft) @ 5m Contour	Bore Length (ft) @ 10m Contour
Bore 01	West	34° 33' 20.3552" N	120° 36' 51.9475" W	1,488	3,048
Bore 02	Southwest	34° 33' 20.3506" N	120° 36' 51.8796" W	1,495	3,171
Bore 03	Anchorage (Spare)	34° 33' 20.3558" N	120° 36' 51.8117" W	1,493	3,172
Bore 04	South	34° 33' 20.3635" N	120° 36' 51.7443" W	1,497	3,051
Bore 05	Southeast	34° 33' 20.3760" N	120° 36' 51.6780" W	1,507	3,031

Table 1.7: Alternate Launch (Landing) Site (WGS84)

Bore No.	Cable	Latitude	Longitude	Bore Length (ft) @ 5m Contour	Bore Length (ft) @ 10m Contour
Bore 01	West	34° 33' 17.7742" N	120° 36' 37.7615" W	1,491	2,751
Bore 02	Southwest	34° 33' 17.7623" N	120° 36' 37.6950" W	1,487	2,509
Bore 03	Anchorage (Spare)	34° 33' 17.7553" N	120° 36' 37.6276" W	1,488	2,280
Bore 04	South	34° 33' 17.7531" N	120° 36' 37.5596" W	1,513	2,238
Bore 05	Southeast	34° 33' 17.7531" N	120° 36' 37.5596" W	1,498	2,269

1.3 Cartography

The routes for the CalWave export power cables are displayed in a series of planning charts of various scales provided within this report. The charts included in this study focus on illustrating offshore datasets collected for this study, as well as the Primary and Alternate landing points and cable routes. For the purposes of the charts contained in this study, only the Primary routes are displayed to avoid congestion of information displayed. The Alternate landing points (HDD entry) and HDD exit points are displayed, however.

Existing cables/pipelines (active and retired), maritime boundaries, hazards and obstructions, regional bathymetry CSMP side scan sonar imagery are displayed on the charts.

Table 1.8: Charts produced for the RTI JGA DTS

Chart Name	Description	Geodetic Parameters		Scale
		Projection / Datum	Lat. True Scale	
CALWAVE_DTS_001	Project Overview	Mercator / WGS84	00°	1:35,000
CALWAVE_DTS_002	Landing Site Overview	Mercator / WGS84	00°	1:1,500
CALWAVE_DTS_003	Offshore Lease Area Overview	Mercator / WGS84	00°	1:100,000

1.4 Cable Routing Specifications

The following criteria were used as general guidelines for the route design for the planned cable segments at the CalWave site.

- Wherever possible, the route should cross perpendicular to steep slopes (if encountered), in particular the continental slope, steep island slopes, and steep ridge/trough features encountered along the route.
- Crossings of other cable systems, in particular active ones, should be minimized to the greatest extent possible. At necessary cable crossings, however, attempts should be made to keep crossing angles as high as reasonable, and greater than 60°.
- Separation of the cable from other cable systems should be as great as possible, particularly for other active cables. If possible, a minimum separation of 3 x WD (water depth) should be maintained. This may not always be possible where numerous cables are already installed, such as in the congested areas described in this document.
- Alter courses (ACs) should be less than 30° where the cable is surface laid and less than 15° in planned burial areas;
- ACs should be at least 3 x WD apart, where possible;
- If possible, ACs should be at least 300 m apart in water depths of less than 300 m, and at least 2 x WD apart in deep waters; and

In particular for the CalWave cable segments, the routes have been designed to avoid, as much as possible, rock outcrops interpreted from side scan sonar imagery collected from CSMP. Rock areas have been interpreted conservatively so as to provide enough buffer from such outcrops in the design of each cable segment.

1.5 Route Descriptions

In this section, the CalWave cable segments are described in addition to the main considerations taken during the design of each segment.

CalWave Primary and Alternate Cable Routes:

Each cable segment has been designed to run from the planned HDD borehole entry points (Landing Points) directly to the planned HDD exit points located approximately 1,500 feet offshore, as advised by The HDD Company. From each HDD exit point, Fugro has designed the routes based on the following parameters:

- Shortest distance from the HDD exit point to the planned cable terminus location
- Adequate cable separation for each segment as the cables are routed from the HDD exit points
- Avoidance of rock outcrop areas, where possible, with preference for cable routing in areas of anticipated sediment coverage along the seabed

Each cable segment exits the HDD borehole in areas of interpreted rock outcrops. Therefore, the cables will “daylight” in an area where the cables will have to be surface-laid on rock before reach areas of softer sediment coverage. Surface laying cables directly on rock outcrops creates a possible risk of abrasion to the cables, often caused by currents pushing the cable back and forth along a rough surface. As a result, cable protection methods should be assessed and implemented in areas where the cable is surface-laid over rock, which may include pinning, rock dumping, etc.

Once the cables clear the 10 m contour offshore, they are beyond the areas of interpreted rock. It is anticipated that the seabed is composed of sediment including silts, sands and clays from approximately the 10 m contour location to the cable terminus at each site.

There are no hazards or obstructions charted on nautical charts that affect the route design from the HDD exit points to the cable terminus locations. In addition, there is no existing seabed infrastructure that affects or conflicts with the CalWave cable segments designed in this study.

2. GEOLOGY AND SEABED CONDITIONS

The CalWave project is sited on a narrow coastal plain on Vandenberg Air Force Base (VAFB), just southeast of Point Arguello. This section of coastline is at the western end of the western Transverse Ranges physiographic province (Figure 3.1). Point Arguello is the northern margin of the larger California Continental Borderland province, which extends south from Point Arguello to Cedros Island off the coast of Baja California, Mexico (Hanson, *et al.* 1994). The section of coastline beginning at Point Pedernales, 3 km north of Point Arguello, and extending south to San Clemente Island in the Santa Barbara Channel, is particularly noteworthy for well-preserved series of marine terraces associated with rapid tectonic uplift of the wester Transverse Ranges.

Figure 2.1: Physiographic setting of the CalWave Project at Point Arguello

The Primary CalWave landing site is located on a marine terrace and is underlain by an extensive marine platform ranging in elevation from 15 to 60 m above present sea level. Dissected remnants of older uplifted platforms are locally preserved nearby at higher elevations within the Transverse Range physiographic province of southwestern California. The evolution of these marine terraces is illustrated in Figure 3.2 below.

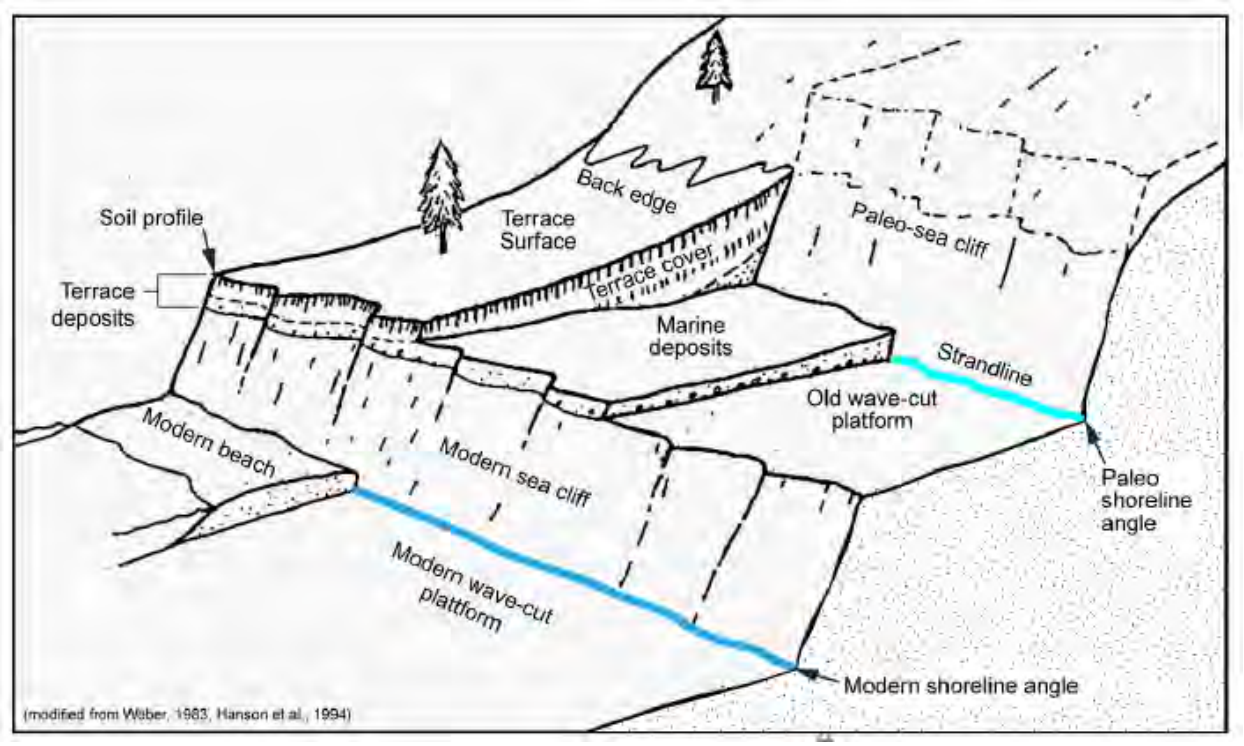

Figure 2.2: Marine terrace development along the coast of southwestern California (after Webber, 1983)

2.1 Geologic Setting of the Point Arguello Area

The onshore CalWave Point Arguello site is underlain by variably thick Quaternary alluvial deposits of sand, silt and gravel that overlie a wave-cut marine platform (Johnson 1984, 1989; Woodring and Bramlette 1950). The landing site sits on sediments mapped as younger alluvium (Qa) (Figure 3.3). The Alternate landing site is located on a dock facility that has been cut into the marine platform.

Older alluvium (Qoa) mantles the higher uplifted marine platforms immediately north of the site area. At least three wave-cut terraces are developed along the coast. The lowest occurs throughout the coast at an elevation of 50 to 150 feet. It forms a broad but much dissected coastal plain north and east of Point Conception, and also near Point Arguello. A higher terrace, at an elevation of 200 feet, is well developed against Burton Mesa, but is preserved only as small remnants elsewhere. Isolated remnants of a still higher terrace occur at an elevation of about 500 feet on the seaward slopes of the hills northeast of Point Conception and Point Arguello.

An upper member of the Monterey Formation accounts for the rock laying beneath the alluvium at the Primary landing site and the rocks exposed in the hill side cuts surrounding the Alternate landing site. This upper member of the Miocene-aged Monterey Formation is hard, laminated, platy, siliceous shale; soft, thin-bedded shale; phosphatic shale; limestone beds inter-bedded with soft, thin-bedded shale and limestone (Dibblee 1950; Dibblee 1988). Measured sections of the Monterey north of Point Conception are reported to be as much as three to four thousand feet thick.

The Monterey Formation is often tightly folded or crumpled (Figure 3.4), and in many places is shattered or fractured extensively. The weaker portions of the Monterey Formation are readily eroded by both marine and non-marine processes. In a portion of the map DF-19 Geology Point Conception and Tranquillon Quadrangles (Figure 3.3) that covers the CalWave site, a thin band of the Monterey Formation (Tm) is mapped along the coast and larger areal exposures can be seen inland. The coastal exposures of Monterey at the CalWave site dip south southwesterly at 12° to 15°. A folded section of the

Monterey Formation is mapped just offshore of the landing sites where the axis of an anticline and adjacent syncline can be traced onshore beneath the alluvial mantle.

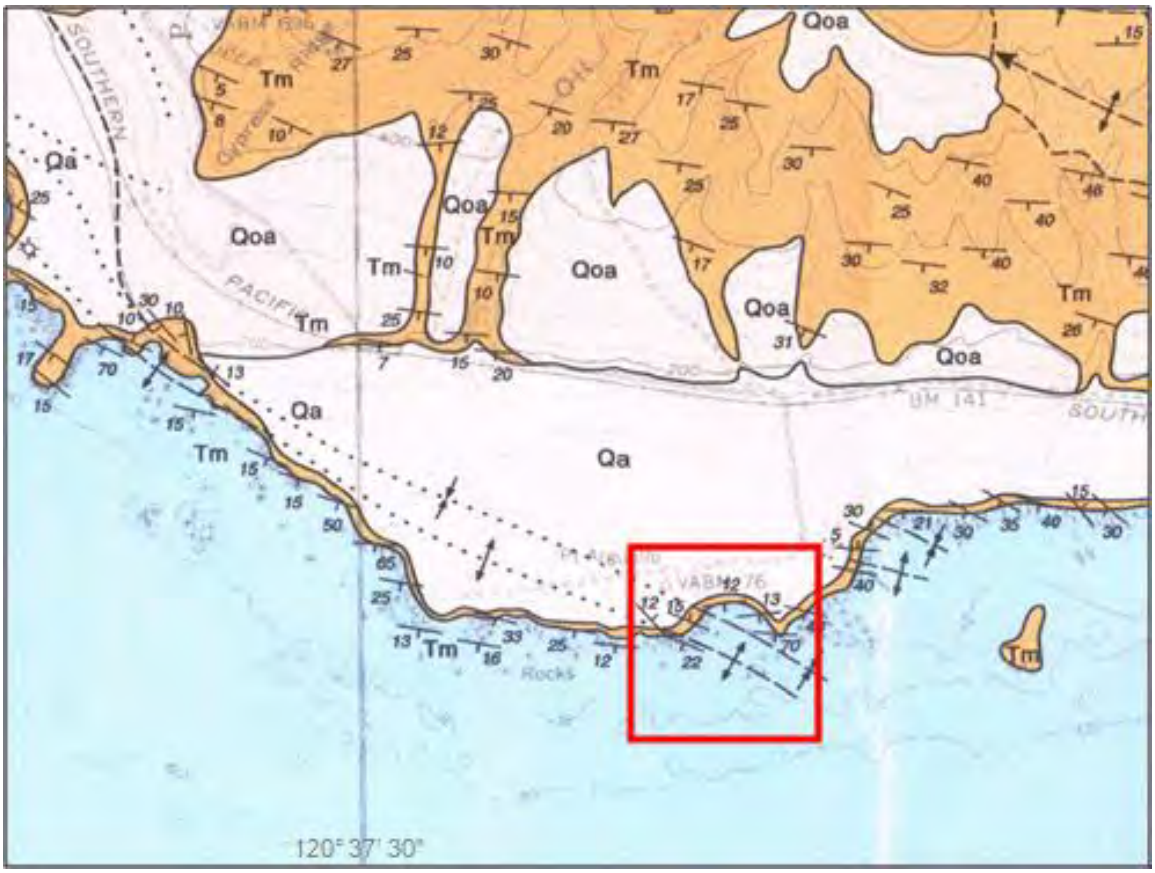

Figure 2.3: Geologic map of the area surrounding the proposed landing sites from Dibblee Geology Center Map #DF-19. (Dibblee, T.W., Jr., 1988).

Figure 2.4: Tightly folded Monterey Formation in an outcrop at the Alternate Landing (Launch) Site.

Although not well documented, the geologic conditions similar to those onshore prevail offshore. The Miocene Monterey Formation underlies a seabed covered, for the most part, by a veneer of unconsolidated sediment.

From the information that is available from seismic reflection profiles, the Monterey generally dips southwest 12° to 16° and the folded and faulted strata continue offshore. A cross section (Figure 3.6) constructed along the north northeast – south southeast trace (Figure 3.5) illustrates the presumed underlying geology. Conformably laying beneath the Monterey, the marine and non-marine, Miocene aged Tranquillon Volcanic Formation are seen in the cross section of Figure 3.6.

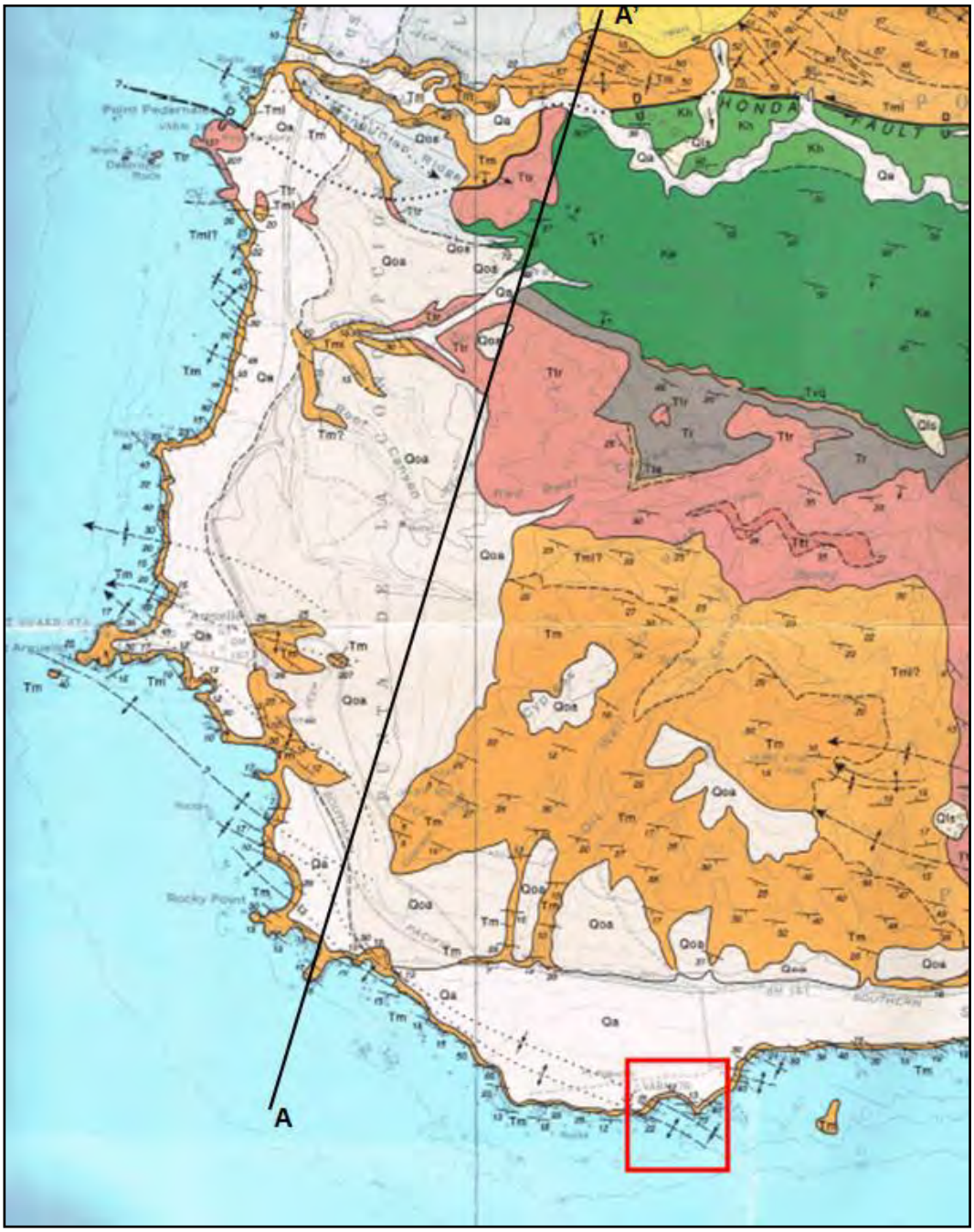

Figure 2.5: Geologic map of the area surrounding the proposed landing sites (Dibblee, T.W., Jr., 1988)

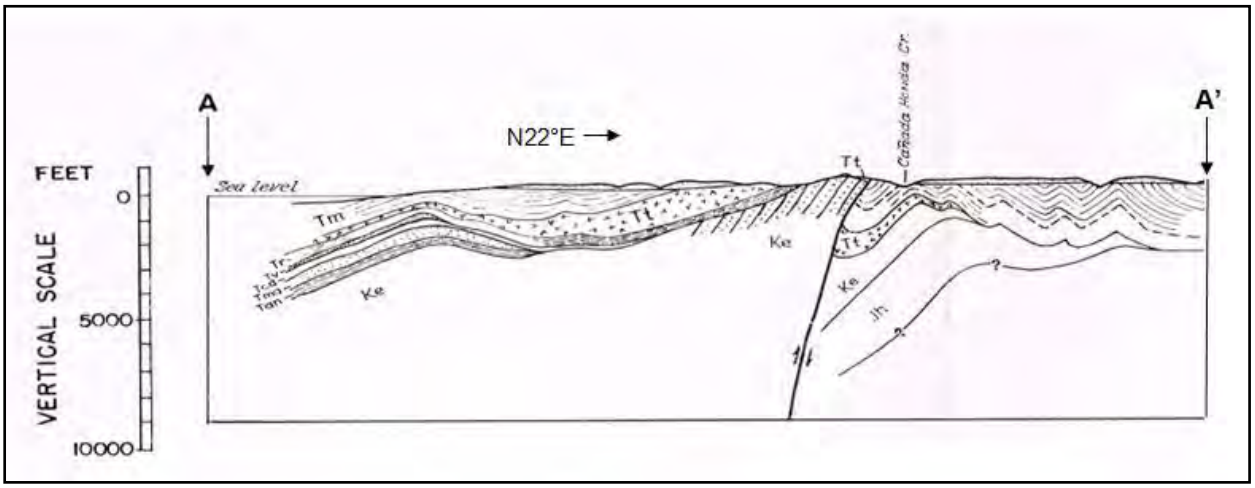

Figure 2.6: Idealized cross section constructed along line A-A' in Figure 3.4

The cross section depicted in Figure 3.6 lies approximately 1.5 miles west of the proposed landing sites. The fault seen in the cross section is the Honda Fault, an east-west trending fault over three and a half miles north of the landing site (after Dibblee, T.W., Jr., 1950).

Early-mid Miocene Tranquillon Volcanics (Tt), Rincon Formation (Tr) and the Vaqueros Formation (Tv) lie beneath the Monterey. Oligocene strata are absent in the section. The Cozy Dell (Tcd), Matilija (Tma) and Anita (Tan) formations of Eocene age overlie the Cretaceous Espada (Ke) basement rock to complete the stratigraphic section beneath the site.

2.2 Geologic Conditions of the Landing Sites

At least three wave-cut terraces are developed along the southwest Santa Barbara County coastline. The lowest occurs throughout the coastline at an elevation of 50 feet (15 m) to 150 feet (45 m). It forms a broad but much dissected coastal plain north and east of Point Conception, and also near Point Arguello. It is upon these terrace deposits that the CalWave landing sites are positioned. Higher terraces are isolated remnants of terraces occur further inland along the coast at elevations of about 200 feet and 500 feet on the seaward slopes of the hills northeast of Point Conception and Point Arguello.

Unconsolidated alluvium comprised of sands, silts and gravels make up the terrace deposits. The thickness of these deposits can be quite variable. Along the coastline at the Primary Landing Site (Figure 3.7) the alluvium is approximately 10 feet to 15 feet in thickness while the alluvium exposed in the cut made during the construction of the dock at the Alternate Landing Site (Figure 3.8) appears to be 30 feet to 40 feet thick.

Beneath the terrace deposits and extending offshore, the Miocene Monterey Formation is ubiquitous. Exposed sections of the Monterey can be seen at both the Landing (Launch) Sites.

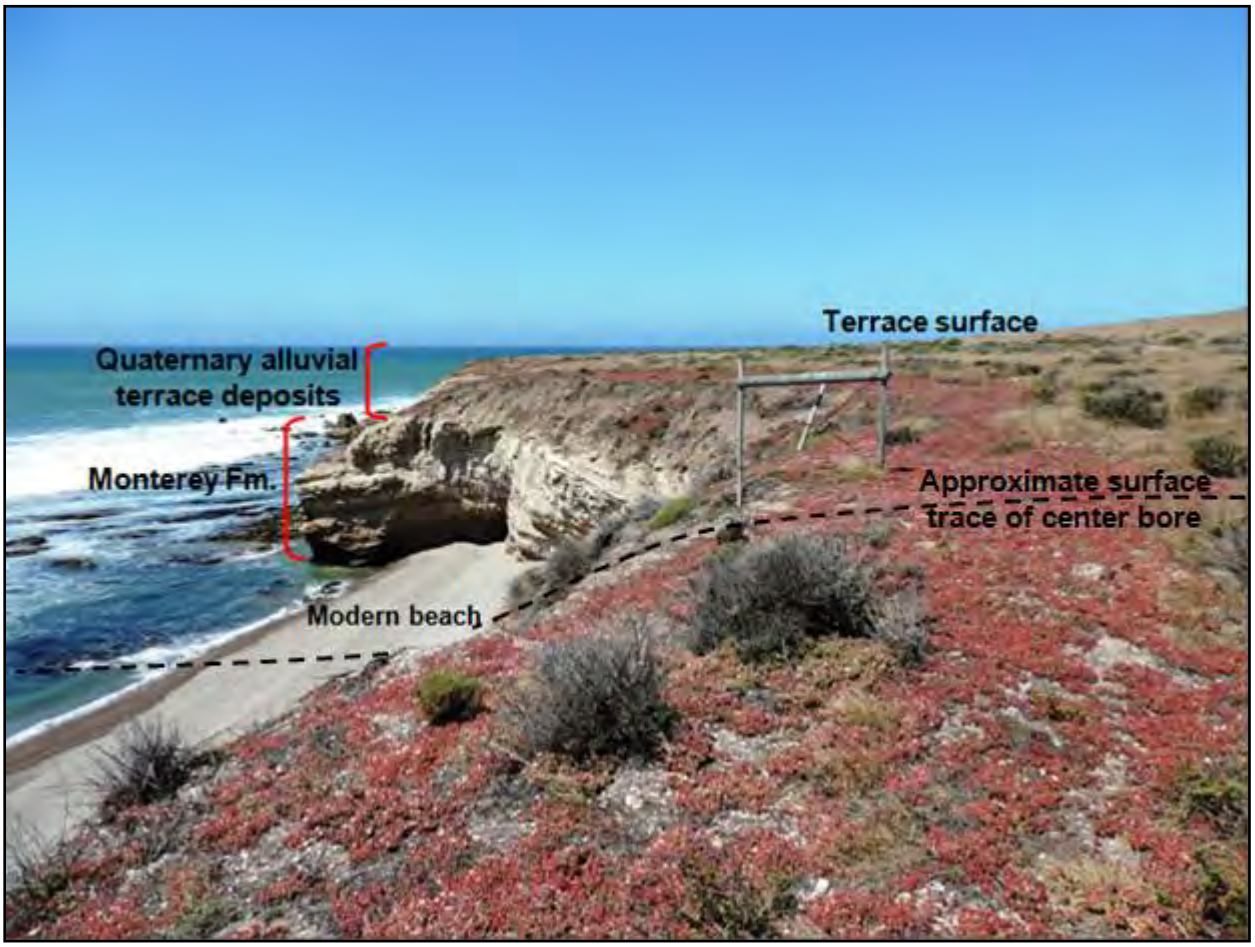

Figure 2.7: The sea cliff south of the Primary Landing (Launch) Point overlying the approximately location of the center bore.

Figure 2.8: Looking north toward the boathouse from the dock at the Alternate Landing (Launch) Point.

2.3 Geologic Conditions Offshore Point Arguello

Water depths within the project area range from 0.0 feet at the shoreline to nearly 310 feet (95 m) at the south and southwest cable termini.

With the exception of the shallow water <65 feet (<20 m) areas the seabed is relatively smooth and sediment covered out near the shelf break at 328 feet (100 m). To the south southeast, however, rock outcrops extend out to 130 feet (40 m) and near the southeast cable termini a large outcrop is found between the 165 feet (50 m) and the 230 feet (70 m) isobaths.

The seafloor slopes between 0.3° and 0.5° south-westward. The thickness of unconsolidated Quaternary sediment in the project area ranges from 0 (bedrock outcrop) to almost 50 m (165 feet) off Point Arguello (Cummings, D. and Johnson, T.A., 1994). The erosional bedrock surface covered by these sediments is irregular nearshore because of differential erosion, but the farther offshore, the bedrock is relatively planar and uniform where the unconsolidated sediments thin against a structural high. The sediments were deposited on bedrock cut by a Pleistocene erosional surface that has been dated by Payne et al. (1979) as 30,000 to 40,000 BP and by PS Associates (1987) as 11,000 BP.

2.4 Faults and Seismicity Offshore Point Arguello

Faults are planes of weakness in the earth's crust where one side has moved relative to the other. They are recognized and mapped by sheared and displaced rock units and by the distinctive landforms created

by repeated rupture of the earth's surface. Earthquakes generated by rupture and displacement of rocks along these faults cause significant damage to manmade structures and can be life threatening. The resulting and sometimes violent shaking poses a serious hazard.

Studies of historic earthquakes generated along these faults provide basic background for projecting future seismic hazards and losses. A listing of historic earthquakes occurring within 150 km (93 miles) of the CalWave site with a magnitude of 4.5 or greater is provided in Table 3.1 and are mapped in Figure 3.11.

Based on these and other data, the California Geological Survey completed a state-wide Earthquake Hazard Map (Figure 3.9) in 2008. The map depicts regions of active faults that will experience stronger more frequent shaking. The CalWave site is located in a region that is more distant from known active faults and can be expected to experience lower levels of shaking less often.

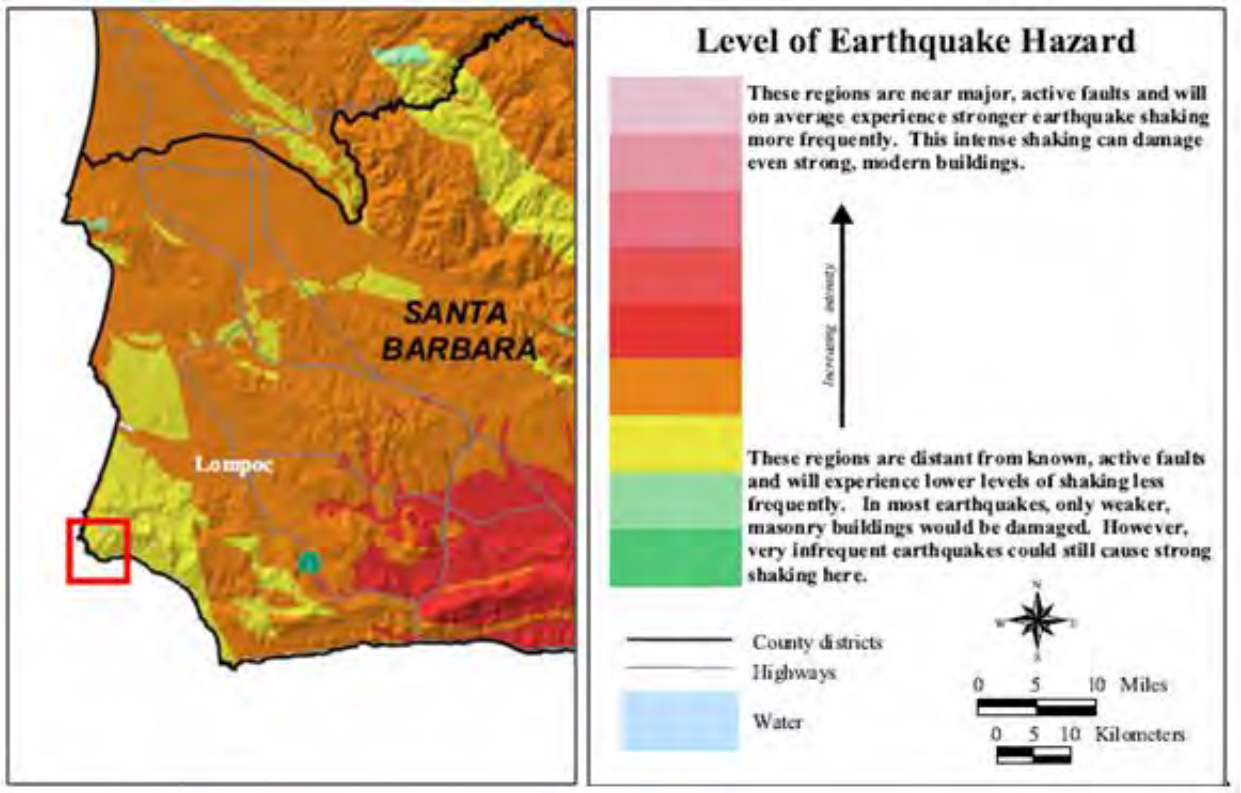

Figure 2.9: Earthquake Hazard Map of California (California Geological Society, 2008).

A fault map has also been constructed by compiling data from literature, published and unpublished, regarding faulting in California. A portion of this map (Figure 3.10) encompassing the general area surrounding the project site depicts what is known about the recent timeframe of displacement along these faults. Both onshore and offshore faults were mapped and age dated where possible.

All offshore faults were based on interpretation of seismic reflection profile records and are shown as solid lines where faults are well defined, dashed where inferred and queried where uncertain. The age of these unnamed offshore faults is reported as <1,600,000 years with slip rates of <0.2 mm/year and having lengths ranging from 2.5 km to 679 km. The offshore faults are approximate in location as mapped by McCulloch (1989).

Figure 2.10: California Geological Survey, Geologic Data Map No. 6, Compilation and Interpretation by: Charles W. Jennings and William A. Bryant

Legend for the California Geological Survey, Geologic Data Map No. 6, (Figure 3-9).

Holocene fault displacement (<11,700years) without historic record

Late Quaternary fault displacement (past 700,000 years)

Quaternary fault (age undifferentiated)

Pre Quaternary fault (>1.6 million years) or
fault without recognized Quaternary displacement

Major onshore faults shown in the California Geological Survey, Geologic Data Map No. 6, (Figure 3-9).
.

Santa Ynez River fault
Age: Late Quaternary
Type: reverse fault
Jennings ID: 299
Source: Sylvester and Darrow (1979)

Honda fault
Age: Late Quaternary
Type: fault, certain
Jennings ID: 300
Source: Sylvester and Darrow (1979)

Pacifico fault
Age: Late Quaternary
Type: fault, concealed
Jennings ID: 301
Source: Dibblee (1988)

Los Alamos fault
Age: Holocene
Type: fault concealed
Jennings ID: 302
Source: Guptill, et al (1981)

Garey fault
Age: Quaternary
Type: fault approximately located
Jennings ID: 303
Source: Buchannan-Banks, et al (1978)

South Branch Santa Ynez fault
Age: Late Quaternary
Type: fault concealed
Jennings ID: 321
Source: Dibblee (1988)

Table 2.1: List of Earthquakes with a Magnitude ≥4.5

Magnitude	Location	Date	Time (UTC)	Depth (km)
6.9	Offshore Central California	4-Nov-27	13:51	10.0
6.8	Santa Barbara Channel	29-Jun-25	14:42	10.0
6.5	Greater Los Angeles	10-Feb-22	11:21	10.0
6.5	18km NNW of Canbria	22-Dec-03	19:15	11.5
6.2	28km NW of Cambria	22-Nov-52	07:46	6.0
6.0	Offshore Central California	5-Nov-69	17:54	10.0
6.0	18km N of Shandon	28-Sep-04	17:15	8.6
5.8	Offshore Central California	22-Oct-69	22:51	10.0
5.8	11km NNE of San Miguel	08-Jun-34	04:47	6.0
5.8	13km WNW of Grapevine	21-Jul-52	12:05	6.0
5.5	9km SSW of Carpinteria	1-Jul-41	07:50	9.6
5.5	8km N of Cholame	28-Jun-66	04:26	6.0
5.1	27km S of Santa Barbara	13-Aug-78	22:54	18.0
5.1	9km SSE of Santa Cruz Is.	06-Aug-73	23:29	16.9
5.1	20km ENE of Santa Cruz Is. (NW end)	5-Jul-68	00:45	0.2
4.9	10km NW of Cholame	28-Sep-04	17:24	0.7
4.9	12km ENE of Santa Cruz Is. (NW end)	1-Apr-45	23:43	0.1
4.8	6km W of Isla Vista	29-May-13	14:39	7.1
4.8	1km WSW of Port Hueneme	18-Mar-57	18:56	6.0
4.8	12km SW of Parkfield	05-Jun-34	21:49	6.0
4.8	18km S of Santa Cruz Is	26-Aug-54	13:48	6.0
4.7	41km WNW of San Miguel Is.	27-Aug-49	14:51	6.0
4.7	18km N of Pine Mountain Club	10-Nov-81	22:34	6.6

4.7	10km N of Cambria	22-Dec-03	19:53	6.5
4.7	27km SSW of Lompoc	1-Oct-59	04:35	6.0
4.7	17km NNW of Santa Cruz Is. (E end)	12-Jul-41	16:18	6.0
4.7	28km SW of Avila Beach	29-May-80	03:38	6.0
4.7	27km SW of Lompoc	17-Dec-34	11:09	6.0
4.6	19km NE of Santa Cruz Is. (NW end)	7-Jul-68	14:33	21.0
4.6	103km WSW of Vandenberg AFB	5-Nov-69	18:48	6.0
4.6	10km N of Cambria	23-Dec-03	18:17	5.1
4.6	10km NNE of Pine Mountain Club	10-Feb-54	23:58	9.6
4.6	33km NW of Santa Barbara Is	16-Mar-02	21:33	6.8
4.6	20km ESE of Maricopa	16-Apr-05	19:18	9.3
4.6	17km WNW of Grapevine	13-May-75	00:21	24.1
4.5	44km WNW of San Miguel Is.	18-Nov-36	18:02	6.0
4.5	14km NNE of Pine Mountain Club	07-Nov-52	08:55	8.4
4.5	18km S of Frazier Park	04-Sep-42	06:34	20.0
4.5	19km S of Santa Barbara	1-Jul-41	23:53	9.7
4.5	8km NNW of Los Olivos	25-Oct-84	10:36	5.0
4.5	87km WSW of Vandenberg AFB	5-Mar-62	07:43	6.0

Figure 3.11 maps the locations of earthquake epicentres (from Table 3.1) of M ≥4.5 within a 150 km (93 mile) radius of the CalWave site from the period between 1916 to 2016. There are 41 earthquakes mapped and noted in the data set of which seven have a magnitude ≥6.0 as identified in Figure 3.11.

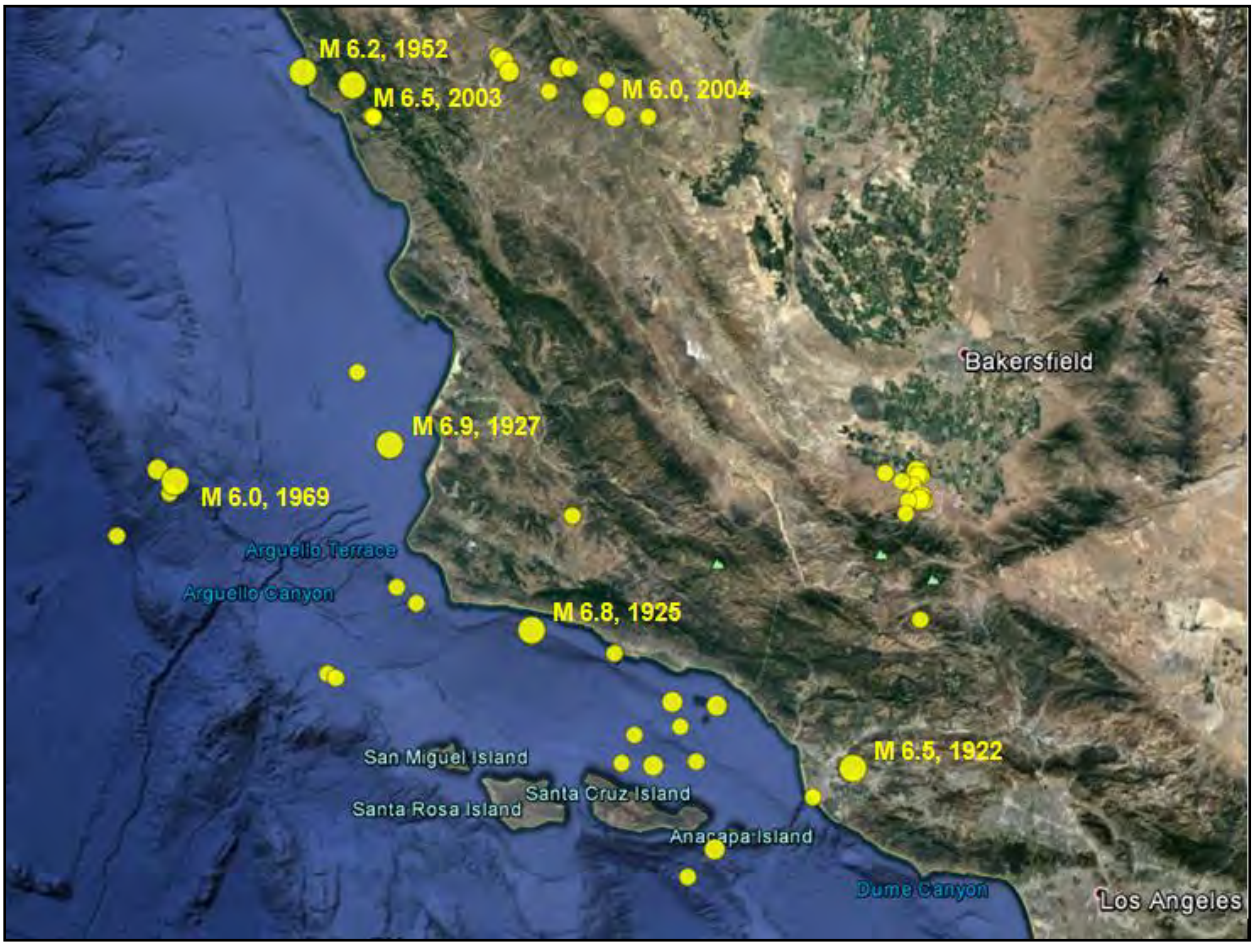

Figure 2.11: Earthquakes of M>4.5 within a 150 km (93 mile) radius of the CalWave site (1916 – 2016).

Earthquake shaking hazards are calculated by projecting earthquake rates based on earthquake history and fault slip rates, the same data used for calculating earthquake probabilities. The California Geological Society Map Sheet shows potential seismic shaking based on National Seismic Hazard Map calculations plus amplification of seismic shaking due to near surface soils.

Seismic shaking maps have been prepared by the California Department of Conservation using consensus information on historical earthquakes, faults, and geologic materials. Historic earthquakes, areas damaged, the slip rates of major faults, and geologic materials were combined to calculate the shaking hazard at peak ground acceleration (Figure 3.12), spectral acceleration for 0.3-second period (Figure 3.13), and spectral acceleration for 1.0-second period (Figure 3.14). The shaking hazard maps show the level of ground motion that has 1 chance in 475 of being exceeded each year, which is equal to a 10% probability of being exceeded in 50 years.

A Shake Map is a representation of ground shaking produced by an earthquake. These maps are not intended for site-specific hazard analysis, but rather provide a regional perspective of earthquake hazard in California. A shake hazard as mapped in Figure 3.12 and in the spectral acceleration maps presented in Figures 3.13 and 3.14, the level of severe damage at the CalWave site is predicted to be very low.

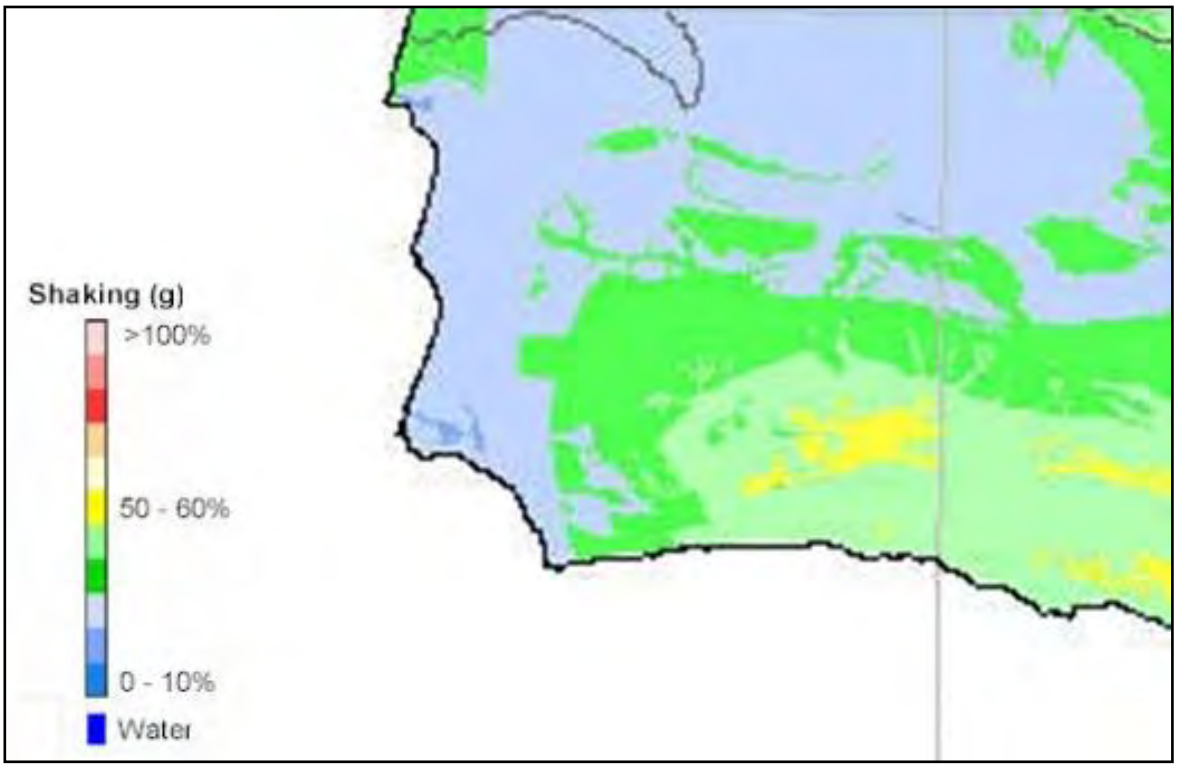

Figure 2.12: Shaking Hazard at Peak Ground Acceleration Map for the Pt. Arguello area, (California Dept. of Conservation, 1999).

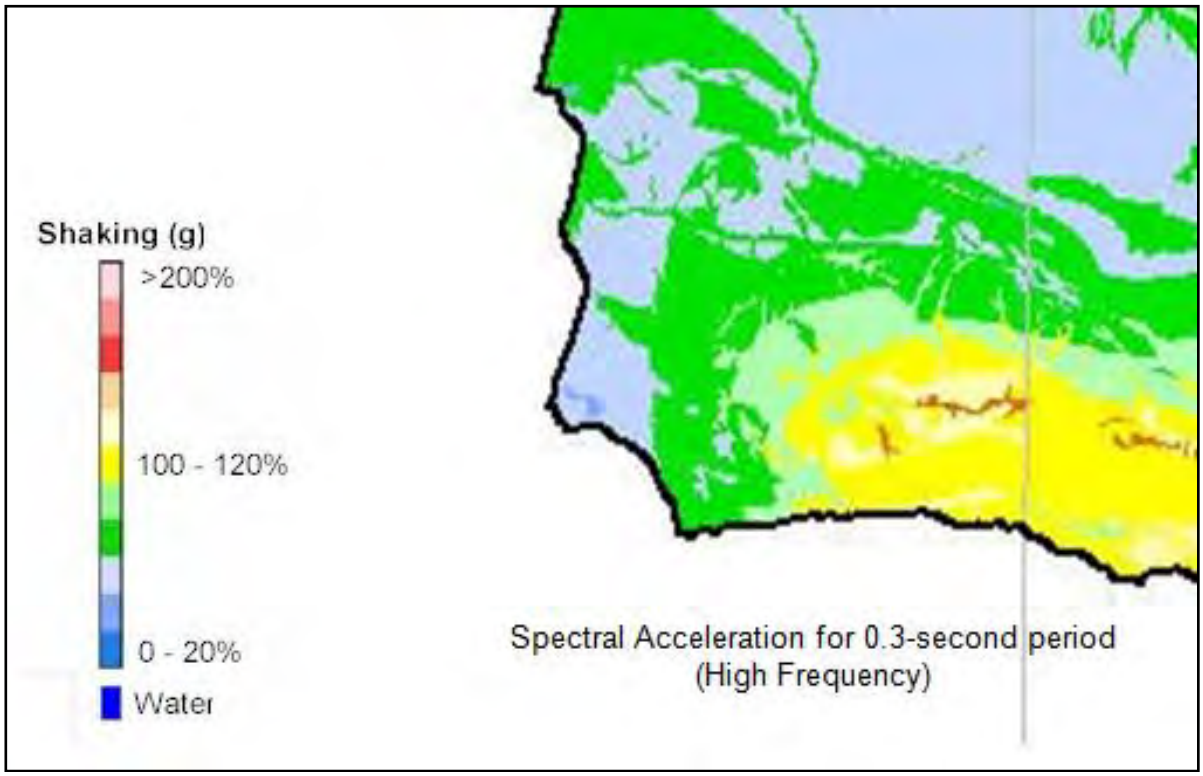

Figure 2.13: High frequency shaking map for the Pt. Arguello area (California Dept. of Conservation, 1999). Short, stiff building and structures are most affected by high frequency shaking.

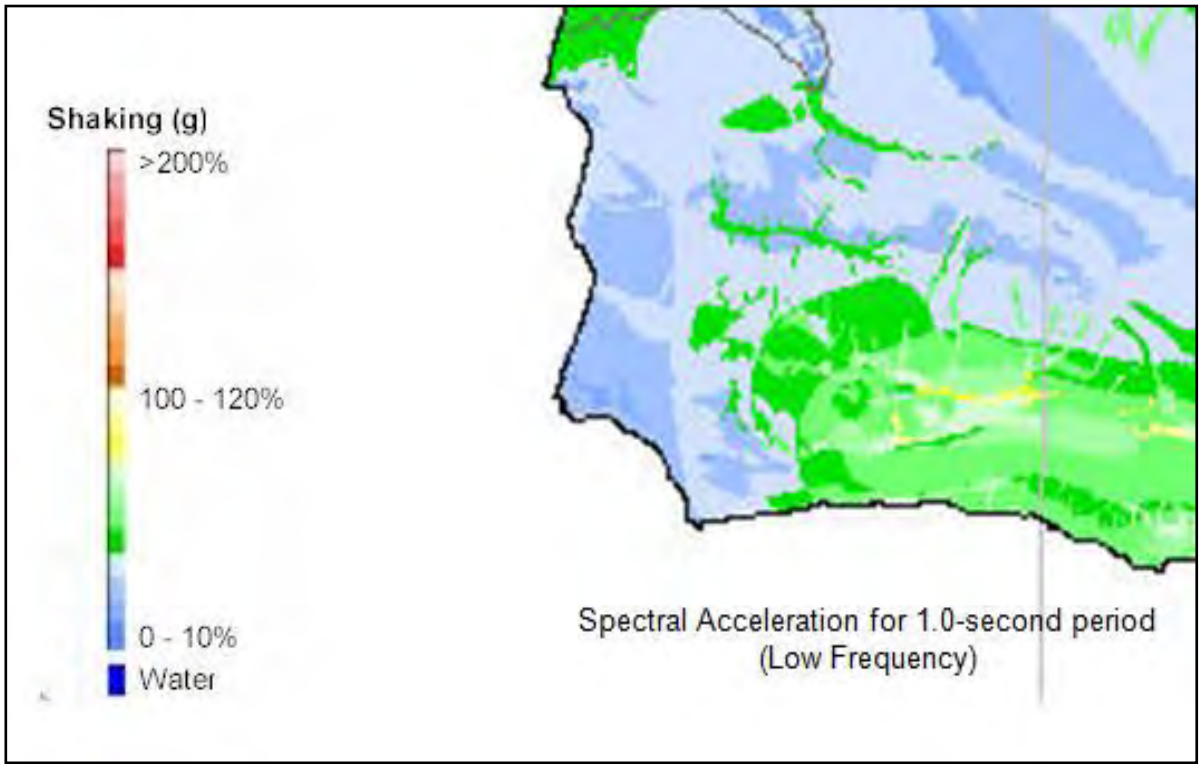

Figure 2.14: Low frequency shaking map for the Pt. Arguello area (California Dept. of Conservation, 1999). Tall buildings and large bridges are most affected by low frequency seismic shaking.

2.5 Sediment Transport Offshore Point Arguello

The long-shore transport of sediment in the area of the project site is generally in a southward direction north of Point Arguello and in an eastward direction between Point Conception and Gaviota. Estimates of the net transport southward around Point Conception range from zero to 180,000 yd^3/year.

3. ENVIRONMENTAL CONDITIONS

3.1 Climate and Weather

Meteorology is the study of Earth's atmosphere including its movements and other phenomena, especially as they relate to weather forecasting. Weather refers to the current state of the atmosphere with respect to wind, temperature, cloudiness, moisture, pressure, etc., at a given point in time while climate refers to a composite or generalization of weather over a given period of time. Since the long-term state of the weather is of most interest in planning cable route surveys and installations, this section has been called Climate and Weather rather than Meteorology.

The CalWave project site lies within a Temperate Mediterranean Climate (Csb) by the Köppen climate classification. These climates usually occur on the western sides of continents between latitudes of 30° and 45°. They are in the polar front region in winter, and thus have moderate temperatures and changeable, rainy weather. Summers are hot and dry due to the domination of the subtropical high pressure systems, except in the immediate coastal areas, where summers are milder due to the nearby presence of cold ocean currents that may bring fog but prevent rain (McKnight, Tom L., and Hess, Darrel, 2000).

The National Oceanic and Atmospheric Administration's National Data Buoy Center http://www.ndbc.noaa.gov provides a wealth of both real-time and historic climatic and oceanographic information. Synoptic data plots of wind speed, air temperature, dew point temperature, air-dew point temperature, sea level pressure, peak wind and wind gusts are often available for most stations.

Data utilized to document climatic and oceanographic conditions in this report were obtained from the following seven stations:

Station PTGC1 - Point Arguello, CA
34.577 N 120.648 W (34°34'36" N 120°38'54" W)
Site elevation: 32.3 m above mean sea level
Air temp height: 9.1 m above site elevation
Anemometer height: 9.4 m above site elevation
Barometer elevation: 33.5 m above mean sea level

Station HRVC1 - 9411406 - Harvest Oil Platform
Water Level Observation Network
34.469 N 120.682 W (34°28'9" N 120°40'55" W)
Site elevation: sea level
Air temp height: 30 m above site elevation
Barometer elevation: 26.1 m above mean sea level

Station 46051 - Harvest Experiment Platform
3-meter discus buoy
34.480 N 120.690 W (34°28'48" N 120°41'24" W)

Station 46257 - Harvest Southeast, CA (216)
Waverider Buoy
34.439 N 120.766 W (34°26'20" N 120°45'56" W)
Site elevation: sea level
Sea temp depth: 0.46 m below water line
Water depth: 576.07 m

Station 46218 - Harvest, CA (071)
Waverider Buoy
34.454 N 120.782 W (34°27'16" N 120°46'56" W)
Site elevation: sea level
Sea temp depth: 0.46 m below water line
Water depth: 548.64 m

Station 46054 (LLNR 198) - West Santa Barbara
3-meter discus buoy
34.265 N 120.477 W (34°15'53" N 120°28'37" W)
Site elevation: sea level
Air temp height: 4 m above site elevation
Anemometer height: 5 m above site elevation
Barometer elevation: sea level
Sea temp depth: 0.6 m below water line
Water depth: 382.3 m

Station 46023 (LLNR 213) - Pt Arguello
10-meter discus buoy
34.714 N 120.967 W (34°42'50" N 120°58'0" W)
Site elevation: sea level
Air temp height: 10 m above site elevation
Anemometer height: 10 m above site elevation
Barometer elevation: sea level
Sea temp depth: 1 m below water line

Water depth: 384.1 m

A monthly climate summary presented in Table 4.1 is derived from historic data (07/01/1948 to 02/28/1979) collected at the Point Arguello Light station (047016). The months of June, July and August are the driest months and January and February are the wettest. Average annual precipitation at the station was 11.82 inches with average temperatures ranging between 50.1° and 63.2°.

Table 3.1: Monthly Climate Summary

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average Max. Temp. (F)	59.3	60.8	59.9	60.2	61.0	62.6	64.8	65.6	69.1	66.7	66.8	62.0	63.2
Average Min Temp (F)	46.5	47.0	46.9	48.1	49.6	49.9	51.9	52.6	54.0	53.6	52.1	48.9	50.1
Average Total Precipitation (in.)	2.52	2.36	1.82	1.19	0.18	0.03	0.03	0.02	0.06	0.37	1.46	1.78	11.82

Wind climate at the CalWave site is summarized in Table 4.2 at the Point Arguello station (047016) for the period between 07/01/1948 to 02/28/1979.

Table 3.2: Monthly Wind Climate Summary

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average Wind Speed (mph)	14	16	17	20	18	18	17	20	17	16	16	16	16
Dominant Wind Direction (°)	337	337	337	337	0	0	0	0	0	0	337	337	0
Wind Probability ≥ Beaufort 4 (%)	52	67	69	75	78	73	69	81	71	64	58	62	68

A monthly plot of average wind speed and peak wind gusts data from the National Data Buoy Center for Station PTGC1 – Point Arguello is provided in Figures 4.1 and 4.2, respectively. The windiest months are the summer months of April through August when average wind speeds are between 17 mph (14 kts) and 20 mph (17 kts). Average peak wind gusts are somewhat higher (between 18 mph (16 kts) and 20 mph (18 kts)). Maximum peak gusts are shown to exceed 60 kts for the winter months of December through February.

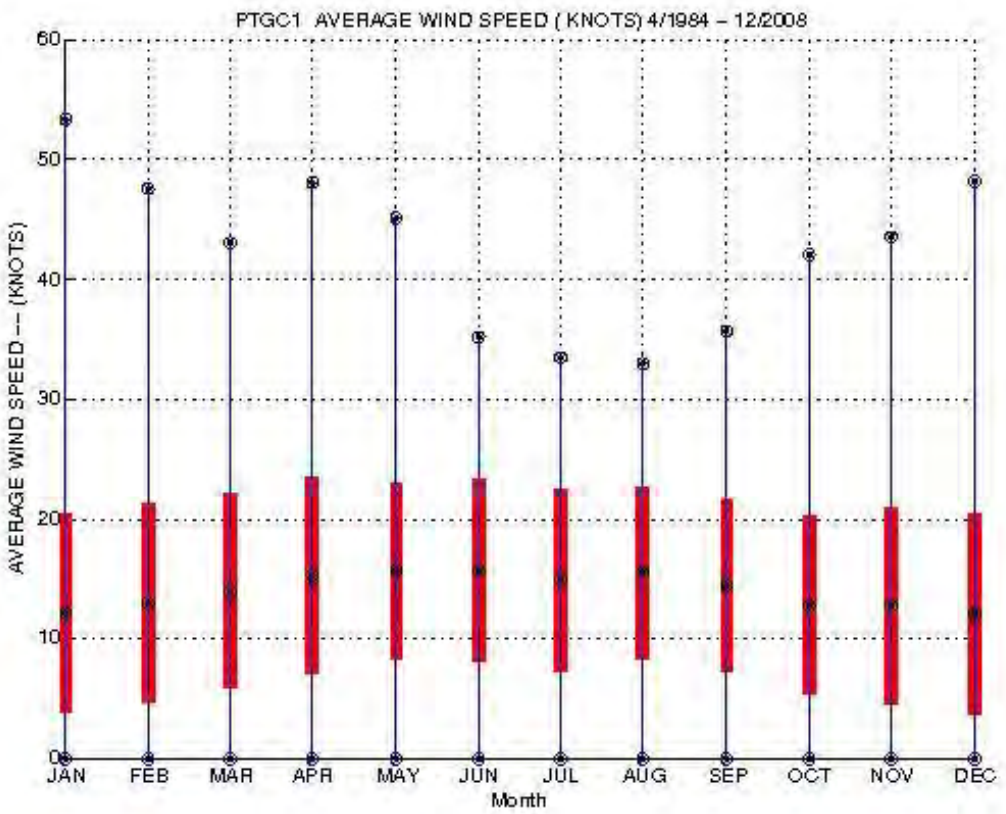

Figure 3.1: Average wind speed at Pt. Arguello Station PTGC1.

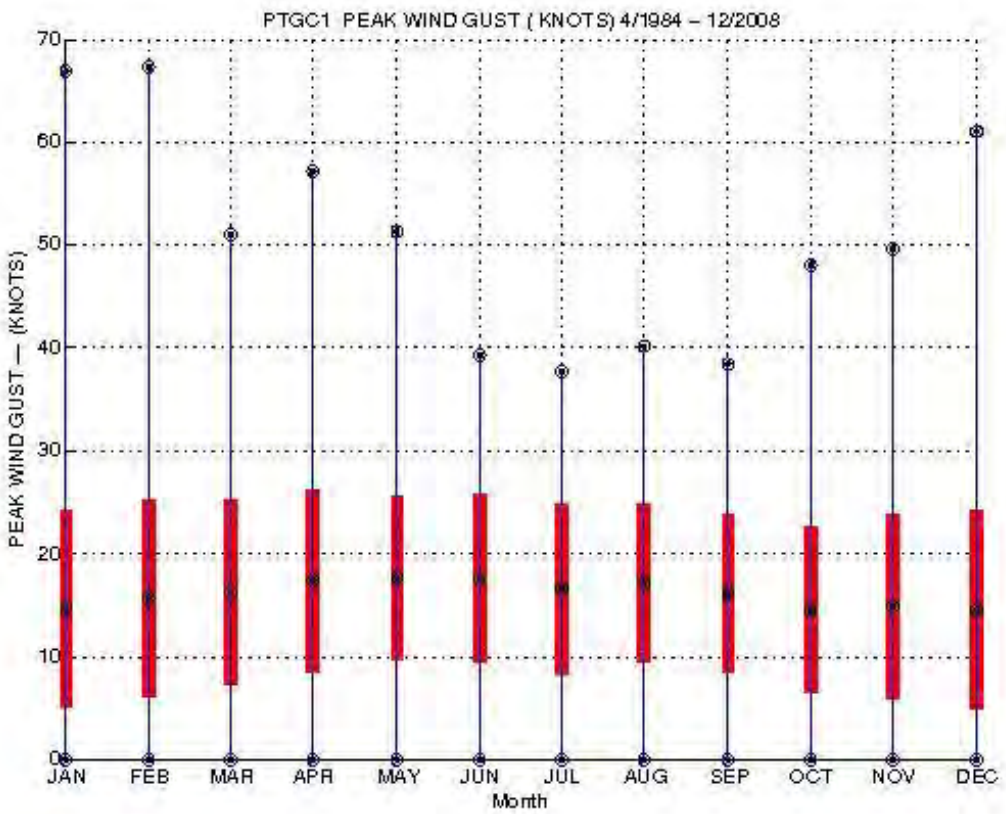

Figure 3.2: Peak wind gusts at Pt. Arguello Station PTGC1.

The top blue dot within the circle indicates the maximum value for the month. The top of the red bar indicates the value of one (1) standard deviation above the mean value. The bottom blue dot within the circle indicates the minimum value. The blue dot within the circle in the middle of the red bar indicates the mean or average value. The bottom of the red bar indicates the value of one (1) standard deviation below the mean value.

Pt. Arguello has an unusual highly persistent wind regime, especially in summer. Due to headland topographical forcing, winds are persistent and strongly northerly, parallel to the coast or “sideshore”. A wind direction rose (Figure 4.3) constructed from data at Pt. Arguello (Station PTGC1) illustrates this persistence associated with a resultant direction of 354°.

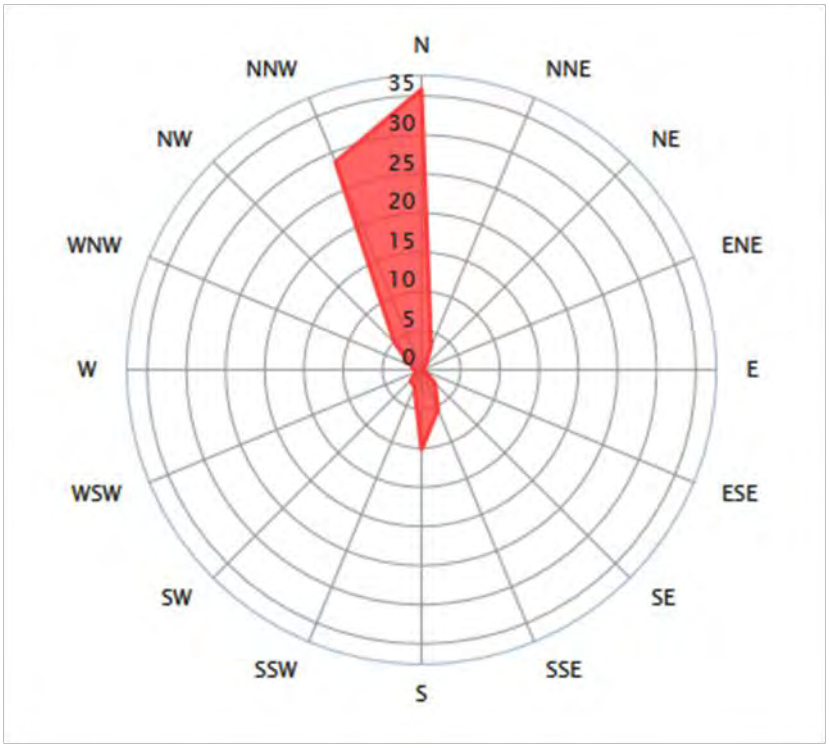

Figure 3.3: Wind direction distribution in (%) for a year.

3.2 Waves

Climatic summary plots of significant wave heights (Figure 4.4) and wave periods (Figure 4.5) were reviewed for NDBC Station 46023, Pt. Arguello. The 10-meter discus buoy is located approximately 20 nautical miles northwest of and closest to the CalWave site. Significant wave height (Hs) is defined traditionally as the mean wave height (trough to crest) of the highest third of the waves. For station 46023 the Hs is highest during the winter months of December through March with values of 2.7 m (8.9 feet) and lowest in July, August and September of about 1.7 m (5.6 feet). As with wave height, wave periods were longest (<8 seconds) in the winter months and shorter (>7 seconds) in July, August and September.

During the 14 June 2016 site visit, waves were 2 to 4 feet offshore in the late morning becoming 3 to 6 feet by early afternoon as the winds picked up.

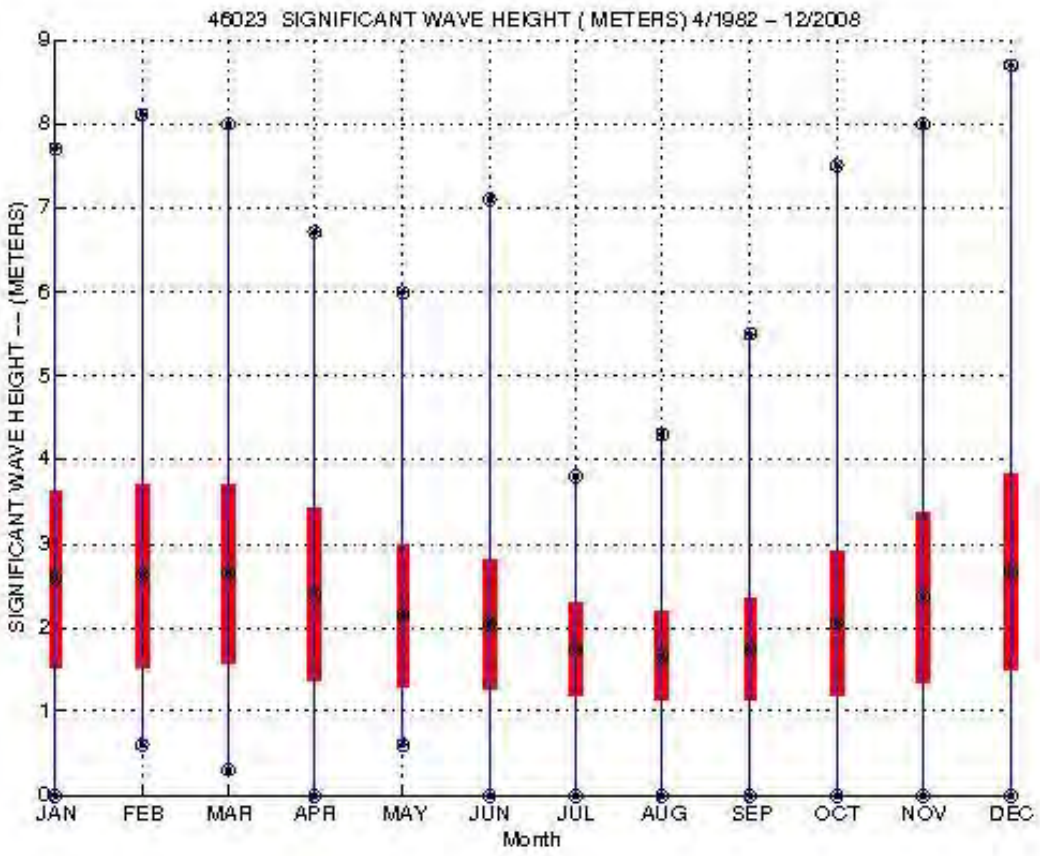

Figure 3.4: Station 46023 – Climate Summary Plots for significant wave height (Mean and Standard Division Plot)

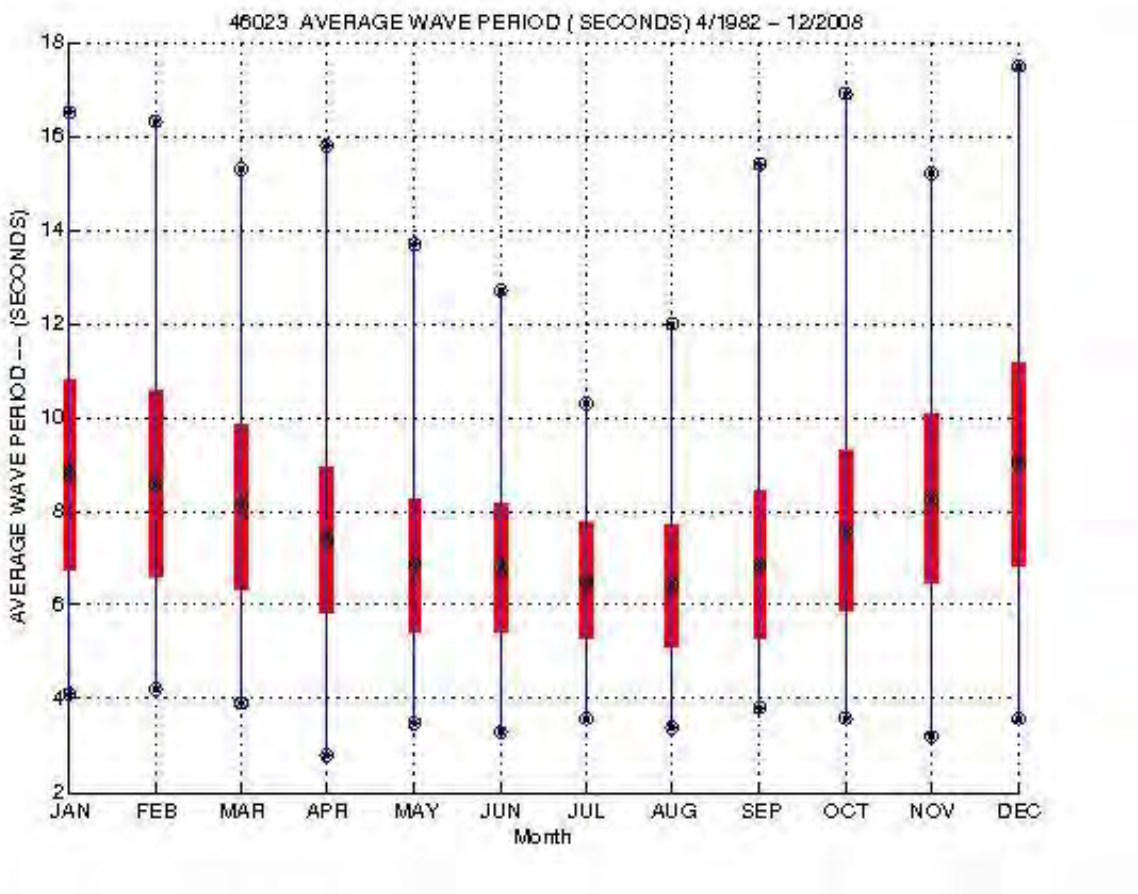

Figure 3.5: Station 46023 – Climate Summary Plots for significant wave period (Mean and Standard Division Plot)

3.3 Tides

Tides in the offshore area of Point Arguello are characterized as a mixed semidiurnal tide cycle. An area has a mixed semidiurnal tidal cycle if it experiences two high and two low tides of different amplitude every lunar day. Many areas on the western coast of North America experience these tidal cycles.

The two tide stations closest to the project site are Point Arguello, Station Id: TWC0473 and Oil Platform Harvest, CA – Station Id: 9411406. The Point Arguello station is referenced to Station Port San Luis (9412110) with a time offset in minutes (high: -3 low: -8) and a height offset in feet (high: *0.96 low: *0.96). The stations water level maximum (ref MHHW) was 2.32 feet on 18 January 1973 and a minimum (ref MLLW) was -2.40 feet on 7 Jan 1951. A mean tidal range for Point Arguello, Station Id: TWC0473 is 3.58 feet and the diurnal range is 5.32 feet.

https://tidesandcurrents.noaa.gov/noaatidepredictions/NOAATidesFacade.jsp?Stationid=TWC0473

Oil Platform Harvest, CA – Station Id: 9411406 is a primary station with a water level maximum (ref MHHW) of 2.22 feet on 6 June 1997 and a water level minimum (ref MLLW) -2.22 feet on 3 June 1992. The mean range for the station is 3.51 feet and the diurnal range is 5.25 feet.

https://tidesandcurrents.noaa.gov/stationhome.html?id=9411406#available

The site visit was completed during near low tide with a height of 1.2 feet referenced to a MLLW vertical datum. Tides recorded at Oil Platform Harvest, CA – Station Id: 9411406 during the site visit (14 June 2016) is shown in Figure 4.6.

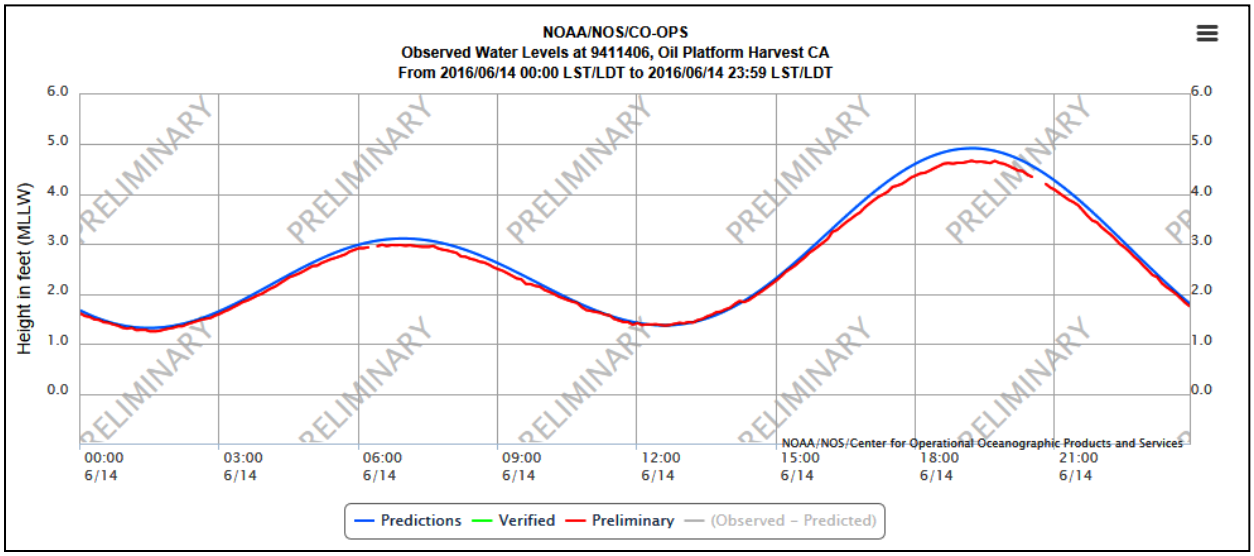

Figure 3.6: Tides recorded at Platform Harvest during the site visit of 14 June 2016.

For reference, an annual predicted tide table is provided in Appendix C. The tide table has been derived from the following website, http://tides.mobilegeographics.com/locations/282.html, and is for the Avila, California location, 35.1700° N, 120.7400° W. The tide table should be used for planning purposes only.

3.4 Currents

The Point Arguello area lies inshore of the California Current system. It is an especially interesting part of the California Current system because it is characterized by a remarkable and systematic seasonal reversal in flow.

California Current is the name that has been given to the eastern limb of the vind-dr1ven subtropical anticyclone of the North Pacific Ocean. It applies to the southeastward flow carrying water from the West Wind Drift to the North Equatorial Current. Its eastern boundary is the coast of North America where it flows past the states of Washington, Oregon, California and Baja California. It has no well-marked western boundary, but it has been common to define one arbitrarily at a distance of about 1,000 km from shore.

The surface currents near the coast vary with season: those waters within about 150 km of the coast flow northwestward along most of the coast in the period from October through February and southeastward during the rest of the year.

The speed of surface flow is usually less than 25 cm/sec. Drift bottles released near the coast off central California in winter (Schwartzlose, 1963) have sometimes been recovered more than 1,000 km northward at time intervals indicating average speeds of at least 25 cm/sec. Short-period variations in the strength of flow have been observed of the same order as the strength flow (5 to 15 cm/sec). Some of these may be related to the tidal flow (Reid, 1958): in any case a great deal of short-period variation about the mean flow has been observed.

3.5 Tsunamis

A tsunami is a wave, or series of waves, generated by an earthquake, landslide, volcanic eruption, or even large meteor hitting the ocean. What typically happens is a large, submarine earthquake (magnitude 8 or higher) creates a significant upward movement of the seafloor resulting in a rise or mounding of water at the ocean surface. This mound of water moves away from this center in all directions as a tsunami. A tsunami can travel across the open ocean at about 500 miles-per-hour. As the wave approaches land and as the ocean shallows, the wave slows down to about 30 miles-per-hour and grows significantly in height (amplitude).

Tsunamis may also be generated by subaerial or submarine landslides which are triggered by seismic shaking or from non-seismic instabilities. It is usually impossible to determine a tsunami's primary cause, particularly when an earthquake has occurred.

There are several measures of the wave size in use. Amplitude in the physical sense – the rise above or drop below the water level. Often it is determined as one-half the total observed rise or fall (wave height). The wave height is the more commonly reported value in the literature although it is sometimes identified as "amplitude". The wave height relates more directly to the potential for generating currents, and the amplitude more directly to run-up and flooding.

Run-up is the measure of the height of the tsunami above a given reference level such as the height of the tide at the time of the tsunami, or mean lower low water (MLLW) or sea level if the tide level at the time of the maximum wave was not observed (Figure 4.7). It usually is greater than the amplitude since it is the highest combination of the tide and the tsunami. Tsunami inundation refers to the distance inland that a tsunami wave penetrates and varies for each different coast or harbor affected by the tsunami. Understanding and modeling how tsunami waves have flooded coastal areas in the past helps forecast the extent of inundation after tsunami generation, and prepare inundation maps.

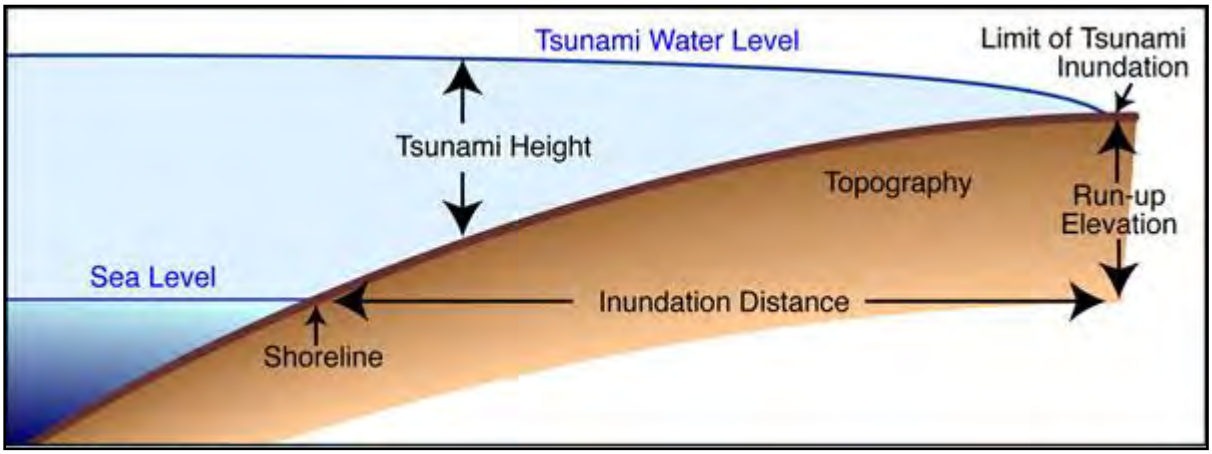

Figure 3.7: Tsunami terminology currently in use.

For the 200 year period from 1812 to 2012, 43 tsunamis were reported for 16 tsunami producing events effecting areas within 200 km of the CalWave site (Table 4.3 – Tsunami wave heights ranged from 0.08 m to 3.4 m). The single highest reported tsunami wave was 3.4 m. Four reported tsunamis were from 2.0 m to 2.5 m high. The majority (38) of tsunami heights were ≤1.9m and of those 20 tsunami waves were <1.0 m in height.

An inundation map prepared by the California Emergency Management Agency (CEMA) for the Point Arguello and adjacent Tranquillon Mountain Quadrangles (Figure 4.8) was constructed from historic data. While coastal California has experienced the ravages of a few devastating tsunamis, most notably the

tsunami at Crescent City in 1964, it should be noted that large sections of coastline have witnessed little effect from the same event.

The inundation map suggests that the CalWave's Primary Upland Landing site would not experience inundation. The possibility that the Alternate site might experience inundation is only slightly less from inundation due to its lower elevation.

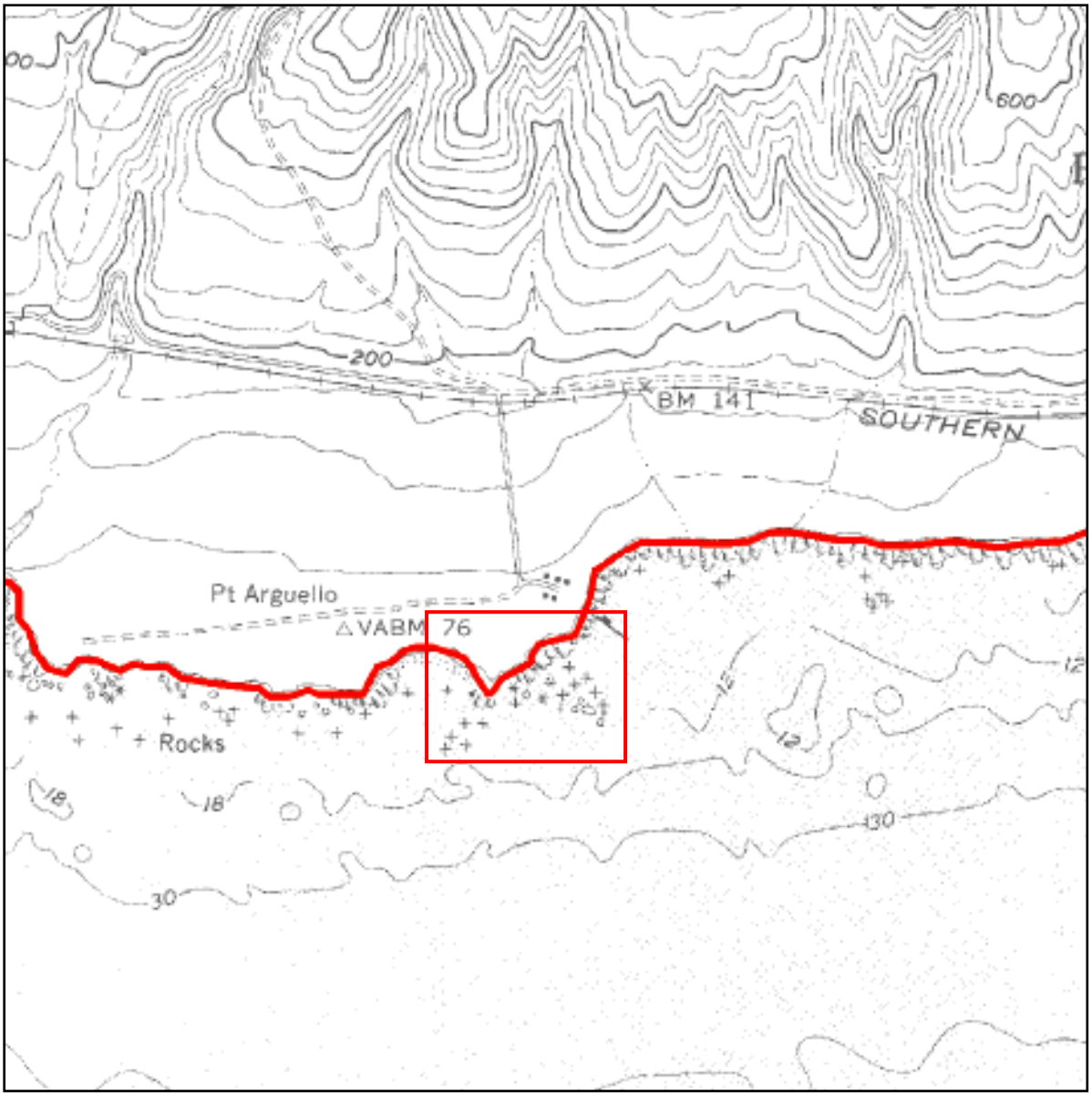

Figure 3.8: A portion of the CEMA inundation map that covers the CalWave landing site area.

Table 3.3: California Tsunamis Associated with Large Magnitude Earthquakes

Date	Travel Time (hrs)	Travel Time (min)	Tsunami Location	Height (m)	Source Location	Source Event	Magnitude (Ms)	Magnitude (Mw)
12/21/1812			El Refugio	**3.4**	Cal	Purismo	7.7	
			Santa Barbara	2				
			Ventura	2				
5/10/1877			Gaviota	1.8	N. Chile		8.3	

12/17/1896			Santa Barbara	2.5	S. Cal			
6/15/1896			Santa Cruz	1.5	Japan	Sanriku	7.6	
11/4/1927			**Surf (Lompoc)**	**1.8**	**Cal**		**7.3**	
4/1/1946	5	36	Avila Beach	1.3	Alaska	Aleutian Islands		
			S. Luis Obispo	1.3			7.3	
			Santa Cruz	1.5				
11/4/1952	8	36	Avila Beach	1.4	Russia	Kamchaka	8.2	9
5/22/1960	14	4	Port Hueneme	1.3	Chile	Cnt. Chile		9.5
3/27/1964	5	10	Avila Beach	1.6	Alaska	Gulf of Alaska		9.2
			Moss Landing	1.4				
			Santa Cruz	1.5				
10/18/1989			Moss Landing	1	Cal	L. Prieta	7.1	
11/4/2000			Pt. Arguello	?	Cal	P Arguello		
11/15/2006			Port San Luis	0,56	Russia	So. Kuril Islands	7.8	8.3
			Santa Barbara	0.4				
9/30/2009	11	8	Monterey	0.15	Samoa	Samoa Islands	8.1	8
	11	43	Port San Luis	0.28				
			Santa Barbara	0.25				
			Santa Cruz	0.7				
2/27/2010			Half Moon Bay	0.6	Chile	Central Chile	8.5	8.8
			Morro Bay	0.5				
			Moss Landing	0.3				
			Pismo Beach	1.2				
			Port San Luis	0.8				
	13	56	Santa Barbara	0.91				
			Santa Cruz	0.9				
			Ventura	0.9				
3/11/2011			Half Moon Bay	0.7	Japan	Honshu	8.3	9.0
	10	1	Monterey	0.7				
			Morro Bay	1.6				
			Oxnard	1.2				
			Pismo Beach	1				
			Plat. Harvest	0.15				
	10	23	Port San Luis	2.02				
			Santa Cruz	1.9				
			Ventura	1.9				
10/28/2012	3	30	Monterey	0.14	Canada	Queen Charlotte Island	7.5	7.7
			Port San Luis	0.27				
	4	19	Santa Monica	0.08				

The earthquake of November 4, 1927, often referred to as the Lompoc earthquake, was one of the most powerful shocks in southern California history. Sufficient disturbance of the ground along the coastal route of the Southern Pacific Railroad interrupted service until repairs could be effected. The magnitude 7.3 event was reported to have produced a sea-quake (compressional shock transmitted by water) and a seismic sea wave. The sea-quake was so violent it killed and stunned fish near Point Arguello and shook at least two ships in the area. The seismic sea wave (tsunami) produced by the shock was approximately two meters high at Surf and Pismo Beach and was recorded from La Jolla (near San Diego) to Fort Point (near San Francisco).

4. FISHERIES

Southern California has ongoing commercial and recreational fishing operations. Commercial operators range in size from small to medium. Fishing operations are predominantly pot/trap fishing and bottom longlining (with many local variations and exceptions). Midwater/surface fish such as squid, sardines and tuna are often abundant off Southern California, but they are taken with gear that is not likely to threaten cables post-installation.

The South Bay Cable / Fisheries Liaison Committee was established when the first fiber optic cables were placed into Southern California. Discussions with the Committee should eventually take place for the CalWave project. Much of the fishing off Southern California occurs shallower than 200 fathoms (365.8 m). It is therefore important to involve local fishermen in the route selection process for each cable if it is determined that fishing occurs at the site. In this event, it is advised to be prepared to negotiate, if necessary, an agreement with local fishermen concerning fishing and cables.

At the time of this study it is unclear the exact jurisdiction claimed by the South Bay Cable / Fisheries Liaison Committee. However, it is understood from public research that an additional organization, the Central California Joint Cable / Fisheries Liaison Committee claims jurisdiction roughly from the Point Arguello area north to Point Piedras Blancas (www.cencalcablefishery.com). It would be advised that each group be contacted regarding the CalWave project at the appropriate stage in project development to discuss the routing of the planned cables.

5. PERMITTING

It is not the intent of this report to provide comprehensive permitting information for all stages and stakeholders involved in the CalWave project. Instead, this section only provides a summarized list of California permits that may apply to the project and should be assessed during the regulatory feasibility stages of planning.

Table 5.1: California Permitting Summary

Permitting Authority	Permit Name	Area of Jurisdiction
U.S. Army Corps of Engineers	Survey Permit –Nationwide Permit 6	Mean High Tide to Outer Continental Shelf
U.S. Army Corps of Engineers. Includes consultations with: NOAA Fisheries, USFWS, SHPO)	Sec 404 Clean Water Act & Sec 10 Rivers and Harbors Act RHA – Preconstruction Notification for Nationwide Permit 12	Mean High Tide to Outer Continental Shelf & Terrestrial Streams and Wetlands
NOAA Fisheries	Endangered Species Act **Consultation** (Marine)	Mean High Tide to Outer Continental Shelf
US Fish and Wildlife Service	Endangered Species Act **Consultation** (Terrestrial)	Terrestrial Portion of Project
State Historic Preservation Office (SHPO)	Section 106 NHPA **Consultation**	All Terrestrial and to Outer Continental Shelf
California Coastal Commission	Coastal Development Permit	Mean High Tide to 3nm Limit
California Coastal Commission	Coastal Zone Management Act – Consistency Determination	Mean High Tide to Outer Continental Shelf
California Regional Water Quality Control Board	Section 401 Clean Water Act - Certification	Mean High Tide to 3nm Limit
South Coast Air Quality Management District	Air Quality Certification	Terrestrial and Marine to Carl Moyer Limit

In addition to the above general permitting summary, a California State Geophysical Survey permit will be required to conduct marine route survey operations in California state waters.

1.1. National Territorial Claims

The United Nations Convention on the Law of the Sea (UNCLOS) defines these maritime boundaries and ratification by each country as discussed below. Reference may also be made to Article 79 of UNCLOS, which relates to “Submarine cables and pipelines on the continental shelf”.

1. *All States are entitled to lay submarine cables and pipelines on the continental shelf, in accordance with the provisions of this article.*
2. *Subject to its right to take reasonable measures for the exploration of the continental shelf, the exploitation of its natural resources and the prevention, reduction and control of pollution from pipelines, the coastal State may not impede the laying or maintenance of such cables or pipelines.*
3. *The delineation of the course for the laying of such pipelines on the continental shelf is subject to the consent of the coastal State.*

4. *Nothing in this Part affects the right of the coastal State to establish conditions for cables or pipelines entering its territory or territorial sea, or its jurisdiction over cables and pipelines constructed or used in connection with the exploration of its continental shelf or exploitation of its resources or the operations of artificial islands, installations and structures under its jurisdiction.*
5. *When laying submarine cables or pipelines, States shall have due regard to cables or pipelines already in position. In particular, possibilities of repairing existing cables or pipelines shall not be prejudiced.*

The U.S. claims rights within their Territorial Sea (12 nautical miles, nm), Contiguous Zone (24nm) and Exclusive Economic Zone (200nm or equidistant line with adjacent marine state).

Further information regarding territorial claims is included in Section 8 of this report. It is noted here that the submarine power cables for the CalWave project terminate in the United States Territorial Sea.

6. HAZARDS AND RESTRICTIONS

6.1 Marine Protected Areas (MPAs)

There are no NOAA designated Marine Protected Areas that are either transited by the submarine power cables or that affect the design of the cables.

As a point of reference, NOAA designated MPAs can be sourced via a downloadable file at this location: http://marineprotectedareas.noaa.gov/dataanalysis/mpainventory

There are, however, two NOAA designated MPAs in the vicinity of the CalWave power cable routes. These MPAs are worth mentioning in this section for reference.

Off Point Arguello, to the west of Vandenberg Air Force Base exists the charted Vandenberg State Marine Reserve. This MPA prohibits commercial and recreational fishing, anchorage is prohibited and vessel activity is restricted. The managing agency for this area is the California Department of Fish and Wildlife.

Offshore beyond the terminus of each CalWave cable route, exists an additional MPA designated as the Point Conception Essential Fish Habitat (EFH) Conservation Area. This MPA is managed by the National Marine Fisheries Service, commercial fishing is restricted, and vessel and anchorage activity is unrestricted.

Below is a figure illustrating the location and extent of the MPAs described above with the Primary cable routes also shown.

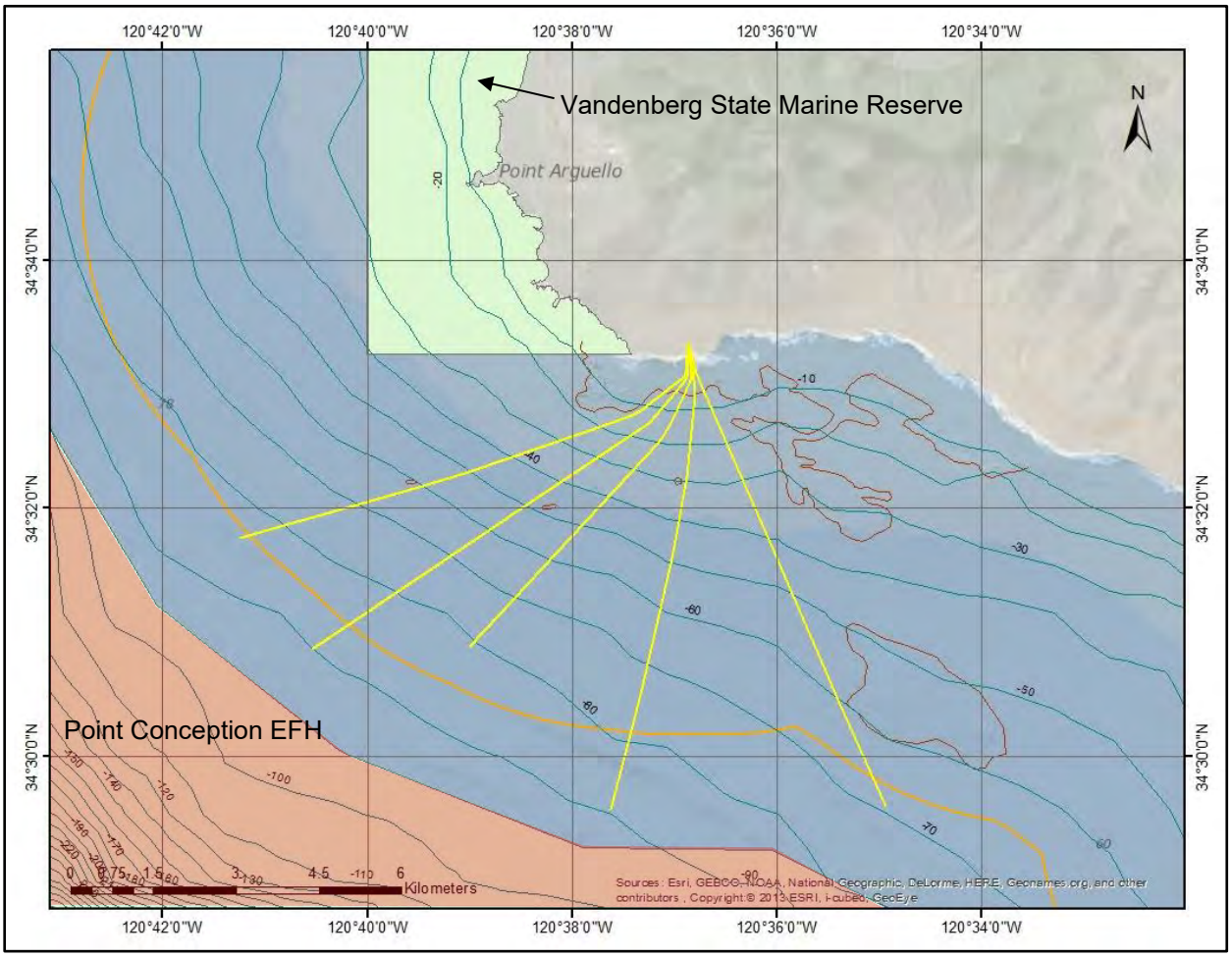

Figure 6.1: Overview of the Marine Protected Areas in the vicinity of the CalWave site

6.2 Military Practice Areas

There are charted military practice areas surrounding the offshore areas off Point Arguello and Vandenberg Air Force Base. Coordination of all marine vessel activity will need to be coordinated with the relevant authorities from VAFB, and possibly the US Navy, as well.

Below is an illustration of the Primary CalWave cable routes transiting the charted military practice areas.

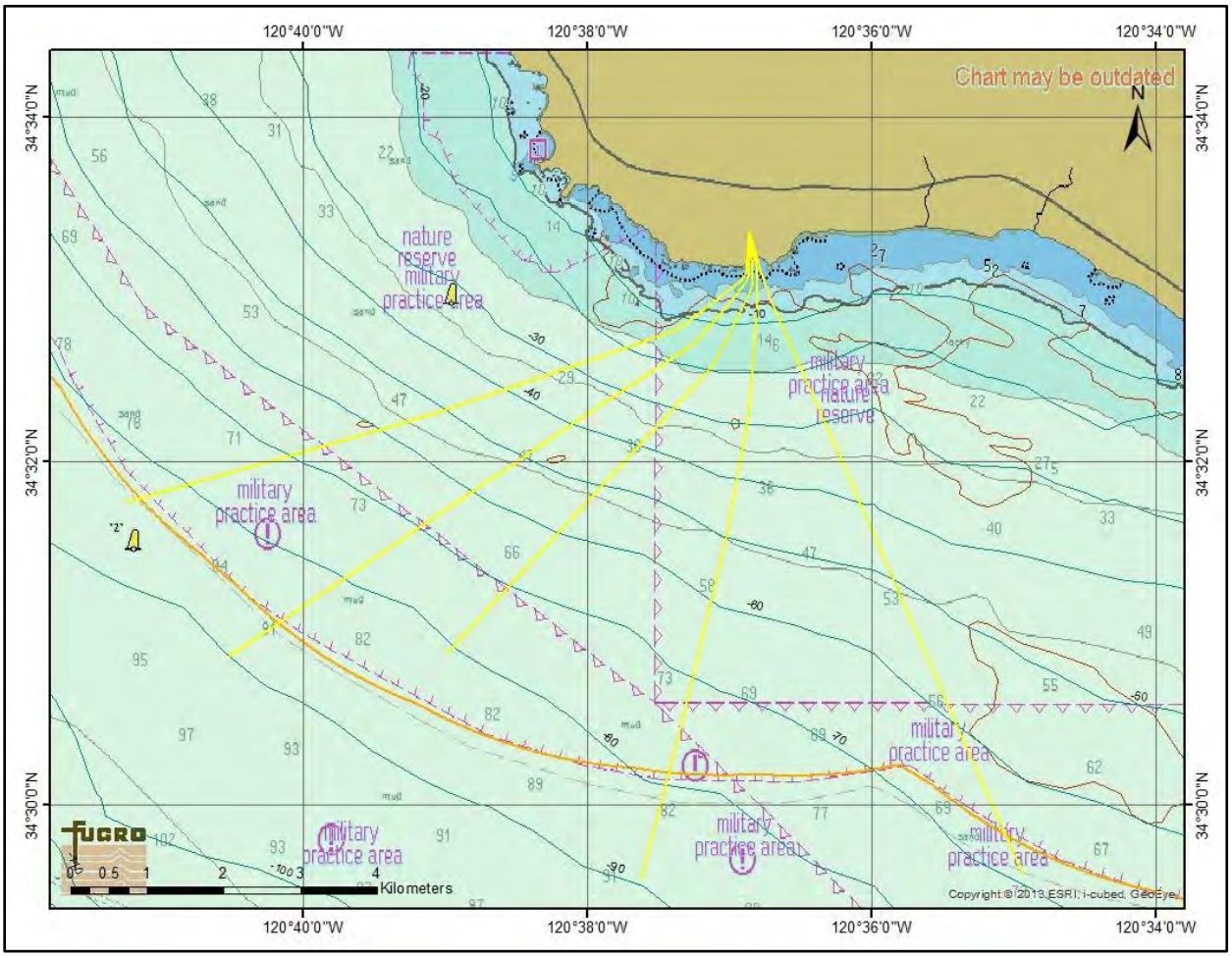

Figure 6.2: Military Practice Area off Point Arguello

6.3 Existing and Planned Cables and Pipelines

The planned CalWave sites and submarine cables do not cross or interfere with any existing or planned submarine cable or pipeline infrastructure.

6.4 Restricted Areas and Obstructions

There are no charted restricted areas or obstructions that pose risk or have affected the design of the submarine power cable routes.

6.5 Shipping

Ship anchors can snag and damage cables laid on the seafloor. This is particularly true of large anchors used on ships that have winching power for deployment and retrieval. Small boat anchors that are deployed by hand are usually unable to harm a cable and are often abandoned when they become entangled with submarine cables.

Most ships large enough to damage a cable are unlikely to be anchoring in the offshore areas traversed by a cable unless there is an emergency; thus the danger from anchors is relatively low. Obviously the danger will increase close to major harbors with the increase in the number of ships traversing the area.

Many harbors have offshore anchorage areas to accommodate ships with dangerous cargoes and to provide waiting areas for arriving ships.

There are no major harbor or port facilities in the immediate vicinity of the CalWave project. Below is a shipping density map for the years of 2014 and 2015 showing the relative density of ship traffic who are transmitting an AIS signal. While there is clear activity in areas of green / yellow / red densities, most of it is confined to shipping lanes that exist well offshore from the planned CalWave sites. The shipping activity in the vicinity of the CalWave site, while not confirmed simply by AIS data, is likely due to offshore vessel activity in the charted military practice areas, vessel traffic to/from the offshore platforms, as well as small recreation and/or fishing boat activity.

Based on the density map below, it does not appear likely that vessels are anchoring offshore in the location of the planned CalWave site. Although difficult to derive a conclusive understand of vessel traffic and patterns, it appears most activity is transit in nature.

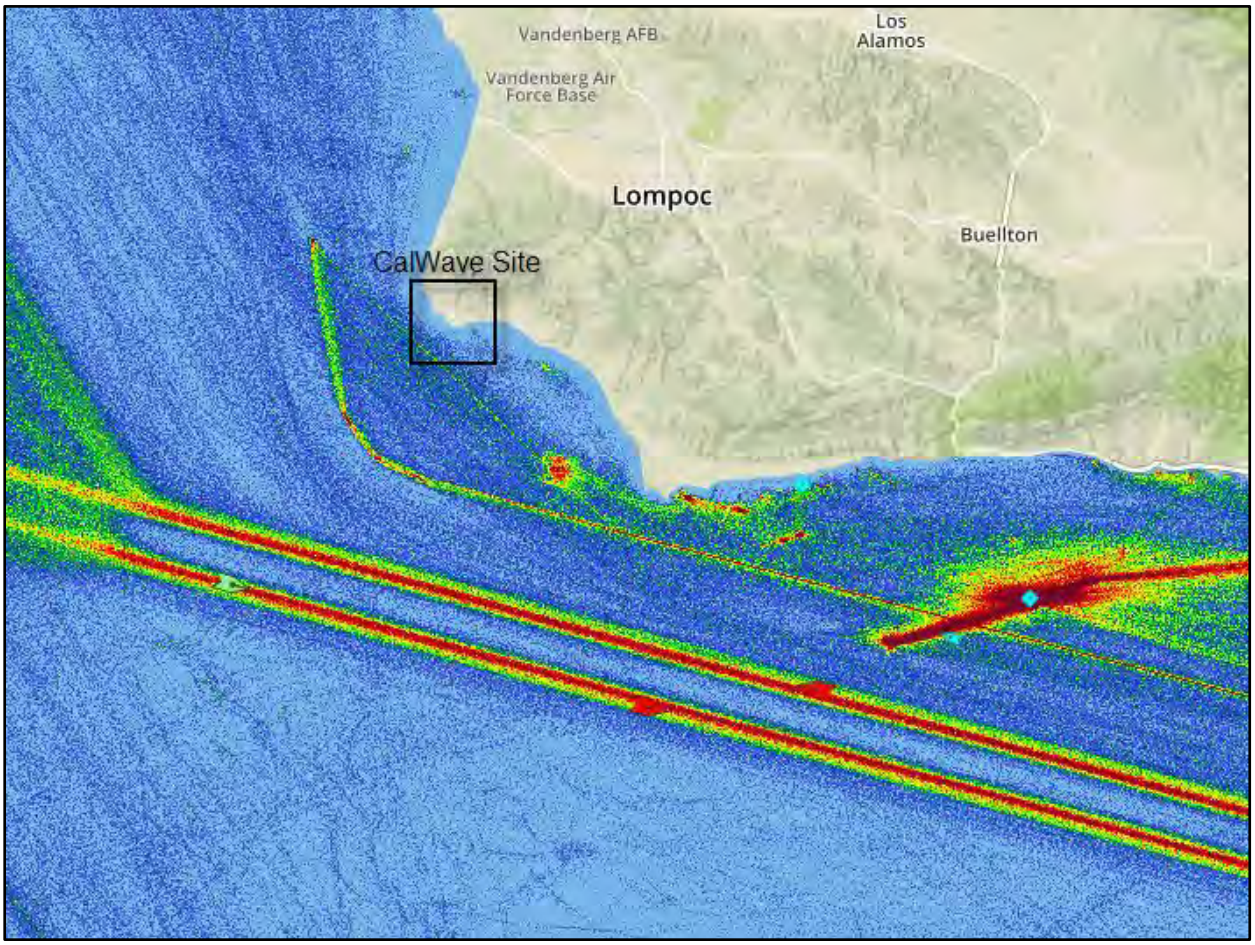

Figure 6.3: Shipping densities from 2014 and 2015 mapped from AIS data (www.marinetraffic.com) in the vicinity of the CalWave site. The black box indicating the cable area.

7. MARITIME BOUNDARIES

For this study, maritime boundaries were compiled from the General Dynamics database (GMBD 2008 Spring edition) and were crossed checked against those published by NOAA..

The various maritime boundaries are defined as follows:

- The State Seaward Boundary is defined as the limit of states jurisdiction under the Submerged Land Act (P.L. 83-31, 67 stat. 29 March 1953), nominally 3 nautical miles off the coast of California.

- The limit of “8(g) Zone” is the limit of a 3 geographic mile zone seaward of the State Seaward Boundary as provided under section 8(g) of the OCS Lands Act Amendments of 1985.

- The Territorial Sea is defined as the belt of sea adjacent to the coast, the outer limits of which is a line, every point of which is at a distance from the nearest point of the baseline equal to the breadth of the Territorial Sea. A 12 nautical mile U.S. Territorial Sea was established by Presidential Proclamation 5928 on December 27, 1988. The normal baseline is the line of mean lower low water (MLLW) along that portion of the coast in direct contact with the open sea, and closing lines across the mouths of bays and rivers.

- The Outer Continental Shelf (OCS) is defined as the seabed and subsoil of the submarine area adjacent to the coast of the mainland or islands, but seaward of the State Seaward Boundary to a depth of 200 meters, or beyond that limit where the depth of the superjacent waters admit the exploitation of the natural resources.

- The Contiguous Zone (CZ) extends 24 nautical miles offshore, and the Exclusive Economic Zone (EEZ) is a 200 nautical mile boundary (or equidistant line with adjacent marine state).

The CalWave power cables cross the California State limit and terminate within the United States Territorial Sea.

8. LANDING SITES

Two Landing (Launch) Points were selected, a Primary and an Alternate, as the onshore termination of the five proposed CalWave cables and as a site for the shore station complex. The shore station complex will include space to locate modular buildings, a power conditioning area and 12 kV and 70 kV substations.

Access to the site was gained by the Vandenberg Air Force Base Main Gate. Base-wide passes were secured before any further travel was allowed. After securing the needed passes, the site visit team proceeded to Base Engineering where a key was obtained to access the sites. The team traveled through the base on W. Ocean Ave, following it until it turned south and became the Coast Road. The Tow Road turnoff from the Coast Road is approximately 9.6 miles from the Surf Amtrak station. Following the Tow Road 0.8 miles to the Primary Site and continuing another 0.25 miles, the Tow Road ends at the Dock and the Alternate Site.

A site visit was conducted on 14 June 2016 during which a project Base Station was established and a notional Primary (Upland) landing point and notional Alternate (Dock) landing point were selected. During the site visit horizontal directional drilling constraints, options for substation and other ancillary building placement and general site conditions were assessed before the selection of the landing points were made.

Two notional landing points and a project Base Station location (Figure 9.1) were determined with a portable GPS receiver as:

- Base Station (0+00): 34° 33' 20.05" N, 120° 36' 53.55" W (Figure 9-1)
- Primary (Upland) Landing Point: 34°33’21.18”N, 120°36’50.88”W
- Alternate (Dock) Landing point: 34°33’17.52”N, 120°36’37.86”W

Figure 8.1: Project Base Station (0+00) and the two notional landing points

Both landing sites are located on a broad coastal plain that is referred to on USGS topographic maps as Sudden Flats. The coastal plain extends from the coastal cliffs (elev. 40 feet) inland to the base of Tranquillon Ridge (elev. 200 feet), the southern edge of the Santa Ynez Mountains. Tucked in against the base of Tranquillon Ridge the Southern Pacific Railroad and the Coast Road follow the trace that divides the coastal plain from the highlands of the Santa Ynez Mountains. At its very widest, the plain is 0.75 km (0.5 miles) to 1 km (0.6 miles) and narrows to the north and easterly directions along the coast.

8.1 Primary (Upland) Landing Point

A Primary Landing Point was selected on the coastal plain along the north side of the Tow Road (Figure 8.2). The coastal plain topography dips seaward at a slope of ±5° to the south southwest and exhibits gently rolling to subdued local relief. The site offers more than ample space for locating substations, power conditioning equipment, modular buildings and parking. The substrate soils are composed of sands, silts and gravels that support low grasses and scrub brush. Signage throughout the area warn of rattlesnakes and encourage personnel to avoid the brush areas.

The site is fronted by the Tow Road which provides direct vehicular access to both the Primary and Alternate sites. It is a paved and well maintained road extending from the Coast Road eastward to the dock at the Alternate site. A 12 kV power line lies along the northern edge of the Tow Road and extends to a substation on the dock at the Alternate Landing Site.

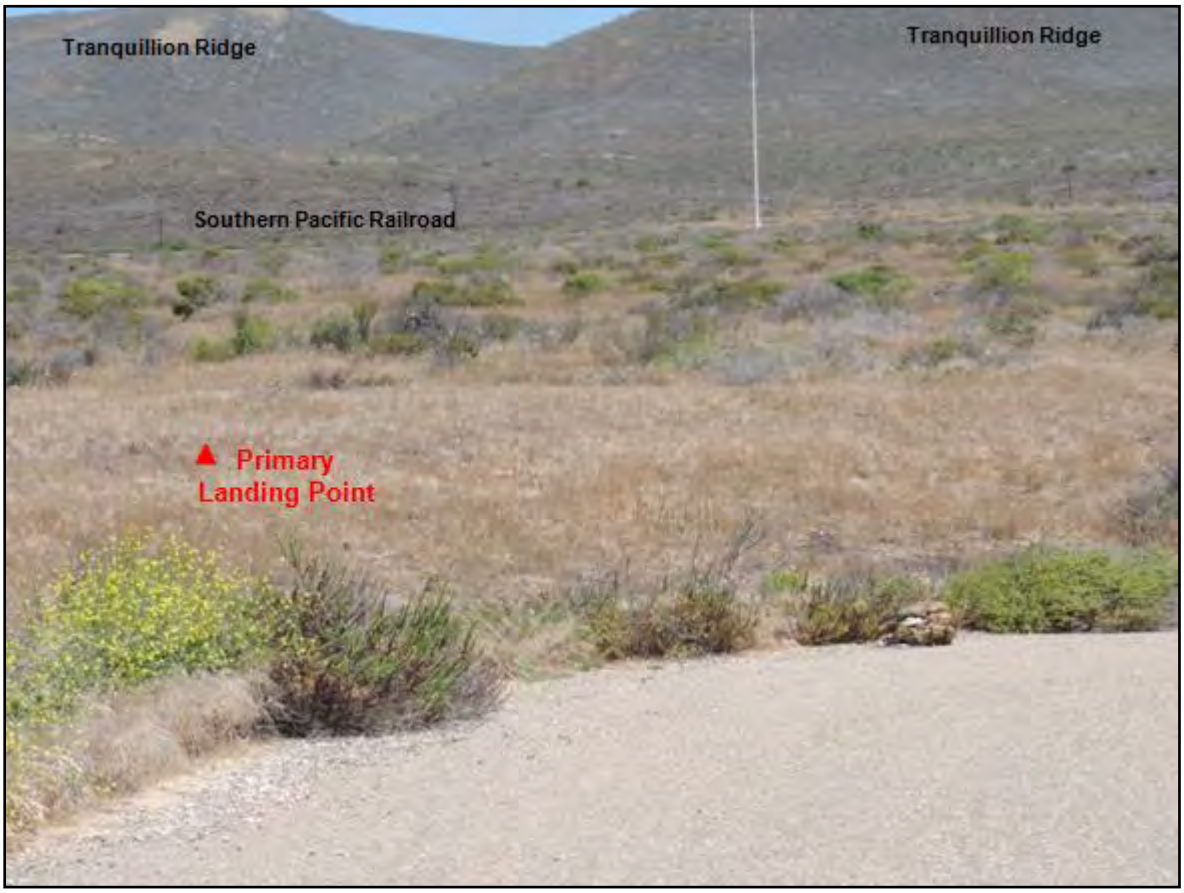

Figure 8.2: Primary Landing Site as seen looking north from the Tow Road

Subsequent to the site visit, The HDD Company adjusted the Landing Point slightly and provided borehole entry and exit coordinates (Table 8.1) for the five bores. The HDD bores would pass beneath the Tow Road in a southward direction and daylight on the seabed approximately 1,500 feet from the Primary Landing Site.

8.2 HDD Primary Landing Points and Site Logistics

The Primary Site entry and exit coordinates for the horizontal directional drilling were provided by The HDD Company (Table 8.1) referenced to a NAD83 HPGN datum. The coordinates have been converted to a WGS84 datum and are provided in Table 8.2 below. In addition, the cable terminus points are provided in Table 8.3 below. Although survey control was not recovered during the site visit, both US Coast and Geodetic and Vandenberg AFB monuments are located throughout the area.

Table 8.1: Primary Site (NAD83 HPGN)

	Entry	Exit	Azimuth
Bore 1 – West Cable	34.55565337° N	34.55154540° N	185°
	120.61443276° W	120.61483930° W	
Bore 2 – Southwest Cable	34.55565209° N	34.55153112° N	180°
	120.61441388° W	120.61438615° W	
Bore 3 – Anchorage Cable (Spare)	34.55565355° N	34.55154958° N	175°
	120.61439502° W	120.61393322° W	
Bore 4 – South Cable	34.55565568° N	34.55160062° N	170°

	120.61437631° W	120.61348395° W	
Bore 5 – Southeast Cable	34.55565914° N	34.55168386° N	165°
	120.61435789° W	120.61304177° W	

Table 8.2: Primary HDD (WGS84)

	Entry		Exit	
	Latitude	Longitude	Latitude	Longitude
Bore 01 – West Cable	34° 33' 20.3552" N	120° 36' 51.9475" W	34° 33' 05.5665" N	120° 36' 53.4111" W
Bore 02 – Southwest Cable	34° 33' 20.3506" N	120° 36' 51.8796" W	34° 33' 05.5151" N	120° 36' 51.7798" W
Bore 03 – Anchorage Cable (Spare)	34° 33' 20.3558" N	120° 36' 51.8117" W	34° 33' 05.5816" N	120° 36' 50.1493" W
Bore 04 – South Cable	34° 33' 20.3635" N	120° 36' 51.7443" W	34° 33' 05.7653" N	120° 36' 48.5319" W
Bore 05 – Southeast Cable	34° 33' 20.3760" N	120° 36' 51.6780" W	34° 33' 06.0650" N	120° 36' 46.9400" W

Table 8.3: Cable Terminus (provided by Leidos) (WGS84)

	Cable Terminus	
	Latitude	Longitude
Bore 01 – West Cable	34°31'45.75"N	120°41'14.84"W
Bore 02 – Southwest Cable	34°30'51.84"N	120°40'31.75"W
Bore 03 – Anchorage Cable (Spare)	34°30'52.83"N	120°38'59.70"W
Bore 04 – South Cable	34°29'33.96"N	120°37'37.48"W
Bore 05 – Southeast Cable	34°29'35.86"N	120°34'56.14"W

The bores as pictured in Figure 8.3 were plotted from these coordinates and extend approximately 1,500 feet offshore from the entry coordinates. The central bore has an azimuth of 175°. Bathymetry from the California Seabed Mapping Program (CSMP) were used to construct the isobaths in the figure. CSMP seabed imagery data were employed in the interpretation of the offshore rocky areas. These rock areas were conservatively delineated from seabed areas of unconsolidated sediments and include areas where rock may be draped with a thin veneer of soils. As shown, the five primary bores would daylight in water depths <30 feet (10 m) in a rocky substrate.

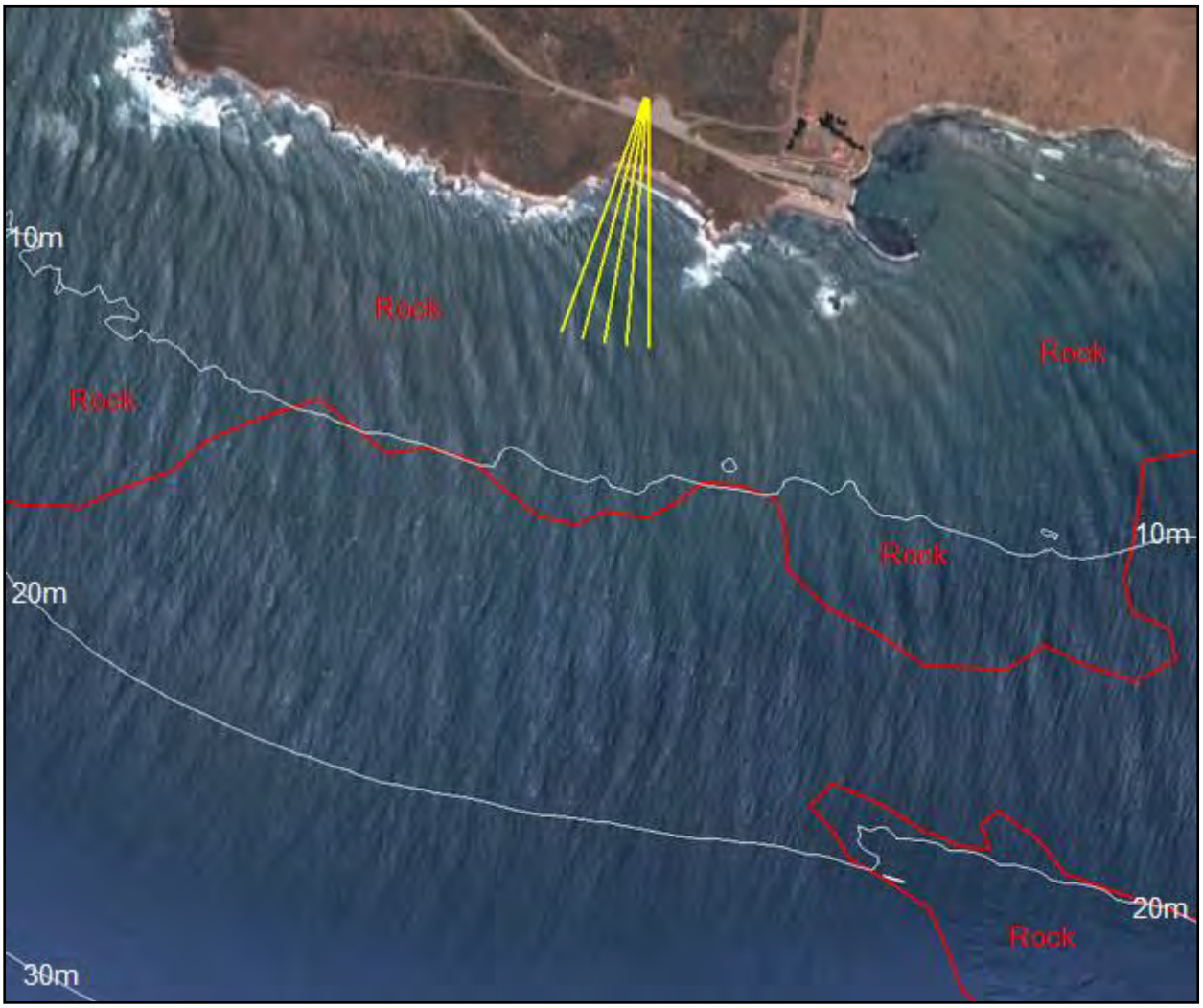

Figure 8.3: Overview of the Primary Site showing CSMP bathymetry, an interpretation of seabed type and the HDD bore trajectories.

8.3 Alternate Landing Site – Boathouse Dock

An evaluation of an Alternate Landing Point was made at the Boathouse Dock (Figure 8.4) located at the eastern end of the Tow Road. The dock was constructed in 1983 when the original boathouse and marine railway system were demolished in order to build a road to accommodate projected activities of the Space Transportation System that never materialized. A large portion of the land between the boathouse barracks veranda and the shore were cut away to make room for the road and dock facility.

The Alternate Landing Site is situated on the dock between a cut bank on the north side and a remnant low ±15 feet high ridge of Monterey Formation along the southern edge of the dock. The Tow Road eastern end terminates at the dock facility. The Tow Road provides direct vehicular access to the Alternate Site and is a paved and well maintained road extending from the Coast Road eastward to the dock. An overhead 12 kV power line lies along the northern edge of the Tow Road as the road descends to the dock and a substation in its northwest corner. The elevation of the dock is estimated to be about ±15 feet (4.5 m).

The dock area has a paved surface that measures approximately 260 feet (80 m) by 100 feet (30 m) with the eastern most 15 feet (4.5 m) of dock constructed of poured concrete that supports mooring bollards.

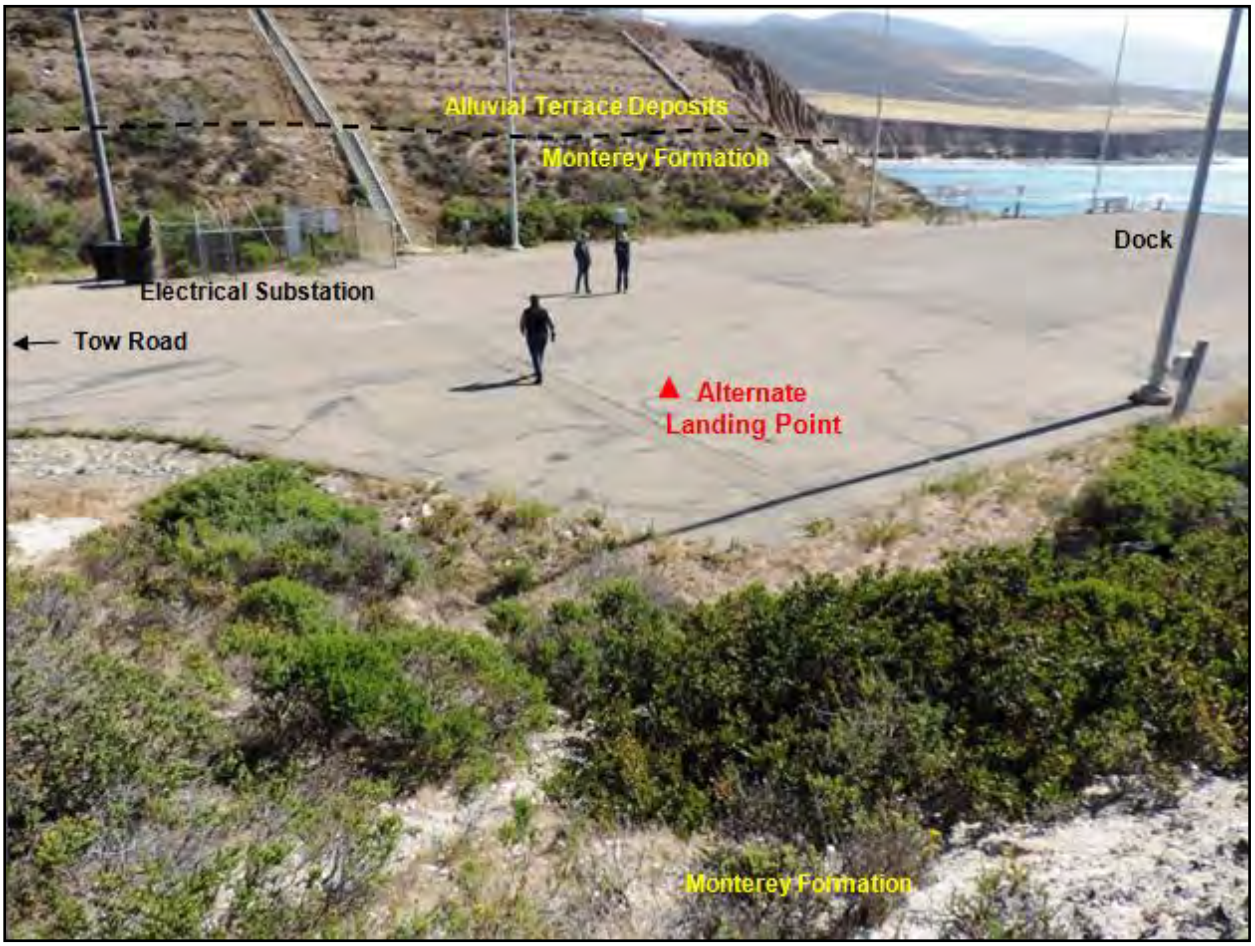

Figure 8.4: Alternate Landing Site at the Boathouse Dock as seen from a ridge along the southern edge of the dock.

Subsequent to the site visit, The HDD Company provided borehole entry and exit coordinates (Table 8.4) for the five bores. The HDD bores would pass beneath the dock and rock ridge in a southward direction and daylight on the seabed approximately 1,500 feet from the Alternate Landing Site.

8.4 HDD Alternate Landing Points and Site Logistics

The Alternate Site entry and exit coordinates for the horizontal directional drilling were provided by The HDD Company (Table 8.4) referenced to a NAD83 HPGN datum. The coordinates have been converted to a WGS84 datum and are provided in Table 8.5 below.

Table 8.4: Alternate Site (NAD83 HPGN)

	Entry	Exit	Azimuth
Bore 1 – West Cable	34.55493642° N 120.61049219° W	34.55094928° N 120.61175482° W	195°
Bore 2 – Southwest Cable	34.55493311° N 120.61047373° W	34.55087010° N 120.61131156° W	190°
Bore 3 – Anchorage Cable (Spare)	34.55493115° N 120.61045499° W	34.55082319° N 120.61086164° W	185°
Bore 4 – South Cable	34.55493056° N 120.61043611° W	34.55080890° N 120.61040849° W	180°

Bore 5 – Southeast Cable	34.55493132° N	34.55082734° N	175°
	120.61041724° W	120.60995556° W	

Table 8.5: Alternate HDD (WGS84)				
	Entry		Exit	
	Latitude	Longitude	Latitude	Longitude
Bore 01 – West Cable	34° 33' 17.7742" N	120° 36' 37.7615" W	34° 33' 03.4205" N	120° 36' 42.3070" W
Bore 02 – Southwest Cable	34° 33' 17.7623" N	120° 36' 37.6950" W	34° 33' 03.1355" N	120° 36' 40.7113" W
Bore 03 – Anchorage Cable (Spare)	34° 33' 17.7553" N	120° 36' 37.6276" W	34° 33' 02.9666" N	120° 36' 39.0916" W
Bore 04 – South Cable	34° 33' 17.7531" N	120° 36' 37.5596" W	34° 33' 02.9152" N	120° 36' 37.4602" W
Bore 05 – Southeast Cable	34° 33' 17.7531" N	120° 36' 37.5596" W	34° 33' 02.9816" N	120° 36' 35.8297" W

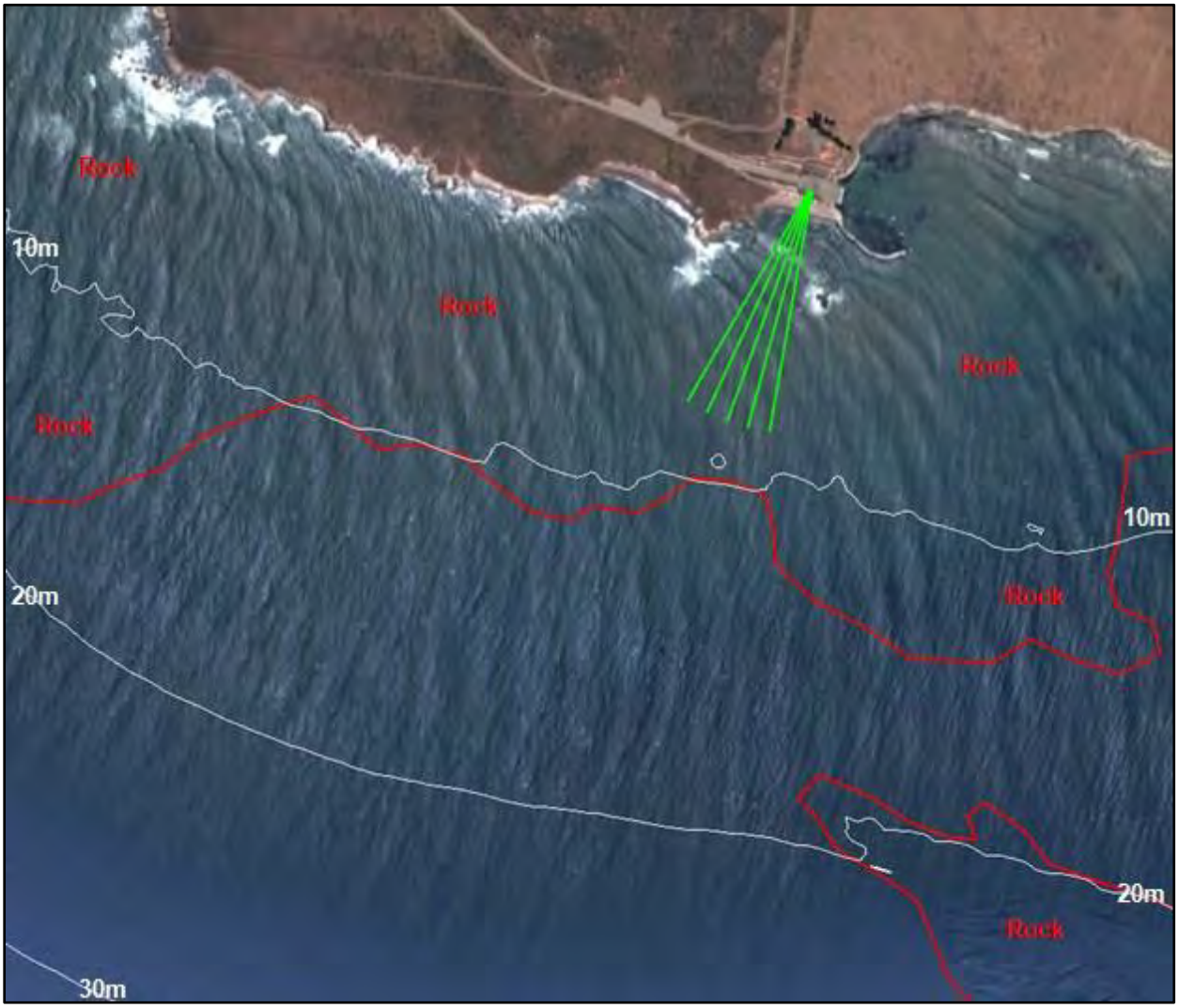

Figure 8.5: Overview of the Alternate Site showing CSMP bathymetry, an interpreted seabed type and the HDD bore trajectories.

The bores as pictured in Figure 8.5 were plotted from coordinates provided by The HDD Company and extend approximately 1,500 feet offshore from the entry coordinates. The central bore has an azimuth of 185°. Bathymetry from the California Seabed Mapping Program (CSMP) were used to construct the isobaths in the figure. CSMP seabed imagery data were employed in the interpretation of the offshore rocky areas. These rock areas were conservatively delineated from seabed areas of unconsolidated sediments and include areas where rock maybe draped with a thin veneer of soils. As shown, the five bores would daylight in water depths <30 feet (10 m) in a rocky substrate.

9. CABLE PROTECTION

The best and most effective means for the protection of submarine power cables is burial. Burial largely protects against bottom-contact fishing activity as well as vessel anchorages. Where these risks do not exist, burial may not be required from a cable protection standpoint, but may be required from a regulatory standpoint.

Submarine telecommunications cables are required by the California Coastal Commission to be buried from shore to a water depth of 1,200 m. Additionally, these cables are required to be inspected every year to identify if any portions of the cable have been uncovered from sediment movement and other natural activity. The inspection interval is relaxed if it is proven no portions of the cable have been uncovered.

Precedence for submarine power cables suggests that surface-laid cables are acceptable to the State of California. While surface laying a cable is more cost effective, it doesn't' mitigate the risks of cable damage from external aggression. In areas where cables may be surface-laid over hard rock, pinning, rock dumping or other methods may be required to protect the cable from abrasion from current activity. If fishing and/or anchorage activity exists in the vicinity of the cables, it will be very important to promote awareness of the existence of the cables. If possible, a cable protection corridor could be designated over the cable routes and charted on nautical charts used for ships navigation.

Further methods of cable protection include installing AIS base stations at each shore landing and setting up software-driven, automated AIS notification systems if vessels approach or are within a pre-defined buffer around the cables. It is not the intent of this report to recommend the best protection methods, but it is worthwhile to understand the standard methods used to protect submarine cable infrastructure.

It is, however, a recommendation of this report that the CalWave team contact the relevant fisheries groups to understand the type of fishing activity near the CalWave site to determine if any threat exists to the planned cables. Additionally, it would be worthwhile talking to the relevant authorities on VAFB to assess the type and frequency of shipping / vessel activity off Point Arguello and whether there are any anchorages that occur offshore. These factors will help determine site-specific cable protection measures that should be implemented to protect the CalWave submarine power cables.

10. SURVEY RECOMMENDATIONS

10.1 Route Survey

A cable route survey should be conducted along the selected route in advance of the cable installation in order to finalize an engineered route.

The surveys should be adequate to:

a. ascertain the presence of shallow geological anomalies or hazards and gather other information to be used as an aid in designing a safe cable route,
b. determine the presence and location of any significant man-made obstructions,
c. determine the position of existing in-service cables and pipelines in the approach to the landings,
d. enable an accurate profiling of the seafloor and cable engineering plan
e. assess burial feasibility along the route to the end of burial (EOB), if the cables are to be buried.

Based on the above criteria, it is essential to have facilities on site that allow immediate routing decisions to be made in case unfavorable seabed conditions are discovered along the route during the survey. In addition, the most complex survey operations will occur within the burial areas. These are areas where the most amount of survey data will have to be collected and analyzed.

The following survey specifications are provided as general recommendations and guidelines for acquiring the data required to engineer and install the cable routes.

Table 10.1: General Survey Recommendations for the CalWave Submarine Power Cable Routes

Survey Phase	Survey Sensor	Description	Survey Corridor
Geophysical Survey	Multibeam Echo Sounder (MBES)	Bathymetric contours to ascertain water depth along the route	250 m corridor (minimum) centered over each submarine power cable route
	Side Scan Sonar (SSS)	SSS mosaics – imagery of the seabed, interpreted for geologic features and sediment classification	250 m corridor (minimum) centered over each submarine power cable route
	Sub-bottom Profiler (SBP)	Sub-bottom profile of the upper 10 m+ of seabed for interpretation of sediment coverage, buried geologic features, etc.	Centerline (minimum) along each submarine power cable route
Geotechnical	Gravity Core	Sediment samples of upper 1 m of seabed for aid in ground-truthing sediment classification from SSS data	1 core / kilometer centered over in-field selected route, conducted after geophysical survey.
	Cone Penetration Tests (CPTs)	Sediment classification at-depth below the seabed to aid burial	1 CPT / kilometer centered over in-field selected route,

		feasibility and sub-bottom conditions	conducted after geophysical survey

Typically the CPT's and the Sub-bottom Profile data would only be collected if there was a possibility the cables would be buried. If the cables are to be surface-laid, a survey including MBES, SSS and Coring would be adequate for a submarine power cable installation, except for areas of planned HDD. Sub-bottom and CPT information would be useful in order to characterize the conditions of the HDD operation.

In addition to a marine route survey which include the geophysical and geotechnical components outlined above, a marine environmental survey will likely be required by the State of California and includes assessment of the benthic habitat and an archaeological assessment. In addition, Marine Mammal Observers (MMOs) will have to be onboard to observe all vessel related activities including survey and installation operations.

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Appendix A

Route Position Lists

Appendix B

Tides

Appendix C

Nautical Charts

Tide table: Avila, California
35.1700° N, 120.7400° W

January 2016

Day	High	Low	High	Low	High	Moon	Sunrise	Sunset
Fri 1	3:46 AM PST / 1.4 ft	9:58 AM PST / -0.2 ft	2:22 PM PST / 0.5 ft	9:11 PM PST / -1.5 ft		Last Quarter	7:11 AM PST	5:01 PM PST
Sat 2	4:32 AM PST / 1.6 ft	11:20 AM PST / -0.7 ft	4:19 PM PST / 0.1 ft	10:01 PM PST / -1.1 ft			7:11 AM PST	5:02 PM PST
Sun 3	5:10 AM PST / 1.8 ft	12:18 PM PST / -1.3 ft	5:58 PM PST / 0.1 ft	10:48 PM PST / -0.8 ft			7:11 AM PST	5:03 PM PST
Mon 4	5:42 AM PST / 2.1 ft	1:00 PM PST / -1.8 ft	7:07 PM PST / 0.2 ft	11:29 PM PST / -0.6 ft			7:11 AM PST	5:03 PM PST
Tue 5	6:11 AM PST / 2.4 ft	1:35 PM PST / -2.3 ft	7:55 PM PST / 0.3 ft				7:11 AM PST	5:04 PM PST
Wed 6		12:07 AM PST / -0.5 ft	6:40 AM PST / 2.7 ft	2:08 PM PST / -2.8 ft	8:33 PM PST / 0.5 ft		7:11 AM PST	5:05 PM PST
Thu 7		12:44 AM PST / -0.5 ft	7:11 AM PST / 3.0 ft	2:39 PM PST / -3.2 ft	9:06 PM PST / 0.6 ft		7:11 AM PST	5:06 PM PST
Fri 8		1:22 AM PST / -0.5 ft	7:45 AM PST / 3.3 ft	3:10 PM PST / -3.4 ft	9:38 PM PST / 0.8 ft		7:11 AM PST	5:07 PM PST
Sat 9		2:03 AM PST / -0.6 ft	8:21 AM PST / 3.4 ft	3:43 PM PST / -3.6 ft	10:12 PM PST / 1.0 ft	New Moon	7:11 AM PST	5:08 PM PST
Sun 10		2:46 AM PST / -0.7 ft	9:00 AM PST / 3.4 ft	4:18 PM PST / -3.7 ft	10:48 PM PST / 1.2 ft		7:11 AM PST	5:09 PM PST
Mon 11		3:32 AM PST / -0.8 ft	9:42 AM PST / 3.3 ft	4:55 PM PST / -3.6 ft	11:28 PM PST / 1.3 ft		7:11 AM PST	5:10 PM PST
Tue 12		4:23 AM PST / -0.8 ft	10:26 AM PST / 3.0 ft	5:35 PM PST / -3.4 ft			7:11 AM PST	5:11 PM PST
Wed 13	12:11 AM PST / 1.5 ft	5:21 AM PST / -0.7 ft	11:15 AM PST / 2.5 ft	6:17 PM PST / -3.1 ft			7:11 AM PST	5:11 PM PST
Thu 14	1:00 AM PST / 1.6 ft	6:28 AM PST / -0.7 ft	12:10 PM PST / 2.0 ft	7:04 PM PST / -2.7 ft			7:11 AM PST	5:12 PM PST
Fri 15	1:54 AM PST / 1.8 ft	7:49 AM PST / -0.8 ft	1:18 PM PST / 1.4 ft	7:57 PM PST / -2.2 ft			7:10 AM PST	5:13 PM PST
Sat 16	2:51 AM PST / 2.0 ft	9:18 AM PST / -1.1 ft	2:44 PM PST / 0.9 ft	8:56 PM PST / -1.8 ft		First Quarter	7:10 AM PST	5:14 PM PST
Sun 17	3:50 AM PST / 2.3 ft	10:41 AM PST / -1.6 ft	4:22 PM PST / 0.7 ft	9:59 PM PST / -1.5 ft			7:10 AM PST	5:15 PM PST
Mon 18	4:45 AM PST / 2.6 ft	11:48 AM PST / -2.2 ft	5:50 PM PST / 0.7 ft	11:02 PM PST / -1.2 ft			7:10 AM PST	5:16 PM PST
Tue 19	5:37 AM PST / 2.9 ft	12:45 PM PST / -2.8 ft	7:00 PM PST / 0.9 ft				7:09 AM PST	5:17 PM PST
Wed 20		12:00 AM PST / -1.1 ft	6:23 AM PST / 3.2 ft	1:33 PM PST / -3.3 ft	7:57 PM PST / 1.1 ft		7:09 AM PST	5:18 PM PST
Thu 21		12:53 AM PST / -1.0 ft	7:08 AM PST / 3.4 ft	2:18 PM PST / -3.7 ft	8:47 PM PST / 1.3 ft		7:08 AM PST	5:19 PM PST

Fri 22		1:41 AM PST / -0.9 ft	7:49 AM PST / 3.5 ft	3:00 PM PST / -3.9 ft	9:32 PM PST / 1.4 ft		7:08 AM PST	5:20 PM PST
Sat 23		2:26 AM PST / -0.8 ft	8:29 AM PST / 3.4 ft	3:41 PM PST / -3.9 ft	10:15 PM PST / 1.4 ft	Full Moon	7:07 AM PST	5:21 PM PST
Sun 24		3:09 AM PST / -0.7 ft	9:09 AM PST / 3.3 ft	4:20 PM PST / -3.8 ft	10:56 PM PST / 1.5 ft		7:07 AM PST	5:22 PM PST
Mon 25		3:52 AM PST / -0.7 ft	9:48 AM PST / 3.0 ft	4:58 PM PST / -3.5 ft	11:37 PM PST / 1.4 ft		7:06 AM PST	5:23 PM PST
Tue 26		4:37 AM PST / -0.6 ft	10:26 AM PST / 2.6 ft	5:36 PM PST / -3.1 ft			7:06 AM PST	5:24 PM PST
Wed 27	12:18 AM PST / 1.4 ft	5:26 AM PST / -0.5 ft	11:07 AM PST / 2.0 ft	6:13 PM PST / -2.6 ft			7:05 AM PST	5:25 PM PST
Thu 28	1:00 AM PST / 1.3 ft	6:23 AM PST / -0.4 ft	11:51 AM PST / 1.5 ft	6:50 PM PST / -2.1 ft			7:05 AM PST	5:26 PM PST
Fri 29	1:44 AM PST / 1.3 ft	7:35 AM PST / -0.4 ft	12:43 PM PST / 0.9 ft	7:26 PM PST / -1.6 ft			7:04 AM PST	5:27 PM PST
Sat 30	2:29 AM PST / 1.4 ft	9:03 AM PST / -0.6 ft	1:58 PM PST / 0.3 ft	8:05 PM PST / -1.1 ft			7:03 AM PST	5:28 PM PST
Sun 31	3:15 AM PST / 1.5 ft	10:28 AM PST / -0.9 ft	3:53 PM PST / 0.0 ft	8:48 PM PST / -0.7 ft		Last Quarter	7:03 AM PST	5:29 PM PST

February 2016

Day	High	Low	High	Low	High	Moon	Sunrise	Sunset
Mon 1	4:00 AM PST / 1.7 ft	11:33 AM PST / -1.4 ft	5:40 PM PST / -0.0 ft	9:39 PM PST / -0.5 ft			7:02 AM PST	5:31 PM PST
Tue 2	4:42 AM PST / 2.0 ft	12:22 PM PST / -1.9 ft	6:48 PM PST / 0.1 ft	10:36 PM PST / -0.3 ft			7:01 AM PST	5:32 PM PST
Wed 3	5:23 AM PST / 2.3 ft	1:01 PM PST / -2.3 ft	7:32 PM PST / 0.3 ft	11:30 PM PST / -0.3 ft			7:00 AM PST	5:33 PM PST
Thu 4	6:03 AM PST / 2.6 ft	1:36 PM PST / -2.7 ft	8:05 PM PST / 0.5 ft				6:59 AM PST	5:34 PM PST
Fri 5		12:19 AM PST / -0.5 ft	6:43 AM PST / 2.9 ft	2:09 PM PST / -3.1 ft	8:35 PM PST / 0.7 ft		6:59 AM PST	5:35 PM PST
Sat 6		1:06 AM PST / -0.6 ft	7:24 AM PST / 3.1 ft	2:42 PM PST / -3.3 ft	9:06 PM PST / 1.0 ft		6:58 AM PST	5:36 PM PST
Sun 7		1:52 AM PST / -0.9 ft	8:06 AM PST / 3.2 ft	3:16 PM PST / -3.4 ft	9:38 PM PST / 1.3 ft		6:57 AM PST	5:37 PM PST
Mon 8		2:39 AM PST / -1.1 ft	8:49 AM PST / 3.2 ft	3:51 PM PST / -3.4 ft	10:13 PM PST / 1.5 ft	New Moon	6:56 AM PST	5:38 PM PST
Tue 9		3:28 AM PST / -1.2 ft	9:33 AM PST / 3.1 ft	4:29 PM PST / -3.3 ft	10:51 PM PST / 1.7 ft		6:55 AM PST	5:39 PM PST
Wed 10		4:19 AM PST / -1.3 ft	10:21 AM PST / 2.8 ft	5:08 PM PST / -3.1 ft	11:33 PM PST / 1.9 ft		6:54 AM PST	5:40 PM PST
Thu 11		5:15 AM PST / -1.4 ft	11:12 AM PST / 2.3 ft	5:50 PM PST / -2.7 ft			6:53 AM PST	5:41 PM PST
Fri 12	12:18 AM PST / 2.0 ft	6:18 AM PST / -1.4 ft	12:09 PM PST / 1.8 ft	6:36 PM PST / -2.3 ft			6:52 AM PST	5:42 PM PST
Sat 13	1:09 AM PST / 2.1 ft	7:30 AM PST / -1.5 ft	1:18 PM PST / 1.3 ft	7:27 PM PST / -1.8 ft			6:51 AM PST	5:43 PM PST
Sun 14	2:05 AM PST / 2.2 ft	8:51 AM PST / -1.7 ft	2:43 PM PST / 0.9 ft	8:27 PM PST / -1.4 ft		First Quarter	6:50 AM PST	5:44 PM PST
Mon 15	3:06 AM PST / 2.3 ft	10:10 AM PST / -2.0 ft	4:17 PM PST / 0.7 ft	9:34 PM PST / -1.0 ft			6:49 AM PST	5:45 PM PST

Tue 16	4:08 AM PST / 2.5 ft	11:20 AM PST / -2.4 ft	5:41 PM PST / 0.8 ft	10:44 PM PST / -0.8 ft			6:48 AM PST	5:46 PM PST
Wed 17	5:06 AM PST / 2.6 ft	12:19 PM PST / -2.8 ft	6:48 PM PST / 1.0 ft	11:47 PM PST / -0.8 ft			6:47 AM PST	5:46 PM PST
Thu 18	5:59 AM PST / 2.8 ft	1:10 PM PST / -3.2 ft	7:43 PM PST / 1.2 ft				6:46 AM PST	5:47 PM PST
Fri 19		12:43 AM PST / -0.8 ft	6:49 AM PST / 2.9 ft	1:56 PM PST / -3.4 ft	8:28 PM PST / 1.4 ft		6:45 AM PST	5:48 PM PST
Sat 20		1:32 AM PST / -0.8 ft	7:34 AM PST / 3.0 ft	2:38 PM PST / -3.5 ft	9:09 PM PST / 1.5 ft		6:43 AM PST	5:49 PM PST
Sun 21		2:17 AM PST / -0.9 ft	8:17 AM PST / 3.0 ft	3:17 PM PST / -3.4 ft	9:46 PM PST / 1.6 ft		6:42 AM PST	5:50 PM PST
Mon 22		3:00 AM PST / -1.0 ft	8:58 AM PST / 2.8 ft	3:54 PM PST / -3.2 ft	10:20 PM PST / 1.6 ft	Full Moon	6:41 AM PST	5:51 PM PST
Tue 23		3:42 AM PST / -1.1 ft	9:38 AM PST / 2.5 ft	4:29 PM PST / -2.9 ft	10:53 PM PST / 1.6 ft		6:40 AM PST	5:52 PM PST
Wed 24		4:25 AM PST / -1.1 ft	10:19 AM PST / 2.2 ft	5:02 PM PST / -2.4 ft	11:25 PM PST / 1.5 ft		6:39 AM PST	5:53 PM PST
Thu 25		5:09 AM PST / -1.1 ft	11:00 AM PST / 1.7 ft	5:33 PM PST / -2.0 ft	11:56 PM PST / 1.5 ft		6:38 AM PST	5:54 PM PST
Fri 26		5:58 AM PST / -1.1 ft	11:45 AM PST / 1.3 ft	6:03 PM PST / -1.5 ft			6:36 AM PST	5:55 PM PST
Sat 27	12:28 AM PST / 1.5 ft	6:55 AM PST / -1.1 ft	12:38 PM PST / 0.8 ft	6:31 PM PST / -1.1 ft			6:35 AM PST	5:56 PM PST
Sun 28	1:04 AM PST / 1.5 ft	8:04 AM PST / -1.2 ft	1:49 PM PST / 0.3 ft	7:01 PM PST / -0.7 ft			6:34 AM PST	5:57 PM PST
Mon 29	1:46 AM PST / 1.6 ft	9:20 AM PST / -1.4 ft	3:30 PM PST / 0.1 ft	7:40 PM PST / -0.4 ft			6:33 AM PST	5:58 PM PST

March 2016

Day	High	Low	High	Low	High	Moon	Sunrise	Sunset
Tue 1	2:37 AM PST / 1.7 ft	10:30 AM PST / -1.6 ft	5:10 PM PST / 0.1 ft	8:40 PM PST / -0.2 ft		Last Quarter	6:31 AM PST	5:59 PM PST
Wed 2	3:34 AM PST / 1.8 ft	11:28 AM PST / -2.0 ft	6:14 PM PST / 0.3 ft	9:59 PM PST / -0.2 ft			6:30 AM PST	5:59 PM PST
Thu 3	4:33 AM PST / 2.0 ft	12:15 PM PST / -2.3 ft	6:55 PM PST / 0.5 ft	11:11 PM PST / -0.3 ft			6:29 AM PST	6:00 PM PST
Fri 4	5:28 AM PST / 2.3 ft	12:56 PM PST / -2.6 ft	7:28 PM PST / 0.8 ft				6:27 AM PST	6:01 PM PST
Sat 5		12:10 AM PST / -0.5 ft	6:20 AM PST / 2.5 ft	1:33 PM PST / -2.8 ft	7:58 PM PST / 1.1 ft		6:26 AM PST	6:02 PM PST
Sun 6		1:01 AM PST / -0.9 ft	7:09 AM PST / 2.7 ft	2:09 PM PST / -3.0 ft	8:29 PM PST / 1.4 ft		6:25 AM PST	6:03 PM PST
Mon 7		1:50 AM PST / -1.2 ft	7:56 AM PST / 2.8 ft	2:45 PM PST / -3.0 ft	9:02 PM PST / 1.7 ft		6:23 AM PST	6:04 PM PST
Tue 8		2:38 AM PST / -1.6 ft	8:43 AM PST / 2.8 ft	3:22 PM PST / -3.0 ft	9:37 PM PST / 2.0 ft	New Moon	6:22 AM PST	6:05 PM PST
Wed 9		3:26 AM PST / -1.9 ft	9:31 AM PST / 2.7 ft	4:01 PM PST / -2.8 ft	10:15 PM PST / 2.2 ft		6:21 AM PST	6:06 PM PST
Thu 10		4:16 AM PST / -2.1 ft	10:21 AM PST / 2.4 ft	4:41 PM PST / -2.5 ft	10:55 PM PST / 2.4 ft		6:19 AM PST	6:06 PM PST
Fri 11		5:09 AM PST / -2.2 ft	11:14 AM PST / 2.1 ft	5:23 PM PST / -2.1 ft	11:38 PM PST / 2.4 ft		6:18 AM PST	6:07 PM PST

Sat 12		6:06 AM PST / -2.3 ft	12:13 PM PST / 1.7 ft	6:08 PM PST / -1.7 ft			6:16 AM PST	6:08 PM PST
Sun 13	12:26 AM PST / 2.4 ft	8:10 AM PDT / -2.3 ft	2:22 PM PDT / 1.3 ft	8:00 PM PDT / -1.3 ft			7:15 AM PDT	7:09 PM PDT
Mon 14	2:19 AM PDT / 2.3 ft	9:21 AM PDT / -2.3 ft	3:43 PM PDT / 1.0 ft	9:02 PM PDT / -0.9 ft			7:14 AM PDT	7:10 PM PDT
Tue 15	3:19 AM PDT / 2.2 ft	10:35 AM PDT / -2.4 ft	5:11 PM PDT / 0.9 ft	10:15 PM PDT / -0.6 ft		First Quarter	7:12 AM PDT	7:11 PM PDT
Wed 16	4:25 AM PDT / 2.2 ft	11:45 AM PDT / -2.6 ft	6:29 PM PDT / 1.0 ft	11:33 PM PDT / -0.5 ft			7:11 AM PDT	7:11 PM PDT
Thu 17	5:33 AM PDT / 2.2 ft	12:47 PM PDT / -2.8 ft	7:31 PM PDT / 1.2 ft				7:10 AM PDT	7:12 PM PDT
Fri 18		12:42 AM PDT / -0.5 ft	6:36 AM PDT / 2.3 ft	1:41 PM PDT / -2.9 ft	8:21 PM PDT / 1.4 ft		7:08 AM PDT	7:13 PM PDT
Sat 19		1:40 AM PDT / -0.7 ft	7:32 AM PDT / 2.3 ft	2:28 PM PDT / -3.0 ft	9:02 PM PDT / 1.6 ft		7:07 AM PDT	7:14 PM PDT
Sun 20		2:29 AM PDT / -1.0 ft	8:22 AM PDT / 2.3 ft	3:10 PM PDT / -2.9 ft	9:38 PM PDT / 1.7 ft		7:05 AM PDT	7:15 PM PDT
Mon 21		3:14 AM PDT / -1.2 ft	9:08 AM PDT / 2.3 ft	3:48 PM PDT / -2.7 ft	10:10 PM PDT / 1.8 ft		7:04 AM PDT	7:16 PM PDT
Tue 22		3:55 AM PDT / -1.4 ft	9:52 AM PDT / 2.2 ft	4:22 PM PDT / -2.4 ft	10:38 PM PDT / 1.8 ft		7:02 AM PDT	7:16 PM PDT
Wed 23		4:34 AM PDT / -1.6 ft	10:34 AM PDT / 2.0 ft	4:54 PM PDT / -2.1 ft	11:04 PM PDT / 1.9 ft	Full Moon	7:01 AM PDT	7:17 PM PDT
Thu 24		5:13 AM PDT / -1.8 ft	11:16 AM PDT / 1.7 ft	5:22 PM PDT / -1.7 ft	11:29 PM PDT / 1.9 ft		7:00 AM PDT	7:18 PM PDT
Fri 25		5:53 AM PDT / -1.9 ft	11:59 AM PDT / 1.4 ft	5:48 PM PDT / -1.3 ft	11:55 PM PDT / 1.9 ft		6:58 AM PDT	7:19 PM PDT
Sat 26		6:36 AM PDT / -1.9 ft	12:45 PM PDT / 1.1 ft	6:13 PM PDT / -0.9 ft			6:57 AM PDT	7:20 PM PDT
Sun 27	12:23 AM PDT / 1.9 ft	7:23 AM PDT / -2.0 ft	1:37 PM PDT / 0.7 ft	6:39 PM PDT / -0.6 ft			6:55 AM PDT	7:20 PM PDT
Mon 28	12:56 AM PDT / 1.9 ft	8:16 AM PDT / -1.9 ft	2:42 PM PDT / 0.5 ft	7:10 PM PDT / -0.4 ft			6:54 AM PDT	7:21 PM PDT
Tue 29	1:36 AM PDT / 1.9 ft	9:17 AM PDT / -1.9 ft	4:05 PM PDT / 0.3 ft	7:54 PM PDT / -0.1 ft			6:53 AM PDT	7:22 PM PDT
Wed 30	2:27 AM PDT / 1.8 ft	10:22 AM PDT / -2.0 ft	5:28 PM PDT / 0.4 ft	9:05 PM PDT / 0.0 ft			6:51 AM PDT	7:23 PM PDT
Thu 31	3:30 AM PDT / 1.8 ft	11:25 AM PDT / -2.1 ft	6:29 PM PDT / 0.6 ft	10:41 PM PDT / -0.0 ft		Last Quarter	6:50 AM PDT	7:24 PM PDT

April 2016

Day	High	Low	High	Low	High	Moon	Sunrise	Sunset
Fri 1	4:43 AM PDT / 1.8 ft	12:21 PM PDT / -2.2 ft	7:11 PM PDT / 0.9 ft				6:48 AM PDT	7:24 PM PDT
Sat 2		12:04 AM PDT / -0.3 ft	5:56 AM PDT / 1.8 ft	1:09 PM PDT / -2.4 ft	7:46 PM PDT / 1.2 ft		6:47 AM PDT	7:25 PM PDT
Sun 3		1:08 AM PDT / -0.7 ft	7:00 AM PDT / 2.0 ft	1:52 PM PDT / -2.5 ft	8:19 PM PDT / 1.6 ft		6:46 AM PDT	7:26 PM PDT
Mon 4		2:01 AM PDT / -1.2 ft	7:57 AM PDT / 2.1 ft	2:33 PM PDT / -2.5 ft	8:53 PM PDT / 1.9 ft		6:44 AM PDT	7:27 PM PDT
Tue 5		2:50 AM PDT / -1.7 ft	8:50 AM PDT / 2.2 ft	3:13 PM PDT / -2.5 ft	9:27 PM PDT / 2.3 ft		6:43 AM PDT	7:28 PM PDT

Wed 6		3:37 AM PDT / -2.2 ft	9:41 AM PDT / 2.3 ft	3:52 PM PDT / -2.4 ft	10:03 PM PDT / 2.6 ft		6:41 AM PDT	7:28 PM PDT
Thu 7		4:24 AM PDT / -2.6 ft	10:31 AM PDT / 2.2 ft	4:32 PM PDT / -2.2 ft	10:41 PM PDT / 2.8 ft	New Moon	6:40 AM PDT	7:29 PM PDT
Fri 8		5:11 AM PDT / -2.9 ft	11:23 AM PDT / 2.1 ft	5:12 PM PDT / -1.9 ft	11:20 PM PDT / 2.9 ft		6:39 AM PDT	7:30 PM PDT
Sat 9		6:01 AM PDT / -3.0 ft	12:17 PM PDT / 1.8 ft	5:55 PM PDT / -1.5 ft			6:37 AM PDT	7:31 PM PDT
Sun 10	12:02 AM PDT / 2.9 ft	6:53 AM PDT / -3.1 ft	1:16 PM PDT / 1.6 ft	6:41 PM PDT / -1.1 ft			6:36 AM PDT	7:32 PM PDT
Mon 11	12:47 AM PDT / 2.7 ft	7:50 AM PDT / -3.0 ft	2:23 PM PDT / 1.3 ft	7:34 PM PDT / -0.7 ft			6:35 AM PDT	7:32 PM PDT
Tue 12	1:36 AM PDT / 2.5 ft	8:52 AM PDT / -2.9 ft	3:40 PM PDT / 1.2 ft	8:39 PM PDT / -0.4 ft			6:33 AM PDT	7:33 PM PDT
Wed 13	2:33 AM PDT / 2.2 ft	9:59 AM PDT / -2.8 ft	4:59 PM PDT / 1.2 ft	10:00 PM PDT / -0.2 ft		First Quarter	6:32 AM PDT	7:34 PM PDT
Thu 14	3:40 AM PDT / 1.9 ft	11:06 AM PDT / -2.7 ft	6:11 PM PDT / 1.3 ft	11:25 PM PDT / -0.2 ft			6:31 AM PDT	7:35 PM PDT
Fri 15	4:56 AM PDT / 1.7 ft	12:09 PM PDT / -2.6 ft	7:08 PM PDT / 1.5 ft				6:30 AM PDT	7:36 PM PDT
Sat 16		12:39 AM PDT / -0.4 ft	6:11 AM PDT / 1.6 ft	1:06 PM PDT / -2.5 ft	7:54 PM PDT / 1.7 ft		6:28 AM PDT	7:36 PM PDT
Sun 17		1:39 AM PDT / -0.8 ft	7:17 AM PDT / 1.6 ft	1:54 PM PDT / -2.4 ft	8:31 PM PDT / 1.8 ft		6:27 AM PDT	7:37 PM PDT
Mon 18		2:27 AM PDT / -1.2 ft	8:14 AM PDT / 1.6 ft	2:36 PM PDT / -2.2 ft	9:02 PM PDT / 2.0 ft		6:26 AM PDT	7:38 PM PDT
Tue 19		3:10 AM PDT / -1.6 ft	9:04 AM PDT / 1.6 ft	3:12 PM PDT / -1.9 ft	9:30 PM PDT / 2.1 ft		6:24 AM PDT	7:39 PM PDT
Wed 20		3:48 AM PDT / -1.9 ft	9:50 AM PDT / 1.5 ft	3:44 PM PDT / -1.6 ft	9:54 PM PDT / 2.2 ft		6:23 AM PDT	7:40 PM PDT
Thu 21		4:25 AM PDT / -2.2 ft	10:33 AM PDT / 1.4 ft	4:12 PM PDT / -1.3 ft	10:17 PM PDT / 2.3 ft	Full Moon	6:22 AM PDT	7:40 PM PDT
Fri 22		5:01 AM PDT / -2.5 ft	11:15 AM PDT / 1.3 ft	4:37 PM PDT / -1.0 ft	10:40 PM PDT / 2.4 ft		6:21 AM PDT	7:41 PM PDT
Sat 23		5:37 AM PDT / -2.6 ft	11:57 AM PDT / 1.1 ft	5:01 PM PDT / -0.8 ft	11:06 PM PDT / 2.5 ft		6:20 AM PDT	7:42 PM PDT
Sun 24		6:14 AM PDT / -2.7 ft	12:42 PM PDT / 0.9 ft	5:27 PM PDT / -0.5 ft	11:35 PM PDT / 2.5 ft		6:18 AM PDT	7:43 PM PDT
Mon 25		6:55 AM PDT / -2.7 ft	1:31 PM PDT / 0.7 ft	5:56 PM PDT / -0.3 ft			6:17 AM PDT	7:44 PM PDT
Tue 26	12:09 AM PDT / 2.4 ft	7:39 AM PDT / -2.7 ft	2:27 PM PDT / 0.6 ft	6:34 PM PDT / -0.1 ft			6:16 AM PDT	7:45 PM PDT
Wed 27	12:49 AM PDT / 2.3 ft	8:29 AM PDT / -2.5 ft	3:33 PM PDT / 0.6 ft	7:27 PM PDT / 0.0 ft			6:15 AM PDT	7:45 PM PDT
Thu 28	1:38 AM PDT / 2.0 ft	9:25 AM PDT / -2.4 ft	4:41 PM PDT / 0.7 ft	8:47 PM PDT / 0.1 ft			6:14 AM PDT	7:46 PM PDT
Fri 29	2:41 AM PDT / 1.7 ft	10:25 AM PDT / -2.3 ft	5:39 PM PDT / 1.0 ft	10:31 PM PDT / -0.0 ft		Last Quarter	6:13 AM PDT	7:47 PM PDT
Sat 30	4:00 AM PDT / 1.5 ft	11:25 AM PDT / -2.2 ft	6:25 PM PDT / 1.3 ft				6:12 AM PDT	7:48 PM PDT

May 2016

Day	High	Low	High	Low	High	Moon	Sunrise	Sunset

Sun 1		12:00 AM PDT / -0.4 ft	5:26 AM PDT / 1.4 ft	12:20 PM PDT / -2.2 ft	7:06 PM PDT / 1.7 ft		6:11 AM PDT	7:49 PM PDT
Mon 2		1:06 AM PDT / -1.0 ft	6:44 AM PDT / 1.4 ft	1:10 PM PDT / -2.1 ft	7:43 PM PDT / 2.1 ft		6:10 AM PDT	7:50 PM PDT
Tue 3		1:59 AM PDT / -1.6 ft	7:49 AM PDT / 1.5 ft	1:55 PM PDT / -2.1 ft	8:19 PM PDT / 2.5 ft		6:09 AM PDT	7:50 PM PDT
Wed 4		2:48 AM PDT / -2.3 ft	8:47 AM PDT / 1.7 ft	2:39 PM PDT / -2.0 ft	8:56 PM PDT / 2.9 ft		6:08 AM PDT	7:51 PM PDT
Thu 5		3:33 AM PDT / -2.8 ft	9:41 AM PDT / 1.8 ft	3:21 PM PDT / -1.8 ft	9:33 PM PDT / 3.1 ft		6:07 AM PDT	7:52 PM PDT
Fri 6		4:18 AM PDT / -3.3 ft	10:32 AM PDT / 1.8 ft	4:03 PM PDT / -1.6 ft	10:11 PM PDT / 3.3 ft	New Moon	6:06 AM PDT	7:53 PM PDT
Sat 7		5:04 AM PDT / -3.6 ft	11:24 AM PDT / 1.8 ft	4:45 PM PDT / -1.4 ft	10:50 PM PDT / 3.3 ft		6:05 AM PDT	7:54 PM PDT
Sun 8		5:50 AM PDT / -3.7 ft	12:18 PM PDT / 1.7 ft	5:29 PM PDT / -1.0 ft	11:30 PM PDT / 3.2 ft		6:04 AM PDT	7:54 PM PDT
Mon 9		6:38 AM PDT / -3.7 ft	1:15 PM PDT / 1.5 ft	6:15 PM PDT / -0.7 ft			6:03 AM PDT	7:55 PM PDT
Tue 10	12:13 AM PDT / 3.0 ft	7:29 AM PDT / -3.5 ft	2:18 PM PDT / 1.4 ft	7:09 PM PDT / -0.3 ft			6:02 AM PDT	7:56 PM PDT
Wed 11	12:59 AM PDT / 2.6 ft	8:24 AM PDT / -3.3 ft	3:27 PM PDT / 1.3 ft	8:16 PM PDT / -0.0 ft			6:01 AM PDT	7:57 PM PDT
Thu 12	1:51 AM PDT / 2.1 ft	9:23 AM PDT / -3.0 ft	4:39 PM PDT / 1.4 ft	9:42 PM PDT / 0.1 ft			6:00 AM PDT	7:58 PM PDT
Fri 13	2:54 AM PDT / 1.6 ft	10:25 AM PDT / -2.7 ft	5:44 PM PDT / 1.5 ft	11:16 PM PDT / -0.1 ft		First Quarter	6:00 AM PDT	7:58 PM PDT
Sat 14	4:16 AM PDT / 1.2 ft	11:27 AM PDT / -2.4 ft	6:38 PM PDT / 1.7 ft				5:59 AM PDT	7:59 PM PDT
Sun 15		12:35 AM PDT / -0.4 ft	5:45 AM PDT / 1.0 ft	12:24 PM PDT / -2.1 ft	7:21 PM PDT / 1.9 ft		5:58 AM PDT	8:00 PM PDT
Mon 16		1:35 AM PDT / -0.9 ft	7:04 AM PDT / 0.9 ft	1:14 PM PDT / -1.8 ft	7:55 PM PDT / 2.0 ft		5:57 AM PDT	8:01 PM PDT
Tue 17		2:22 AM PDT / -1.4 ft	8:08 AM PDT / 0.9 ft	1:56 PM PDT / -1.5 ft	8:24 PM PDT / 2.2 ft		5:57 AM PDT	8:02 PM PDT
Wed 18		3:02 AM PDT / -1.9 ft	9:02 AM PDT / 1.0 ft	2:31 PM PDT / -1.3 ft	8:49 PM PDT / 2.4 ft		5:56 AM PDT	8:02 PM PDT
Thu 19		3:38 AM PDT / -2.4 ft	9:49 AM PDT / 1.0 ft	3:00 PM PDT / -1.0 ft	9:11 PM PDT / 2.5 ft		5:55 AM PDT	8:03 PM PDT
Fri 20		4:12 AM PDT / -2.7 ft	10:31 AM PDT / 1.0 ft	3:26 PM PDT / -0.8 ft	9:34 PM PDT / 2.7 ft		5:55 AM PDT	8:04 PM PDT
Sat 21		4:45 AM PDT / -3.0 ft	11:10 AM PDT / 0.9 ft	3:51 PM PDT / -0.6 ft	10:00 PM PDT / 2.9 ft	Full Moon	5:54 AM PDT	8:05 PM PDT
Sun 22		5:18 AM PDT / -3.2 ft	11:49 AM PDT / 0.9 ft	4:18 PM PDT / -0.5 ft	10:28 PM PDT / 3.0 ft		5:53 AM PDT	8:05 PM PDT
Mon 23		5:52 AM PDT / -3.3 ft	12:29 PM PDT / 0.9 ft	4:49 PM PDT / -0.4 ft	11:01 PM PDT / 3.0 ft		5:53 AM PDT	8:06 PM PDT
Tue 24		6:29 AM PDT / -3.3 ft	1:12 PM PDT / 0.8 ft	5:26 PM PDT / -0.2 ft	11:38 PM PDT / 2.8 ft		5:52 AM PDT	8:07 PM PDT
Wed 25		7:09 AM PDT / -3.2 ft	2:00 PM PDT / 0.8 ft	6:12 PM PDT / -0.1 ft			5:52 AM PDT	8:07 PM PDT
Thu 26	12:19 AM PDT / 2.5 ft	7:52 AM PDT / -3.0 ft	2:54 PM PDT / 0.9 ft	7:13 PM PDT / 0.0 ft			5:51 AM PDT	8:08 PM PDT
Fri 27	1:08 AM PDT / 2.1 ft	8:41 AM PDT / -2.7 ft	3:52 PM PDT / 1.1 ft	8:36 PM PDT / 0.0 ft			5:51 AM PDT	8:09 PM PDT
Sat 28	2:09 AM PDT / 1.7 ft	9:36 AM PDT / -2.5 ft	4:49 PM PDT / 1.4 ft	10:19 PM PDT / -0.2 ft			5:51 AM PDT	8:10 PM PDT

Sun 29	3:28 AM PDT / 1.2 ft	10:34 AM PDT / -2.2 ft	5:41 PM PDT / 1.7 ft	11:50 PM PDT / -0.7 ft		Last Quarter	5:50 AM PDT	8:10 PM PDT
Mon 30	5:02 AM PDT / 1.0 ft	11:33 AM PDT / -2.0 ft	6:27 PM PDT / 2.1 ft				5:50 AM PDT	8:11 PM PDT
Tue 31		12:57 AM PDT / -1.3 ft	6:31 AM PDT / 0.9 ft	12:29 PM PDT / -1.8 ft	7:09 PM PDT / 2.5 ft		5:49 AM PDT	8:11 PM PDT

June 2016

Day	High	Low	High	Low	High	Moon	Sunrise	Sunset
Wed 1		1:52 AM PDT / -2.0 ft	7:44 AM PDT / 1.1 ft	1:20 PM PDT / -1.7 ft	7:49 PM PDT / 2.9 ft		5:49 AM PDT	8:12 PM PDT
Thu 2		2:41 AM PDT / -2.7 ft	8:45 AM PDT / 1.2 ft	2:08 PM PDT / -1.6 ft	8:29 PM PDT / 3.3 ft		5:49 AM PDT	8:13 PM PDT
Fri 3		3:26 AM PDT / -3.3 ft	9:39 AM PDT / 1.4 ft	2:53 PM PDT / -1.4 ft	9:07 PM PDT / 3.5 ft		5:49 AM PDT	8:13 PM PDT
Sat 4		4:09 AM PDT / -3.7 ft	10:30 AM PDT / 1.5 ft	3:37 PM PDT / -1.2 ft	9:46 PM PDT / 3.6 ft	New Moon	5:48 AM PDT	8:14 PM PDT
Sun 5		4:53 AM PDT / -4.0 ft	11:21 AM PDT / 1.6 ft	4:21 PM PDT / -1.0 ft	10:25 PM PDT / 3.6 ft		5:48 AM PDT	8:14 PM PDT
Mon 6		5:36 AM PDT / -4.1 ft	12:12 PM PDT / 1.5 ft	5:05 PM PDT / -0.7 ft	11:05 PM PDT / 3.4 ft		5:48 AM PDT	8:15 PM PDT
Tue 7		6:21 AM PDT / -4.0 ft	1:05 PM PDT / 1.5 ft	5:53 PM PDT / -0.5 ft	11:46 PM PDT / 3.1 ft		5:48 AM PDT	8:15 PM PDT
Wed 8		7:07 AM PDT / -3.8 ft	2:01 PM PDT / 1.4 ft	6:46 PM PDT / -0.2 ft			5:48 AM PDT	8:16 PM PDT
Thu 9	12:30 AM PDT / 2.6 ft	7:56 AM PDT / -3.4 ft	3:02 PM PDT / 1.4 ft	7:52 PM PDT / 0.0 ft			5:48 AM PDT	8:16 PM PDT
Fri 10	1:17 AM PDT / 2.0 ft	8:47 AM PDT / -3.0 ft	4:06 PM PDT / 1.5 ft	9:18 PM PDT / 0.1 ft			5:48 AM PDT	8:17 PM PDT
Sat 11	2:16 AM PDT / 1.4 ft	9:43 AM PDT / -2.5 ft	5:07 PM PDT / 1.6 ft	10:57 PM PDT / -0.1 ft			5:47 AM PDT	8:17 PM PDT
Sun 12	3:36 AM PDT / 0.8 ft	10:40 AM PDT / -2.0 ft	5:59 PM PDT / 1.7 ft			First Quarter	5:47 AM PDT	8:18 PM PDT
Mon 13		12:20 AM PDT / -0.6 ft	5:19 AM PDT / 0.5 ft	11:37 AM PDT / -1.6 ft	6:41 PM PDT / 1.9 ft		5:47 AM PDT	8:18 PM PDT
Tue 14		1:23 AM PDT / -1.1 ft	6:52 AM PDT / 0.4 ft	12:28 PM PDT / -1.3 ft	7:15 PM PDT / 2.1 ft		5:48 AM PDT	8:18 PM PDT
Wed 15		2:10 AM PDT / -1.7 ft	8:03 AM PDT / 0.5 ft	1:10 PM PDT / -1.0 ft	7:43 PM PDT / 2.3 ft		5:48 AM PDT	8:19 PM PDT
Thu 16		2:48 AM PDT / -2.2 ft	8:59 AM PDT / 0.5 ft	1:44 PM PDT / -0.7 ft	8:08 PM PDT / 2.6 ft		5:48 AM PDT	8:19 PM PDT
Fri 17		3:22 AM PDT / -2.6 ft	9:44 AM PDT / 0.6 ft	2:14 PM PDT / -0.6 ft	8:33 PM PDT / 2.8 ft		5:48 AM PDT	8:19 PM PDT
Sat 18		3:53 AM PDT / -3.0 ft	10:22 AM PDT / 0.7 ft	2:42 PM PDT / -0.5 ft	8:59 PM PDT / 3.0 ft		5:48 AM PDT	8:20 PM PDT
Sun 19		4:25 AM PDT / -3.3 ft	10:56 AM PDT / 0.7 ft	3:12 PM PDT / -0.5 ft	9:29 PM PDT / 3.2 ft		5:48 AM PDT	8:20 PM PDT
Mon 20		4:56 AM PDT / -3.5 ft	11:30 AM PDT / 0.8 ft	3:46 PM PDT / -0.4 ft	10:01 PM PDT / 3.3 ft	Full Moon	5:48 AM PDT	8:20 PM PDT
Tue 21		5:28 AM PDT / -3.6 ft	12:05 PM PDT / 0.9 ft	4:25 PM PDT / -0.4 ft	10:38 PM PDT / 3.2 ft		5:49 AM PDT	8:20 PM PDT
Wed 22		6:03 AM PDT / -3.5 ft	12:42 PM PDT / 1.0 ft	5:09 PM PDT / -0.4 ft	11:17 PM PDT / 3.0 ft		5:49 AM PDT	8:21 PM PDT

Thu 23		6:40 AM PDT / -3.4 ft	1:24 PM PDT / 1.1 ft	6:01 PM PDT / -0.3 ft			5:49 AM PDT	8:21 PM PDT
Fri 24	12:01 AM PDT / 2.6 ft	7:21 AM PDT / -3.1 ft	2:11 PM PDT / 1.2 ft	7:04 PM PDT / -0.3 ft			5:49 AM PDT	8:21 PM PDT
Sat 25	12:51 AM PDT / 2.1 ft	8:06 AM PDT / -2.8 ft	3:04 PM PDT / 1.4 ft	8:24 PM PDT / -0.3 ft			5:50 AM PDT	8:21 PM PDT
Sun 26	1:52 AM PDT / 1.6 ft	8:56 AM PDT / -2.4 ft	4:00 PM PDT / 1.7 ft	10:00 PM PDT / -0.5 ft			5:50 AM PDT	8:21 PM PDT
Mon 27	3:10 AM PDT / 1.0 ft	9:52 AM PDT / -2.1 ft	4:56 PM PDT / 2.0 ft	11:30 PM PDT / -1.0 ft		Last Quarter	5:50 AM PDT	8:21 PM PDT
Tue 28	4:48 AM PDT / 0.7 ft	10:53 AM PDT / -1.8 ft	5:48 PM PDT / 2.4 ft				5:51 AM PDT	8:21 PM PDT
Wed 29		12:40 AM PDT / -1.7 ft	6:22 AM PDT / 0.7 ft	11:54 AM PDT / -1.5 ft	6:37 PM PDT / 2.8 ft		5:51 AM PDT	8:21 PM PDT
Thu 30		1:38 AM PDT / -2.4 ft	7:38 AM PDT / 0.8 ft	12:51 PM PDT / -1.3 ft	7:22 PM PDT / 3.1 ft		5:52 AM PDT	8:21 PM PDT

July 2016

Day	High	Low	High	Low	High	Moon	Sunrise	Sunset
Fri 1		2:27 AM PDT / -3.0 ft	8:40 AM PDT / 1.0 ft	1:43 PM PDT / -1.2 ft	8:04 PM PDT / 3.4 ft		5:52 AM PDT	8:21 PM PDT
Sat 2		3:12 AM PDT / -3.5 ft	9:33 AM PDT / 1.2 ft	2:31 PM PDT / -1.1 ft	8:46 PM PDT / 3.6 ft		5:52 AM PDT	8:21 PM PDT
Sun 3		3:55 AM PDT / -3.9 ft	10:23 AM PDT / 1.4 ft	3:17 PM PDT / -1.0 ft	9:26 PM PDT / 3.7 ft		5:53 AM PDT	8:21 PM PDT
Mon 4		4:38 AM PDT / -4.1 ft	11:09 AM PDT / 1.5 ft	4:02 PM PDT / -0.8 ft	10:06 PM PDT / 3.6 ft	New Moon	5:53 AM PDT	8:21 PM PDT
Tue 5		5:19 AM PDT / -4.1 ft	11:56 AM PDT / 1.5 ft	4:48 PM PDT / -0.7 ft	10:46 PM PDT / 3.4 ft		5:54 AM PDT	8:20 PM PDT
Wed 6		6:01 AM PDT / -4.0 ft	12:43 PM PDT / 1.5 ft	5:35 PM PDT / -0.5 ft	11:27 PM PDT / 3.0 ft		5:54 AM PDT	8:20 PM PDT
Thu 7		6:43 AM PDT / -3.6 ft	1:32 PM PDT / 1.5 ft	6:27 PM PDT / -0.3 ft			5:55 AM PDT	8:20 PM PDT
Fri 8	12:10 AM PDT / 2.5 ft	7:26 AM PDT / -3.2 ft	2:24 PM PDT / 1.4 ft	7:29 PM PDT / -0.2 ft			5:56 AM PDT	8:20 PM PDT
Sat 9	12:56 AM PDT / 1.8 ft	8:12 AM PDT / -2.7 ft	3:18 PM PDT / 1.4 ft	8:47 PM PDT / -0.2 ft			5:56 AM PDT	8:19 PM PDT
Sun 10	1:50 AM PDT / 1.2 ft	8:59 AM PDT / -2.1 ft	4:13 PM PDT / 1.5 ft	10:21 PM PDT / -0.3 ft			5:57 AM PDT	8:19 PM PDT
Mon 11	3:06 AM PDT / 0.6 ft	9:49 AM PDT / -1.6 ft	5:04 PM PDT / 1.6 ft	11:49 PM PDT / -0.7 ft		First Quarter	5:57 AM PDT	8:19 PM PDT
Tue 12	4:56 AM PDT / 0.2 ft	10:42 AM PDT / -1.1 ft	5:48 PM PDT / 1.8 ft				5:58 AM PDT	8:18 PM PDT
Wed 13		12:56 AM PDT / -1.3 ft	6:41 AM PDT / 0.1 ft	11:33 AM PDT / -0.8 ft	6:26 PM PDT / 2.0 ft		5:59 AM PDT	8:18 PM PDT
Thu 14		1:45 AM PDT / -1.8 ft	7:56 AM PDT / 0.2 ft	12:18 PM PDT / -0.5 ft	6:58 PM PDT / 2.3 ft		5:59 AM PDT	8:17 PM PDT
Fri 15		2:24 AM PDT / -2.3 ft	8:50 AM PDT / 0.3 ft	12:58 PM PDT / -0.4 ft	7:28 PM PDT / 2.5 ft		6:00 AM PDT	8:17 PM PDT
Sat 16		2:57 AM PDT / -2.7 ft	9:29 AM PDT / 0.5 ft	1:33 PM PDT / -0.4 ft	7:58 PM PDT / 2.8 ft		6:00 AM PDT	8:16 PM PDT
Sun 17		3:28 AM PDT / -3.0 ft	10:00 AM PDT / 0.6 ft	2:09 PM PDT / -0.4 ft	8:31 PM PDT / 3.1 ft		6:01 AM PDT	8:16 PM PDT

Mon 18		3:59 AM PDT / -3.3 ft	10:29 AM PDT / 0.7 ft	2:48 PM PDT / -0.5 ft	9:06 PM PDT / 3.2 ft		6:02 AM PDT	8:15 PM PDT
Tue 19		4:30 AM PDT / -3.5 ft	10:59 AM PDT / 0.9 ft	3:29 PM PDT / -0.6 ft	9:43 PM PDT / 3.3 ft	Full Moon	6:03 AM PDT	8:15 PM PDT
Wed 20		5:02 AM PDT / -3.5 ft	11:30 AM PDT / 1.1 ft	4:13 PM PDT / -0.7 ft	10:23 PM PDT / 3.2 ft		6:03 AM PDT	8:14 PM PDT
Thu 21		5:36 AM PDT / -3.5 ft	12:05 PM PDT / 1.3 ft	5:01 PM PDT / -0.8 ft	11:06 PM PDT / 3.0 ft		6:04 AM PDT	8:14 PM PDT
Fri 22		6:12 AM PDT / -3.3 ft	12:44 PM PDT / 1.4 ft	5:55 PM PDT / -0.8 ft	11:52 PM PDT / 2.6 ft		6:05 AM PDT	8:13 PM PDT
Sat 23		6:52 AM PDT / -3.0 ft	1:28 PM PDT / 1.6 ft	6:57 PM PDT / -0.8 ft			6:05 AM PDT	8:12 PM PDT
Sun 24	12:45 AM PDT / 2.0 ft	7:35 AM PDT / -2.6 ft	2:17 PM PDT / 1.8 ft	8:11 PM PDT / -0.9 ft			6:06 AM PDT	8:12 PM PDT
Mon 25	1:46 AM PDT / 1.5 ft	8:23 AM PDT / -2.2 ft	3:12 PM PDT / 2.0 ft	9:36 PM PDT / -1.1 ft			6:07 AM PDT	8:11 PM PDT
Tue 26	3:05 AM PDT / 1.0 ft	9:18 AM PDT / -1.8 ft	4:11 PM PDT / 2.2 ft	11:01 PM PDT / -1.5 ft		Last Quarter	6:08 AM PDT	8:10 PM PDT
Wed 27	4:41 AM PDT / 0.6 ft	10:21 AM PDT / -1.4 ft	5:09 PM PDT / 2.5 ft				6:08 AM PDT	8:09 PM PDT
Thu 28		12:15 AM PDT / -2.0 ft	6:14 AM PDT / 0.6 ft	11:27 AM PDT / -1.2 ft	6:04 PM PDT / 2.8 ft		6:09 AM PDT	8:08 PM PDT
Fri 29		1:15 AM PDT / -2.6 ft	7:30 AM PDT / 0.8 ft	12:29 PM PDT / -1.0 ft	6:56 PM PDT / 3.0 ft		6:10 AM PDT	8:08 PM PDT
Sat 30		2:07 AM PDT / -3.1 ft	8:30 AM PDT / 1.0 ft	1:26 PM PDT / -1.0 ft	7:43 PM PDT / 3.3 ft		6:10 AM PDT	8:07 PM PDT
Sun 31		2:54 AM PDT / -3.5 ft	9:21 AM PDT / 1.2 ft	2:17 PM PDT / -0.9 ft	8:28 PM PDT / 3.4 ft		6:11 AM PDT	8:06 PM PDT

August 2016

Day	High	Low	High	Low	High	Moon	Sunrise	Sunset
Mon 1		3:37 AM PDT / -3.8 ft	10:07 AM PDT / 1.4 ft	3:05 PM PDT / -0.9 ft	9:11 PM PDT / 3.4 ft		6:12 AM PDT	8:05 PM PDT
Tue 2		4:18 AM PDT / -3.9 ft	10:49 AM PDT / 1.5 ft	3:51 PM PDT / -0.9 ft	9:52 PM PDT / 3.3 ft	New Moon	6:13 AM PDT	8:04 PM PDT
Wed 3		4:58 AM PDT / -3.8 ft	11:30 AM PDT / 1.6 ft	4:36 PM PDT / -0.9 ft	10:34 PM PDT / 3.1 ft		6:14 AM PDT	8:03 PM PDT
Thu 4		5:38 AM PDT / -3.5 ft	12:11 PM PDT / 1.6 ft	5:22 PM PDT / -0.9 ft	11:16 PM PDT / 2.7 ft		6:14 AM PDT	8:02 PM PDT
Fri 5		6:17 AM PDT / -3.2 ft	12:51 PM PDT / 1.5 ft	6:11 PM PDT / -0.8 ft	11:58 PM PDT / 2.2 ft		6:15 AM PDT	8:01 PM PDT
Sat 6		6:55 AM PDT / -2.7 ft	1:33 PM PDT / 1.5 ft	7:07 PM PDT / -0.7 ft			6:16 AM PDT	8:00 PM PDT
Sun 7	12:45 AM PDT / 1.6 ft	7:33 AM PDT / -2.1 ft	2:16 PM PDT / 1.5 ft	8:12 PM PDT / -0.7 ft			6:17 AM PDT	7:59 PM PDT
Mon 8	1:39 AM PDT / 1.0 ft	8:11 AM PDT / -1.6 ft	3:01 PM PDT / 1.5 ft	9:32 PM PDT / -0.8 ft			6:17 AM PDT	7:58 PM PDT
Tue 9	2:51 AM PDT / 0.5 ft	8:51 AM PDT / -1.1 ft	3:48 PM PDT / 1.5 ft	10:57 PM PDT / -1.0 ft			6:18 AM PDT	7:57 PM PDT
Wed 10	4:37 AM PDT / 0.1 ft	9:35 AM PDT / -0.7 ft	4:36 PM PDT / 1.6 ft			First Quarter	6:19 AM PDT	7:56 PM PDT
Thu 11		12:09 AM PDT / -1.4 ft	6:26 AM PDT / 0.1 ft	10:27 AM PDT / -0.4 ft	5:23 PM PDT / 1.8 ft		6:20 AM PDT	7:55 PM PDT

Fri 12		1:04 AM PDT / -1.8 ft	7:41 AM PDT / 0.2 ft	11:25 AM PDT / -0.2 ft	6:06 PM PDT / 2.1 ft		6:20 AM PDT	7:54 PM PDT
Sat 13		1:47 AM PDT / -2.2 ft	8:27 AM PDT / 0.3 ft	12:19 PM PDT / -0.2 ft	6:47 PM PDT / 2.3 ft		6:21 AM PDT	7:53 PM PDT
Sun 14		2:23 AM PDT / -2.6 ft	8:59 AM PDT / 0.5 ft	1:08 PM PDT / -0.3 ft	7:28 PM PDT / 2.6 ft		6:22 AM PDT	7:51 PM PDT
Mon 15		2:55 AM PDT / -2.9 ft	9:26 AM PDT / 0.7 ft	1:53 PM PDT / -0.5 ft	8:08 PM PDT / 2.8 ft		6:23 AM PDT	7:50 PM PDT
Tue 16		3:27 AM PDT / -3.1 ft	9:52 AM PDT / 0.9 ft	2:37 PM PDT / -0.8 ft	8:49 PM PDT / 3.0 ft		6:23 AM PDT	7:49 PM PDT
Wed 17		3:59 AM PDT / -3.2 ft	10:20 AM PDT / 1.2 ft	3:22 PM PDT / -1.0 ft	9:31 PM PDT / 3.0 ft		6:24 AM PDT	7:48 PM PDT
Thu 18		4:32 AM PDT / -3.2 ft	10:51 AM PDT / 1.4 ft	4:09 PM PDT / -1.3 ft	10:15 PM PDT / 2.9 ft	Full Moon	6:25 AM PDT	7:47 PM PDT
Fri 19		5:07 AM PDT / -3.1 ft	11:26 AM PDT / 1.7 ft	4:58 PM PDT / -1.4 ft	11:01 PM PDT / 2.7 ft		6:26 AM PDT	7:45 PM PDT
Sat 20		5:44 AM PDT / -2.9 ft	12:04 PM PDT / 1.9 ft	5:51 PM PDT / -1.6 ft	11:51 PM PDT / 2.3 ft		6:26 AM PDT	7:44 PM PDT
Sun 21		6:23 AM PDT / -2.6 ft	12:46 PM PDT / 2.0 ft	6:49 PM PDT / -1.6 ft			6:27 AM PDT	7:43 PM PDT
Mon 22	12:45 AM PDT / 1.9 ft	7:06 AM PDT / -2.2 ft	1:33 PM PDT / 2.1 ft	7:55 PM PDT / -1.7 ft			6:28 AM PDT	7:42 PM PDT
Tue 23	1:48 AM PDT / 1.4 ft	7:54 AM PDT / -1.8 ft	2:26 PM PDT / 2.2 ft	9:10 PM PDT / -1.8 ft			6:29 AM PDT	7:40 PM PDT
Wed 24	3:06 AM PDT / 1.0 ft	8:50 AM PDT / -1.4 ft	3:24 PM PDT / 2.3 ft	10:29 PM PDT / -2.0 ft		Last Quarter	6:29 AM PDT	7:39 PM PDT
Thu 25	4:38 AM PDT / 0.7 ft	9:56 AM PDT / -1.0 ft	4:28 PM PDT / 2.4 ft	11:42 PM PDT / -2.4 ft			6:30 AM PDT	7:38 PM PDT
Fri 26	6:06 AM PDT / 0.8 ft	11:09 AM PDT / -0.8 ft	5:31 PM PDT / 2.5 ft				6:31 AM PDT	7:36 PM PDT
Sat 27		12:46 AM PDT / -2.7 ft	7:17 AM PDT / 1.0 ft	12:18 PM PDT / -0.7 ft	6:30 PM PDT / 2.7 ft		6:32 AM PDT	7:35 PM PDT
Sun 28		1:41 AM PDT / -3.1 ft	8:14 AM PDT / 1.2 ft	1:19 PM PDT / -0.8 ft	7:24 PM PDT / 2.8 ft		6:32 AM PDT	7:34 PM PDT
Mon 29		2:29 AM PDT / -3.3 ft	9:01 AM PDT / 1.4 ft	2:12 PM PDT / -0.9 ft	8:13 PM PDT / 2.9 ft		6:33 AM PDT	7:33 PM PDT
Tue 30		3:13 AM PDT / -3.4 ft	9:43 AM PDT / 1.6 ft	3:00 PM PDT / -1.1 ft	9:00 PM PDT / 2.9 ft		6:34 AM PDT	7:31 PM PDT
Wed 31		3:55 AM PDT / -3.4 ft	10:21 AM PDT / 1.7 ft	3:45 PM PDT / -1.2 ft	9:44 PM PDT / 2.8 ft		6:35 AM PDT	7:30 PM PDT

September 2016

Day	High	Low	High	Low	High	Moon	Sunrise	Sunset
Thu 1		4:33 AM PDT / -3.2 ft	10:56 AM PDT / 1.8 ft	4:29 PM PDT / -1.3 ft	10:27 PM PDT / 2.6 ft	New Moon	6:35 AM PDT	7:28 PM PDT
Fri 2		5:10 AM PDT / -2.9 ft	11:31 AM PDT / 1.8 ft	5:13 PM PDT / -1.4 ft	11:10 PM PDT / 2.2 ft		6:36 AM PDT	7:27 PM PDT
Sat 3		5:45 AM PDT / -2.4 ft	12:03 PM PDT / 1.7 ft	5:58 PM PDT / -1.4 ft	11:55 PM PDT / 1.8 ft		6:37 AM PDT	7:26 PM PDT
Sun 4		6:18 AM PDT / -2.0 ft	12:35 PM PDT / 1.7 ft	6:46 PM PDT / -1.4 ft			6:38 AM PDT	7:24 PM PDT
Mon 5	12:42 AM PDT / 1.4 ft	6:50 AM PDT / -1.5 ft	1:07 PM PDT / 1.7 ft	7:40 PM PDT / -1.4 ft			6:38 AM PDT	7:23 PM PDT

Tue 6	1:36 AM PDT / 0.9 ft	7:20 AM PDT / -1.0 ft	1:42 PM PDT / 1.6 ft	8:42 PM PDT / -1.4 ft			6:39 AM PDT	7:21 PM PDT
Wed 7	2:45 AM PDT / 0.5 ft	7:50 AM PDT / -0.6 ft	2:21 PM PDT / 1.6 ft	9:53 PM PDT / -1.5 ft			6:40 AM PDT	7:20 PM PDT
Thu 8	4:20 AM PDT / 0.2 ft	8:25 AM PDT / -0.3 ft	3:08 PM PDT / 1.6 ft	11:05 PM PDT / -1.7 ft			6:41 AM PDT	7:19 PM PDT
Fri 9	6:00 AM PDT / 0.2 ft	9:19 AM PDT / -0.1 ft	4:05 PM PDT / 1.7 ft			First Quarter	6:41 AM PDT	7:17 PM PDT
Sat 10		12:06 AM PDT / -1.9 ft	7:09 AM PDT / 0.3 ft	10:41 AM PDT / 0.0 ft	5:07 PM PDT / 1.8 ft		6:42 AM PDT	7:16 PM PDT
Sun 11		12:56 AM PDT / -2.2 ft	7:48 AM PDT / 0.5 ft	11:58 AM PDT / -0.1 ft	6:06 PM PDT / 2.0 ft		6:43 AM PDT	7:14 PM PDT
Mon 12		1:37 AM PDT / -2.4 ft	8:17 AM PDT / 0.8 ft	12:57 PM PDT / -0.4 ft	7:00 PM PDT / 2.2 ft		6:44 AM PDT	7:13 PM PDT
Tue 13		2:15 AM PDT / -2.6 ft	8:44 AM PDT / 1.0 ft	1:48 PM PDT / -0.7 ft	7:50 PM PDT / 2.4 ft		6:44 AM PDT	7:11 PM PDT
Wed 14		2:50 AM PDT / -2.7 ft	9:11 AM PDT / 1.3 ft	2:36 PM PDT / -1.1 ft	8:38 PM PDT / 2.5 ft		6:45 AM PDT	7:10 PM PDT
Thu 15		3:24 AM PDT / -2.7 ft	9:41 AM PDT / 1.7 ft	3:21 PM PDT / -1.6 ft	9:25 PM PDT / 2.5 ft		6:46 AM PDT	7:09 PM PDT
Fri 16		4:00 AM PDT / -2.7 ft	10:13 AM PDT / 2.0 ft	4:08 PM PDT / -1.9 ft	10:12 PM PDT / 2.5 ft	Full Moon	6:46 AM PDT	7:07 PM PDT
Sat 17		4:36 AM PDT / -2.6 ft	10:48 AM PDT / 2.3 ft	4:55 PM PDT / -2.2 ft	11:01 PM PDT / 2.3 ft		6:47 AM PDT	7:06 PM PDT
Sun 18		5:14 AM PDT / -2.4 ft	11:26 AM PDT / 2.5 ft	5:46 PM PDT / -2.4 ft	11:53 PM PDT / 2.1 ft		6:48 AM PDT	7:04 PM PDT
Mon 19		5:55 AM PDT / -2.0 ft	12:08 PM PDT / 2.5 ft	6:39 PM PDT / -2.5 ft			6:49 AM PDT	7:03 PM PDT
Tue 20	12:49 AM PDT / 1.7 ft	6:39 AM PDT / -1.7 ft	12:52 PM PDT / 2.5 ft	7:38 PM PDT / -2.5 ft			6:49 AM PDT	7:01 PM PDT
Wed 21	1:53 AM PDT / 1.4 ft	7:28 AM PDT / -1.3 ft	1:42 PM PDT / 2.5 ft	8:44 PM PDT / -2.5 ft			6:50 AM PDT	7:00 PM PDT
Thu 22	3:08 AM PDT / 1.1 ft	8:25 AM PDT / -0.9 ft	2:39 PM PDT / 2.3 ft	9:55 PM PDT / -2.5 ft			6:51 AM PDT	6:58 PM PDT
Fri 23	4:32 AM PDT / 1.0 ft	9:36 AM PDT / -0.6 ft	3:44 PM PDT / 2.2 ft	11:06 PM PDT / -2.6 ft		Last Quarter	6:52 AM PDT	6:57 PM PDT
Sat 24	5:53 AM PDT / 1.1 ft	10:57 AM PDT / -0.4 ft	4:55 PM PDT / 2.1 ft				6:52 AM PDT	6:55 PM PDT
Sun 25		12:12 AM PDT / -2.8 ft	6:59 AM PDT / 1.3 ft	12:13 PM PDT / -0.5 ft	6:04 PM PDT / 2.1 ft		6:53 AM PDT	6:54 PM PDT
Mon 26		1:09 AM PDT / -2.9 ft	7:52 AM PDT / 1.5 ft	1:17 PM PDT / -0.7 ft	7:06 PM PDT / 2.2 ft		6:54 AM PDT	6:53 PM PDT
Tue 27		2:00 AM PDT / -2.9 ft	8:36 AM PDT / 1.7 ft	2:11 PM PDT / -1.0 ft	8:02 PM PDT / 2.2 ft		6:55 AM PDT	6:51 PM PDT
Wed 28		2:45 AM PDT / -2.8 ft	9:13 AM PDT / 1.9 ft	2:58 PM PDT / -1.4 ft	8:53 PM PDT / 2.2 ft		6:55 AM PDT	6:50 PM PDT
Thu 29		3:26 AM PDT / -2.7 ft	9:47 AM PDT / 2.0 ft	3:42 PM PDT / -1.6 ft	9:40 PM PDT / 2.1 ft		6:56 AM PDT	6:48 PM PDT
Fri 30		4:03 AM PDT / -2.4 ft	10:18 AM PDT / 2.0 ft	4:23 PM PDT / -1.9 ft	10:25 PM PDT / 2.0 ft	New Moon	6:57 AM PDT	6:47 PM PDT

October 2016

Day	High	Low	High	Low	High	Moon	Sunrise	Sunset

Sat 1		4:37 AM PDT / -2.0 ft	10:46 AM PDT / 2.1 ft	5:03 PM PDT / -2.1 ft	11:09 PM PDT / 1.7 ft		6:58 AM PDT	6:45 PM PDT
Sun 2		5:08 AM PDT / -1.6 ft	11:13 AM PDT / 2.1 ft	5:44 PM PDT / -2.2 ft	11:54 PM PDT / 1.4 ft		6:59 AM PDT	6:44 PM PDT
Mon 3		5:36 AM PDT / -1.2 ft	11:40 AM PDT / 2.1 ft	6:26 PM PDT / -2.2 ft			6:59 AM PDT	6:43 PM PDT
Tue 4	12:42 AM PDT / 1.1 ft	6:02 AM PDT / -0.9 ft	12:07 PM PDT / 2.1 ft	7:10 PM PDT / -2.2 ft			7:00 AM PDT	6:41 PM PDT
Wed 5	1:34 AM PDT / 0.8 ft	6:28 AM PDT / -0.5 ft	12:37 PM PDT / 2.0 ft	7:59 PM PDT / -2.2 ft			7:01 AM PDT	6:40 PM PDT
Thu 6	2:37 AM PDT / 0.5 ft	6:55 AM PDT / -0.2 ft	1:12 PM PDT / 1.9 ft	8:55 PM PDT / -2.1 ft			7:02 AM PDT	6:38 PM PDT
Fri 7	3:56 AM PDT / 0.4 ft	7:32 AM PDT / 0.0 ft	1:56 PM PDT / 1.8 ft	9:56 PM PDT / -2.1 ft			7:03 AM PDT	6:37 PM PDT
Sat 8	5:18 AM PDT / 0.4 ft	8:35 AM PDT / 0.2 ft	2:54 PM PDT / 1.7 ft	10:58 PM PDT / -2.1 ft		First Quarter	7:03 AM PDT	6:36 PM PDT
Sun 9	6:18 AM PDT / 0.6 ft	10:15 AM PDT / 0.2 ft	4:06 PM PDT / 1.5 ft	11:55 PM PDT / -2.1 ft			7:04 AM PDT	6:34 PM PDT
Mon 10	6:58 AM PDT / 0.8 ft	11:48 AM PDT / -0.1 ft	5:24 PM PDT / 1.5 ft				7:05 AM PDT	6:33 PM PDT
Tue 11		12:44 AM PDT / -2.2 ft	7:30 AM PDT / 1.1 ft	12:54 PM PDT / -0.5 ft	6:35 PM PDT / 1.6 ft		7:06 AM PDT	6:32 PM PDT
Wed 12		1:28 AM PDT / -2.2 ft	8:01 AM PDT / 1.5 ft	1:47 PM PDT / -1.1 ft	7:36 PM PDT / 1.8 ft		7:07 AM PDT	6:30 PM PDT
Thu 13		2:08 AM PDT / -2.3 ft	8:31 AM PDT / 1.9 ft	2:35 PM PDT / -1.6 ft	8:31 PM PDT / 1.9 ft		7:07 AM PDT	6:29 PM PDT
Fri 14		2:47 AM PDT / -2.2 ft	9:04 AM PDT / 2.3 ft	3:20 PM PDT / -2.2 ft	9:22 PM PDT / 2.0 ft		7:08 AM PDT	6:28 PM PDT
Sat 15		3:26 AM PDT / -2.2 ft	9:38 AM PDT / 2.6 ft	4:05 PM PDT / -2.6 ft	10:12 PM PDT / 2.0 ft	Full Moon	7:09 AM PDT	6:27 PM PDT
Sun 16		4:05 AM PDT / -2.0 ft	10:15 AM PDT / 2.9 ft	4:51 PM PDT / -3.0 ft	11:03 PM PDT / 1.9 ft		7:10 AM PDT	6:25 PM PDT
Mon 17		4:45 AM PDT / -1.8 ft	10:53 AM PDT / 3.0 ft	5:38 PM PDT / -3.2 ft	11:55 PM PDT / 1.8 ft		7:11 AM PDT	6:24 PM PDT
Tue 18		5:27 AM PDT / -1.5 ft	11:34 AM PDT / 3.0 ft	6:28 PM PDT / -3.3 ft			7:12 AM PDT	6:23 PM PDT
Wed 19	12:52 AM PDT / 1.6 ft	6:12 AM PDT / -1.1 ft	12:17 PM PDT / 2.9 ft	7:21 PM PDT / -3.3 ft			7:13 AM PDT	6:22 PM PDT
Thu 20	1:54 AM PDT / 1.4 ft	7:02 AM PDT / -0.8 ft	1:04 PM PDT / 2.7 ft	8:19 PM PDT / -3.1 ft			7:13 AM PDT	6:20 PM PDT
Fri 21	3:05 AM PDT / 1.3 ft	8:03 AM PDT / -0.4 ft	1:58 PM PDT / 2.4 ft	9:22 PM PDT / -3.0 ft			7:14 AM PDT	6:19 PM PDT
Sat 22	4:21 AM PDT / 1.3 ft	9:20 AM PDT / -0.2 ft	3:01 PM PDT / 2.0 ft	10:28 PM PDT / -2.8 ft		Last Quarter	7:15 AM PDT	6:18 PM PDT
Sun 23	5:34 AM PDT / 1.4 ft	10:49 AM PDT / -0.2 ft	4:17 PM PDT / 1.7 ft	11:33 PM PDT / -2.7 ft			7:16 AM PDT	6:17 PM PDT
Mon 24	6:36 AM PDT / 1.6 ft	12:10 PM PDT / -0.4 ft	5:37 PM PDT / 1.5 ft				7:17 AM PDT	6:16 PM PDT
Tue 25		12:33 AM PDT / -2.5 ft	7:25 AM PDT / 1.8 ft	1:16 PM PDT / -0.8 ft	6:51 PM PDT / 1.5 ft		7:18 AM PDT	6:15 PM PDT
Wed 26		1:25 AM PDT / -2.4 ft	8:06 AM PDT / 2.0 ft	2:09 PM PDT / -1.3 ft	7:54 PM PDT / 1.5 ft		7:19 AM PDT	6:13 PM PDT
Thu 27		2:11 AM PDT / -2.2 ft	8:41 AM PDT / 2.1 ft	2:55 PM PDT / -1.7 ft	8:50 PM PDT / 1.5 ft		7:20 AM PDT	6:12 PM PDT
Fri 28		2:52 AM PDT / -1.9 ft	9:11 AM PDT / 2.3 ft	3:36 PM PDT / -2.1 ft	9:39 PM PDT / 1.5 ft		7:20 AM PDT	6:11 PM PDT

Sat 29		3:27 AM PDT / -1.6 ft	9:38 AM PDT / 2.4 ft	4:15 PM PDT / -2.4 ft	10:25 PM PDT / 1.4 ft		7:21 AM PDT	6:10 PM PDT
Sun 30		3:58 AM PDT / -1.3 ft	10:03 AM PDT / 2.5 ft	4:51 PM PDT / -2.7 ft	11:10 PM PDT / 1.3 ft	New Moon	7:22 AM PDT	6:09 PM PDT
Mon 31		4:25 AM PDT / -1.0 ft	10:27 AM PDT / 2.5 ft	5:28 PM PDT / -2.8 ft	11:53 PM PDT / 1.1 ft		7:23 AM PDT	6:08 PM PDT

November 2016

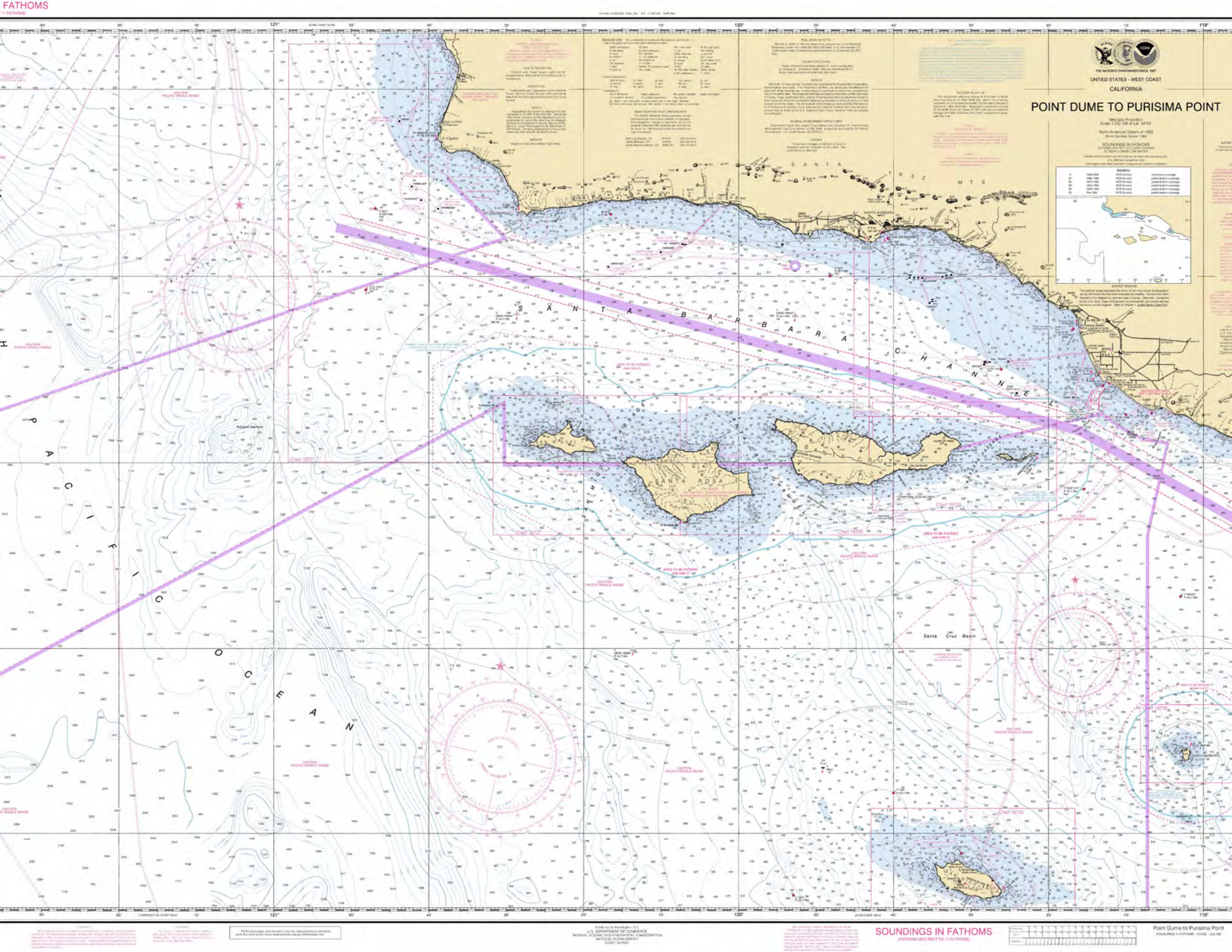
Day	High	Low	High	Low	High	Moon	Sunrise	Sunset
Tue 1		4:50 AM PDT / -0.7 ft	10:52 AM PDT / 2.6 ft	6:05 PM PDT / -2.9 ft			7:24 AM PDT	6:07 PM PDT
Wed 2	12:38 AM PDT / 0.9 ft	5:14 AM PDT / -0.4 ft	11:19 AM PDT / 2.6 ft	6:43 PM PDT / -2.9 ft			7:25 AM PDT	6:06 PM PDT
Thu 3	1:25 AM PDT / 0.8 ft	5:41 AM PDT / -0.2 ft	11:50 AM PDT / 2.5 ft	7:24 PM PDT / -2.8 ft			7:26 AM PDT	6:05 PM PDT
Fri 4	2:19 AM PDT / 0.7 ft	6:15 AM PDT / -0.0 ft	12:26 PM PDT / 2.3 ft	8:09 PM PDT / -2.6 ft			7:27 AM PDT	6:04 PM PDT
Sat 5	3:19 AM PDT / 0.6 ft	7:01 AM PDT / 0.1 ft	1:09 PM PDT / 2.0 ft	8:59 PM PDT / -2.5 ft			7:28 AM PDT	6:04 PM PDT
Sun 6	3:23 AM PST / 0.7 ft	7:12 AM PST / 0.2 ft	1:04 PM PST / 1.7 ft	8:55 PM PST / -2.3 ft			6:29 AM PST	5:03 PM PST
Mon 7	4:20 AM PST / 0.9 ft	8:58 AM PST / 0.2 ft	2:17 PM PST / 1.4 ft	9:52 PM PST / -2.1 ft		First Quarter	6:30 AM PST	5:02 PM PST
Tue 8	5:05 AM PST / 1.2 ft	10:37 AM PST / -0.2 ft	3:47 PM PST / 1.1 ft	10:48 PM PST / -2.0 ft			6:31 AM PST	5:01 PM PST
Wed 9	5:44 AM PST / 1.6 ft	11:48 AM PST / -0.8 ft	5:14 PM PST / 1.1 ft	11:39 PM PST / -1.9 ft			6:32 AM PST	5:00 PM PST
Thu 10	6:20 AM PST / 2.0 ft	12:42 PM PST / -1.4 ft	6:25 PM PST / 1.2 ft				6:33 AM PST	4:59 PM PST
Fri 11		12:26 AM PST / -1.9 ft	6:55 AM PST / 2.4 ft	1:30 PM PST / -2.1 ft	7:26 PM PST / 1.4 ft		6:34 AM PST	4:59 PM PST
Sat 12		1:10 AM PST / -1.8 ft	7:32 AM PST / 2.8 ft	2:15 PM PST / -2.7 ft	8:21 PM PST / 1.5 ft		6:35 AM PST	4:58 PM PST
Sun 13		1:53 AM PST / -1.7 ft	8:09 AM PST / 3.2 ft	2:59 PM PST / -3.3 ft	9:12 PM PST / 1.6 ft		6:36 AM PST	4:57 PM PST
Mon 14		2:35 AM PST / -1.5 ft	8:46 AM PST / 3.4 ft	3:43 PM PST / -3.6 ft	10:03 PM PST / 1.6 ft	Full Moon	6:37 AM PST	4:57 PM PST
Tue 15		3:18 AM PST / -1.3 ft	9:25 AM PST / 3.5 ft	4:28 PM PST / -3.8 ft	10:55 PM PST / 1.6 ft		6:38 AM PST	4:56 PM PST
Wed 16		4:01 AM PST / -1.1 ft	10:05 AM PST / 3.4 ft	5:14 PM PST / -3.9 ft	11:49 PM PST / 1.5 ft		6:39 AM PST	4:56 PM PST
Thu 17		4:48 AM PST / -0.8 ft	10:48 AM PST / 3.2 ft	6:03 PM PST / -3.8 ft			6:40 AM PST	4:55 PM PST
Fri 18	12:48 AM PST / 1.5 ft	5:40 AM PST / -0.4 ft	11:33 AM PST / 2.8 ft	6:54 PM PST / -3.5 ft			6:41 AM PST	4:54 PM PST
Sat 19	1:52 AM PST / 1.4 ft	6:42 AM PST / -0.2 ft	12:23 PM PST / 2.4 ft	7:50 PM PST / -3.2 ft			6:42 AM PST	4:54 PM PST
Sun 20	3:00 AM PST / 1.5 ft	8:02 AM PST / -0.0 ft	1:23 PM PST / 1.8 ft	8:50 PM PST / -2.8 ft			6:43 AM PST	4:53 PM PST
Mon 21	4:07 AM PST / 1.6 ft	9:37 AM PST / -0.1 ft	2:39 PM PST / 1.3 ft	9:52 PM PST / -2.5 ft		Last Quarter	6:44 AM PST	4:53 PM PST
Tue 22	5:05 AM PST / 1.8 ft	11:03 AM PST / -0.4 ft	4:10 PM PST / 1.0 ft	10:52 PM PST / -2.2 ft			6:45 AM PST	4:53 PM PST

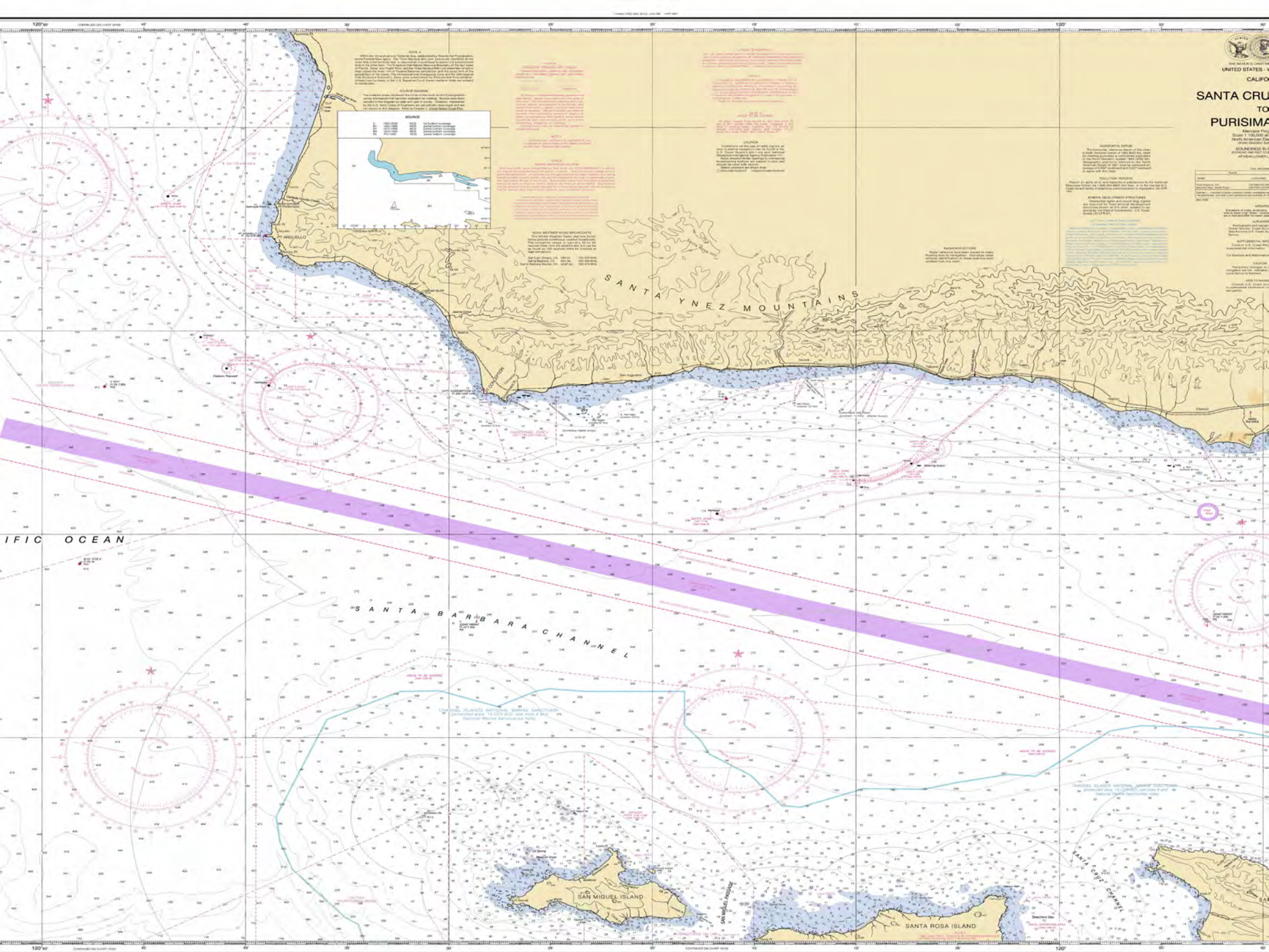
Wed 23	5:53 AM PST / 2.0 ft	12:11 PM PST / -0.9 ft	5:37 PM PST / 0.9 ft	11:46 PM PST / -1.8 ft			6:46 AM PST	4:52 PM PST
Thu 24	6:32 AM PST / 2.2 ft	1:04 PM PST / -1.5 ft	6:49 PM PST / 0.9 ft				6:47 AM PST	4:52 PM PST
Fri 25		12:33 AM PST / -1.5 ft	7:05 AM PST / 2.3 ft	1:48 PM PST / -2.0 ft	7:48 PM PST / 0.9 ft		6:48 AM PST	4:52 PM PST
Sat 26		1:13 AM PST / -1.2 ft	7:34 AM PST / 2.5 ft	2:27 PM PST / -2.5 ft	8:39 PM PST / 1.0 ft		6:48 AM PST	4:51 PM PST
Sun 27		1:46 AM PST / -1.0 ft	7:59 AM PST / 2.7 ft	3:02 PM PST / -2.8 ft	9:24 PM PST / 1.0 ft		6:49 AM PST	4:51 PM PST
Mon 28		2:15 AM PST / -0.7 ft	8:23 AM PST / 2.8 ft	3:36 PM PST / -3.1 ft	10:05 PM PST / 0.9 ft		6:50 AM PST	4:51 PM PST
Tue 29		2:41 AM PST / -0.5 ft	8:48 AM PST / 2.9 ft	4:09 PM PST / -3.3 ft	10:44 PM PST / 0.9 ft	New Moon	6:51 AM PST	4:51 PM PST
Wed 30		3:06 AM PST / -0.4 ft	9:15 AM PST / 3.0 ft	4:42 PM PST / -3.4 ft	11:23 PM PST / 0.8 ft		6:52 AM PST	4:50 PM PST

December 2016

Day	High	Low	High	Low	High	Moon	Sunrise	Sunset
Thu 1		3:35 AM PST / -0.3 ft	9:45 AM PST / 3.0 ft	5:16 PM PST / -3.3 ft			6:53 AM PST	4:50 PM PST
Fri 2	12:03 AM PST / 0.8 ft	4:09 AM PST / -0.2 ft	10:19 AM PST / 2.8 ft	5:53 PM PST / -3.2 ft			6:54 AM PST	4:50 PM PST
Sat 3	12:46 AM PST / 0.8 ft	4:50 AM PST / -0.1 ft	10:57 AM PST / 2.6 ft	6:32 PM PST / -3.0 ft			6:55 AM PST	4:50 PM PST
Sun 4	1:34 AM PST / 0.9 ft	5:45 AM PST / 0.0 ft	11:41 AM PST / 2.2 ft	7:15 PM PST / -2.7 ft			6:56 AM PST	4:50 PM PST
Mon 5	2:27 AM PST / 1.0 ft	7:00 AM PST / 0.1 ft	12:36 PM PST / 1.7 ft	8:04 PM PST / -2.4 ft			6:56 AM PST	4:50 PM PST
Tue 6	3:21 AM PST / 1.3 ft	8:40 AM PST / -0.1 ft	1:47 PM PST / 1.2 ft	8:59 PM PST / -2.1 ft			6:57 AM PST	4:50 PM PST
Wed 7	4:12 AM PST / 1.6 ft	10:20 AM PST / -0.5 ft	3:19 PM PST / 0.8 ft	9:57 PM PST / -1.9 ft		First Quarter	6:58 AM PST	4:50 PM PST
Thu 8	4:59 AM PST / 2.0 ft	11:34 AM PST / -1.1 ft	4:57 PM PST / 0.7 ft	10:54 PM PST / -1.7 ft			6:59 AM PST	4:50 PM PST
Fri 9	5:42 AM PST / 2.4 ft	12:31 PM PST / -1.8 ft	6:17 PM PST / 0.8 ft	11:48 PM PST / -1.5 ft			7:00 AM PST	4:50 PM PST
Sat 10	6:23 AM PST / 2.8 ft	1:20 PM PST / -2.5 ft	7:21 PM PST / 1.0 ft				7:00 AM PST	4:51 PM PST
Sun 11		12:38 AM PST / -1.4 ft	7:03 AM PST / 3.2 ft	2:05 PM PST / -3.2 ft	8:17 PM PST / 1.2 ft		7:01 AM PST	4:51 PM PST
Mon 12		1:25 AM PST / -1.3 ft	7:43 AM PST / 3.5 ft	2:48 PM PST / -3.7 ft	9:08 PM PST / 1.4 ft		7:02 AM PST	4:51 PM PST
Tue 13		2:10 AM PST / -1.2 ft	8:23 AM PST / 3.7 ft	3:31 PM PST / -4.0 ft	9:57 PM PST / 1.5 ft	Full Moon	7:03 AM PST	4:51 PM PST
Wed 14		2:55 AM PST / -1.0 ft	9:03 AM PST / 3.7 ft	4:14 PM PST / -4.2 ft	10:47 PM PST / 1.5 ft		7:03 AM PST	4:52 PM PST
Thu 15		3:41 AM PST / -0.8 ft	9:44 AM PST / 3.6 ft	4:58 PM PST / -4.1 ft	11:37 PM PST / 1.5 ft		7:04 AM PST	4:52 PM PST
Fri 16		4:28 AM PST / -0.6 ft	10:26 AM PST / 3.3 ft	5:43 PM PST / -3.9 ft			7:05 AM PST	4:52 PM PST
Sat 17	12:30 AM PST / 1.5 ft	5:21 AM PST / -0.4 ft	11:09 AM PST / 2.8 ft	6:30 PM PST / -3.6 ft			7:05 AM PST	4:53 PM PST

Sun 18	1:27 AM PST / 1.5 ft	6:23 AM PST / -0.2 ft	11:57 AM PST / 2.3 ft	7:19 PM PST / -3.2 ft			7:06 AM PST	4:53 PM PST
Mon 19	2:27 AM PST / 1.5 ft	7:41 AM PST / -0.1 ft	12:54 PM PST / 1.6 ft	8:13 PM PST / -2.7 ft			7:06 AM PST	4:54 PM PST
Tue 20	3:29 AM PST / 1.6 ft	9:15 AM PST / -0.2 ft	2:07 PM PST / 1.0 ft	9:10 PM PST / -2.2 ft		Last Quarter	7:07 AM PST	4:54 PM PST
Wed 21	4:25 AM PST / 1.8 ft	10:45 AM PST / -0.6 ft	3:46 PM PST / 0.6 ft	10:09 PM PST / -1.7 ft			7:07 AM PST	4:55 PM PST
Thu 22	5:13 AM PST / 2.0 ft	11:56 AM PST / -1.1 ft	5:26 PM PST / 0.4 ft	11:04 PM PST / -1.3 ft			7:08 AM PST	4:55 PM PST
Fri 23	5:53 AM PST / 2.2 ft	12:50 PM PST / -1.7 ft	6:45 PM PST / 0.4 ft	11:52 PM PST / -1.0 ft			7:08 AM PST	4:56 PM PST
Sat 24	6:27 AM PST / 2.4 ft	1:33 PM PST / -2.2 ft	7:46 PM PST / 0.5 ft				7:09 AM PST	4:56 PM PST
Sun 25		12:31 AM PST / -0.7 ft	6:56 AM PST / 2.6 ft	2:10 PM PST / -2.7 ft	8:35 PM PST / 0.6 ft		7:09 AM PST	4:57 PM PST
Mon 26		1:04 AM PST / -0.5 ft	7:22 AM PST / 2.8 ft	2:44 PM PST / -3.0 ft	9:15 PM PST / 0.7 ft		7:09 AM PST	4:57 PM PST
Tue 27		1:34 AM PST / -0.4 ft	7:49 AM PST / 3.0 ft	3:15 PM PST / -3.3 ft	9:50 PM PST / 0.7 ft		7:10 AM PST	4:58 PM PST
Wed 28		2:02 AM PST / -0.4 ft	8:17 AM PST / 3.1 ft	3:46 PM PST / -3.4 ft	10:23 PM PST / 0.8 ft	New Moon	7:10 AM PST	4:59 PM PST
Thu 29		2:34 AM PST / -0.4 ft	8:48 AM PST / 3.2 ft	4:16 PM PST / -3.5 ft	10:54 PM PST / 0.8 ft		7:10 AM PST	4:59 PM PST
Fri 30		3:09 AM PST / -0.4 ft	9:22 AM PST / 3.2 ft	4:49 PM PST / -3.5 ft	11:28 PM PST / 0.9 ft		7:11 AM PST	5:00 PM PST
Sat 31		3:51 AM PST / -0.4 ft	9:59 AM PST / 3.0 ft	5:25 PM PST / -3.4 ft			7:11 AM PST	5:01 PM PST


FATHOMS
11 FATHOMS
THE NATION'S CHARTMAKER SINCE 1807
UNITED STATES - WEST COAST
CALIFORNIA
POINT DUME TO PURISIMA POINT
Mercator Projection
Scale 1:232,168 at Lat 34°00
North American Datum of 1983
(World Geodetic System 1984)
SOUNDINGS IN FATHOMS
AT MEAN LOWER LOW WATER
SOURCE DIAGRAM
SOURCE DIAGRAM
SANTA YNEZ MTS
SANTA BARBARA CHANNEL
SANTA ROSA ISLAND
SANTA CRUZ ISLAND
SANTA BARBARA ISLAND
ANACAPA ISLAND
PACIFIC OCEAN
Santa Cruz Basin
SOUNDINGS IN FATHOMS
(FATHOMS AND FEET TO 11 FATHOMS)
Point Dume to Purisima Point
SOUNDINGS IN FATHOMS - SCALE - 232,168



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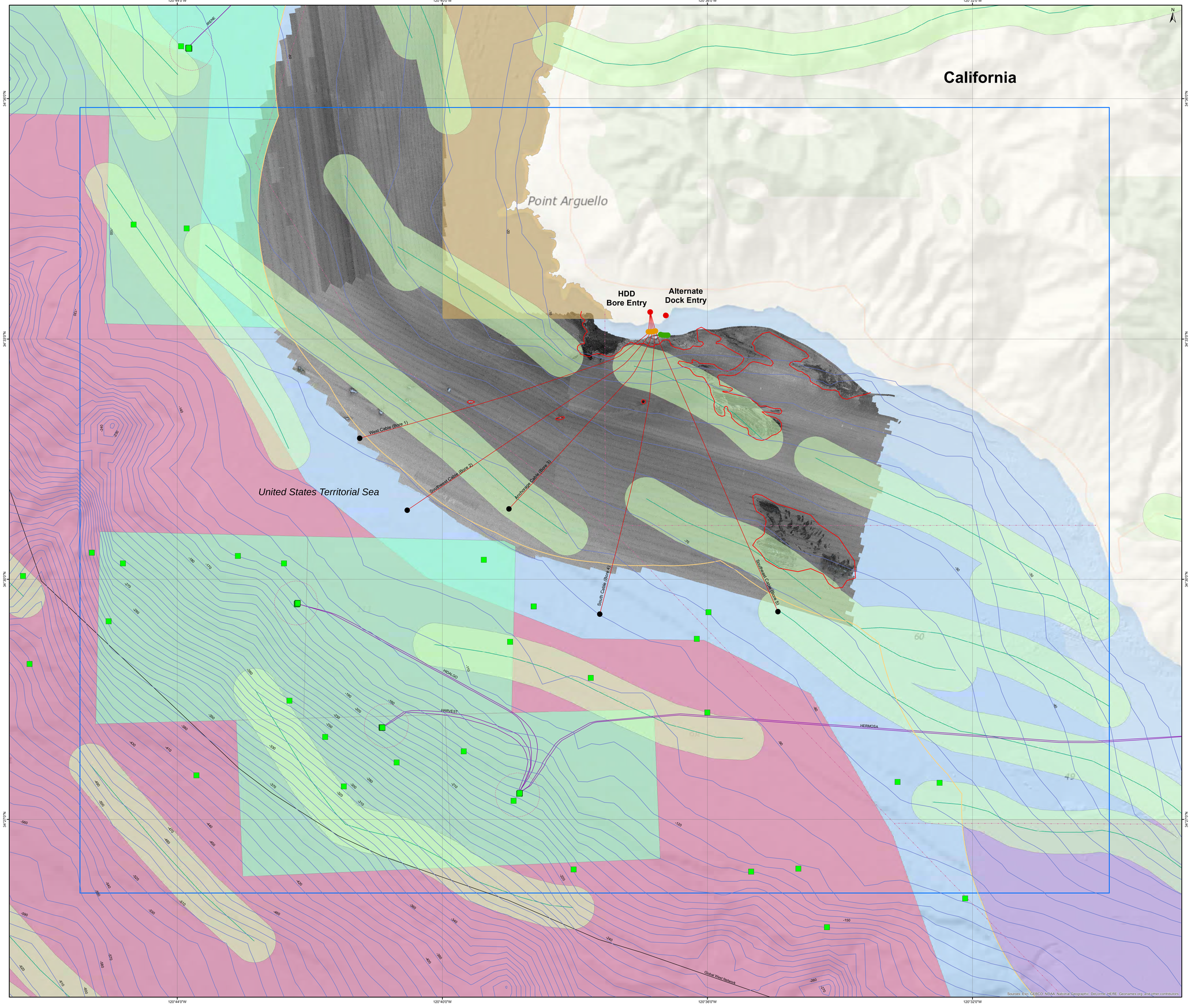
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL OCEAN SERVICE
COAST SURVEY

Santa Cruz Island to Purisima



Legend

- HDD Bore Entry
- HDD Bore Exit
- Alternate Dock Entry
- Alternate Dock Exit
- SubSea Cable Terminus Positions
- Pacific Offshore Well Locations
- Proposed Primary Routes
- Military Protected Area
- Restricted Areas
- Bathymetric Contours (10m)
- State Boundary 3nm Limit
- BOEM Pacific Pipelines
- In-service telecommunications cable
- Out-of-service telecommunications cable
- Rock Outcrop Areas
- Quarternary Faults
- Project Boundary
- Fault Activity Buffer
- BOEM Pacific Leases
- Point Conception Essential Fish Habitat Conservation Area
- Point Conception State Marine Reserve
- Vandenberg State Marine Reserve

Notes:

1. Bathymetry contours are from SRTM30 data
2. Maritime and territorial boundaries compiled from General Dynamics GMBD 2008 Spring edition.
3. Color background base map is from ArcGIS Online Base Maps.
4. Cables compiled from Fugro Cable Database, other in-house sources, and National Oceanic and Atmospheric Administration (NOAA) online sources.
5. Coastline, hazards, obstructions, wrecks, and restricted areas gathered from NOAA online sources.
6. Marine Protected Areas compiled from NOAA published data.
7. California state boundary 3nm limit provided by BOEM online sources.
8. Previous Side Scan Sonar data downloaded from Seafloor Mapping Lab, CSU Monterey Bay. Imagery provided by CSMP (Southern CAL-H11953)
9. Fault activity data provided by USGS.

GEODETIC PARAMETERS:

Projection	Mercator	False Easting	0 m
Spheroid and Datum	WGS84	False Northing	0 m
Semi Major Axis	6378137.00 m	Latitude of Origin	0°N
Inverse Flattening	298.257223563	Longitude of Origin	0°W

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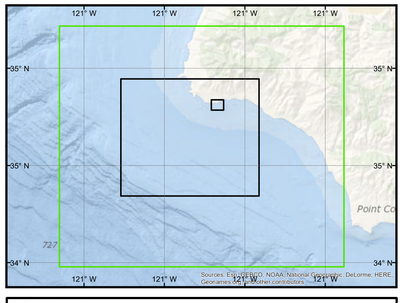


CH2M HILL
2485 Natomas Park Drive, Suite 600
Sacramento, CA, 95833-2937, USA

FUGRO PELAGOS, INC.
3574 Ruffin Road
San Diego, California 92123 USA .
Tel: (858) 292 8922
Fax: (858) 292-5308
http://www.fugro.com

CALWAVE Desktop Study

Desktop Study

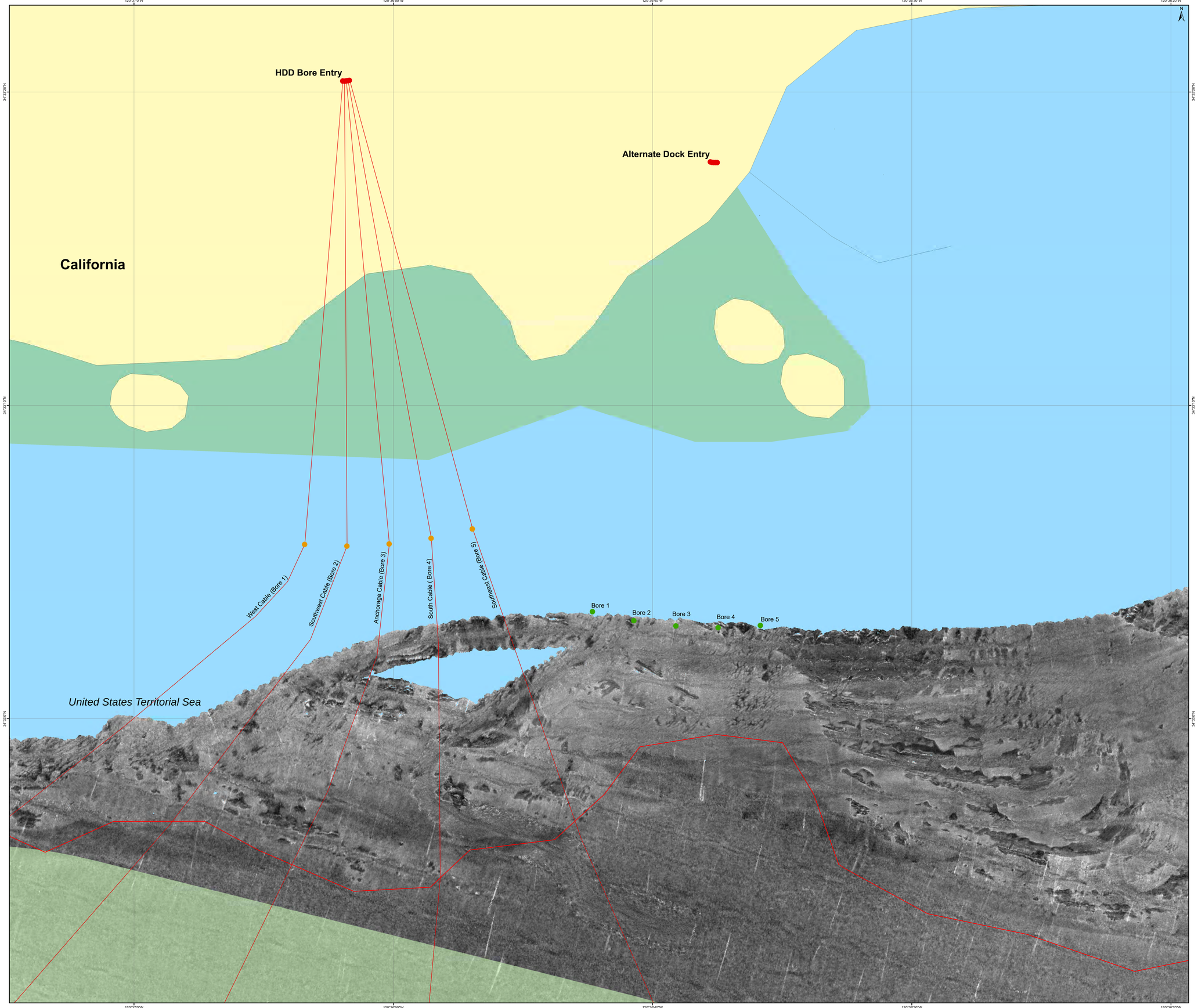
Project Overview

SCALE: 1:35,000

0 0.35 0.7 1.4 2.1 2.8 3.5 4.2 Kilometers

Issue:	Date:	Description:	Drawn:	Chkd:	Appr:
0	29 July 2016	Draft	AM	RW	RW
1	9 Nov 2016	Final	AM	RW	RW

Issue:		Chart:
FINAL		CALWAVE_DTS_001_35K



Legend

- HDD Bore Entry
- HDD Bore Exit
- Alternate Dock Entry
- Alternate Dock Exit
- Proposed Primary Route
- Bathymetric Contours (10m)
- In-service telecommunications cable
- Out-of-service telecommunications cable
- Rock Outcrop Area
- Fault Activity Buffer

Notes:

1. Bathymetry contours are from SRTM30 data
2. Maritime and territorial boundaries compiled from General Dynamics GMBD 2008 Spring edition.
3. Color background base map is from ArcGIS Online Base Maps.
4. Cables compiled from Fugro Cable Database, other in-house sources, and National Oceanic and Atmospheric Administration (NOAA) online sources.
5. Coastline, hazards, obstructions, wrecks, and restricted areas gathered from NOAA online sources.
6. Marine Protected Areas compiled from NOAA published data.
7. California state boundary 3nm limit provided by BOEM online sources.
8. Previous Side Scan Sonar data downloaded from Seafloor Mapping Lab, CSU Monterey Bay. Imagery provided by CSMP (Southern CAL-H11953)
9. Fault activity data provided by USGS.

GEODETIC PARAMETERS:

Projection	Mercator	False Easting	0 m
Spheroid and Datum	WGS84	False Northing	0 m
Semi Major Axis	6378137.00 m	Latitude of Origin	0°N
Inverse Flattening	298.257223563	Longitude of Origin	0°W

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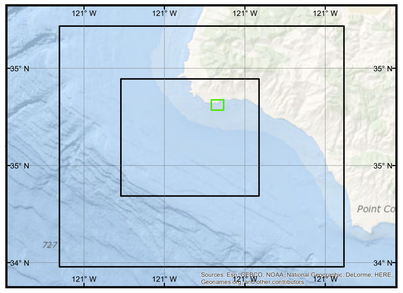


ch2m
CH2M HILL
2485 Natomas Park Drive, Suite 600
Sacramento, CA, 95833-2937, USA

FUGRO PELAGOS, INC.
3574 Ruffin Road
San Diego, California 92123 USA .
Tel: (858) 292 8922
Fax: (858) 292-6308
http://www.fugro.com

CALWAVE Desktop Study

Desktop Study

Landing Site Overview

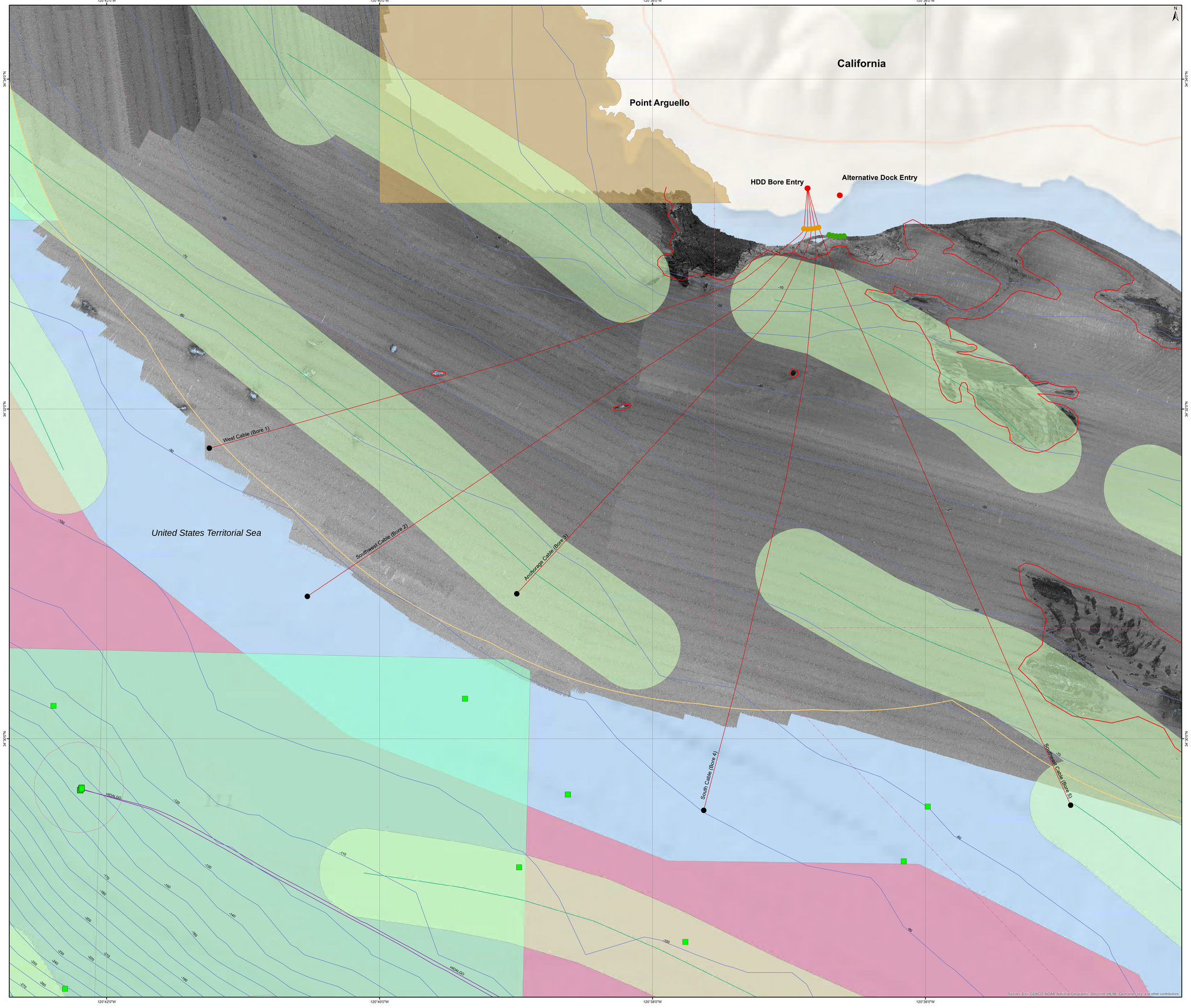
SCALE: 1:1,500

0 0.0150.03 0.06 0.09 0.12 0.15 0.18 Kilometers

Issue:	Date:	Description:	Drawn:	Chkd:	Appr:
0	29 July 2016	Draft	AM	RW	RW
1	9 Nov 2016	Final	AM	RW	RW

Issue: FINAL

Chart: CALWAVE_DTS_002_1500



Legend

- HDD Bore Entry
- HDD Bore Exits
- Alternate Dock Entry
- Alternate Dock Exit
- SubSea Cable Terminus Positions
- Pacific Well Locations
- Proposed Primary Routes
- Bathymetric Contours (10m)
- State Boundary 3nm Limit
- Military Protected Area
- Restricted Areas
- BOEM Pacific Pipelines
- In-service telecommunications cable
- Out-of-service telecommunications cable
- Rock Outcrop Areas
- Quarternary Faults
- Fault Activity Buffer
- BOEM Pacific Leases
- Point Conception Essential Fish Habitat Conservation Area
- Vandenberg State Marine Reserve

Notes:

1. Bathymetry contours are from SRTM30 data
2. Maritime and territorial boundaries compiled from General Dynamics GMBD 2008 Spring edition.
3. Color background base map is from ArcGIS Online Base Maps.
4. Cables compiled from Fugro Cable Database, other in-house sources, and National Oceanic and Atmospheric Administration (NOAA) online sources.
5. Coastline, hazards, obstructions, wrecks, and restricted areas gathered from NOAA online sources.
6. Marine Protected Areas compiled from NOAA published data.
7. California state boundary 3nm limit provided by BOEM online sources.
8. Previous Side Scan Sonar data downloaded from Seafloor Mapping Lab, CSU Montery Bay. Imagery provided by CSMP (Southern CAL-H11953)
9. Fault activity data provided by USGS.

GEODETIC PARAMETERS:

Projection	Mercator	False Easting	0 m
Spheroid and Datum	WGS84	False Northing	0 m
Semi Major Axis	6378137.00 m	Latitude of Origin	0°N
Inverse Flattening	298.257223563	Longitude of Origin	0°W

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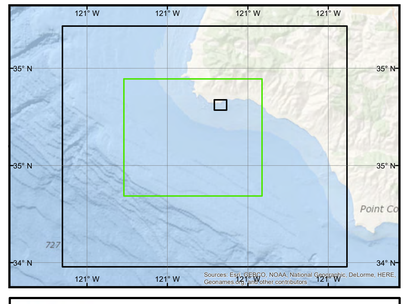


CH2M HILL
2485 Natomas Park Drive, Suite 600
Sacramento, CA, 95833-2937, USA

FUGRO PELAGOS, INC.
3574 Ruffin Road
San Diego, California 92123 USA .
Tel: (858) 292 8922
Fax: (858) 292-6308
http://www.fugro.com

CALWAVE Desktop Study

Desktop Study

Offshore Lease Area Overview

SCALE: 1:17,000

0 0.15 0.3 0.6 0.9 1.2 1.5 1.8 Kilometers

Issue:	Date:	Description:	Drawn:	Chkd:	Appr:
0	29 July 2016	Draft	AM	RW	RW
1	9 Nov 2016	Final	AM	RW	RW

Issue:		Chart:
FINAL		CALWAVE_DTS_003_17K

Attribute
System Name
Acronym
Segment ID
Cable Status
Start
End
Owner Name
Comments

Value
CalWave
Alternate - West Cable
Segment 1
Desktop Study Route

System Name: CalWave

Index	Name	Latitude	Longitude	Azimuth deg	Distance (km) Between Positions	Distance (km) Cumulative Total	Slack Surface %	Cab Between Positions
1		34 ° 33.296 ' N	120 ° 36.629 ' W			0.000		
				194.7	0.457		0.00%	0.457
2		34 ° 33.057 ' N	120 ° 36.705 ' W			0.457		
				224.0	0.020		0.00%	0.020
3		34 ° 33.049 ' N	120 ° 36.714 ' W			0.477		
				235.5	0.047		0.00%	0.047
4		34 ° 33.035 ' N	120 ° 36.739 ' W			0.523		
				242.3	1.170		0.00%	1.170
5		34 ° 32.741 ' N	120 ° 37.416 ' W			1.694		
				244.6	0.140		0.00%	0.140
6		34 ° 32.708 ' N	120 ° 37.499 ' W			1.834		
				249.9	0.190		0.00%	0.190
7		34 ° 32.673 ' N	120 ° 37.616 ' W			2.024		
				250.4	0.234		0.00%	0.234
8		34 ° 32.631 ' N	120 ° 37.760 ' W			2.258		
				251.7	2.798		0.00%	2.798
9		34 ° 32.156 ' N	120 ° 39.497 ' W			5.057		
				254.8	2.775		0.00%	2.775
10		34 ° 31.763 ' N	120 ° 41.247 ' W			7.832		

System Name: CalWave

le(km) Cumulative Total	Event	Cable Type	Depth (m)	Comments
0.000			4.5	Bore 1 Entry
0.457			-5.0	Bore 1 Exit
0.477			-5.0	
0.523			-6.0	
1.694			-18.0	
1.834			-19.0	
2.024			-19.0	
2.258			-21.0	
5.057			-60.0	
7.832			-85.0	Cable Terminus

Attribute
System Name
Acronym
Segment ID
Cable Status
Start
End
Owner Name
Comments

Value
CalWave
Segment 1
Desktop Study Route

System Name: CalWave

Index	Name	Latitude	Longitude	Azimuth deg	Between Positions	Cumulative Total	Surface %	Between Positions
1		34 ° 33.339 ' N	120 ° 36.866 ' W			0.000		
				184.7	0.457		0.00%	0.457
2		34 ° 33.093 ' N	120 ° 36.890 ' W			0.457		
				204.9	0.040		0.00%	0.040
3		34 ° 33.073 ' N	120 ° 36.901 ' W			0.498		
				222.7	0.046		0.00%	0.046
4		34 ° 33.055 ' N	120 ° 36.922 ' W			0.544		
				230.1	0.171		0.00%	0.171
5		34 ° 32.995 ' N	120 ° 37.008 ' W			0.715		
				231.9	0.615		0.00%	0.615
6		34 ° 32.790 ' N	120 ° 37.324 ' W			1.331		
				244.8	0.164		0.00%	0.164
7		34 ° 32.752 ' N	120 ° 37.421 ' W			1.495		
				249.1	0.294		0.00%	0.294
8		34 ° 32.695 ' N	120 ° 37.601 ' W			1.789		
				251.1	2.287		0.00%	2.287
9		34 ° 32.294 ' N	120 ° 39.015 ' W			4.076		
				253.3	0.825		0.00%	0.825
10		34 ° 32.166 ' N	120 ° 39.532 ' W			4.901		
				254.2	2.729		0.00%	2.729
11		34 ° 31.763 ' N	120 ° 41.247 ' W			7.630		

System Name: CalWave

Cumulative Total	Event	Type	Depth (m)	Comments
0.000			4.5	Bore 1 Entry
0.457			-5.0	Bore 1 Exit
0.498			-5.0	
0.544			-6.0	
0.715			-8.0	
1.331			-12.0	
1.495			-15.0	
1.789			-18.0	
4.076			-50.0	
4.901			-61.0	
7.630			-86.0	Cable Terminus

Attribute
System Name
Acronym
Segment ID
Cable Status
Start
End
Owner Name
Comments

Value
CalWave
Alternate - Southwest Cable
Segment 2
Desktop Study Route

System Name: CalWave

Index	Name	Latitude	Longitude	Azimuth deg	Between Positions	Cumulative Total	Surface %	Between Positions
1		34 ° 33.296 ' N	120 ° 36.628 ' W			0.000		
				189.7	0.457		0.00%	0.457
2		34 ° 33.052 ' N	120 ° 36.679 ' W			0.457		
				209.6	0.015		0.00%	0.015
3		34 ° 33.045 ' N	120 ° 36.684 ' W			0.473		
				226.6	0.016		0.00%	0.016
4		34 ° 33.039 ' N	120 ° 36.691 ' W			0.489		
				232.1	0.064		0.00%	0.064
5		34 ° 33.018 ' N	120 ° 36.724 ' W			0.553		
				234.7	0.314		0.00%	0.314
6		34 ° 32.920 ' N	120 ° 36.891 ' W			0.866		
				235.7	2.256		0.00%	2.256
7		34 ° 32.232 ' N	120 ° 38.110 ' W			3.122		
				235.7	4.484		0.00%	4.484
8		34 ° 30.864 ' N	120 ° 40.529 ' W			7.606		

System Name: CalWave

Cumulative Total	Event	Type	Depth (m)	Comments
0.000			4.5	Bore 2 Entry
0.457			-5.0	Bore 2 Exit
0.473			-5.0	
0.489			-6.0	
0.553			-7.0	
0.866			-9.0	
3.122			-39.0	
7.606			-90.0	Cable Terminus

Attribute
System Name
Acronym
Segment ID
Cable Status
Start
End
Owner Name
Comments

Value
CalWave
Segment 2
Desktop Study Route

System Name: CalWave

				deg	Positions	Total	%	Positions
1		34 ° 33.339 ' N	120 ° 36.865 ' W			0.000		
				179.7	0.457		0.00%	0.457
2		34 ° 33.092 ' N	120 ° 36.863 ' W			0.457		
				201.4	0.099		0.00%	0.099
3		34 ° 33.042 ' N	120 ° 36.887 ' W			0.556		
				217.2	0.227		0.00%	0.227
4		34 ° 32.944 ' N	120 ° 36.976 ' W			0.783		
				221.1	0.476		0.00%	0.476
5		34 ° 32.750 ' N	120 ° 37.181 ' W			1.259		
				224.5	0.161		0.00%	0.161
6		34 ° 32.688 ' N	120 ° 37.255 ' W			1.421		
				232.8	0.181		0.00%	0.181
7		34 ° 32.629 ' N	120 ° 37.349 ' W			1.602		
				237.1	1.158		0.00%	1.158
8		34 ° 32.288 ' N	120 ° 37.985 ' W			2.760		
				235.9	4.700		0.00%	4.700
9		34 ° 30.864 ' N	120 ° 40.529 ' W			7.460		

System Name: CalWave

Total			(m)	
0.000			4.5	Bore 2 Entry
0.457			-4.0	Bore 2 Exit
0.556			-6.0	
0.783			-9.0	
1.259			-13.0	
1.421			-16.0	
1.602			-18.0	
2.760			-37.0	
7.460			-90.0	Cable Terminus

Attribute
System Name
Acronym
Segment ID
Cable Status
Start
End
Owner Name
Comments

Value
CalWave
Alternate - Anchorage Cable
Segment 3
Desktop Study Route

System Name: CalWave

Index	Name	Latitude	Longitude	Azimuth deg	Between Positions	Cumulative Total	Surface %	Between Positions
1		34 ° 33.296 ' N	120 ° 36.627 ' W			0.000		
				184.7	0.457		0.00%	0.457
2		34 ° 33.049 ' N	120 ° 36.652 ' W			0.457		
				201.7	0.014		0.00%	0.014
3		34 ° 33.042 ' N	120 ° 36.655 ' W			0.471		
				213.7	0.019		0.00%	0.019
4		34 ° 33.034 ' N	120 ° 36.662 ' W			0.490		
				217.9	0.045		0.00%	0.045
5		34 ° 33.015 ' N	120 ° 36.680 ' W			0.535		
				220.6	0.201		0.00%	0.201
6		34 ° 32.932 ' N	120 ° 36.765 ' W			0.735		
				221.9	1.908		0.00%	1.908
7		34 ° 32.165 ' N	120 ° 37.598 ' W			2.644		
				222.0	3.194		0.00%	3.194
8		34 ° 30.881 ' N	120 ° 38.995 ' W			5.838		

System Name: CalWave

Cumulative Total	Event	Type	Depth (m)	Comments
0.000			4.5	Bore 3 Entry
0.457			-5.0	Bore 3 Exit
0.471			-5.0	
0.490			-6.0	
0.535			-7.0	
0.735			-10.0	
2.644			-37.0	
5.838			-80.0	Cable Terminus

Attribute
System Name
Acronym
Segment ID
Cable Status
Start
End
Owner Name
Comments

Value
CalWave
Segment 3
Desktop Study Route

System Name: CalWave

Index	Name	Latitude	Longitude	Azimuth deg	Distance (km) Between Positions	Distance (km) Cumulative Total	Slack Surface %	Cab Between Positions
1		34 ° 33.339 ' N	120 ° 36.864 ' W			0.000		
				174.7	0.457		0.00%	0.457
2		34 ° 33.093 ' N	120 ° 36.836 ' W			0.457		
				186.3	0.110		0.00%	0.110
3		34 ° 33.034 ' N	120 ° 36.844 ' W			0.567		
				199.9	0.141		0.00%	0.141
4		34 ° 32.962 ' N	120 ° 36.875 ' W			0.709		
				206.0	0.602		0.00%	0.602
5		34 ° 32.669 ' N	120 ° 37.048 ' W			1.311		
				209.2	0.170		0.00%	0.170
6		34 ° 32.589 ' N	120 ° 37.102 ' W			1.481		
				216.7	0.150		0.00%	0.150
7		34 ° 32.524 ' N	120 ° 37.161 ' W			1.631		
				222.7	4.137		0.00%	4.137
8		34 ° 30.881 ' N	120 ° 38.995 ' W			5.767		

System Name: CalWave

le(km) Cumulative Total	Event	Cable Type	Depth (m)	Comments
0.000			4.5	Bore 3 Entry
0.457			-4.0	Bore 3 Exit
0.567			-6.0	
0.709			-7.0	
1.311			-18.0	
1.481			-19.0	
1.631			-21.0	
5.767			-80.0	Cable Terminus

Attribute
System Name
Acronym
Segment ID
Cable Status
Start
End
Owner Name
Comments

Value
CalWave
Alternate - South Cable
Segment 4
Desktop Study Route

System Name: CalWave

Index	Name	Latitude	Longitude	Azimuth deg	Distance (km) Between Positions	Distance (km) Cumulative Total	Slack Surface %	Cab Between Positions
1		34 ° 33.296 ' N	120 ° 36.626 ' W			0.000		
				179.7	0.457		0.00%	0.457
2		34 ° 33.049 ' N	120 ° 36.624 ' W			0.457		
				187.7	0.019		0.00%	0.019
3		34 ° 33.038 ' N	120 ° 36.626 ' W			0.476		
				191.1	0.060		0.00%	0.060
4		34 ° 33.007 ' N	120 ° 36.634 ' W			0.536		
				193.1	0.085		0.00%	0.085
5		34 ° 32.962 ' N	120 ° 36.646 ' W			0.621		
				193.5	2.682		0.00%	2.682
6		34 ° 31.551 ' N	120 ° 37.054 ' W			3.304		
				193.4	3.772		0.00%	3.772
7		34 ° 29.566 ' N	120 ° 37.625 ' W			7.076		

System Name: CalWave

le(km) Cumulative Total	Event	Cable Type	Depth (m)	Comments
0.000			4.5	Bore 4 Entry
0.457			-5.0	Bore 4 Exit
0.476			-5.0	
0.536			-6.0	
0.621			-9.0	
3.304			-50.0	
7.076			-91.0	Cable Terminus

Attribute
System Name
Acronym
Segment ID
Cable Status
Start
End
Owner Name
Comments

Value
CalWave
Segment 4
Desktop Study Route

System Name: CalWave

Index	Name	Latitude	Longitude	Azimuth deg	Between Positions	Cumulative Total	Surface %	Between Positions
1		34 ° 33.339 ' N	120 ° 36.862 ' W			0.000		
				169.7	0.457		0.00%	0.457
2		34 ° 33.096 ' N	120 ° 36.809 ' W			0.457		
				176.1	0.104		0.00%	0.104
3		34 ° 33.040 ' N	120 ° 36.804 ' W			0.562		
				179.6	0.230		0.00%	0.230
4		34 ° 32.915 ' N	120 ° 36.803 ' W			0.792		
				185.1	1.216		0.00%	1.216
5		34 ° 32.260 ' N	120 ° 36.873 ' W			2.008		
				190.2	1.261		0.00%	1.261
6		34 ° 31.589 ' N	120 ° 37.019 ' W			3.269		
				193.4	2.137		0.00%	2.137
7		34 ° 30.465 ' N	120 ° 37.343 ' W			5.406		
				194.6	1.716		0.00%	1.716
8		34 ° 29.566 ' N	120 ° 37.625 ' W			7.122		

System Name: CalWave

Cumulative Total	Event	Type	Depth (m)	Comments
0.000			4.5	Bore 4 Entry
0.457			-3.0	Bore 4 Exit
0.562			-4.0	
0.792			-9.0	
2.008			-29.0	
3.269			-49.0	
5.406			-74.0	
7.122			-91.0	Cable Terminus

Attribute
System Name
Acronym
Segment ID
Cable Status
Start
End
Owner Name
Comments

Value
CalWave
Alternate - Southeast Cable
Segment 5
Desktop Study Route

System Name: CalWave

Index	Name	Latitude	Longitude	Azimuth deg	Distance (km) Between Positions	Distance (km) Cumulative Total	Slack Surface %	Cab Between Positions
1		34 ° 33.296 ' N	120 ° 36.626 ' W			0.000		
				174.5	0.457		0.00%	0.457
2		34 ° 33.050 ' N	120 ° 36.597 ' W			0.457		
				179.3	0.054		0.00%	0.054
3		34 ° 33.021 ' N	120 ° 36.597 ' W			0.511		
				177.9	0.060		0.00%	0.060
4		34 ° 32.988 ' N	120 ° 36.595 ' W			0.571		
				176.3	0.082		0.00%	0.082
5		34 ° 32.944 ' N	120 ° 36.592 ' W			0.653		
				175.3	0.074		0.00%	0.074
6		34 ° 32.904 ' N	120 ° 36.588 ' W			0.727		
				173.2	0.089		0.00%	0.089
7		34 ° 32.857 ' N	120 ° 36.581 ' W			0.815		
				166.7	0.136		0.00%	0.136
8		34 ° 32.785 ' N	120 ° 36.561 ' W			0.952		
				164.9	0.154		0.00%	0.154
9		34 ° 32.705 ' N	120 ° 36.534 ' W			1.105		
				161.3	0.212		0.00%	0.212
10		34 ° 32.596 ' N	120 ° 36.490 ' W			1.317		
				157.2	4.346		0.00%	4.346
11		34 ° 30.428 ' N	120 ° 35.391 ' W			5.664		
				155.6	1.687		0.00%	1.687
12		34 ° 29.598 ' N	120 ° 34.936 ' W			7.350		

System Name: CalWave

le(km) Cumulative Total	Event	Cable Type	Depth (m)	Comments
0.000			4.5	Bore 5 Entry
0.457			-5.0	Bore 5 Exit
0.511			-7.0	
0.571			-9.0	
0.653			-11.0	
0.727			-12.0	
0.815			-12.0	
0.952			-15.0	
1.105			-18.0	
1.317			-21.0	
5.664			-65.0	
7.350			-71.0	Cable Terminus

Attribute
System Name
Acronym
Segment ID
Cable Status
Start
End
Owner Name
Comments

Value
CalWave
Segment 5
Desktop Study Route

System Name: CalWave

Index	Name	Latitude	Longitude	Azimuth deg	Between Positions	Cumulative Total	Surface %	Between Positions
1		34 ° 33.340 ' N	120 ° 36.861 ' W			0.000		
				164.7	0.457		0.00%	0.457
2		34 ° 33.101 ' N	120 ° 36.782 ' W			0.457		
				160.7	0.323		0.00%	0.323
3		34 ° 32.936 ' N	120 ° 36.712 ' W			0.781		
				156.2	2.450		0.00%	2.450
4		34 ° 31.724 ' N	120 ° 36.067 ' W			3.230		
				156.5	2.613		0.00%	2.613
5		34 ° 30.428 ' N	120 ° 35.387 ' W			5.843		
				155.8	1.682		0.00%	1.682
6		34 ° 29.598 ' N	120 ° 34.936 ' W			7.525		

System Name: CalWave

Cumulative Total	Event	Type	Depth (m)	Comments
0.000			4.5	Bore 5 Entry
0.457			-3.0	Bore 5 Exit
0.781			-8.0	
3.230			-40.0	
5.843			-60.0	
7.525			-73.0	Cable Terminus

Attachment 11-6: Horizontal Directional Drill (HDD) Profiles

CalWave II included collaboration with The Horizontal Direction Drill (HDD) Company that is summarized below.

The site selection process narrowed the test berth siting to the South and Southeast test berth locations near the Vandenberg Dock which will utilize Vandenberg Air Force Base (VAFB) Substation "N".

An extreme events analysis was performed on the five proposed shore sites that included Tsunami modeling, historic weather modeling, and a seismic ground shaking assessment in order to inform the shore station down selection process.

The South Base Site was selected as the conceptual shore station and the site plan was refined based on a topographic field survey that was performed by a Cal Poly Team of students, professional surveyor instructor and Architectural Engineering Professor. This detailed land survey informed the conceptual civil, mechanical, and electrical engineering and architectural designs.

An extensive industry survey was conducted by the CalWave[sm] Subsea Cable Route Design Team. As a result, the preferred Horizontal Directional Drilling (HDD) launch site was selected as well as an alternate launch site. The selection was based on integrating the conceptual shore station design and location with the offshore test berth locations, topography, bathymetry, subsea cable capabilities and constraints, in conjunction with host facility requirements. The Team included:

- The CalWave II Project Manager
- The CalWave II Chief Engineer
- The CalWave II Electrical Engineer
- Key VAFB personnel,
- The HDD Company: a company that performs marine horizontal directional drilling services,
- The Fugro Pelagos marine geologist on the cable route desktop subcontractor team.
- The CalWave II environmental/permitting lead from CH2M who subcontracted to Fugro Pelagos,

The Shore Station location is on the high ground above Vandenberg Dock as shown below.

This industry survey of the site, and subsequent meetings with marine construction industry members, further illuminated survey/data needs for the HDD bore and cable landing design.

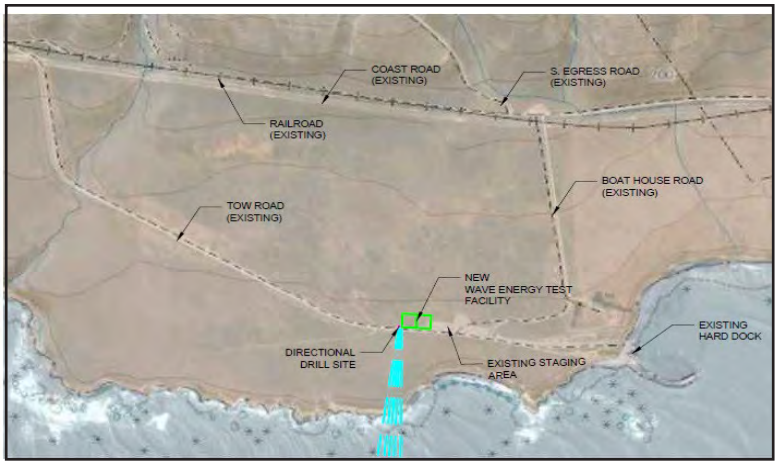


Figure 11-6-1: South Base Site (Source Leidos, Inc.)

The “Upland Site” is planned as the site of two modular buildings and space for modular power conditioning equipment to be provided by the WEC developers. An adjacent 12 kV switchyard has been designed to connect with local distribution at 12 kV as well as a 70 kV Substation

The cables from test berths will come to the shore outboard of Vandenberg Dock.

Figure 11-6-2: Conceptual Shore Station– Primary HDD Upland Launch Location (Source Leidos, Inc.)

The cables from test berths will come to the shore outboard of Vandenberg Dock.

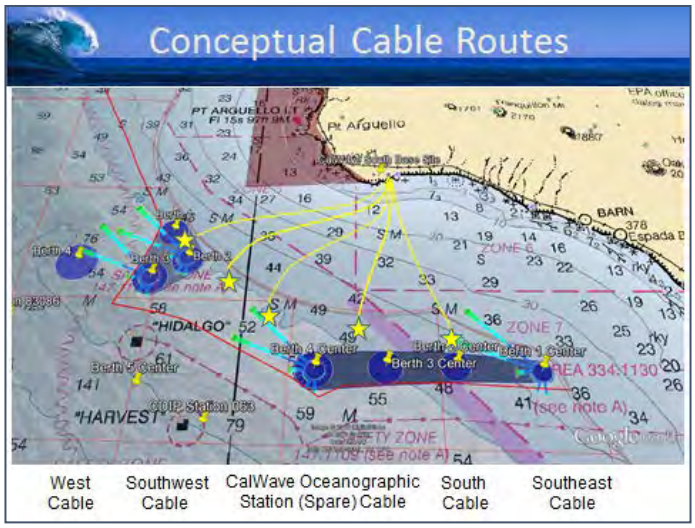


Figure 11-6-3: Conceptual Cable Routes (Source Leidos, Inc.)

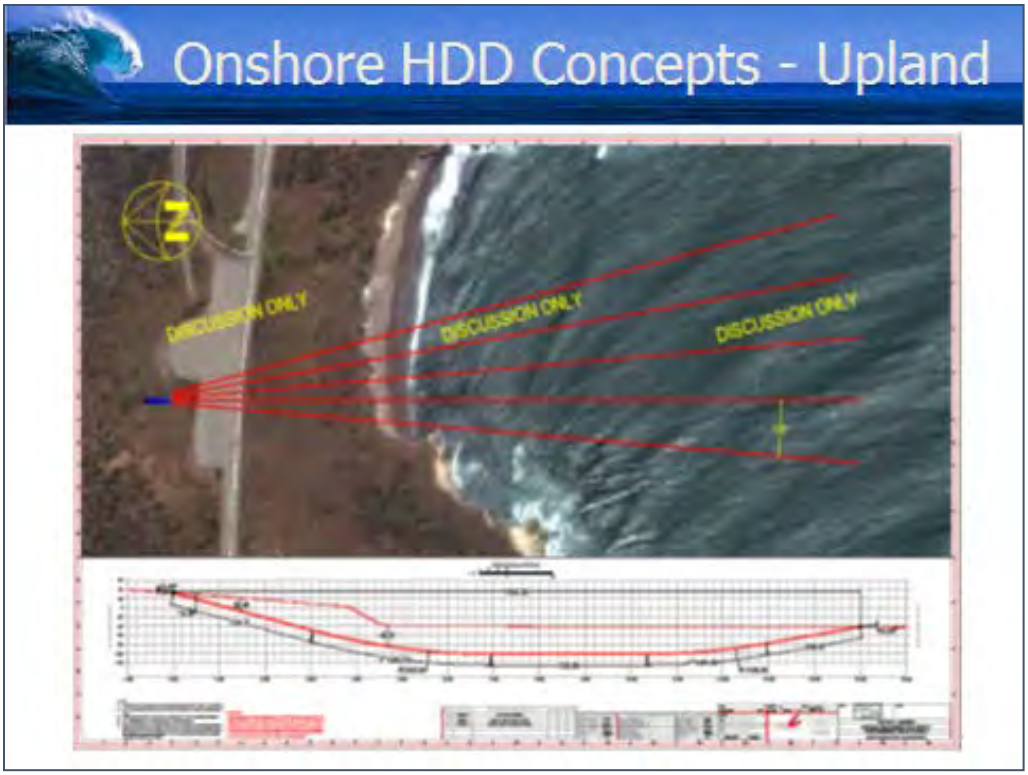


Figure 11-6-4: Onshore HDD Concepts – Upland (Source Leidos, Inc.)

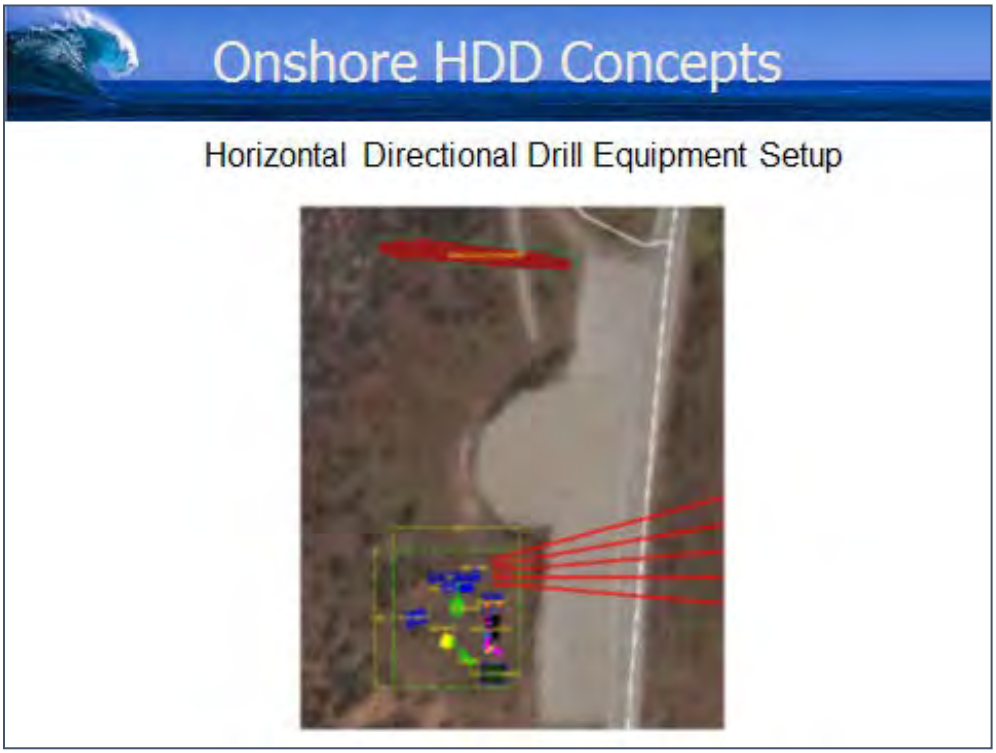


Figure 1-6-5: HDD Upland Launch - Equipment Setup (Source Leidos, Inc.)

The alternative Dock HDD Launch scenario and HDD bore profiles remain viable.

Figure 11-6-6: Alternate HDD Dock Launch Location (Source Leidos, Inc.)

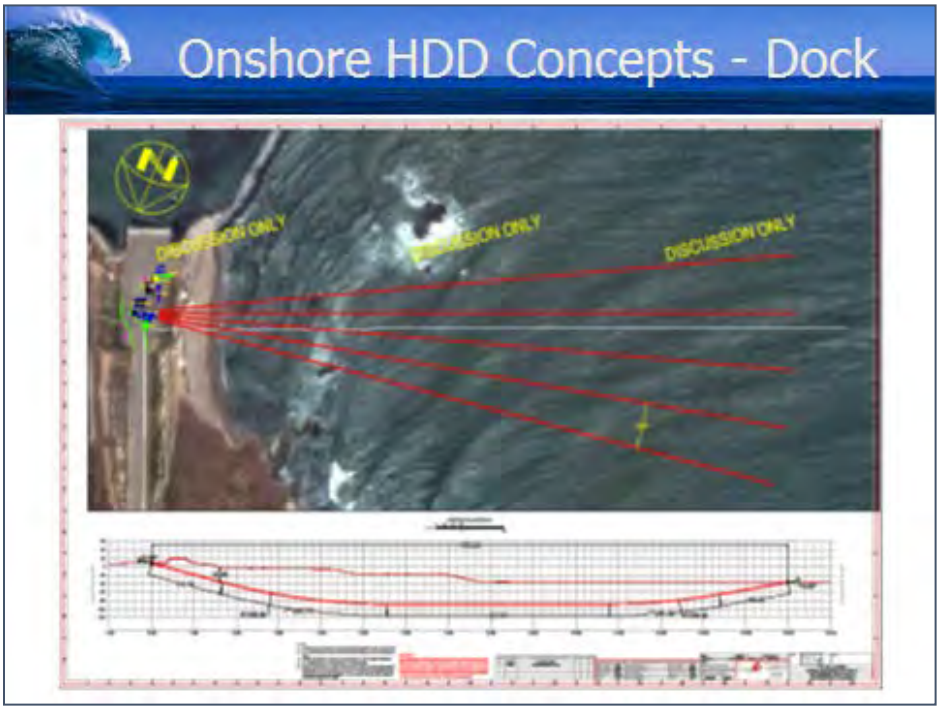


Figure 11-6-7: HDD Launch at Dock (Source Leidos, Inc.)

Attachment 11-7: Civil/Architectural Engineering and Extreme Events Analysis

Cal Poly University provided Faculty, Staff and Student support to CalWave II, including topographical survey, civil engineering and architectural engineering as well as the extreme events analysis.

Civil Engineering Analysis:

The CalWave Shore Station will support the electrical infrastructure and the Operations Buildings that will host key site personnel and WEC developer staff during test center operations.

A Cal Poly Survey Team performed a site investigation and executed a detailed topographic land survey of the conceptual onshore site location. This topographic information guided the civil, architectural, and shore-side infrastructure site layout aspects of the conceptual design.

Architectural Engineering Analysis:

The top level architectural requirement could be satisfied with two standard construction job site trailers for the shore station building. Given the historical nature of the site, and the expected constraints to use of jobsite trailers at the location, the Cal Poly Architectural Engineering group has designed two affordable pre-manufactured, mobile, modular buildings as an alternative operations building that are architecturally consistent with the historical design of the remaining Coast Guard structure.

Conference rooms, guest offices, and internet connectivity are included. The Vandenberg Dock area is located at the former US Coast Guard Surf Station, which may be available for office functions on a not-to-interfere basis

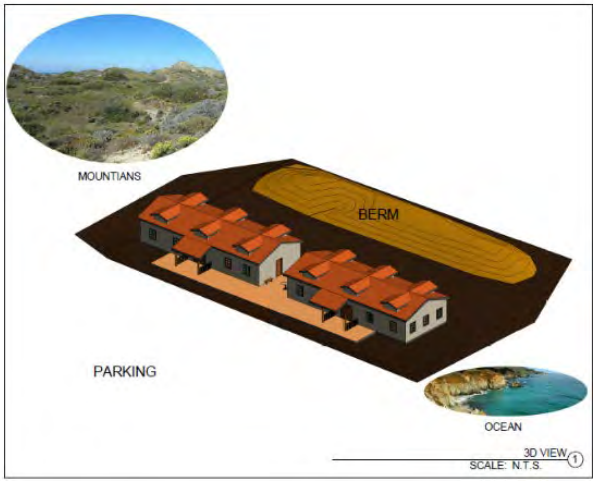


Figure 11-7-1: Conceptual Architectural Plan

Extreme Events Analysis:

An extreme events analysis was performed on the five proposed shore sites that included Tsunami modeling, historic weather modeling, and a seismic ground shaking assessment The South Base Shore Station is outside the inundation zone. A subsequent update of the extreme events analysis for the office building option at Surf Station location was also completed.

Cal Poly civil engineering department faculty performed an extreme event analysis for down selection and design consideration on each of the notional CalWave^{sm} shore station sites and the HDD launch primary and alternative sites for tsunami inundation and seismic ground shaking based upon inundation maps and USGS Spectral Acceleration summary maps in order to inform the shore station down selection process. This analysis was peer reviewed by CalWave team partner PG&E. This review builds upon the Evaluation Matrix of the CalWave Final Technical Report and is categorized per the Construction Specification Institute MasterFormat of titles and numbers for reference.

Below is an explanation and summary of the findings:

The Extreme Events Review was an input to shore site down-selection.

- The preferred CalWave Shore Station location alternative is the South Base.
- The South Base Shore Station was identified as the "notion conceptual shore location" in the Feasibility Study (Phase I).
- The South Base Shore Station will be included in the draft project description.

The Extreme Events Review was an input to horizontal directional drill (HDD) launch site down-selection.

- The preferred HDD Launch Site alternative is the Upland HDD Launch Site, adjacent to the power conditioning area, at a higher elevation.
- The Upland HDD Launch Site is intended to be included in the draft project description, subject to submarine cable design constraints.
- The alternative Dock HDD Launch Site, at the lower elevation, remains viable.

RESULTS (CSI 02 24 13 and CSI 02 31 13)

1. Southern Shore Station

No visible Inundation on the Southern Shore Station Site. (Appendix Attachment 11-7-2 Pg. 3)
Spectral Response Acceleration at the Southern Shore Station Site is SDS = 0.689g.
(Appendix Attachment 11-7-2 Pg. 9)

2. Vandenberg Air Force Base Dock (Tsunami and Seismic)

No Visible Inundation on the Vandenberg Dock however further research is recommended for Inundation effects at this location due to its visible low elevation. (Appendix Attachment 11-7-2 Pg. 3)
Spectral Response Acceleration at the South Central Shore Station Site is SDS = 0.689g.
(Appendix Attachment 11-7-2 Pg. 9)

3. South Central Shore Station Site

Visible Inundation at South Central Shore Station Site Vicinity. Visible Inundation along possible tsunami evacuation route from South Central Shore Station heading Northbound along Coast Rd.
(Appendix Attachment 11-7-2 Pg. 4)
Spectral Response Acceleration at the South Central Shore Station Site is SDS = 0.700g.
(Appendix Attachment 11-7-2 Pg. 10)

4. North Central Shore Station Site

Visible Inundation at North Central Shore Station Site Vicinity. Visible Inundation along possible tsunami evacuation route from North Central Shore Station heading Northbound along Point Sal Rd and along Southbound Roads. (Appendix Attachment 11-7-2 Pg. 5)
Spectral Response Acceleration at the North Central Shore Station Site is SDS = 0.733g.
(Appendix Attachment 11-7-2 Pg. 11)

5. North Shore Station

Visible Inundation at North Central Shore Station Site Vicinity. Visible Inundation along possible tsunami evacuation route from North Central Shore Station heading Northbound along Point Sal Rd and along Southbound Roads. (Appendix Attachment 11-7-2 Pg. 6 and 7)
Spectral Response Acceleration at the South Central Shore Station Site is SDS = 0.772g.
(Appendix Attachment 11-7-2 Pg. 12)

6. Directional Drill Launch Site Alternatives

a. Primary Location: No Visible Inundation. (Appendix Attachment 11-7-2 Pg. 2)

b. Boat Dock Alternative: No Visible Inundation per TsIM (Appendix Attachment 11-7-2 Pg.1-2).

- Further research is recommended for Inundation effects at this location due to its visible low elevation.

The Extreme Events Study also reviewed the Cal Poly Pier as a potential check-out site and shallow/mid-depth area:

Cal Poly Pier, Port San Luis

Significant Visible Inundation at the Cal Poly Pier Site. Significant Visible Inundation along Tsunami Evacuation Route Westbound on Avila Beach Dr. (Appendix Attachment 11-7-2 Pg. 8).

After the Conceptual Design Review observations are considered, and a proposed project description is written (estimate August 2016), the Extreme Events Study will be referred for peer review by our PG&E partner, who conducted a similar study for Diablo Canyon Nuclear Plant.

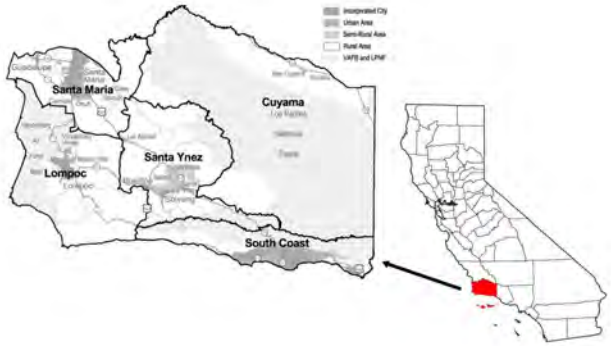
The referenced Extreme Events Review of the CalWave Feasibility Report (the Extreme Events Review) was considered during preparations for the Conceptual Design Review (CDR) and discussed with permitting agencies.

The full “CalWave Extreme Event Design Considerations with Appendix” 11-7-2 dated June 25, 2016 report is attached.

Institute for Advanced Technology and Public Policy

NATIONAL WAVE ENERGY TEST FACILITY

JULY 2016



N **LOCATION MAP**

N **VICINITY MAP**

THIS PROJECT REQUIRES A CLASS 'A' GENERAL ENGINEERING CONTRACTORS LICENSE

FEASIBILITY STUDY
NOT FOR CONSTRUCTION

DRAWING INDEX

DESIGNATION	SHEET	DESCRIPTION
G-1	1 of 10	COVER SHEET
C-1	2 of 10	SITE PLAN 1
C-2	3 of 10	SITE PLAN 2
C-3	4 of 10	SITE PLAN 3
A-1	5 of 10	ARCHITECTURE
A-2a	6 of 10	ARCHITECTURE
A-2b	7 of 10	ARCHITECTURE
A-3a	8 of 10	ARCH. FLOOR PLAN
A-3b	9 of 10	ARCH. FLOOR PLAN
A-4	10 of 10	ARCH. SECTION

1 GRAND AVENUE
SAN LUIS OBISPO, CA 93410
530-306-5800
sjdilley@calpoly.edu

VANDENBERG AFB: CALPOLY CALWAVE PLANS

CALIFORNIA POLYTECHNIC STATE UNIVERSITY, SAN LUIS OBISPO
CAL WAVE PROJECT
SUMMER 2016
CRAIG BALTIMORE, Ph.D., S.E.

CALWAVE II

Cover Sheet

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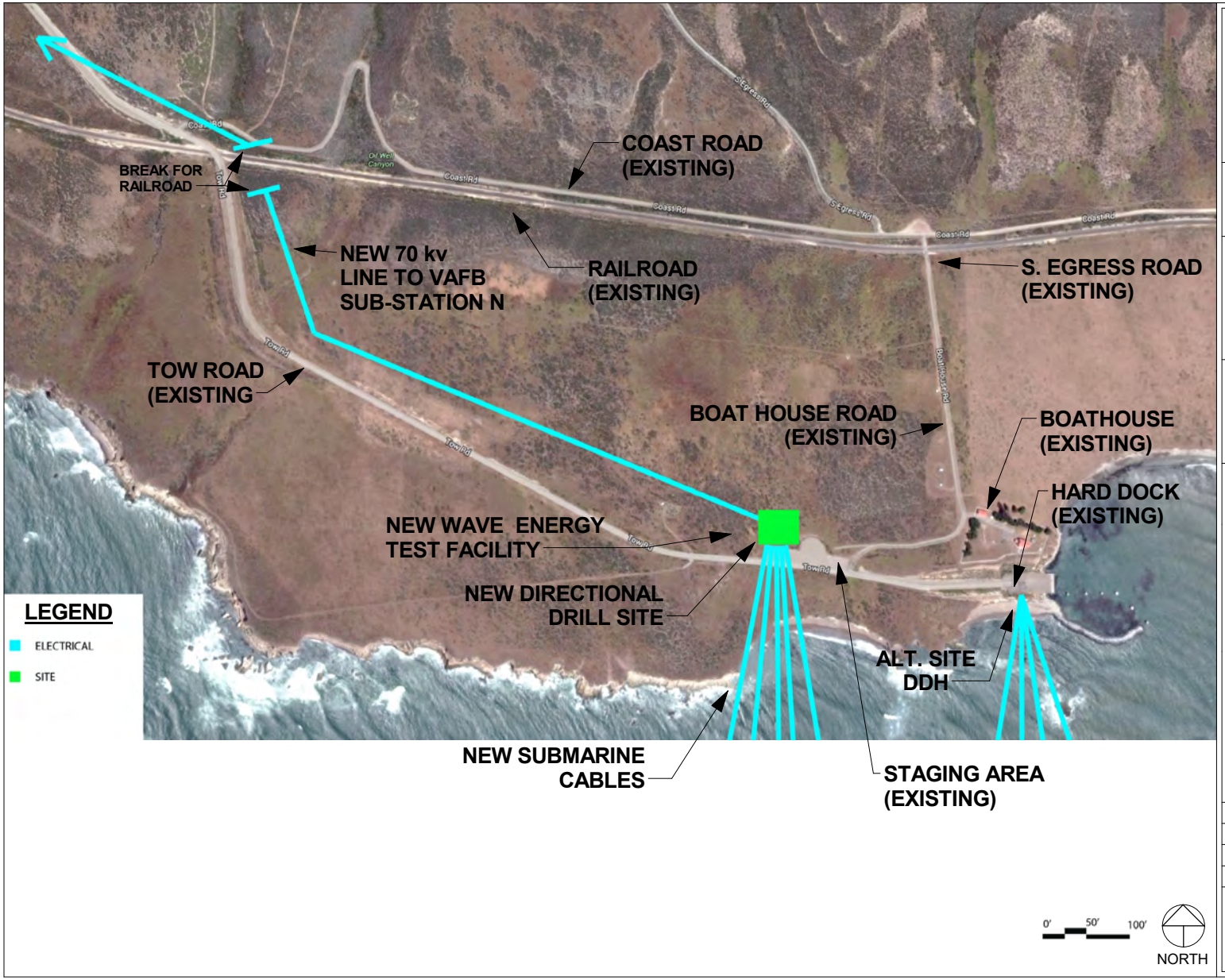
SHEET NUMBER:	G-1



CalWave
Cal Poly

1 GRAND AVENUE
SAN LUIS OBISPO, CA 93410
530-306-5800
sjdilley@calpoly.edu

VANDENBERG AFB: CALPOLY CALWAVE PLANS

CALIFORNIA POLYTECHNIC STATE UNIVERSITY, SAN LUIS OBISPO
CAL WAVE PROJECT
SUMMER 2016
CRAIG BALTIMORE, Ph.D., S.E.

CALWAVE II

SITE PLAN 1

DRAWN BY:	Spencer Dilley
DATE:	7/8/2016 9:33:58 AM
SCALE:	
TITLE:	SITE PLAN 1
SHEET NUMBER:	C-1

DESCRIPTION
NOTIONAL 70kv EXTENSION LINE ROUTE TO VAFB SUB-STATION N

APPROX LENGTH OF EXTENSION LINE = 4 MILES

NOTE:
PARALLEL LINES: BREAK FOR ROAD

NORTH

CALWAVE
CAL POLY

1 GRAND AVENUE
SAN LUIS OBISPO, CA 93410
530-306-5800
sjdilley@calpoly.edu

VANDENBERG AFB: CALPOLY CALWAVE PLANS

CALIFORNIA POLYTECHNIC STATE UNIVERSITY, SAN LUIS OBISPO
CAL WAVE PROJECT
SUMMER 2016
CRAIG BALTIMORE, Ph.D., S.E.

CALWAVE II

SITE PLAN 2

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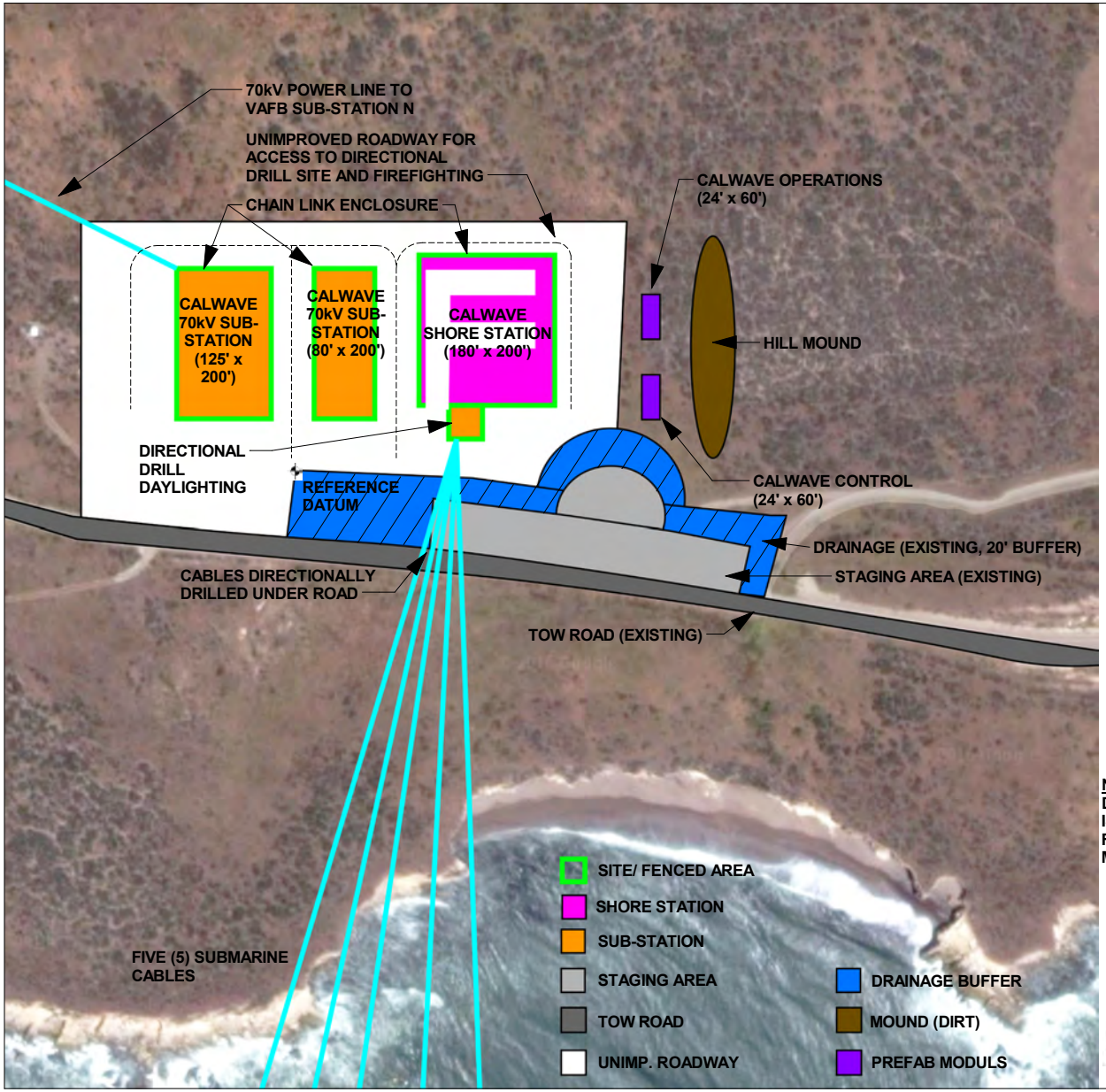

NOTE: HORIZANTAL DIRECTIONAL DRILLING IS THE PREFERRED OPTION FOR INSTALLING THE MARINE CABLES

0' 50' 100'

NORTH

CALWAVE
CAL POLY

1 GRAND AVENUE
SAN LUIS OBISPO, CA 93410
530-306-5800
sjdilley@calpoly.edu

VANDENBERG AFB: CALPOLY CALWAVE PLANS

CALIFORNIA POLYTECHNIC STATE UNIVERSITY, SAN LUIS OBISPO
CAL WAVE PROJECT
SUMMER 2016
CRAIG BALTIMORE, Ph.D., S.E.

CALWAVE II

SITE PLAN 3

DRAWN BY:	Spencer Dilley
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TITLE:	SITE PLAN 3
SHEET NUMBER:	C-3

Review of CalWave I Final Report and Appendix,
"Feasibility Study for the California Wave Energy Test Center",
for reference to **Extreme Events**

The CalWave I Final Report was reviewed for references to Extreme Events, where extreme events is defined as Tsunamis and Seismic Ground Shaking. The review is given in outline format and each outline heading conforms to the Construction Specification Institute MasterFormat of titles and numbers. The MasterFormat Specification Divisions are used as an industry standard in categorizing each element within a report as it pertains to construction and engineering. MasterFormat Specification Divisions are given after each section title in parenthesis.

This review builds upon the Evaluation Matrix of the CalWave 1 Final Report; and this reviews gives an assessment of each proposed Shore Station Site for tsunami inundation and seismic ground shaking based upon the inundation maps and USGS Spectral Acceleration summary maps.

GENERAL (CSI 00 00 00)
This section gives the location of each citation within the report or appendix and a description of the citation.

1. Location: Report (pg. 1-8), Table 1-1 ***Site Selection Criteria, SOPO Task #1***
   Description: The Table list Extreme event design environment as criteria #4 of 19. There were 19 criteria established in order to evaluate the site selection.

2. Location: Appendix 1-2B (pg. 9), ***CalWave Site Evaluation Matrix***.
   The Site Evaluation Matrix describes and gives a weighted score to each criteria (1-19). Criteria #4, Extreme event design environment included 100 yrs. storms, seismic ground shaking, and tsunami inundation. There were two citations.
   a. California Tsunami Inundation Maps (http://www.conservation.ca.gov/cgs/geologic_hazards/Tsunami/Inundation_Maps/Pages/Statewide_Maps.aspx)
   b. California Probabilistic Seismic Hazard Maps http://www.consrv.ca.gov/cgs/rghm/psha/pages/index.aspx

ABBREVIATIONS (CSI 01 42 13)

CADOC	California Department of Conservation
CSI	Construction Specification Institute
CWIFR	Cal Wave I Final Report
ESA	Existing Staging Area
SDS	Spectral Seismic Design acceleration assuming 5 percent damped, for short period ground motions.
SOPO	Statement Of Project Objectives
TsIM	Tsunami Inundation Map
USGS	United States Geological Survey
VAFB	Vandenberg Air Force Base

DEFINITIONS (CSI 01 42 16)

Significant Visible Inundation: Site is completely within the inundation zone per visual assessment of Tsunami Inundation Map.

Visible Inundation: Site are partially within inundation zone per visual assessment of Tsunami Inundation Map.

Spectral Response Coefficient: A unit measured in "g-force" that describes the maximum acceleration in an earthquake on an object (USGS 2016)

REVIEW METHODS (CSI 02 24 00)

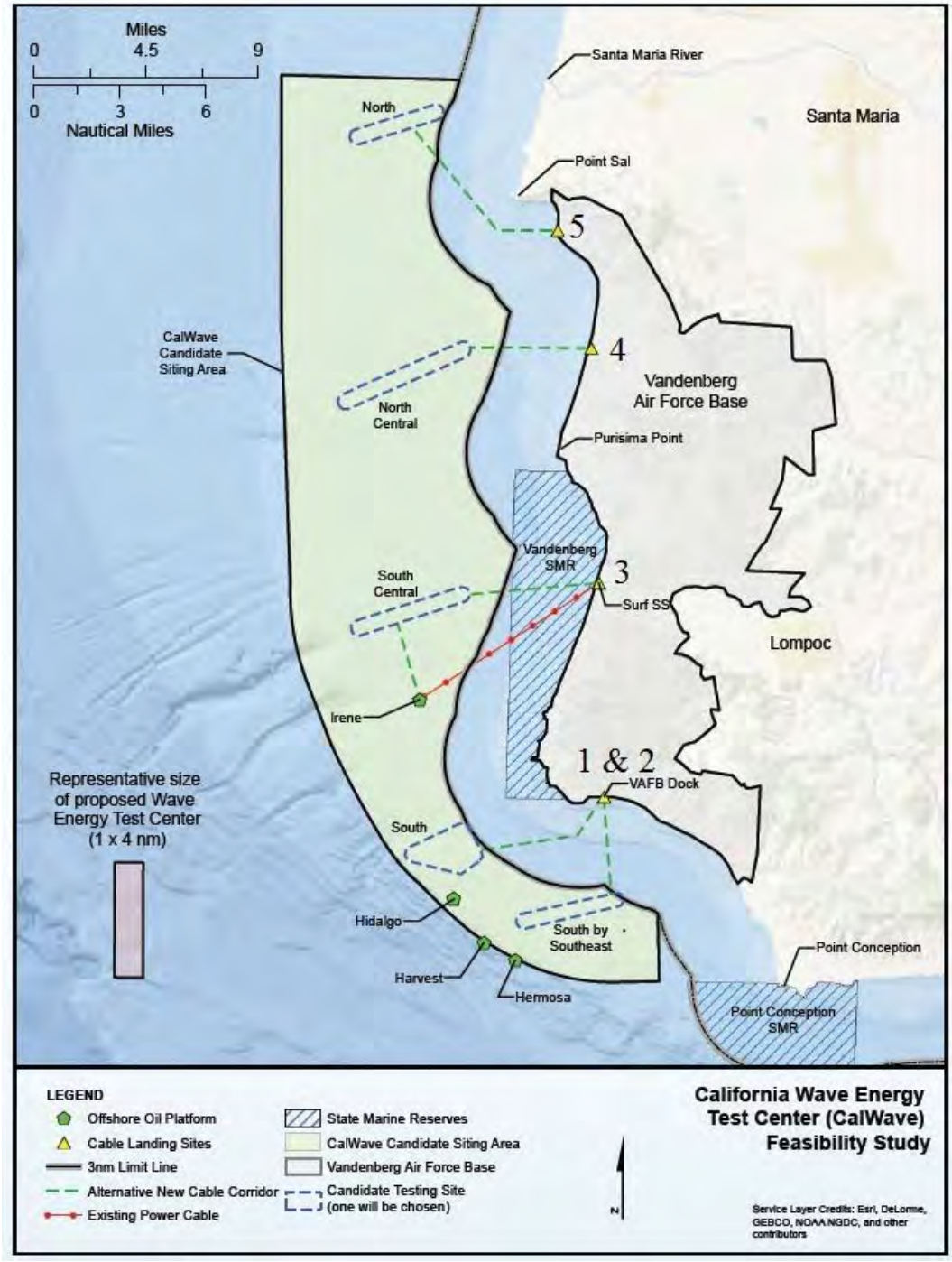
An assessment of each site was made based on a visual review of the inundation and ground shaking maps. The shore station site reviewed were

1. Southern Shore Station (Tsunami and Seismic),
2. Vandenberg Air Force Base Dock (Tsunami and Seismic),
3. South Central Shore Station (Tsunami and Seismic),
4. North Central Shore Station (Tsunami and Seismic)
5. Cal Poly Pier, Port San Luis (Tsunami), and
6. Directional Drill Pit Alternatives at Southern Shore Station Site (Tsunami)
    a Primary Location (Daylighting at NE Corner of ESA ref. Fig 2-3, CWIFR)
    b Alternative Location (Daylighting at Canada Aqua Vida ref. Fig. 2-2, CWIFR)
    c Boat Dock Location (Not in CWIFR, see Appendix Pg. 1, Fig. 1a, 1b)

Two sources were used for tsunami assessment.

- Tsunami Inundation Map for Emergency Planning (TsIM)
- County of Santa Barbara Planning and Development Department, North County Oil and Gas Facility Siting and Planning Analysis

Map of considered site



RESULTS (CSI 02 24 13 and CSI 02 31 13)

1. **Southern Shore Station**
   No visible Inundation on the Southern Shore Station Site. (Appendix Pg. 3)

   Spectral Response Acceleration at the Southern Shore Station Site is S_{DS} = 0.689g. (Appendix Pg. 9)

2. **Vandenberg Air Force Base Dock (Tsunami and Seismic**
   No Visible Inundation on the Vandenberg Dock however further research is recommended for Inundation effects at this location due to its visible low elevation. (Appendix Pg. 3)

   Spectral Response Acceleration at the South Central Shore Station Site is S_{DS} = 0.689g. (Appendix Pg. 9)

3. **South Central Shore Station Site**
   Visible Inundation at South Central Shore Station Site Vicinity. Visible Inundation along possible tsunami evacuation route from South Central Shore Station heading Northbound along Coast Rd. (Appendix Pg. 4)

   Spectral Response Acceleration at the South Central Shore Station Site is SDS = 0.700g. (Appendix Pg. 10)

4. **North Central Shore Station Site**
   Visible Inundation at North Central Shore Station Site Vicinity. Visible Inundation along possible tsunami evacuation route from North Central Shore Station heading Northbound along Point Sal Rd and along Southbound Roads. (Appendix Pg. 5)

   Spectral Response Acceleration at the North Central Shore Station Site is SDS = 0.733g. (Appendix Pg. 11)

5. **North Shore Station**
   Visible Inundation at North Central Shore Station Site Vicinity. Visible Inundation along possible tsunami evacuation route from North Central Shore Station heading Northbound along Point Sal Rd and along Southbound Roads. (Appendix Pg. 6 and 7)

   Spectral Response Acceleration at the South Central Shore Station Site is SDS = 0.772g. (Appendix Pg. 12)

6. **Cal Poly Pier, Port San Luis**
   Significant Visible Inundation at the Cal Poly Pier Site. Significant Visible Inundation along Tsunami Evacuation Route Westbound on Avila Beach Dr. (Appendix Pg. 8)

7. **Directional Drill Pit Alternatives**
   a. Primary Location: No Visible Inundation. (Appendix Pg. 2)
   b. Boat Dock Alternative: No Visible Inundation per TsIM (Appendix Pg.1-2). Further research is recommended for Inundation effects at this location due to its visible low elevation

REFERENCES (CSI 01 42 00)

California Department of Conservation. (2009). "Tsunami Inundation Map for Emergency Planning, Tranquillon Mountain Quadrangle." *MUD history,* <http://www.conservation.ca.gov/ > (April 28th, 2016).

California Department of Conservation. (2009). "Tsunami Inundation Map for Emergency Planning, Pismo Beach Quadrangle." *MUD history,* <http://www.conservation.ca.gov/ > (April 28th, 2016).

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California Department of Conservation. (2009). "Tsunami Inundation Map for Emergency Planning, Point Sal Quadrangle." *MUD history,* <http://www.conservation.ca.gov/ > (April 28th, 2016).

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Cal Poly Institute for Advanced Technology and Public Policy.(2015). "Feasibility Study for California Wave Energy Test Center".

United States Geological Survey. (2014). "U.S. Seismic Design Maps" *MUD History*, <http://earthquake.usgs.gov/designmaps/us/application.php?> (May 4th,2016).

County of Santa Barbara Planning and Development Department, "North County Oil and Gas Facility Siting and Planning Analysis" MUD History, < http://www.sbcountyplanning.org> (May 4th, 2016)

APPENDIX

Appendix Pg. 1

Figure 1a. Approximate Location for Directional Drill Pit Alternative at VAFB Boat Dock

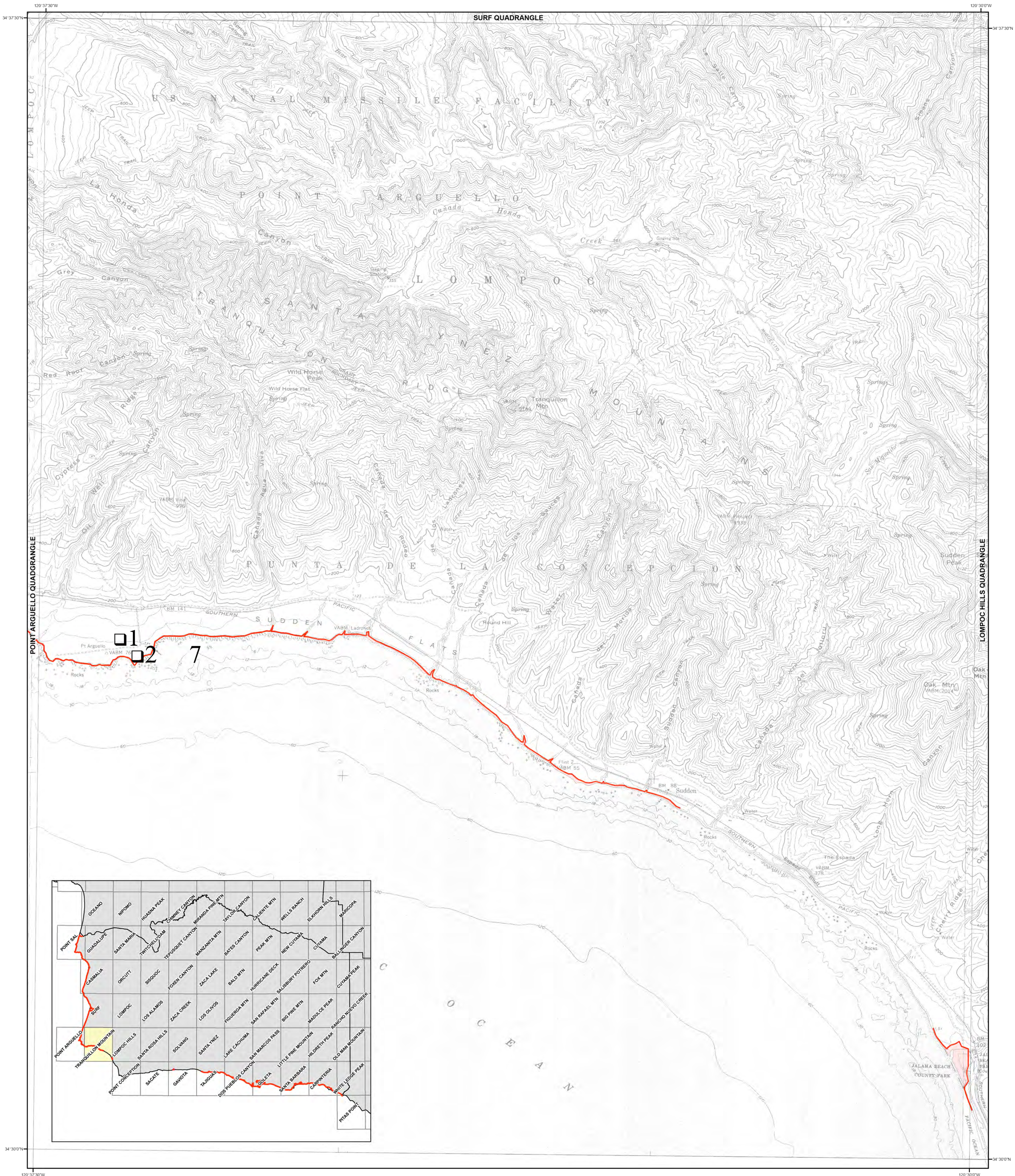
Appendix Pg. 2

Figure 1b. Approximate Location for Directional Drill Pit Alternative at VAFB Boat Dock

California Emergency Management Agency
California Geological Survey
University of Southern California

Tsunami Inundation Map for Emergency Planning
Tranquillon Mountain Quadrangle

State of California
County of Santa Barbara



METHOD OF PREPARATION

Initial tsunami modeling was performed by the University of Southern California (USC) Tsunami Research Center funded through the California Emergency Management Agency (CalEMA) by the National Tsunami Hazard Mitigation Program. The tsunami modeling process utilized the MOST (Method of Splitting Tsunamis) computational program (Version 0), which allows for wave evolution over a variable bathymetry and topography used for the inundation mapping (Titov and Gonzalez, 1997; Titov and Synolakis, 1998).

The bathymetric/topographic data that were used in the tsunami models consist of a series of nested grids. Near-shore grids with a 3 arc-second (75- to 90-meters) resolution or higher, were adjusted to "Mean High Water" sea-level conditions, representing a conservative sea level for the intended use of the tsunami modeling and mapping.

A suite of tsunami source events was selected for modeling, representing realistic local and distant earthquakes and hypothetical extreme undersea, near-shore landslides (Table 1). Local tsunami sources that were considered include offshore reverse-thrust faults, restraining bends on strike-slip fault zones and large submarine landslides capable of significant seafloor displacement and tsunami generation. Distant tsunami sources that were considered include great subduction zone events that are known to have occurred historically (1960 Chile and 1964 Alaska earthquakes) and others which can occur around the Pacific Ocean "Ring of Fire."

In order to enhance the result from the 75- to 90-meter inundation grid data, a method was developed utilizing higher-resolution digital topographic data (3- to 10-meters resolution) that better defines the location of the maximum inundation line (U.S. Geological Survey, 1993; Intermap, 2003; NOAA, 2004). The location of the enhanced inundation line was determined by using digital imagery and terrain data on a GIS platform with consideration given to historic inundation information (Lander, et al., 1993). This information was verified, where possible, by field work coordinated with local county personnel.

The accuracy of the inundation line shown on these maps is subject to limitations in the accuracy and completeness of available terrain and tsunami source information, and the current understanding of tsunami generation and propagation phenomena as expressed in the models. Thus, although an attempt has been made to identify a credible upper bound to inundation at any location along the coastline, it remains possible that actual inundation could be greater in a major tsunami event.

This map does not represent inundation from a single scenario event. It was created by combining inundation results for an ensemble of source events affecting a given region (Table 1). For this reason, all of the inundation region in a particular area will not likely be inundated during a single tsunami event.

References:

Intermap Technologies, Inc., 2003, Intermap product handbook and quick start guide: Intermap NEXTmap document on 5-meter resolution data, 112 p.

Lander, J.F., Lockridge, P.A., and Kozuch, M.J., 1993, Tsunamis Affecting the West Coast of the United States 1806-1992: National Geophysical Data Center Key to Geophysical Record Documentation No. 29, NOAA, NESDIS, NGDC, 242 p.

National Atmospheric and Oceanic Administration (NOAA), 2004, Interferometric Synthetic Aperture Radar (IfSAR) Digital Elevation Models from GeoSAR platform (EarthData): 3-meter resolution data.

Titov, V.V., and Gonzalez, F.I., 1997, Implementation and Testing of the Method of Tsunami Splitting (MOST): NOAA Technical Memorandum ERL PMEL – 112, 11 p.

Titov, V.V., and Synolakis, C.E., 1998, Numerical modeling of tidal wave runup: Journal of Waterways, Port, Coastal and Ocean Engineering, ASCE, 124 (4), pp 157-171.

U.S. Geological Survey, 1993, Digital Elevation Models: National Mapping Program, Technical Instructions, Data Users Guide 5, 48 p.

TSUNAMI INUNDATION MAP FOR EMERGENCY PLANNING

State of California ~ County of Santa Barbara

TRANQUILLON MOUNTAIN QUADRANGLE

January 31, 2009

SCALE 1:24,000

0.5 0.25 0 0.5 1 Miles

1,000 500 0 1,000 2,000 3,000 4,000 5,000 Feet

0.5 0.25 0 0.5 1 Kilometers

Table 1: Tsunami sources modeled for the Santa Barbara County coastline.

Sources (M = moment magnitude used in modeled event)		Areas of Inundation Map Coverage and Sources Used		
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	Central Aleutians Subduction Zone#2 (M8.9)	X		
	Central Aleutians Subduction Zone#3 (M9.2)	X	X	X
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	1960 Chile Earthquake (M9.3)	X	X	
	1964 Alaska Earthquake (M9.2)	X		X
	Cascadia Subduction Zone #2 (M9.2)	X		
	Japan Subduction Zone #2 (M8.8)	X		
	Kuril Islands Subduction Zone #2 (M8.8)	X		
	Kuril Islands Subduction Zone #3 (M8.8)	X		
	Kuril Islands Subduction Zone #4 (M8.8)	X		

Cal EMA CALIFORNIA EMERGENCY MANAGEMENT AGENCY

CGS CALIFORNIA GEOLOGICAL SURVEY

USC UNIVERSITY OF SOUTHERN CALIFORNIA

MAP EXPLANATION

Tsunami Inundation Line

Tsunami Inundation Area

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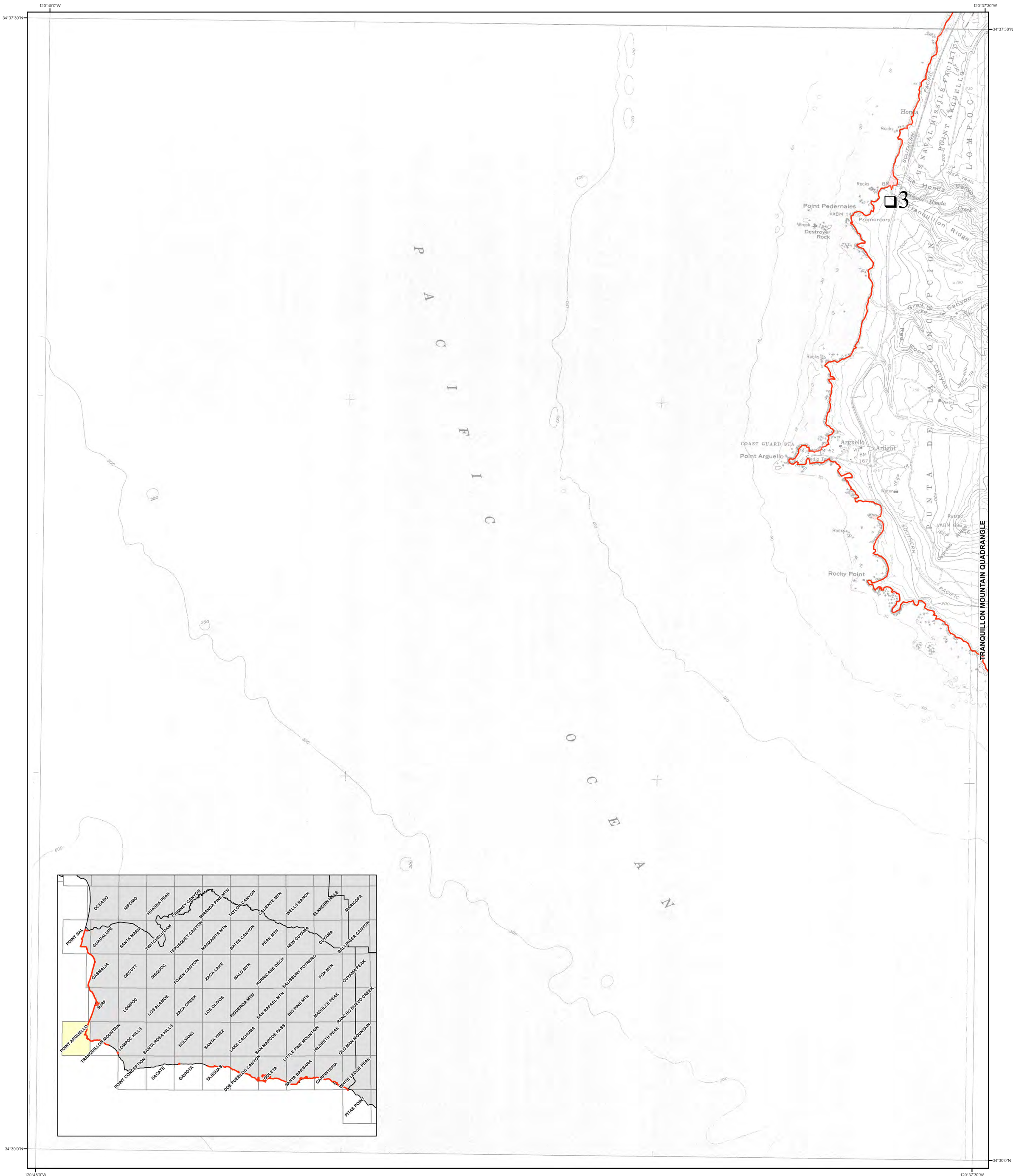
California Emergency Management Agency
California Geological Survey
University of Southern California

Tsunami Inundation Map for Emergency Planning
Point Arguello Quadrangle

State of California
County of Santa Barbara



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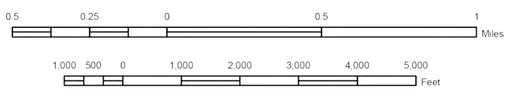
TSUNAMI INUNDATION MAP FOR EMERGENCY PLANNING

State of California ~ County of Santa Barbara

POINT ARGUELLO QUADRANGLE

January 31, 2009

SCALE 1:24,000



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	Central Aleutians Subduction Zone#3 (M9.2)	X	X	X
	Chile North Subduction Zone (M9.4)	X	X	X
	1960 Chile Earthquake (M9.3)	X	X	
	1964 Alaska Earthquake (M9.2)	X		X
	Cascadia Subduction Zone #2 (M9.2)	X		
	Japan Subduction Zone #2 (M8.8)	X		
	Kuril Islands Subduction Zone #2 (M8.8)	X		
	Kuril Islands Subduction Zone #3 (M8.8)	X		
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MAP EXPLANATION

Tsunami Inundation Line

Tsunami Inundation Area

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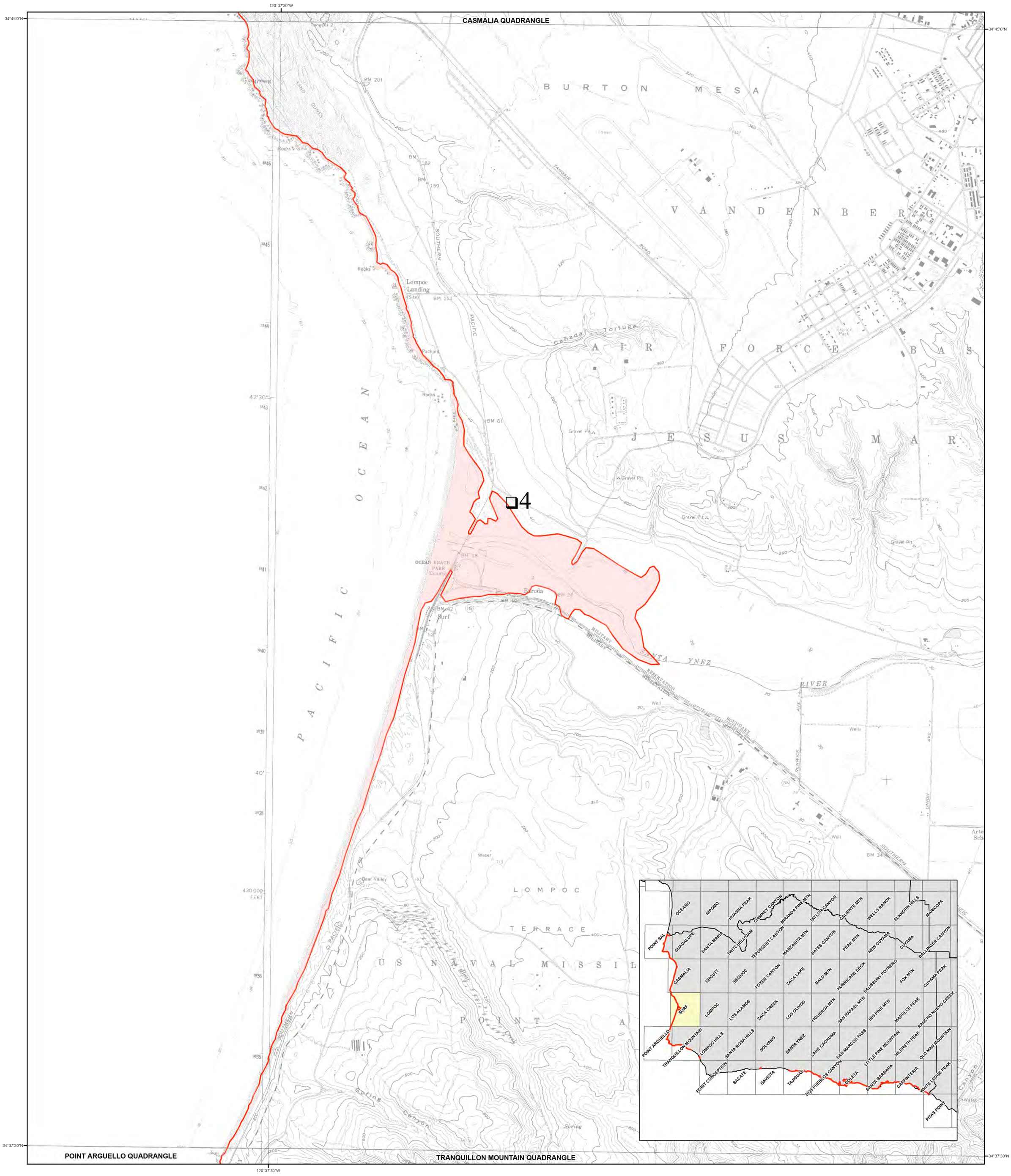
Tsunami Inundation Map for Emergency Planning
Surf Quadrangle

State of California
County of Santa Barbara



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TSUNAMI INUNDATION MAP FOR EMERGENCY PLANNING

State of California ~ County of Santa Barbara

SURF QUADRANGLE

January 31, 2009

SCALE 1:24,000

0.5 0.25 0 0.5 1 Miles

1,000 500 0 1,000 2,000 3,000 4,000 5,000 Feet

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MAP EXPLANATION

Tsunami Inundation Line

Tsunami Inundation Area

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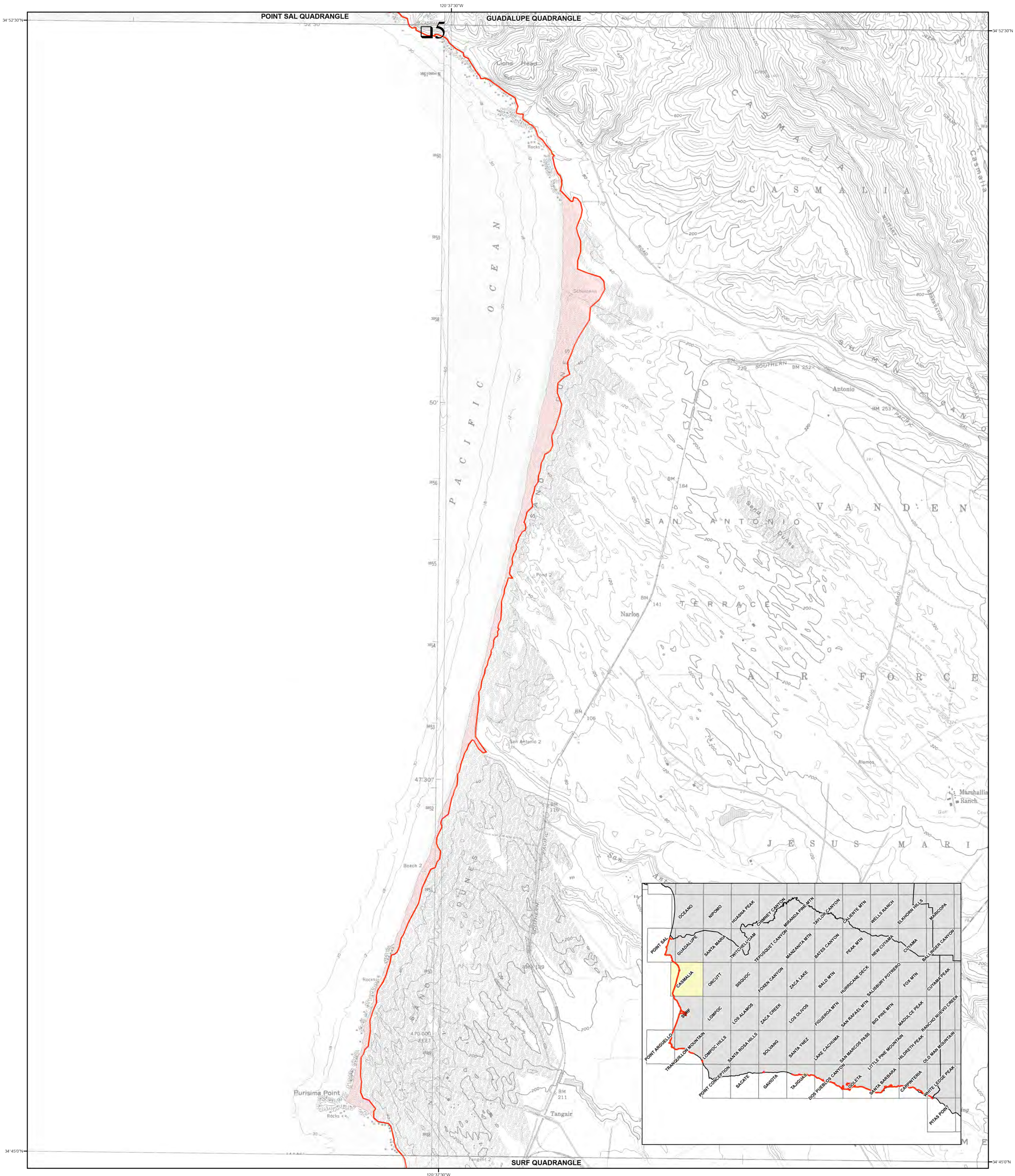

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State of California ~ County of Santa Barbara

CASMALIA QUADRANGLE

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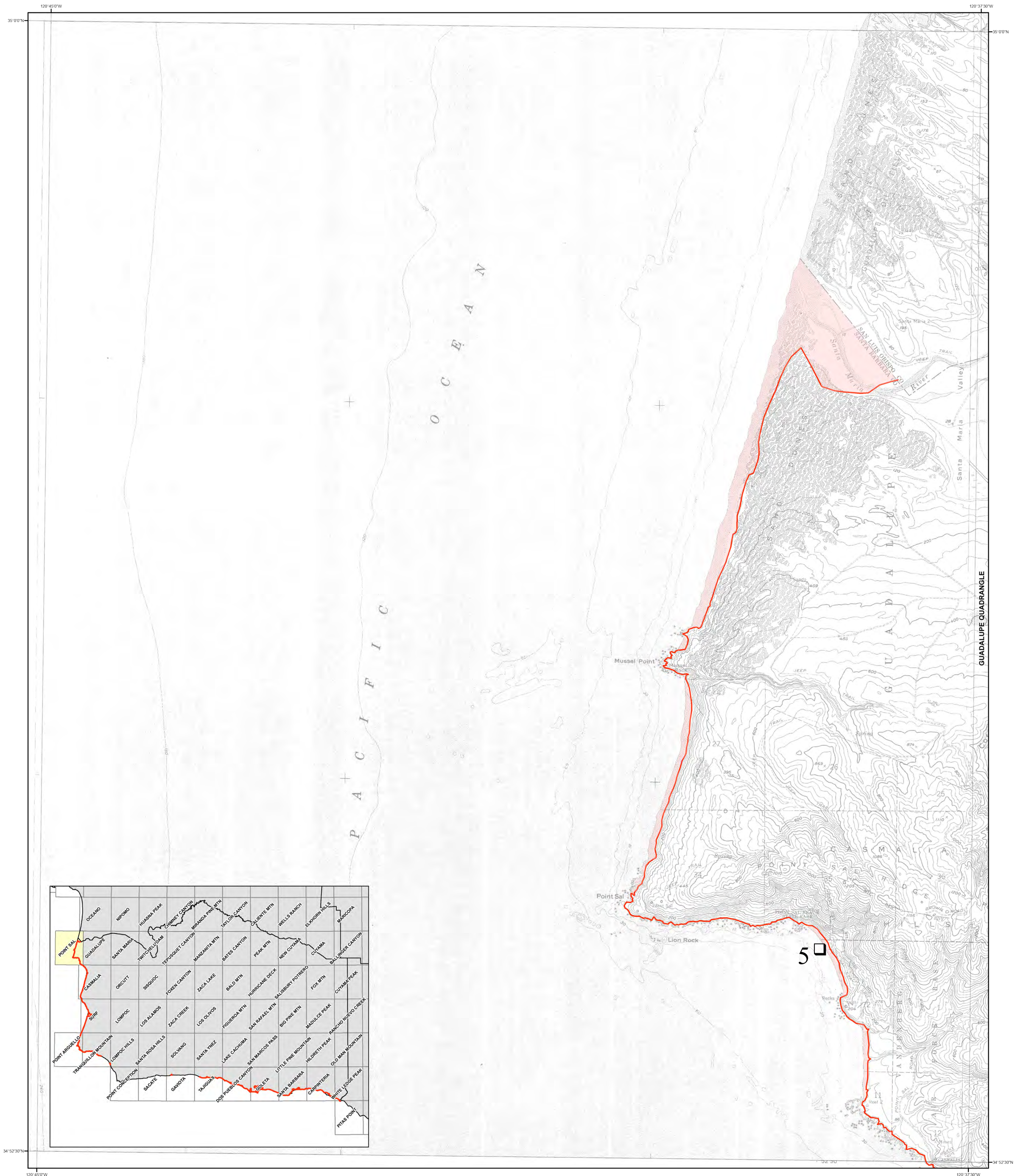

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A suite of tsunami source events was selected for modeling, representing realistic local and distant earthquakes and hypothetical extreme undersea, near-shore landslides (Table 1). Local tsunami sources that were considered include offshore reverse-thrust faults, restraining bends on strike-slip fault zones and large submarine landslides capable of significant seafloor displacement and tsunami generation. Distant tsunami sources that were considered include great subduction zone events that are known to have occurred historically (1960 Chile and 1964 Alaska earthquakes) and others which can occur around the Pacific Ocean "Ring of Fire."

In order to enhance the result from the 75- to 90-meter inundation grid data, a method was developed utilizing higher-resolution digital topographic data (3- to 10-meters resolution) that better defines the location of the maximum inundation line (U.S. Geological Survey, 1993; Intermap, 2003; NOAA, 2004). The location of the enhanced inundation line was determined by using digital imagery and terrain data on a GIS platform with consideration given to historic inundation information (Lander, et al., 1993). This information was verified, where possible, by field work coordinated with local county personnel.

The accuracy of the inundation line shown on these maps is subject to limitations in the accuracy and completeness of available terrain and tsunami source information, and the current understanding of tsunami generation and propagation phenomena as expressed in the models. Thus, although an attempt has been made to identify a credible upper bound to inundation at any location along the coastline, it remains possible that actual inundation could be greater in a major tsunami event.

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References:

Intermap Technologies, Inc., 2003, Intermap product handbook and quick start guide: Intermap NEXTmap document on 5-meter resolution data, 112 p.

Lander, J.F., Lockridge, P.A., and Kozuch, M.J., 1993, Tsunamis Affecting the West Coast of the United States 1806-1992: National Geophysical Data Center Key to Geophysical Record Documentation No. 29, NOAA, NESDIS, NGDC, 242 p.

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Titov, V.V., and Gonzalez, F.I., 1997, Implementation and Testing of the Method of Tsunami Splitting (MOST): NOAA Technical Memorandum ERL PMEL – 112, 11 p.

Titov, V.V., and Synolakis, C.E., 1998, Numerical modeling of tidal wave runup: Journal of Waterways, Port, Coastal and Ocean Engineering, ASCE, 124 (4), pp 157-171.

U.S. Geological Survey, 1993, Digital Elevation Models: National Mapping Program, Technical Instructions, Data Users Guide 5, 48 p.

TSUNAMI INUNDATION MAP FOR EMERGENCY PLANNING

State of California ~ County of Santa Barbara

POINT SAL QUADRANGLE

January 31, 2009

SCALE 1:24,000

0.5 0.25 0 0.5 1 Miles

1,000 500 0 1,000 2,000 3,000 4,000 5,000 Feet

0.5 0.25 0 0.5 1 Kilometers

Table 1: Tsunami sources modeled for the Santa Barbara County coastline.

Sources (M = moment magnitude used in modeled event)		Areas of Inundation Map Coverage and Sources Used		
		Lompoc	Santa Barbara	Santa Barbara – Ventura
Local Sources	Anacapa-Dume Fault		X	
	Channel Island Thrust Fault		X	X
	Goleta Offshore Landslide #1		X	X
	Goleta Offshore Landslide #2		X	X
	1927 Point Arguello Earthquake (M7.3)	X		
Distant Sources	Central Aleutians Subduction Zone#1 (M8.9)	X		X
	Central Aleutians Subduction Zone#2 (M8.9)	X		
	Central Aleutians Subduction Zone#3 (M9.2)	X	X	X
	Chile North Subduction Zone (M9.4)	X	X	X
	1960 Chile Earthquake (M9.3)	X	X	
	1964 Alaska Earthquake (M9.2)	X		X
	Cascadia Subduction Zone #2 (M9.2)	X		
	Japan Subduction Zone #2 (M8.8)	X		
	Kuril Islands Subduction Zone #2 (M8.8)	X		
	Kuril Islands Subduction Zone #3 (M8.8)	X		
	Kuril Islands Subduction Zone #4 (M8.8)	X		

Cal EMA CALIFORNIA EMERGENCY MANAGEMENT AGENCY

CGS CALIFORNIA GEOLOGICAL SURVEY

USC UNIVERSITY OF SOUTHERN CALIFORNIA

MAP EXPLANATION

Tsunami Inundation Line

Tsunami Inundation Area

PURPOSE OF THIS MAP

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The inundation map has been compiled with best currently available scientific information. The inundation line represents the maximum considered tsunami runup from a number of extreme, yet realistic, tsunami sources. Tsunamis are rare events; due to a lack of known occurrences in the historical record, this map includes no information about the probability of any tsunami affecting any area within a specific period of time.

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State of California Emergency Management Agency, Earthquake and Tsunami Program:
http://www.oes.ca.gov/WebPage/oeswebsite.nsf/Content/B1EC51BA215931768825741F005E8D80?OpenDocument

University of Southern California – Tsunami Research Center:
http://www.usc.edu/dept/tsunamis/2005/index.php

State of California Geological Survey Tsunami Information:
http://www.conservation.ca.gov/cgs/geologic_hazards/Tsunami/index.htm

National Oceanic and Atmospheric Agency Center for Tsunami Research (MOST model):
http://nctr.pmel.noaa.gov/time/background/models.html

MAP BASE

Topographic base maps prepared by U.S. Geological Survey as part of the 7.5-minute Quadrangle Map Series (originally 1:24,000 scale). Tsunami inundation line boundaries may reflect updated digital orthophotographic and topographic data that can differ significantly from contours shown on the base map.

DISCLAIMER

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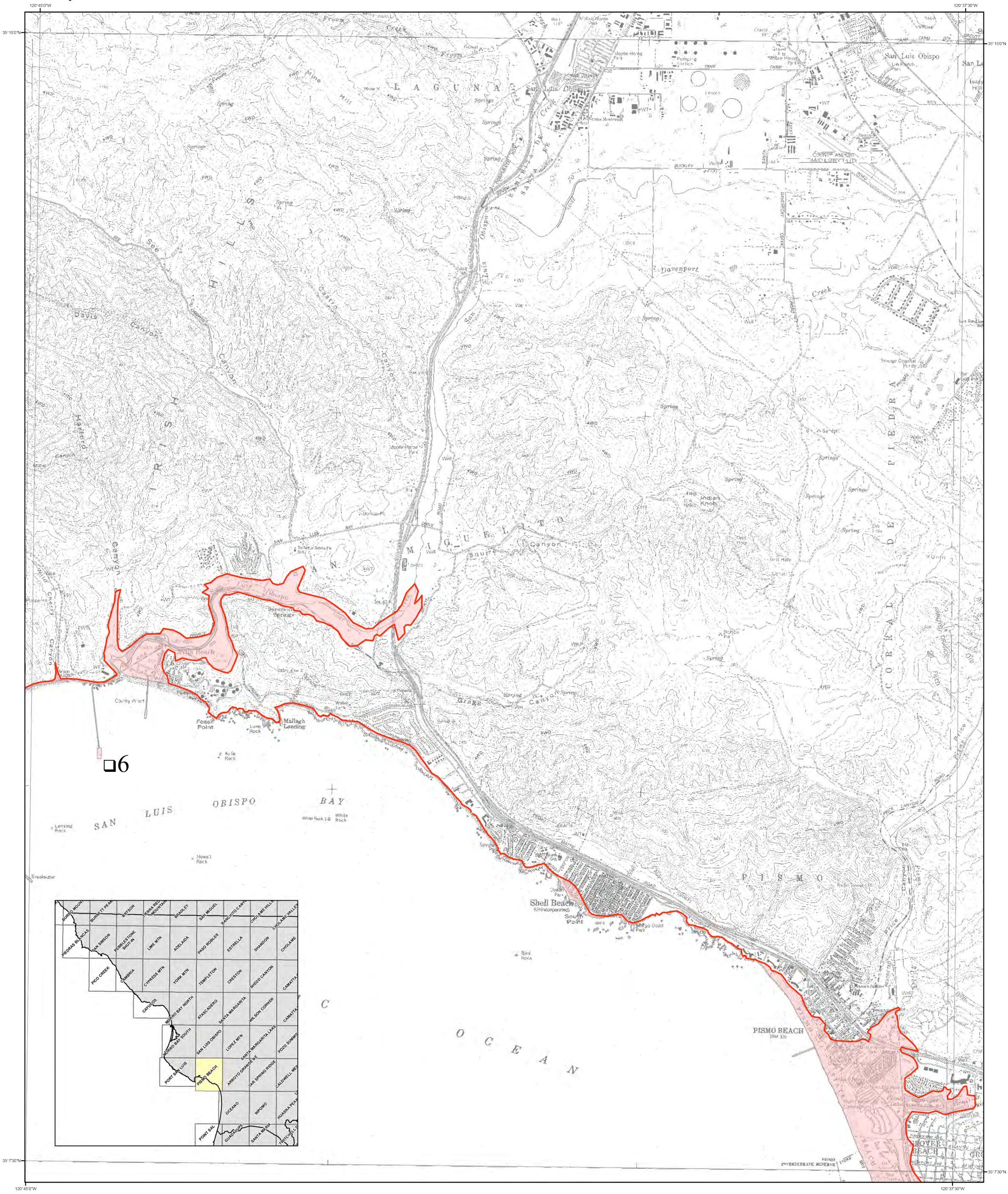
California Emergency Management Agency
California Geological Survey
University of Southern California

Tsunami Inundation Map for Emergency Planning
Pismo Beach Quadrangle

State of California
County of San Luis Obispo



❑6

METHOD OF PREPARATION

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TSUNAMI INUNDATION MAP FOR EMERGENCY PLANNING

State of California ~ County of San Luis Obispo

PISMO BEACH QUADRANGLE

July 1, 2009

SCALE 1:24,000

0.5 0.25 0 0.5 1 Miles

1,000 500 0 1,000 2,000 3,000 4,000 5,000 Feet

0.5 0.25 0 0.5 1 Kilometers

Table 1: Tsunami sources modeled for the San Luis Obispo County coastline.

Sources (M = moment magnitude used in modeled event)		Areas of Inundation Map Coverage and Sources Used			
		North Morro	Morro Bay	San Diablo	Port San Luis
Local Source	1927 Point Arguello Earthquake (M7.3)		X		X
Distant Sources	Cascadia Subduction Zone-full rupture (M9.0)		X		X
	Central Aleutians Subduction Zone #1 (M8.9)	X	X	X	X
	Central Aleutians Subduction Zone #2 (M8.9)		X		X
	Central Aleutians Subduction Zone #3 (M9.2)	X	X	X	X
	Chile North Subduction Zone (M9.4)	X	X	X	X
	1960 Chile Earthquake (M9.3)		X		X
	1964 Alaska Earthquake (M9.2)	X	X	X	X
	1952 Kamchatka Earthquake (M9.0)				X
	Japan Subduction Zone #2 (M8.8)	X	X		X
	Kuril Islands Subduction Zone #2 (M8.8)		X		X
	Kuril Islands Subduction Zone #3 (M8.8)		X		X
	Kuril Islands Subduction Zone #4 (M8.8)		X		X
	Marianas Subduction Zone (M8.6)	X	X	X	X

MAP EXPLANATION

Tsunami Inundation Line

Tsunami Inundation Area

PURPOSE OF THIS MAP

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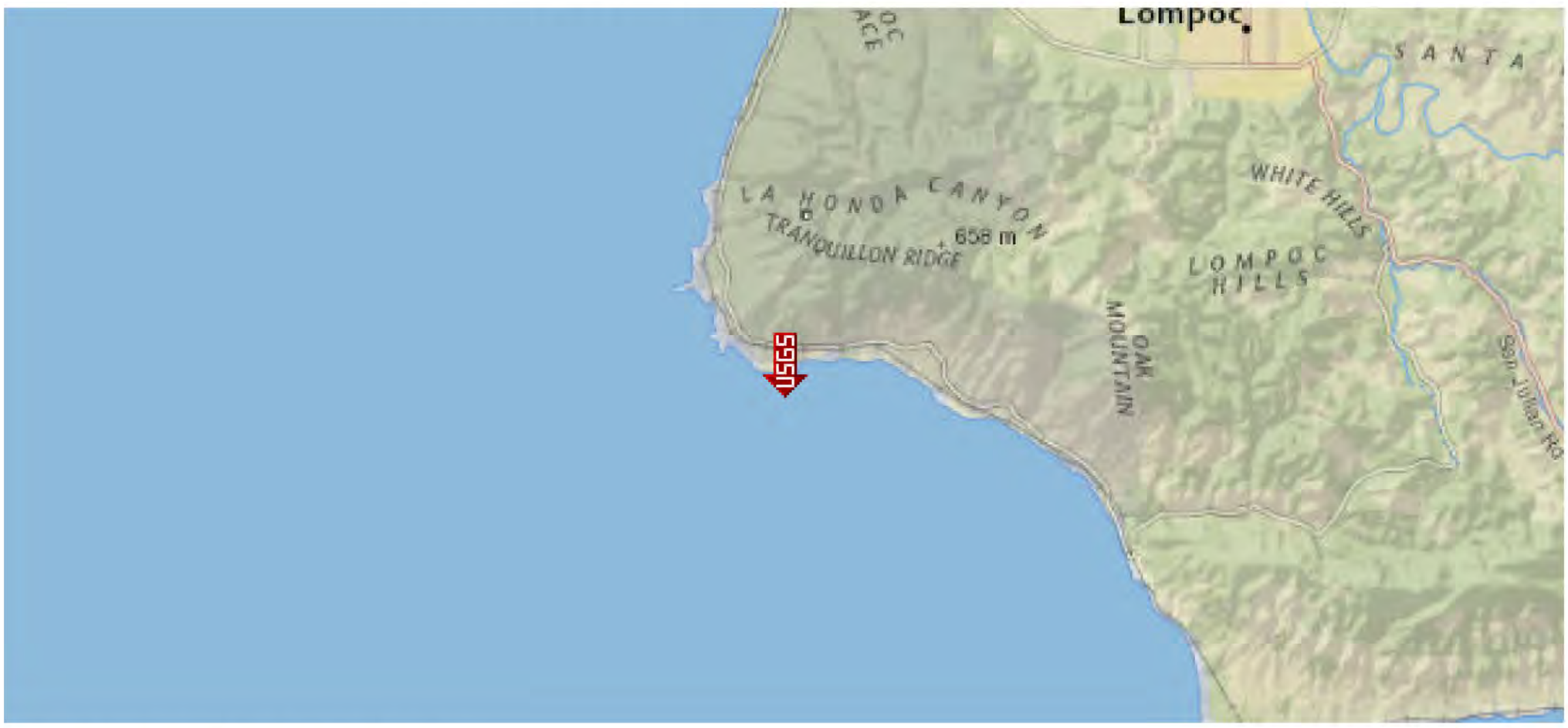
USGS Design Maps Summary Report

User–Specified Input

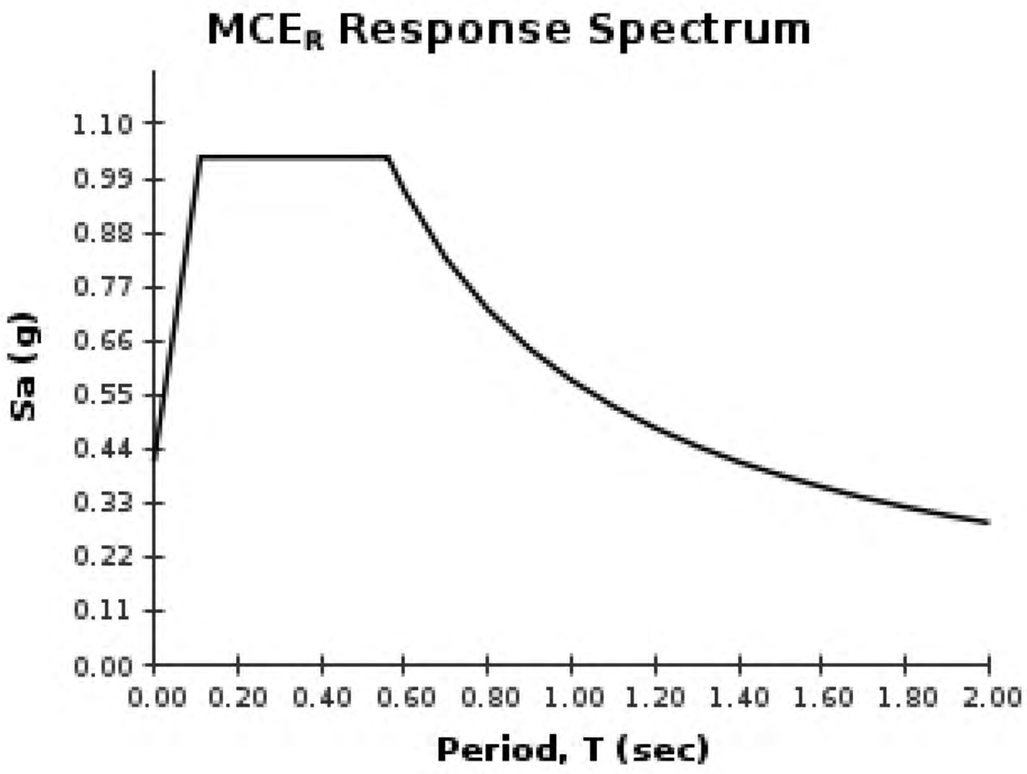
Report Title	South Site Thu May 5, 2016 01:14:44 UTC
Building Code Reference Document	ASCE 7-10 Standard (which utilizes USGS hazard data available in 2008)
Site Coordinates	34.55536°N, 120.61489°W
Site Soil Classification	Site Class D – "Stiff Soil"
Risk Category	I/II/III

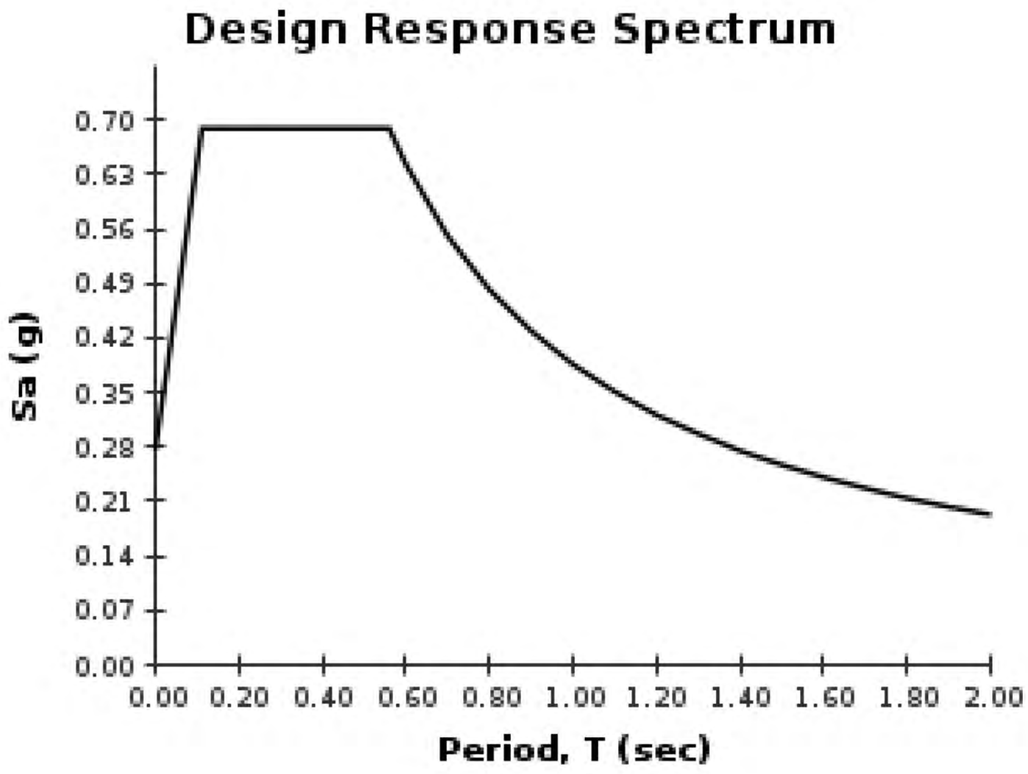


USGS–Provided Output

S_S =	0.909 g	S_{MS} =	1.033 g	S_{DS} =	0.689 g
S_1 =	0.334 g	S_{M1} =	0.579 g	S_{D1} =	0.386 g

For information on how the SS and S1 values above have been calculated from probabilistic (risk-targeted) and deterministic ground motions in the direction of maximum horizontal response, please return to the application and select the "2009 NEHRP" building code reference document.



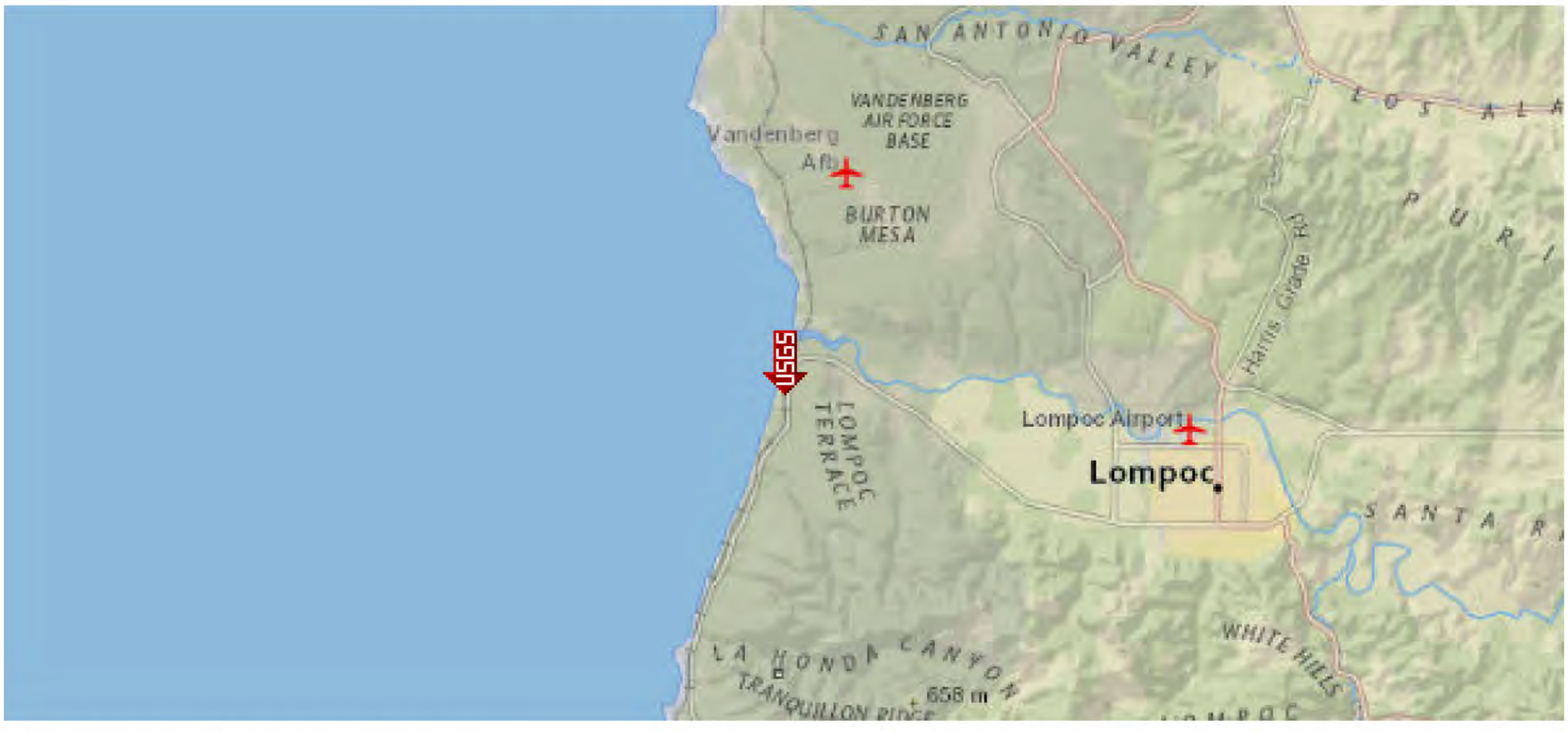


For PGA_M, T_L, C_{RS}, and C_{R1} values, please view the detailed report.

USGS Design Maps Summary Report

User–Specified Input

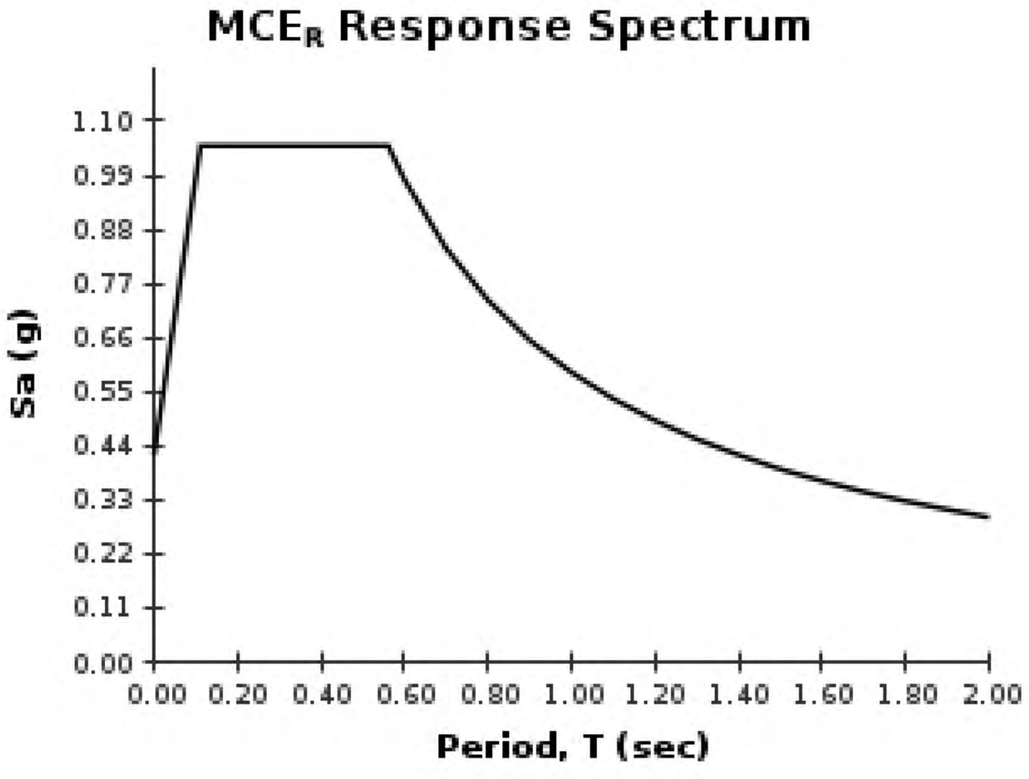
Report Title	South Central Site Thu May 5, 2016 01:30:29 UTC
Building Code Reference Document	ASCE 7-10 Standard (which utilizes USGS hazard data available in 2008)
Site Coordinates	34.68436°N, 120.60542°W
Site Soil Classification	Site Class D – "Stiff Soil"
Risk Category	I/II/III

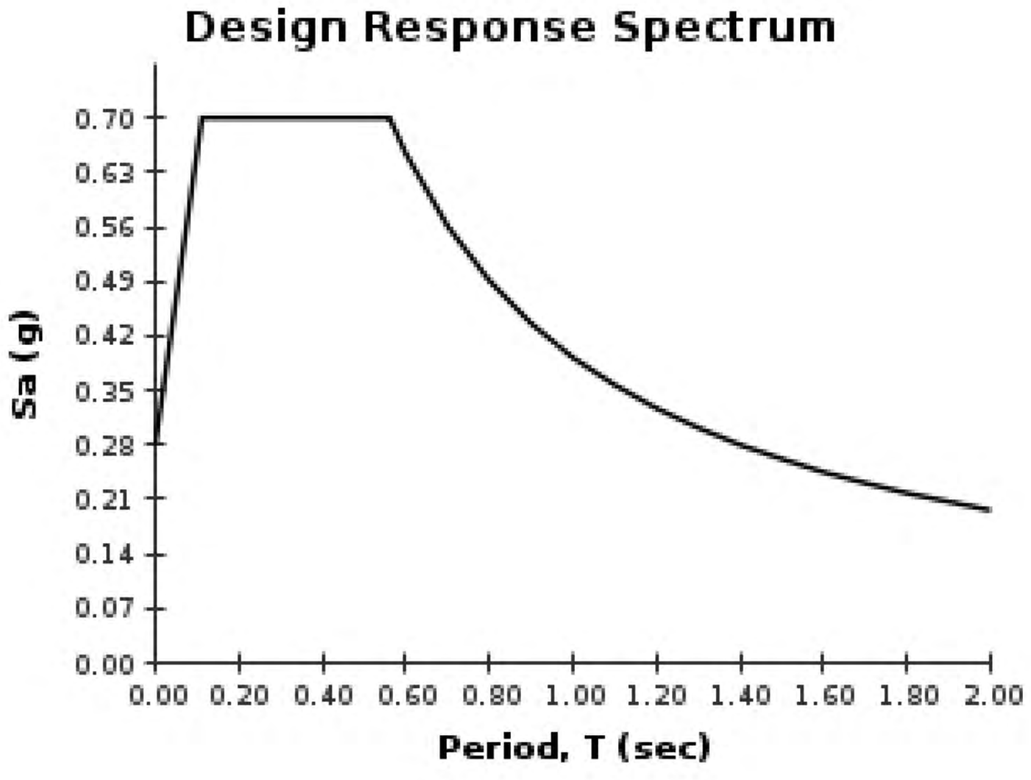


USGS–Provided Output

S_S =	0.931 g	S_{MS} =	1.050 g	S_{DS} =	0.700 g
S_1 =	0.344 g	S_{M1} =	0.589 g	S_{D1} =	0.392 g

For information on how the SS and S1 values above have been calculated from probabilistic (risk-targeted) and deterministic ground motions in the direction of maximum horizontal response, please return to the application and select the "2009 NEHRP" building code reference document.





For PGA_M, T_L, C_{RS}, and C_{R1} values, please view the detailed report.

USGS Design Maps Summary Report

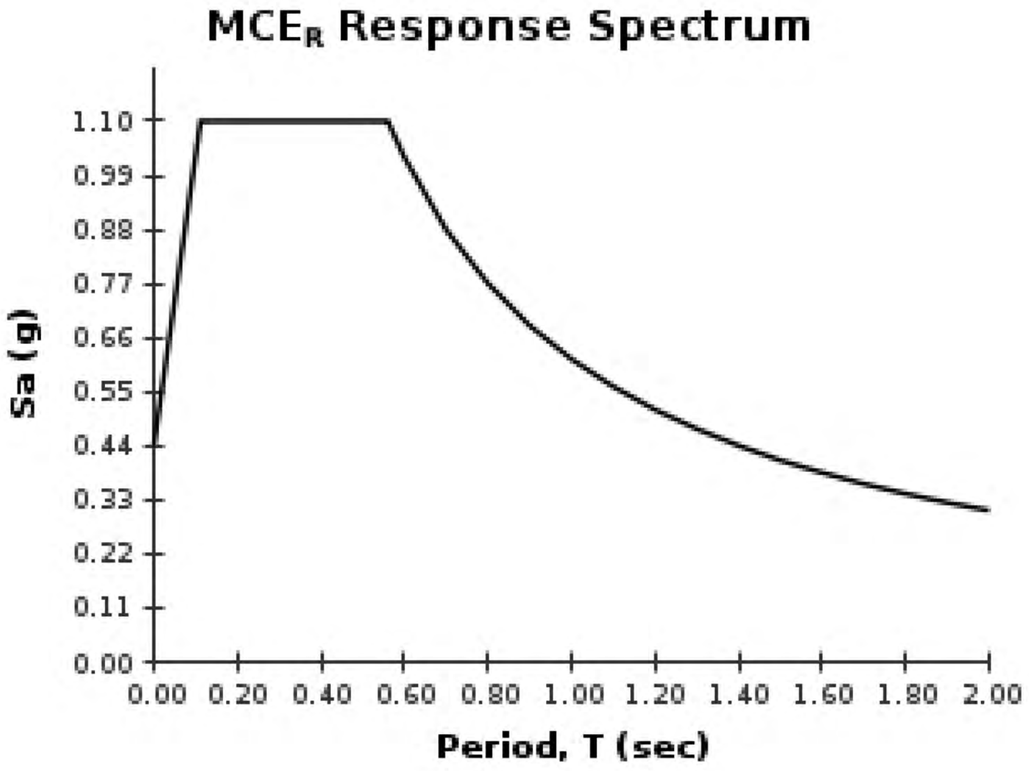
User–Specified Input

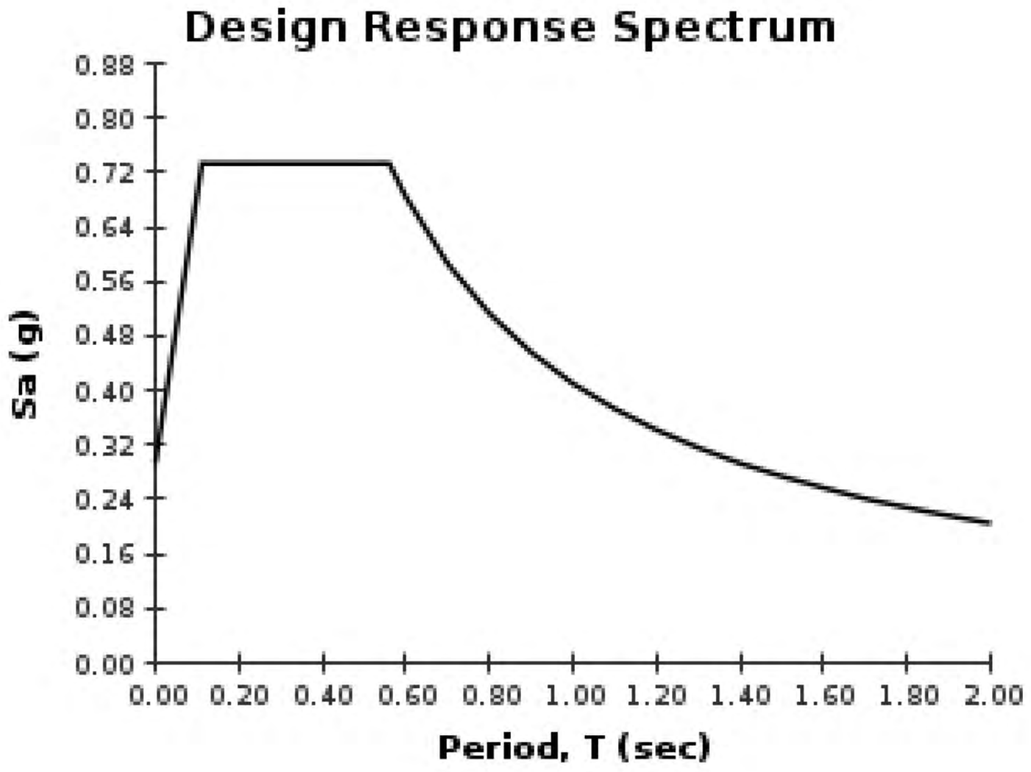
Report Title	North Central Site Thu May 5, 2016 01:31:37 UTC
Building Code Reference Document	ASCE 7-10 Standard (which utilizes USGS hazard data available in 2008)
Site Coordinates	34.81579°N, 120.61295°W
Site Soil Classification	Site Class D – "Stiff Soil"
Risk Category	I/II/III

USGS–Provided Output

S_S =	1.000 g	S_{MS} =	1.100 g	S_{DS} =	0.733 g
S_1 =	0.372 g	S_{M1} =	0.616 g	S_{D1} =	0.410 g

For information on how the SS and S1 values above have been calculated from probabilistic (risk-targeted) and deterministic ground motions in the direction of maximum horizontal response, please return to the application and select the "2009 NEHRP" building code reference document.





For PGA_M, T_L, C_{RS}, and C_{R1} values, please view the detailed report.

5. North Shore Station

USGS Design Maps Summary Report

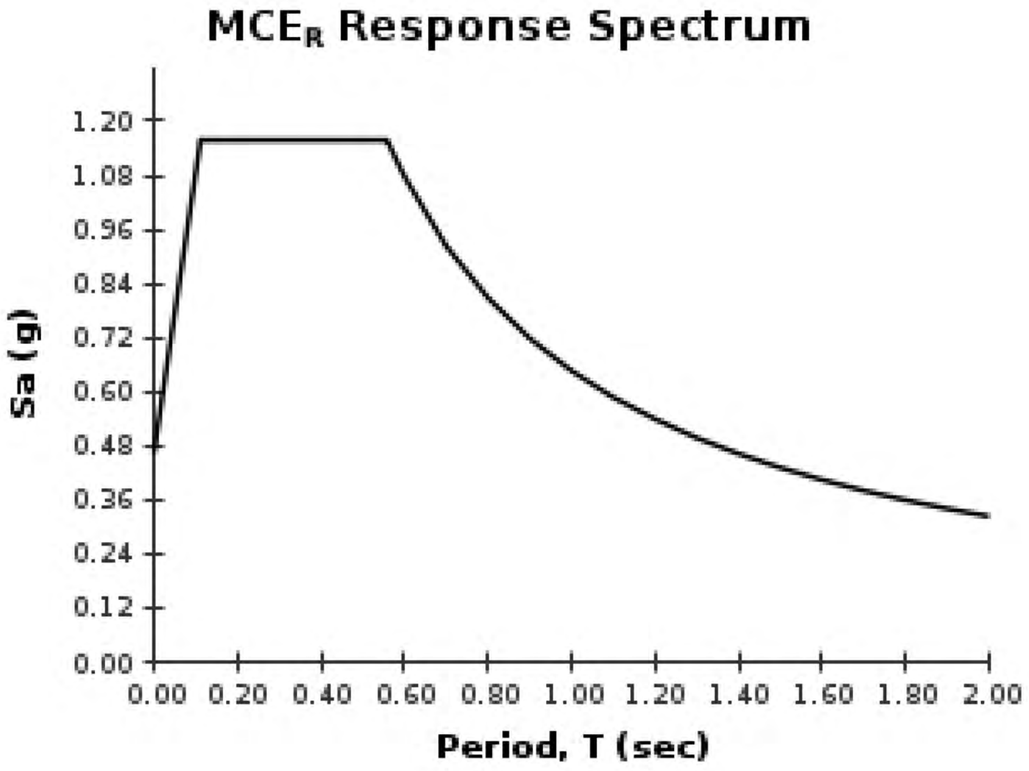
User–Specified Input

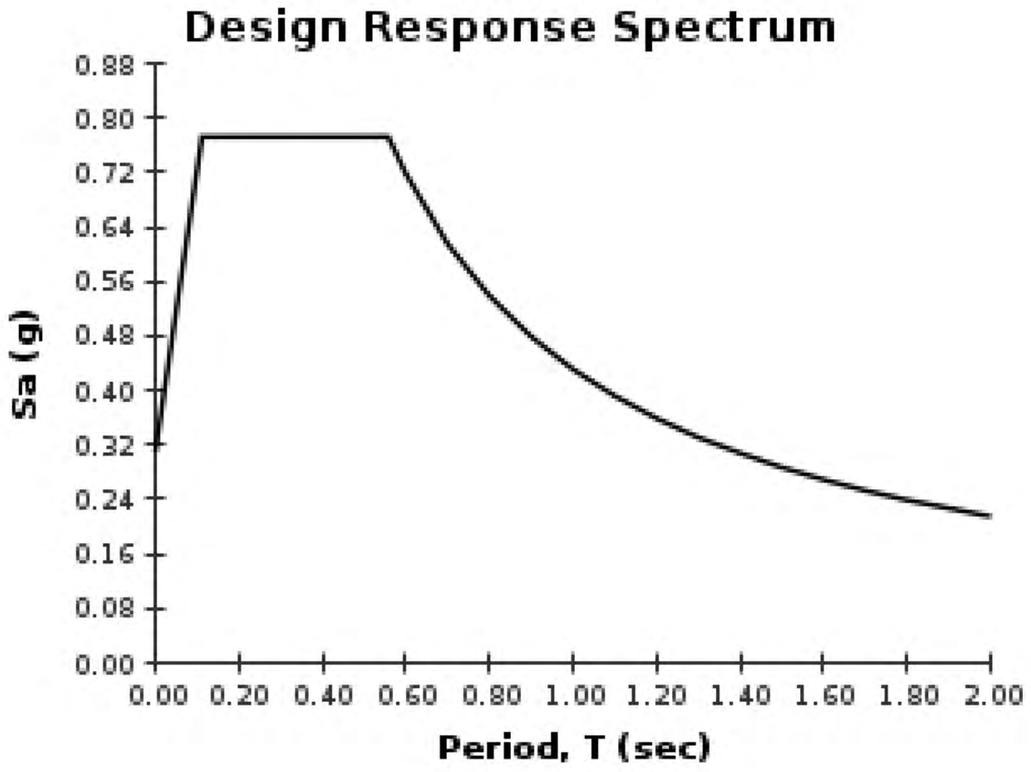
Report Title	North Site Thu May 5, 2016 01:28:10 UTC
Building Code Reference Document	ASCE 7-10 Standard (which utilizes USGS hazard data available in 2008)
Site Coordinates	34.88244°N, 120.63575°W
Site Soil Classification	Site Class D – "Stiff Soil"
Risk Category	I/II/III

USGS–Provided Output

S_S =	1.087 g	S_{MS} =	1.158 g	S_{DS} =	0.772 g
S_1 =	0.405 g	S_{M1} =	0.646 g	S_{D1} =	0.431 g

For information on how the SS and S1 values above have been calculated from probabilistic (risk-targeted) and deterministic ground motions in the direction of maximum horizontal response, please return to the application and select the "2009 NEHRP" building code reference document.





For PGA_M, T_L, C_{RS}, and C_{R1} values, please view the detailed report.

Attachment 11-8: Electrical Engineering and Interconnect Study

Omega Power Engineers provided electrical engineering support for both Sea-based Infrastructure and Shore-based Infrastructure as well as the grid integration interconnect study.

Overview:

The electrical design is modular in concept and uses readily available components from commercial and utility construction. The VAFB approved material list was also referenced for compliance to base regulations.

Basis of Design:

The basis of design is to interconnect the WECs, to shore, then to the grid, with proper isolation and instrumentation.

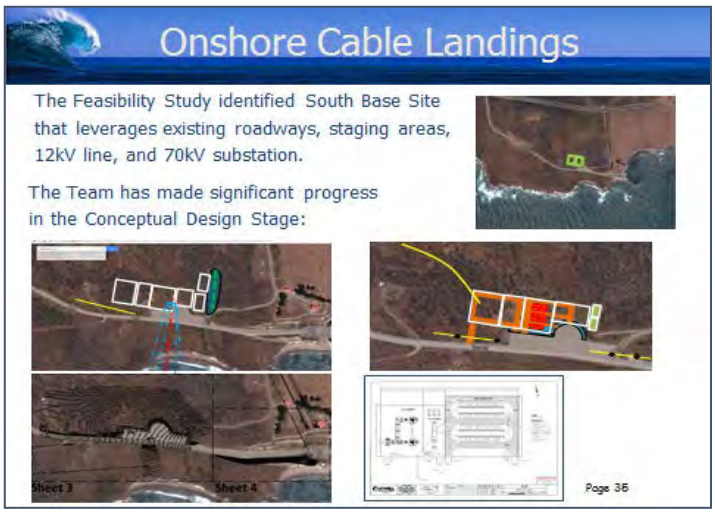


Figure 11-8-1: South Base Site (Source Leidos, Inc.)

The design is place-based and focused on the shore site location that was selected to the South Base Site near the VAFB dock.

The site provides proximity to the test berths and leverages the overall quality of the shore-side infrastructure.

The site is located outside of VAFB launch areas which come with significant operational restrictions/constraints.

The site was analyzed favorably in Extreme Events Study.

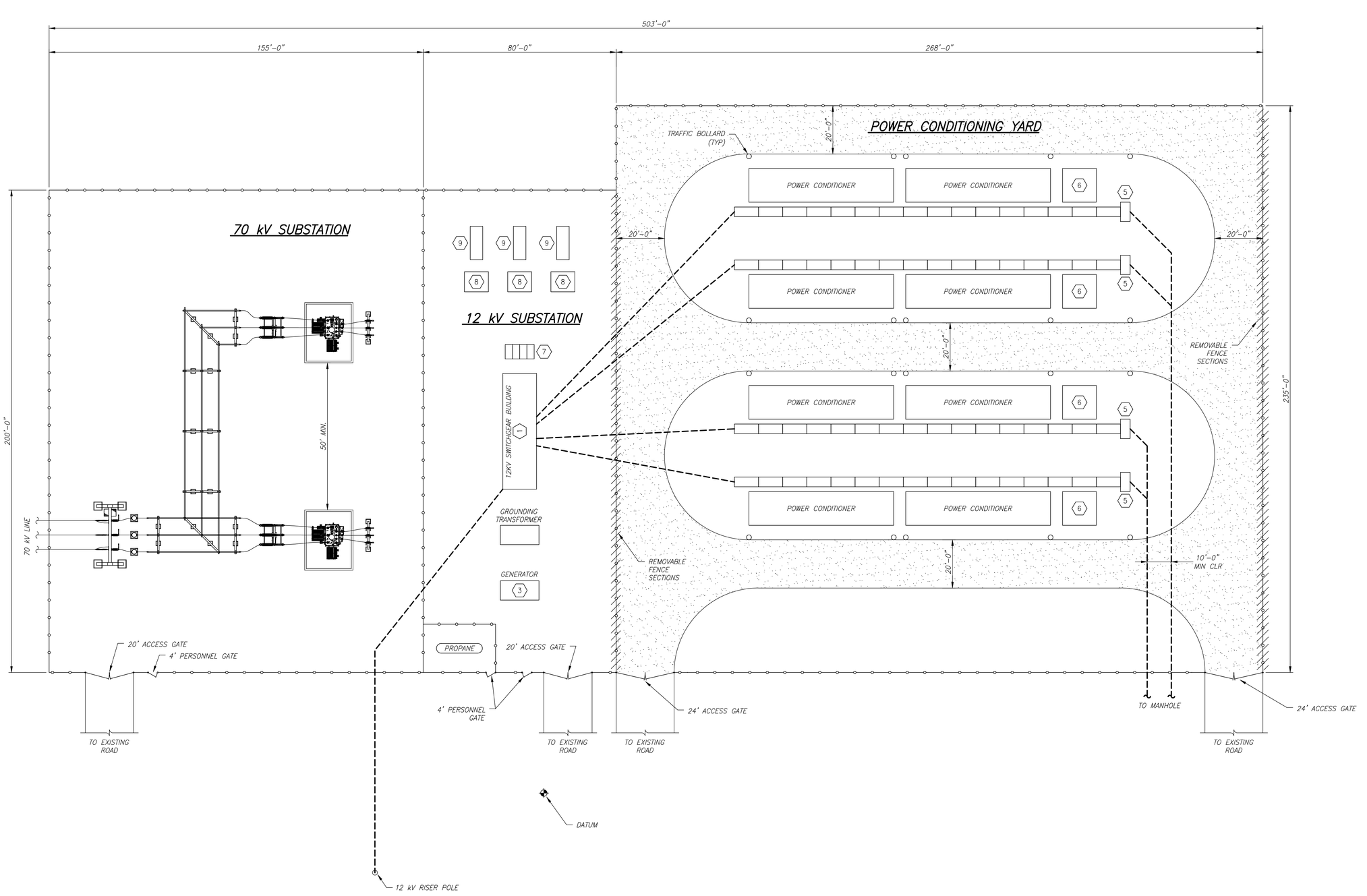
The useable open space for power conditioning equipment and a substation yard, existing electrical transmission infrastructure for interconnection access (12kV line with a 70kV substation for upgrade capacity), access roads and staging areas, and the VAFB dock infrastructure itself are all critical for logistics/operational and engineering/design considerations which makes the South shore site the most viable in conjunction with the South and Southeast ocean test sites.

Grid interconnection impact study summary

The Western Electric Coordinating Council (WECC) and the WECC database was released to Omega Power and our subcontractor, Atwell, LLC for the Transmission Impact Study. The net determination was that there is no material impact to the PG&E system as a result of installing the CalWave project.

Attachments:

- Attachment 11-8-1: CalWave Electrical Shore Facilities
- Attachment 11-8-2: CalWave Transmission Line Report Volume 1
- Attachment 11-8-3: CalWave System Impact Study Letter



LEGEND

NEW CONSTRUCTION

EQUIPMENT KEY:

1. SWITCHGEAR BUILDING 14'W x 48'L X 10'H
2. UNDERGROUND VAULT 6'W x 8'L x 8'D
3. DIESEL GENERATOR SET XXXKW 4' x 8'
4. CABLE TRENCH 3'W x 1'D
5. 25 kV METAL ENCLOSED GROUNDING SWITCH
6. TRANSFORMERS 14'W x 14'L X 14'H OUTSIDE DIMENSION INCLUDES OIL CONTAINMENT CURB (FUTURE)
7. 12.5 kV SWITCHES SW-LB-101, 102, 103, 104, SW-LB-C.
8. 3300 kVA TRANSFORMER T-LB-1, 2, 3, 4.
9. 3.3MW LOAD BANK LB-1, 2, 3.

CONCEPTUAL

NOT FOR CONSTRUCTION

PLOTTED: 06/23/16 10:22:01 AM FILENAME: F:\proj\16000578 - Cal Wave\3.0 Design\3.2 Drawings\16000578-0001.dwg USER: bwatson

ATWELL
866.850.4200 www.atwell-group.com
143 UNION BOULEVARD, SUITE 700
LAKEWOOD, CO 80228
303.462.1100

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ST: | REG: | EXP:

OMEGA POWER ENGINEERS, LLC
22221 EAST NOVA PLACE
AURORA, CO 80016
303.330.6920

REV	DESCRIPTION	ENG	DWN	CHK	DATE
A	CONCEPTUAL DESIGN	RC	DRL	CW	4/24/16

ENG: R. CONNETT
DWN: D. LANGSTON
CHK:
APP:
DATE:

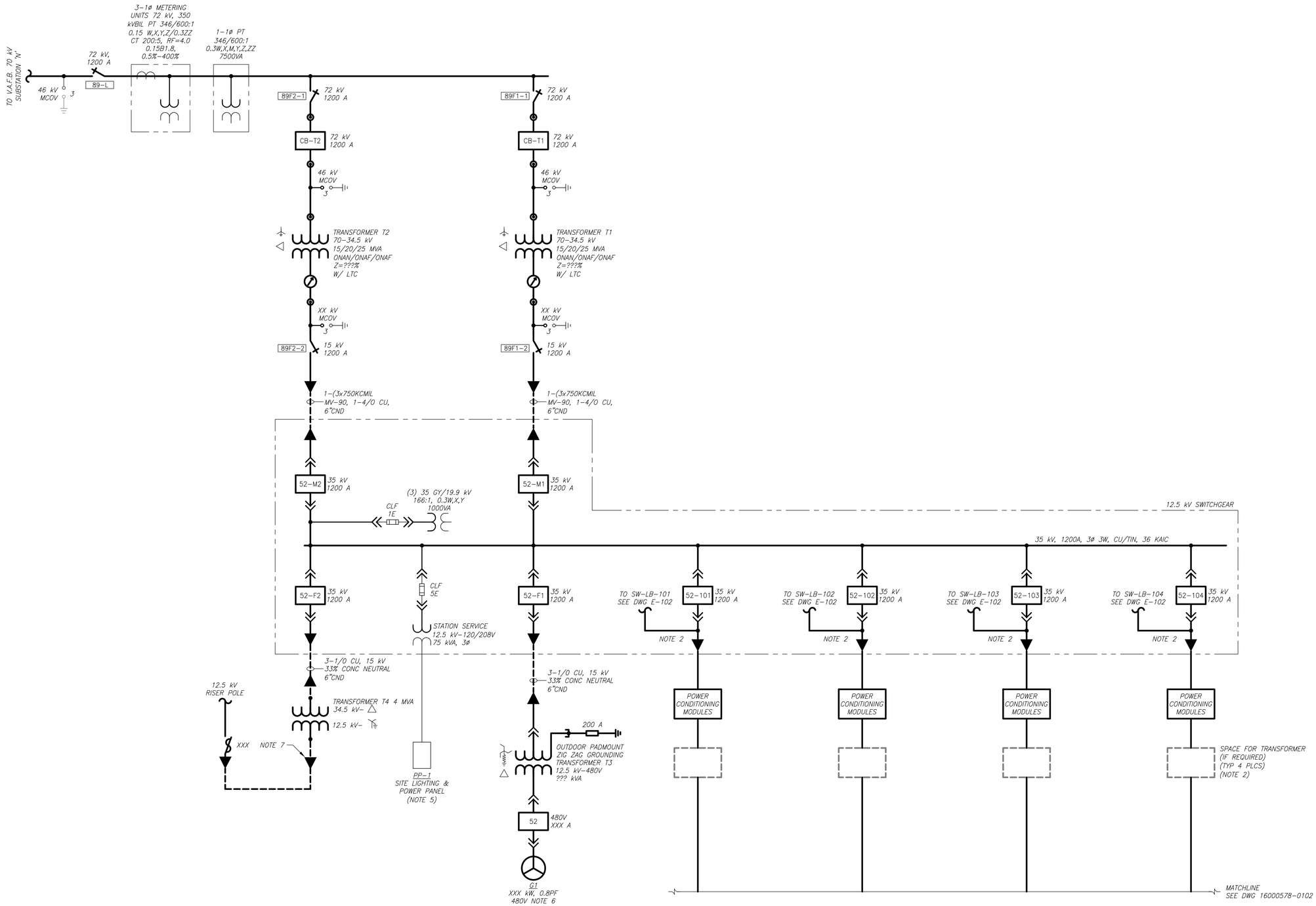
CAL POLY
CALWAVE

GENERAL ARRANGEMENT

SCALE 1"=20' (0, 20', 40', 60')

DRAWING 16000578-0001

REV A



LEGEND

- POWER TRANSFORMER
- CURRENT TRANSFORMER
- DRAW OUT CIRCUIT BREAKER
- FUSED DISCONNECT
- FUSE
- DRAW OUT
- CIRCUIT BREAKER
- VOLTAGE TRANSFORMER
- GROUP OPERATED AIR-BREAK SWITCH
- SURGE ARRESTER
- BUSHING
- NEUTRAL MAKEUP
- LTC

NOTES

1. OFFSHORE WAVE ENERGY CONVERTERS (WEC) RATED AT 10MW MAXIMUM @ 0.8PF.
2. SPACE IS ALLOWED FOR POSSIBLE FUTURE TRANSFORMERS FOR INPUT & OUTPUT OF SHORE POWER CONDITIONER, IF REQUIRED BY WEC SUPPLIER.
3. SHORE POWER CONDITIONING MODULES TO BE 35 kV IN/35 kV OUT, OR AS REQUIRED BY WEC SUPPLIER.
4. PROTECTION, CONTROL & INSTRUMENTATION NOT SHOWN FOR CLARITY.
5. STATION POWER SERVICES LOCAL HVAC, BATTERY CHARGER, LIGHTING, UPS (IF, REQUIRED) & SHORE POWER.
6. DG-1 TO PROVIDE EXCITATION POWER FOR WAVE ENERGY SYSTEM FOR WAVE ENERGY MODULES, IF REQUIRED, TO ALLOW POSSIBLE ISLANDED OPERATION OF V.A.F.B. POWER SYSTEM.
7. PT & CT's SHALL BE FITTED TO 12.5 kV CONNECTION TO SUPPORT APPROPRIATE RELAYING AS REQUIRED. RELAYING SHALL TRIP BREAKER 52-F2.

CONCEPTUAL

NOT FOR CONSTRUCTION

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OMEGA POWER ENGINEERS, LLC
22221 EAST NOVA PLACE
AURORA, CO 80016
303.330.6920

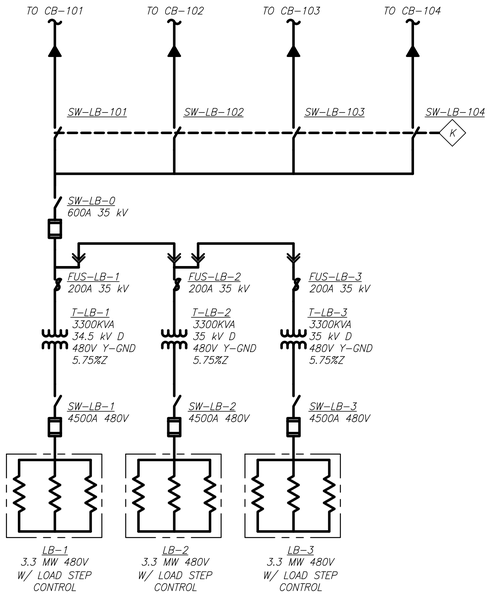
REV	DESCRIPTION	ENG	DWN	CHK	DATE
A	CONCEPTUAL DESIGN	RC	DRL	CW	4/24/16
B	RE-ISSUE CONCEPTUAL DESIGN	RC	DRL	CW	07/26/16

ENG: R. CONNETT
DWN: D. LANGSTON
CHK: R. CONNETT
APP:
DATE:

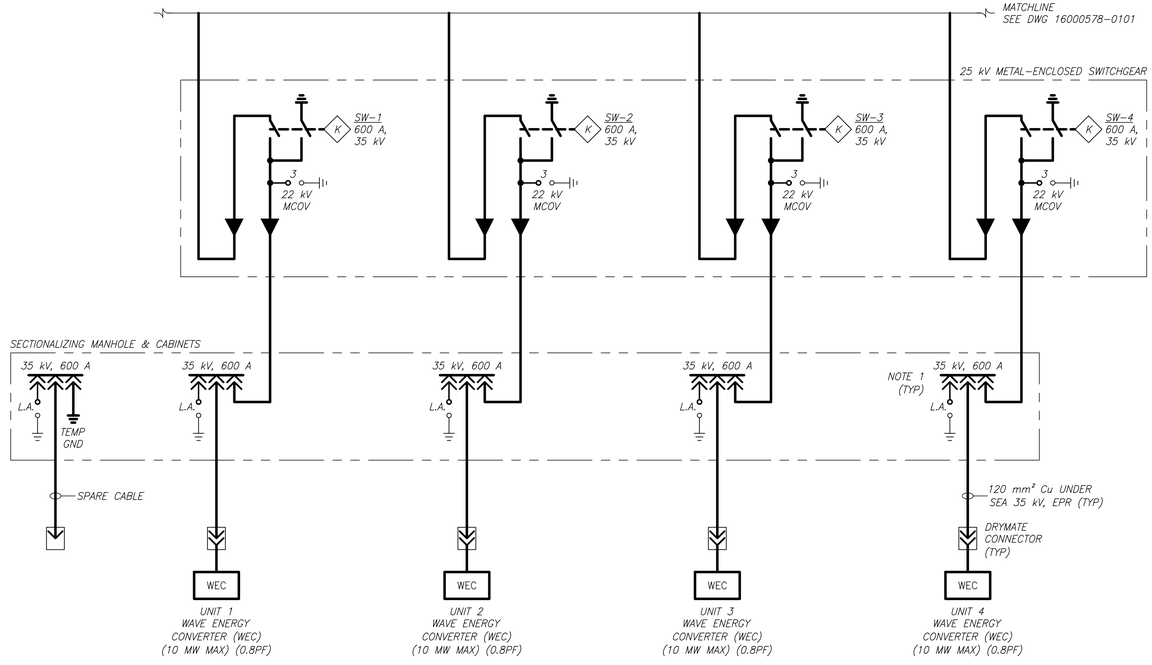
CAL POLY
CALWAVE

ONE LINE DIAGRAM

SCALE	DRAWING	REV
NONE	16000578-0101	B



PARTIAL 1-LINE LOAD BANK



PARTIAL 1-LINE SUBMARINE CABLE SECTIONALIZING

NOTES

1. 35 kV SECTIONALIZING STAND REQUIRED TO ACCOMMODATE 133% CABLE AND ELBOW.

CONCEPTUAL
NOT FOR CONSTRUCTION

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303.330.6920

REV	DESCRIPTION	ENG	DWN	CHK	DATE
A	CONCEPTUAL DESIGN	RC	DRL		
B	RE-ISSUE CONCEPTUAL DESIGN	RC	KKM	RC	07/26/16

ENG: R. CONNETT
DWN: D. LANGSTON
CHK: R. CONNETT
APP:
DATE:

CAL POLY
CALWAVE

ONE LINE DIAGRAM

SCALE	DRAWING	REV
NONE	16000578-0102	B

CalWave® Transmission Line Preliminary Design

Vandenberg Air Force Base, CA

September, 2016

Omega Power Engineers

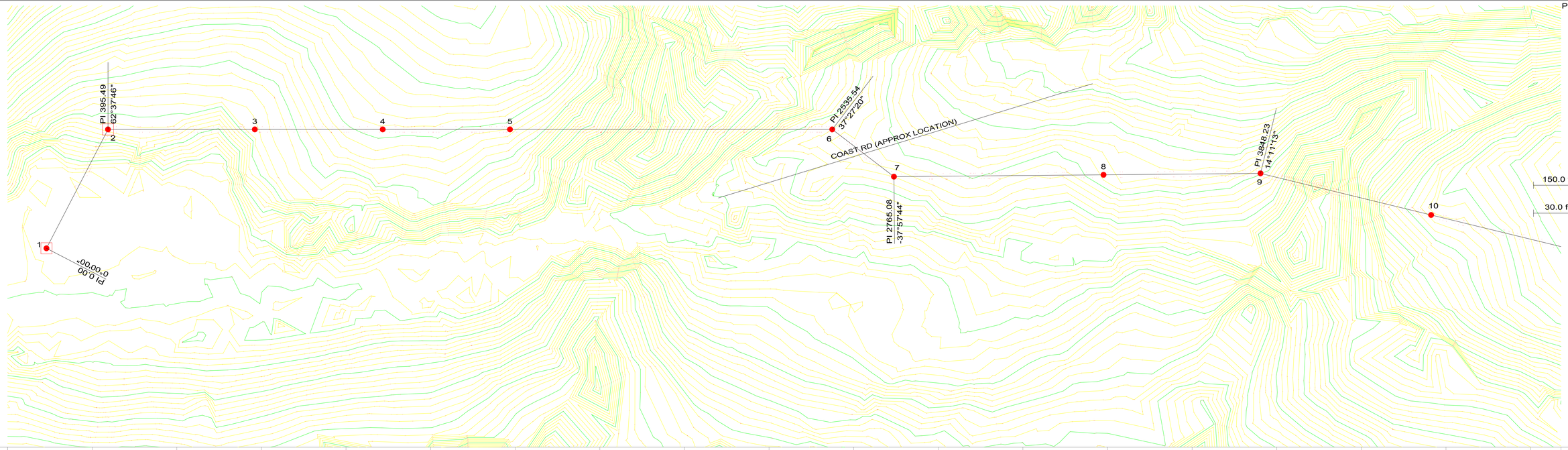
Randall M Connett, CA PE #E21698

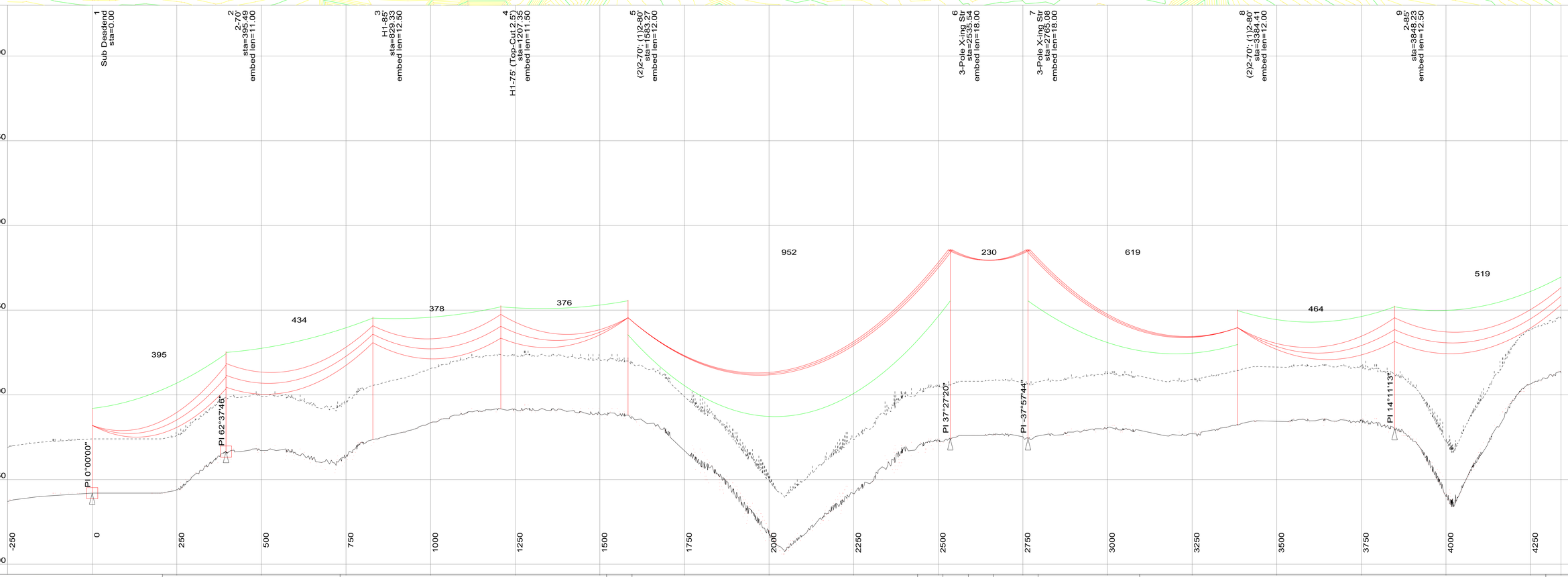
Sept 20, 2016

Subcontractor: Atwell California

Transmission Line Plan & Profile Drawings

PLS-CADD Drawing





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AURORA, CO 80016
303.320.8020

REV	DESCRIPTION	ENG	DWN	CHK	DATE
A	CONCEPTUAL DESIGN	GN	GN		09/15/16

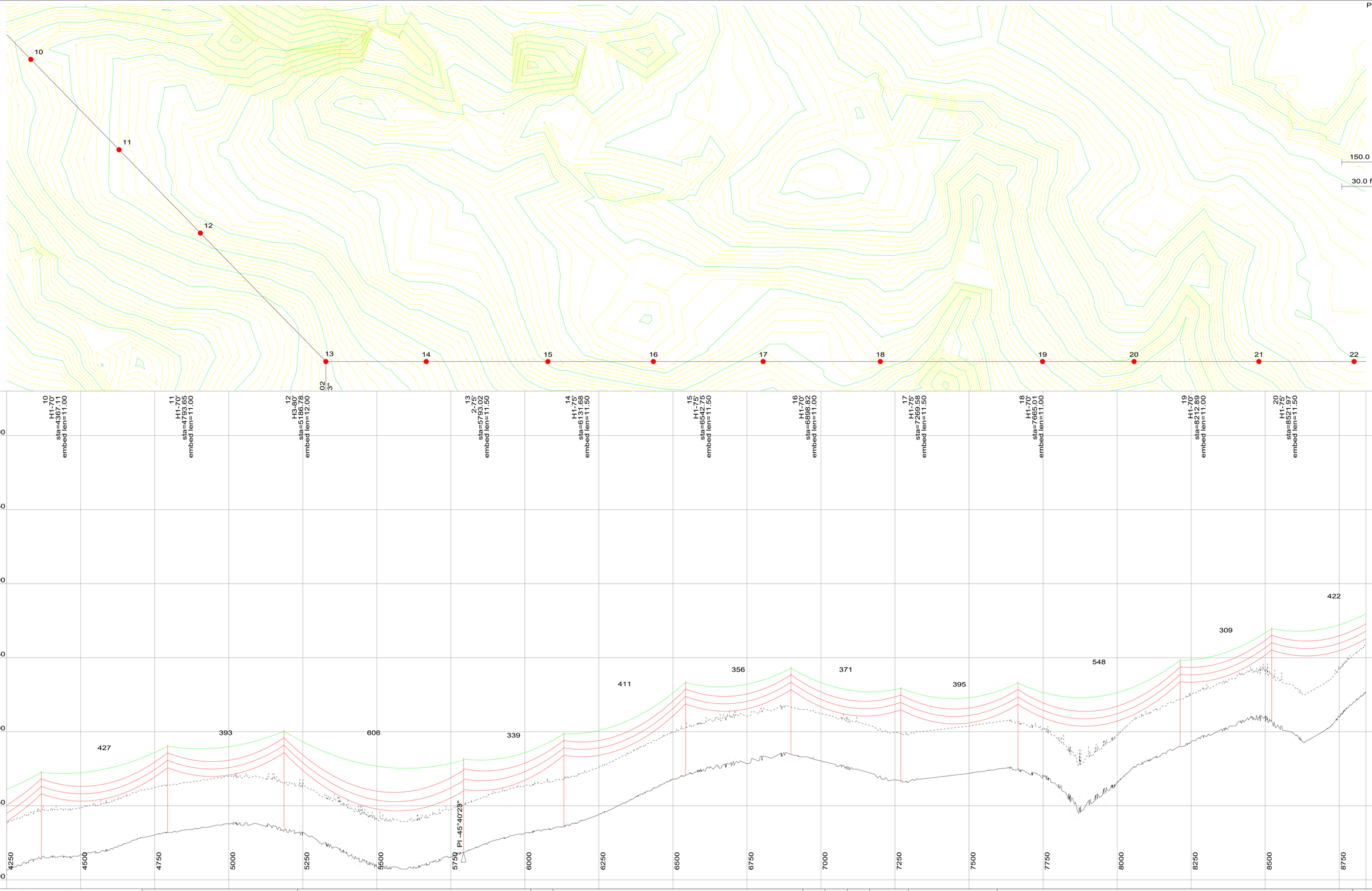
ENG: G. NARAYANAN
DWN: G. NARAYANAN
CHK:
APP:
DATE:

CAL POLY
CALWAVE

PLAN AND PROFILE
SHEET 1 OF 5

SCALE	DRAWING	REV
AS SHOWN	16000578-2101	A

PLS-CADD Drawing



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A	CONCEPTUAL DESIGN	GN	GN		09/15/16

ENG: G. NARAYANAN
DWN: G. NARAYANAN
CHK:
APP:
DATE:

CAL POLY
CALWAVE

PLAN AND PROFILE
SHEET 2 OF 5

SCALE	DRAWING	REV
AS SHOWN	16000578-2102	A

PLS-CADD Drawing

North

150.0 ft. Horiz. Scale

30.0 ft. Vert. Scale

COAST RD (APPROX LOCATION)

PI 13127.86
40°14'48"

PI 12675.06
-68°27'23"

21 H1-70' sta=8943.55 embed len=11.00
22 H1-70' sta=9265.74 embed len=11.00
23 H1-75' sta=9673.48 embed len=11.50
24 H1-75' sta=10037.40 embed len=11.50
25 H1-70' sta=10376.67 ht adjust=-5.00 embed len=11.00
26 H1-70' sta=10705.34 ht adjust=-2.00 embed len=11.00
27 H1-75' sta=10899.81 embed len=11.50
28 H2-95' sta=11459.00 embed len=13.50
29 (2)2-70'; (1)2-80' sta=12045.08 embed len=12.00
30 3-Pole X-ing Str sta=12679.06 embed len=18.00
31 3-Pole X-ing Str sta=13127.86 embed len=18.00

322 408 364 339 329 194 558 587 630 453

PI 40°14'48"

PI -68°27'23"

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A	CONCEPTUAL DESIGN	GN	GN		09/15/16

ENG: G. NARAYANAN
DWN: G. NARAYANAN
CHK:
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DATE:

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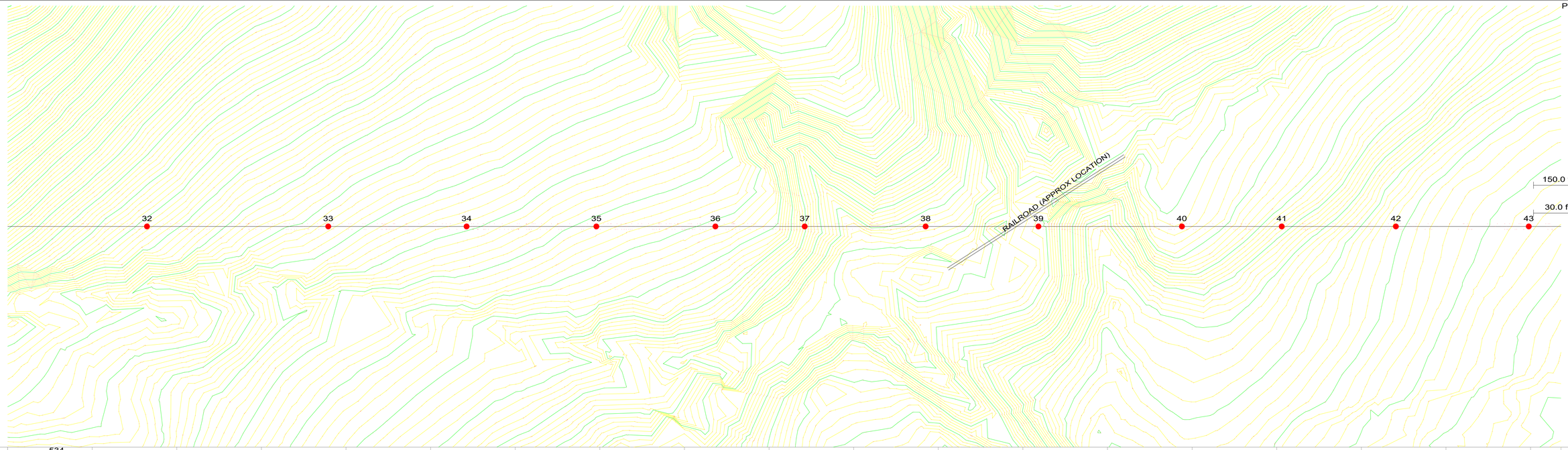
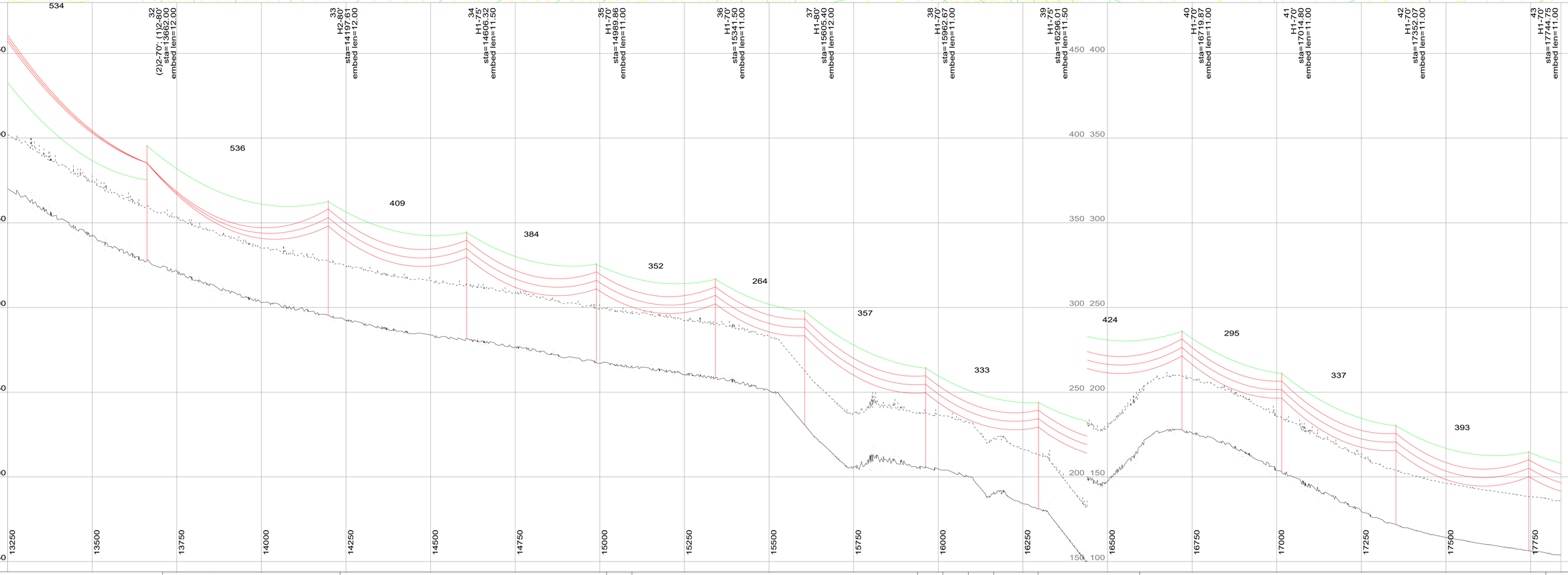
PLAN AND PROFILE
SHEET 3 OF 5

SCALE	DRAWING	REV
AS SHOWN	16000578-2103	A

PLS-CADD Drawing





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303.320.8920

REV	DESCRIPTION	ENG	DWN	CHK	DATE
A	CONCEPTUAL DESIGN	GN	GN		09/15/16

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DWN: G. NARAYANAN
CHK:
APP:
DATE:

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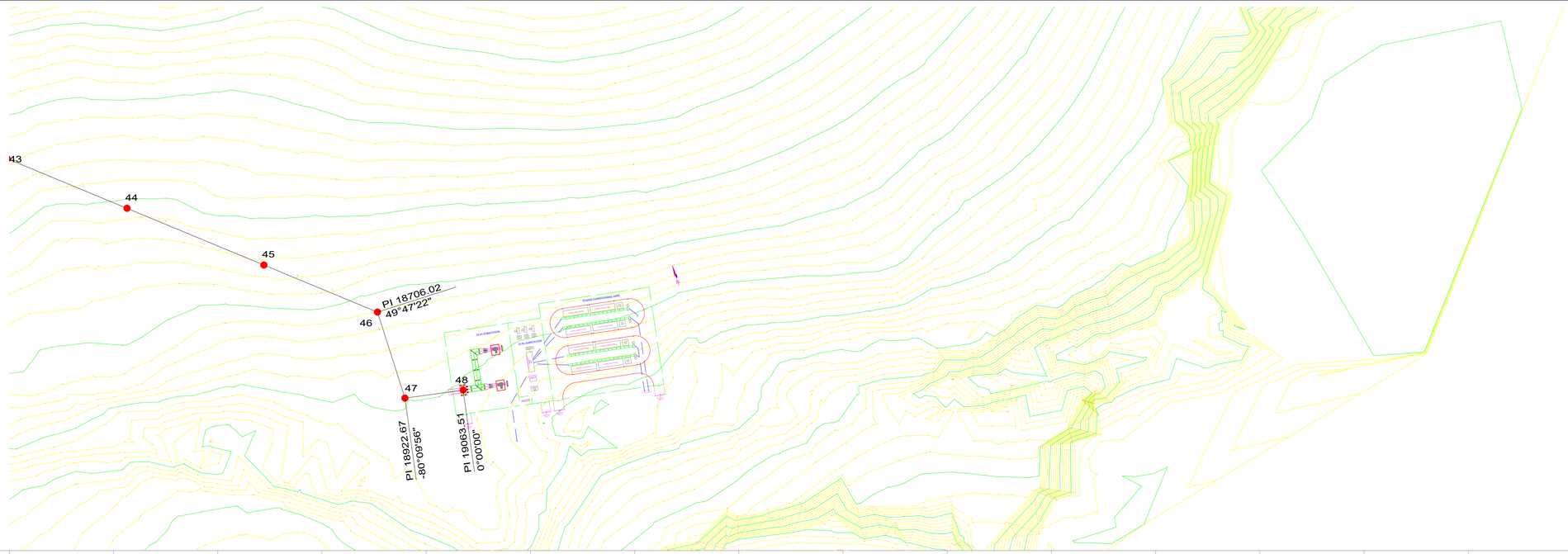
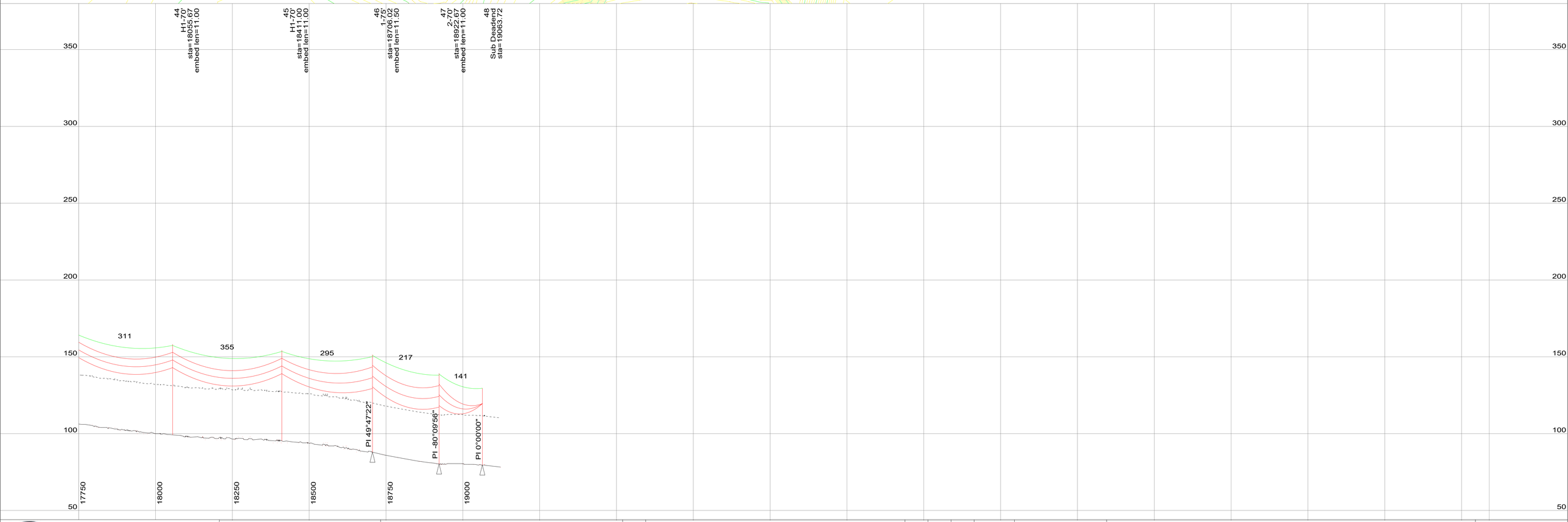
PLAN AND PROFILE
SHEET 4 OF 5

SCALE	DRAWING	REV
AS SHOWN	16000578-2104	A

PLS-CADD Drawing





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REV	DESCRIPTION	ENG	DWN	CHK	DATE
A	CONCEPTUAL DESIGN	GN	GN		09/15/16

ENG: G. NARAYANAN
DWN: G. NARAYANAN
CHK:
APP:
DATE:

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CALWAVE

PLAN AND PROFILE
SHEET 5 OF 5

SCALE	DRAWING	REV
AS SHOWN	16000578-2105	A

Transmission Line Route – Google Earth

Transmission Line Design Criteria

7/28/2016

Transmission Line Design Summary

Project Number: 16000578
Client: California Polytechnic University
Project Name: Cal Wave

Project Location: Near Lompoc, CA
Project Elevation: 500ft
Line Length: ≈4 miles

Environmental Considerations:

GO 95 Loading District:	**LIGHT**	
GO 95 LIGHT Temp.:	25	°F
GO 95 Wind Pressure	8	psf
Concurrent Wind&Ice Temp:	15	°F
Concurrent Wind&Ice Ice Thickness:	0	in
Concurrent Wind&Ice Wind Pressure:	30	mph
Extreme Wind Temperature:	60	°F
Extreme Wind Speed:	85	mph
Extreme Wind Ice thickness:	0	in
Maximum Operating Temp:	212	°F
Everyday Temp:	60	°F
Seismic Zone	4	
Grade of Construction	B	

Conductor/Wire Data

Wire Type	Voltage kV	Size kcmil, in	Code Name/Type	Stranding	Material	Diameter in	Weight lbs/ft	Rated Strength lbs	No./phase
Phase	70	795	Arbutus	37	AAC	1.026	0.7453	13,900	1
OPGW	0	0.472"	AFL - CC-27/27/472	48 fiber	CentraCore	0.472	0.244	10,523	1

Structure Data:

Structure	Description	Type	Material	Height Range	Support
Tangent	Tangent horizontal post	TP-69G	Concrete		
Dead-end	Monopole Deadend	-	Concrete		
In-line Deadend	3-pole	-	Concrete		
X-ing Deadend	3-pole	-	Lam-Wood		

Insulator Data:

Voltage	Type	Length	Weight	Strength	Flashover	Manuf.
115 kV	Polymer	49.2"	57 lbs	7500 lbs	385 Dry-kV	Hubbell

Notes:

1. AAC (All Aluminum conductor) used for better corrosion performance due to salt clouds and proximity to the coast line
2. Concrete and laminated wood poles used for better corrosion performance than steel poles
3. Insulators used will provide extended creep path and leakage distances than a typical 70kV insulator

Project No.: 16000578
Client: Cal Poly
Project: Cal Wave
Engineer: G. NARAYANAN
Checked:

Voltage: 70 **kV**
Elevation: 500 **Ft.**

Clearances:

VERTICAL CLEARANCES	GO 95 Clear(ft)	Survey Tolerance(ft)	Construction Tolerance(ft)	Calculated GO 95 Clear (ft)	Line Design Clearance(ft)
Railroad Tracks (23 ft UPRR Ref Height) T1-1	34.0	2		36.00	36
Tow Rd/Coast Rd/Luner Rd Main run					100
Other Roads, Driveways, Cultivated lands T1-3	30.0	2		32.00	32
Pedestrian Only Access T1-5	25.0	2		27.00	27
(Radial)Lighting,Traffic or other Line Support T1-10	10.0	2		12.00	12
(Vertical) Buildings Non-Pedestrian Access, Bridges T1-6a	8.0	2		10.00	10
(Vertical) Buildings Pedestrian Accessible T1-6	12.0	2		14.00	14
(Vertical) Signs,Chimneys,Billboards,Tanks accessable T2A-1	12.0	2		14.00	14
HORIZONTAL and Radial CLEARANCES	**GO 95 Clear(ft)**	**Survey Tolerance(ft)**	**Construction Tolerance(ft)**	**Calculated GO 95 Clear (ft)**	**Line Design Clearance(ft)**
(Radial) Guys supported on other poles T2-18	3.0		0.5	3.50	3.5
(Radial) Guys and span wires on same pole T2-19	1.5		0.5	2.00	2
(Horizontal)Buildings,Walls,Projections, Windows,etc T1-7	6.0		0.5	6.50	6.5
(Vertical) Conductors over 75 kV to 230 kV Conductors same structure T2-7	8.0		0.5	8.50	8.5
OTHER CLEARANCES	**GO 95 Clear(ft)**	**Survey Tolerance(ft)**	**Construction Tolerance(ft)**	**Calculated GO 95 Clear (ft)**	**Line Design Clearance(ft)**
(Radial) Clearance to cross arm, pole or structure where it is attached T2-17	2.0			2.0	2
(Vertical and Horizontal) Phases of Same Circuit in Span T2-20	4.0		0.5	4.5	4.5
(Radial) Clearance of conductors to tree branches or foliage T1-13	1.0000	2	1	4.0	4

Calculated Clearances Include Tolerances for Survey, Construction and Altitude Correction

16000578
Cal Poly

Structure Load Cases

Tangent and Deadend Structures

Load case	Description	Temp	Wind	Radial Ice	OLF		
		(°F)	Speed (psf)	Thick (in)	Vertical	Wire	Wind
1	G.O. 95 LIGHT Loading	25	8	0	1.1	1.1	1.1
2	CONCURRENT WIND & ICE	15	2.31	0	1.1	1.1	1.1
3	CUSTOMER HIGH WIND	60	18.5	0	1.1	1.1	1.1
4	EVERYDAY	60	0	0	1	1	1
5	STRINGING (Deadend Only)	32	2	0	1.1	1.1	1.1
6	G.O. 95 LIGHT DE (Deadend Only)	25	8	0	1.1	1.1	1.1

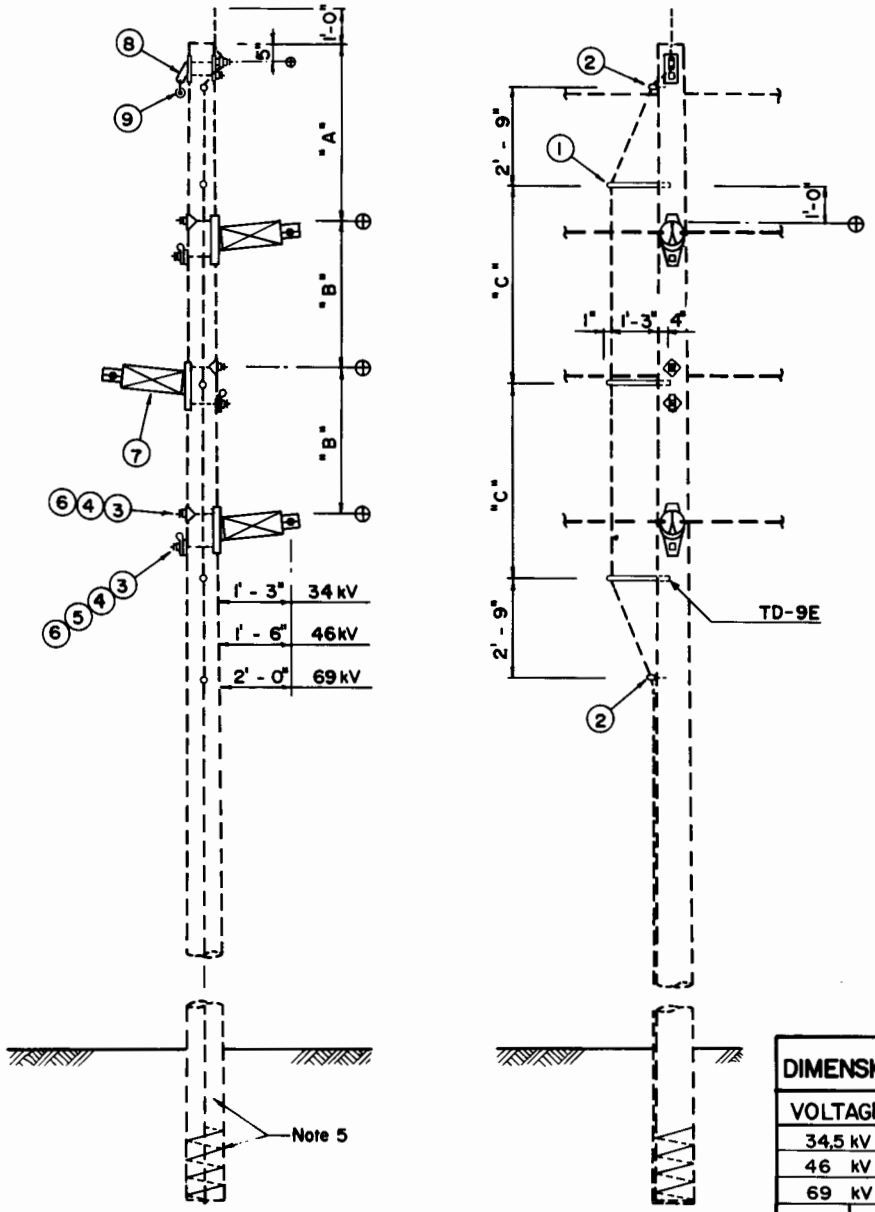
	Hawk ACSR		OPGW	
Tension Limits	**Breaking Strength (%)**	**Temp. (°F)**	**Breaking Strength (%)**	**Temp. (°F)**
G.O. 95 LIGHT (INITIAL)	50	25	50	25
CONCURRENT WIND & ICE (INITIAL)	50	15	50	15
EXTREME WIND (INITIAL)	50	60	50	60
EVERYDAY (FINAL)	17	60	17	60

Representative Transmission Structure Details (Partial)

(Structures to be similar to Rural Utilities Service Construction Details

for 69 kV Construction, modified for marine environment, per VAFB materials list)

Note: Actual poles to be used anticipated as being spun concrete, with road crossings requiring laminated wood poles due to height; structures shown require modification for concrete poles)



LIST OF MATERIALS

DRG. REF.	QTY.	DESCRIPTION	ITEM	DET.	CODE No.
1	3	Rod, Fiberglass, 3/4" x 1'-8"			
2	2	Wireholder, w/#22 wood screw	ar		
3	6	3/4" Bolt, Machine, by req'd length	c		
4	6	Washer, Curved, 4" sq.x 1/4", 13/16" hole	d		
5	3	Washer, Spring, 13/16" hole	aw		
6	6	3/4" Locknut, MF Type	ek		
7	3	INSULATOR, HORIZONTAL POST, WITH CLAMP	-	TM-3	
8	1	OHGW SUPPORT ASSEMBLY	-	TM-6	
9	1	OHGW ASSEMBLY, TANGENT	-	TM-4	

NOTES:

1. Metal shims should be used to adjust post insulator when brackets are located on uneven pole surfaces.
2. Strength limitations of horizontal post:
   a. Maximum cantilever load 2,800 lbs.
   b. Maximum tensile and compression 5,000 lbs.
   (Loads a and b are simultaneous)
3. For strength limitations of overhead ground wire support assembly, see TM-6.
4. Drawing TE-1 gives guidance to subassembly alternatives.
5. The following materials are to be specified on the plan and profile drawings and staking sheets: POLE, POLE GROUNDING ASSEMBLY, AND ANY ADDITIONAL GROUNDING OR FOUNDATION UNITS.

DIMENSIONS A, B, AND C			
VOLTAGE	A	B	C
34.5 kV	5' - 0"	4' - 0"	5' - 5"
46 kV	5' - 6"	4' - 6"	5' - 11"
69 kV	6' - 0"	5' - 0"	6' - 6"

NO.	REVISION	DATE

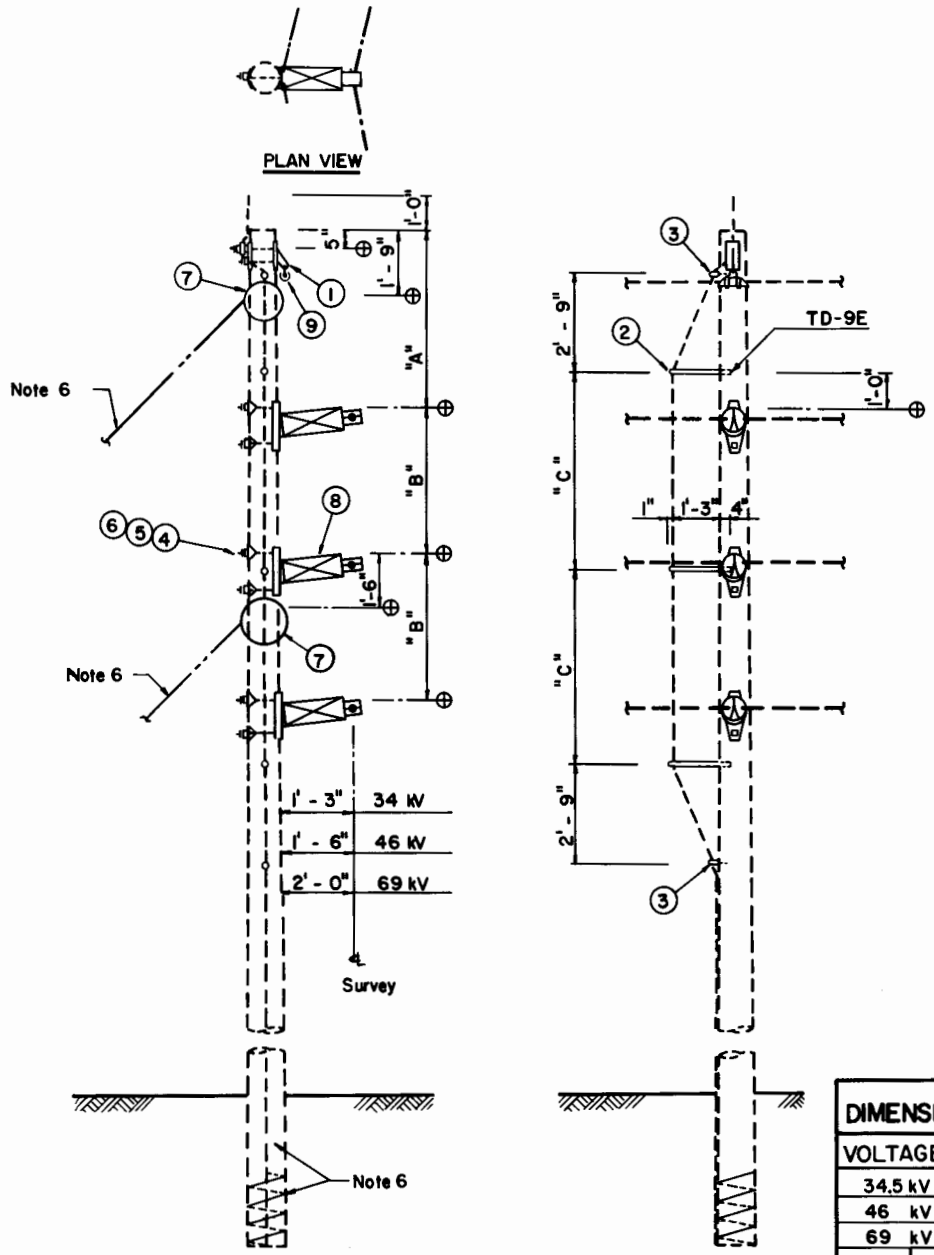
Reissued 03/98

TRANSMISSION LINE STRUCTURE

TANGENT HORIZONTAL LINE POST
(69 kV MAXIMUM)

Aug., 1986

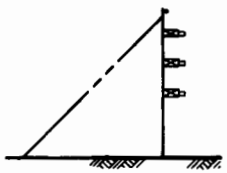
TP-34G,46G,69G



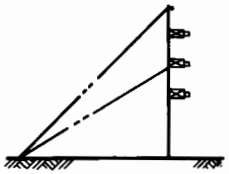
DRG. REF.	TP-34G, TP-46G, TP-69G B1	B2	LIST OF MATERIALS DESCRIPTION	ITEM	DET.	CODE No.
1	1	1	OHGW Support Assembly, double bolt	-	TM-6B	
2	3	3	Rod, Fiberglass, 3/4" x 1'-8"			
3	2	2	Wireholder, w/#22 wood screw	ar		
4	6	6	3/4" Bolt, Machine, by req'd length	c		
5	6	6	Washer, Curved, 4" sq. x 1/4", 13/16" hole	d		
6	6	6	3/4" Locknut, MF Type	ek		
7	1	2	GUY ATTACHMENT, _____ DUTY	-	TG-___C	
8	3	3	INSULATOR, HORIZONTAL POST WITH CLAMP	-	TM-3___	
9	1	1	OHGW ASSEMBLY, TANGENT	-	TM-4___	

NOTES:

1. Metal shims should be used to adjust post insulator when brackets are located on uneven pole surfaces.
2. This structure is to be used for line angles up to 15 degrees.
3. Strength limitations of horizontal post:
   a. Maximum cantilever load 2,800 lbs.
   b. Maximum tensile load 5,000 lbs.
   (Loads a plus b are simultaneous)
4. Strength limitations of overhead ground wire support assembly, see TM-6B.
5. See drawing TE-1 for guidance to subassembly alternatives.
6. The following materials are to be specified on the plan and profile drawings and staking sheets: POLE, POLE GROUNDING ASSEMBLY, GUYING ASSEMBLIES, ANCHORS, AND ANY ADDITIONAL GROUNDING OR FOUNDATION UNITS.



TYPE B1



TYPE B2

DIMENSIONS A, B, & C			
VOLTAGE	A	B	C
34.5 kV	6'-0"	5'-0"	6'-5"
46 kV	6'-6"	5'-6"	6'-11"
69 kV	7'-0"	6'-0"	7'-6"

No.	REVISION	DATE

Reissued 03/98

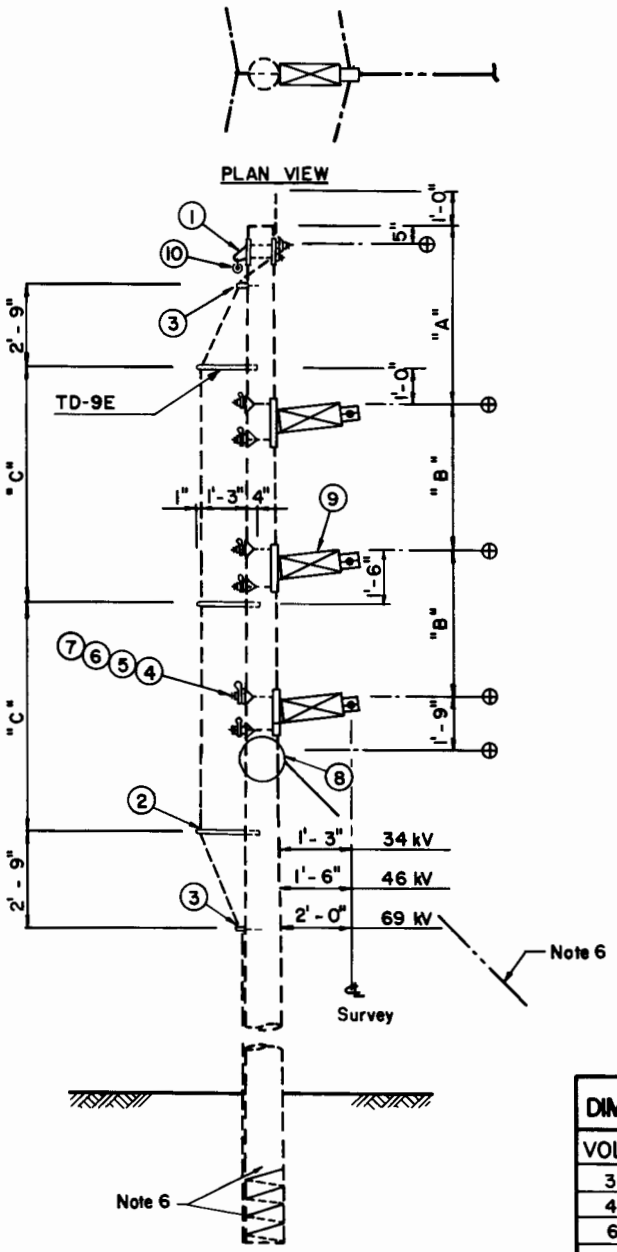
TRANSMISSION LINE STRUCTURE

SMALL ANGLE HORIZONTAL LINE POST

(69 kV MAXIMUM)

Aug., 1986

TP-34GB, 46GB, 69GB



LIST OF MATERIALS

DRG. REF.	QTY.	DESCRIPTION	ITEM	DET.	CODE No.
1	1	OHGW Support Assembly, double bolt	-	TM-6B	
2	3	Rod, Fiberglass, 3/4" x 1'-8"			
3	2	Wireholder, w/#22 wood screw	ar		
4	6	3/4" Bolt, Machine by req'd length	c		
5	6	Washer, Curved, 4"sq.x 1/4", 13/16" hole	d		
6	6	Washer, Spring, 13/16" hole	aw		
7	6	3/4" Locknut, MF Type	ek		
8	1	GUY ATTACHMENT, _____ DUTY	-	TG-___C	
9	3	INSULATOR, HORIZONTAL POST, WITH CLAMP	-	TM-3___	
10	1	OHGW ASSEMBLY, TANGENT	-	TM-4___	

NOTES:

1. Metal shims should be used to adjust post insulator when brackets are located on uneven pole surfaces.
2. This structure is to be used for line angles up to 15 degrees.
3. Strength limitations of horizontal post:

   a. Maximum cantilever load 2,800 lbs.
   b. Maximum compressive load 5,000 lbs.
   (Loads a plus b are simultaneous)

   (Engineer shall evaluate pole strength at the guy attachment and pole deflection at the top)
4. Strength limitations of overhead ground wire support assembly, see TM-6B.
5. See drawing TE-1 for guidance to subassembly alternatives.
6. The following materials are to be specified on the plan and profile drawings and staking sheets: POLE, POLE GROUNDING ASSEMBLY, GUYING ASSEMBLY, ANCHOR, AND ANY ADDITIONAL GROUNDING OR FOUNDATION UNITS.

DIMENSIONS A, B, & C			
VOLTAGE	A	B	C
34.5 kV	6'-0"	5'-0"	7'-6"
46 kV	6'-6"	5'-6"	8'-0"
69 kV	7'-0"	6'-0"	8'-6"

NO.	REVISION	DATE

Reissued 03/98

TRANSMISSION LINE STRUCTURE

SMALL ANGLE HORIZONTAL LINE POST

(69 kV MAXIMUM)

Aug., 1986

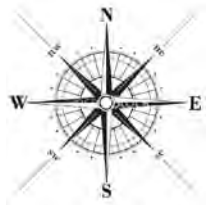
TP-34GC,46GC,69GC

Structure List

Structure Number	Str Type
1	Substation Deadend
2	2-70'
3	H1-85'
4	H1-75'
5	3-pole {(2)2-70'; (1)2-80'}
6	3-Pole X-ing Str - Laminated Wood 130'
7	3-Pole X-ing Str - Laminated Wood 130'
8	3-pole {(2)2-70'; (1)2-80'}
9	2-85'
10	H1-70'
11	H1-70'
12	H3-80'
13	2-75'
14	H1-75'
15	H1-75'
16	H1-70'
17	H1-75'
18	H1-70'
19	H1-70'
20	H1-75'
21	H1-70'
22	H1-70'
23	H1-75'
24	H1-75'
25	H1-70'
26	H1-70'
27	H1-75'
28	H2-95'
29	3-pole {(2)2-70'; (1)2-80'}
30	3-Pole X-ing Str - Laminated Wood 130'
31	3-Pole X-ing Str - Laminated Wood 130'
32	3-pole {(2)2-70'; (1)2-80'}
33	H2-80'
34	H1-75'
35	H1-70'
36	H1-70'
37	H1-80'
38	H1-70'
39	H1-75'
40	H1-70'
41	H1-70'
42	H1-70'
43	H1-70'
44	H1-70'
45	H1-70'
46	1-75'
47	2-70'
48	Substation Deadend

Attachment 11-9: Cable Logistics Lessons Learned

Center Marine provided lessons learned for submarine power cable logistics and installation.



CENTER MARINE SERVICES, INC.

January 16, 2017

TO: Doug Davy, Program Manager CH2M

FROM: Cliff Center, Principal, Center Marine Services

RE: Cable Installation Lessons Learned Report
California Wave Energy Test Center (CalWave^{sm}) Phase II

With a decade or more of submarine cables installed worldwide, especially in the wind farm market, there are some very good "lessons learned" papers published. Center Marine contacted sales people, cable masters and deck superintendents, researched company files for lessons learned, and reviewed published lessons learned on the web, consolidated this information, and reflected on the lessons learned from personal experience. A list of the documents reviewed is included below in the References section.

The Scope of this study includes the following:

- Consider lessons learned from cable installations on the Pacific, Atlantic, and Gulf coasts
- Evaluate lessons learned from recent cable installations near the Los Angeles/Long Beach Basin
- Evaluate lessons learned in dynamic umbilicals and array interconnections
- Leverage lessons learned in cable specification, procurement, logistics and installation to provide recommendations
- Lessons learned in deployment of subsea cables and electrical interconnections

Topics

- Cable selection
- Cable procurement
- Factory acceptance
- Cable transport
- Cable route survey
- Cable route clearing
- Cable installation vessel selection
- Cable installation

Cable selection, factory acceptance, cable transport

- Competition is cost effective if there is a clearly defined specification for an off-the-shelf product.
- If the cable is unique, it is always best to commit to a supplier early and stick with them. They will be a lot more forthcoming and open with engineering and suggestions for installation.
- There is often a 12-months plus lead on cable manufacturing and delivery.
- Using existing cable design, previously type-tested for another application.
- Avoiding counter-helix armor saves money because the cable does not need to be shipped on or installed from a turntable.
- Using a supplier that has broad internal engineering capability is beneficial.

- Using a supplier active in the windfarm market capitalizes on significant and current experience
- Factories may be too busy to prioritize a smaller project, such as CalWave[sm]. As long as the windmill market stays strong, high volume orders will get priority. Fortunately, there are a number of factories that can produce medium-voltage cable.

Cable route survey

- The more information you provide the installer, the easier it will be to obtain a fixed-price quote.
- Customers often add a disclaimer to the survey provided in the RFP stating that this is for information only and the contractor has to do his own survey. This is not cost effective. The initial survey should be conducted by a reputable cable route surveyor and have sufficient data to install the cable. Then, if the contractor elects to do more, it is their option to do so.
- Measuring water depths in the shallows and surf zone is difficult. Again, the more data you have the better off you will be.
- Route survey should include weather data. We need waves to generate power, but waves and swells create safety risks for divers and cable vessel. Accurate weather data, current data and sea condition history is essential. Local knowledge is invaluable.
- The basic survey will employ a multibeam depth sounder. Side-scan sonar and a magnetometer is recommended, and possibly sub bottom profiling if cable burial is being considered.

Cable route clearing

- Since CalWave[sm] does not propose a cable burial, route clearing is not as important as it would be with a buried cable, but, in terms of liability, if there is manmade debris, trash or a ship wreck in the route, it will damage the cable. Hopefully the route survey will find all the debris, but there may be many months between the survey and the installation.
- Route clearing by grappling is very important but may l have environmental restrictions.
- If grappling is not allowed, a route inspection with a remotely operated vehicle (ROV) fitted with cameras and sonar may be an alternate method. If debris is discovered on the route, it can be recovered, or the cable route can be altered.

HDD and conduit end prep

- The conduits will either be steel pipe or high density polyethylene (HDPE).
- Because there will be time between horizontal directional drill (HDD) work and cable installation, the Driller will leave some length of pipe above the natural bottom.
- The HDD conduit needs to be capped and made water tight to prevent sand and marine life intrusion.
- The backside of the cap should have an attachment point for the messenger wire.
- Often, the driller secures the end cap by pulling and securing the messenger wire. This is not sufficient. The end cap has to be robust enough to withstand ground swell, being buried in sand, and then excavated.
- Dive support—Fiber optic cable installers have hired every sort of vessel available for shore end support. Keep in mind they may have started the cable crossing from Indonesia where the divers worked from canoes and hiring a fishing boat out Avila Beach seems like a huge leap forward. In reality, the vessel must have a three of four point mooring system, twin engines and hopefully a bow thruster, comfortable accommodations for the boat crew, 4 to 5 man dive crew, owner representative and a surveyor.
- Mooring—After the first cable pull, the as-laid cable is vulnerable to anchor damage by the dive support vessel. It is best to use pre-set moorings.
- The dive contractor needs to be a reputable, experienced, bonded contractor with experienced

surface supplied divers. No scuba diving allowed.

- The task for the divers will include the following: Locating and uncovering the conduit end, removing the cap, possibility cutting the conduit back to the mud line, retrieving the messenger, attaching the pull line from the cable lay vessel to the messenger, monitoring the power cable entry into the conduit, removing float bags, surveying the cable on bottom and plugging the conduit to prevent sand intrusion.
- During the cable pull, the cable master on the dive vessel will be watching the diver head-mounted camera or the ROV to communicate between the cable ship and the shore pull winch. Having the cable master on the dive vessel is essential for diver safety.
- It can be a logistical challenge to get the cable master on board the dive vessel; thus the need for bunk space.

Vessel Selection

- This project will require a Cable laying vessel with dynamic positioning (DP), computer control systems that accurately maintain the vessel's position.
- A vessel suitability survey or inspection should be performed by a Marine Warranty Surveyor to confirm that the vessels and their principal equipment meet the specified requirements and are suitable for the intended work.
- Accommodation requirements, including for employer representative(s) shall be defined and met by the selected vessel(s).
- The scale of fire-fighting and lifesaving appliances on board is covered by its safety certificates and shall, as a minimum, be in accordance with the scales prescribed in SOLAS corresponding to the number of personnel on board the vessel.
- At the present time, with oil prices low, there are numerous DP2 and DP3 vessels available in the Gulf of Mexico and overseas.
- A DP2 system is composed of the same modules as a DP1 system, but the number of modules have been increased for redundancy in order to comply with Class 2 rules. A DP2 system will use three control computers and, typically, two operator stations. Using three control computers makes it possible to perform majority voting between the computers, and it is thus possible to reject a computer should it fail.
- The number of I/O units is typically much higher on a DP2 system, as there will be a dedicated I/O unit for each set of sensors, each position reference system, power source and each thruster. This configuration is used to provide redundancy at all levels to make sure that any single failure will not result in loss of position.
- A DP 3 system has an extended hardware configuration compared to a DP2 system. The triple redundant DP controller is still used and a minimum of three operator stations is required. There will also be three I/O units to interface components, as opposed to a double set of sensors typically used in a DP2 configuration. A DP3 system also needs a physically separate, fire-safe compartment where one control computer, one operator station and one sensor IO unit have to be located in order to comply with Class 3 requirements. DP 3 is typically used for extensive deep dive operations and is extremely expensive.
- Some vessels have tier 3 air emissions ratings and many do not. Tier 4 engines will be required.
- The larger the vessel, the fewer down days there will be. Obviously, there will be a cost-benefit analysis done. The DP vessel first and foremost must be able to work at this location. DP vessels have an engineered and tested watch circle on all points of the vessel (360 degrees). Often Offshore Supply Vessels are built to stand by at a platform, or hold station for ROV operations. It takes additional power to follow a line and heading in all conditions. Be sure the vessel is capable of the work.
- Even though a vessel may not be a dedicated cable lay vessel, a good cable crew can work with it.
- A major lesson learned from previous projects is that a DP vessel captain and crew have the

responsibility to safely operate the vessel and may communicate poorly with the Cable Master. Protecting the cable and following orders from a cable master is not generally at the top of their priorities. Add language barriers and there is a strong potential for miscommunication that can lead to major difficulties.

- It is best to hire a cable installer who owns their own vessel or to have a working history with the vessel owner for cable laying.
- Vessels shall meet statutory requirements and in general have a valid class certificate with a recognized classification society or National Authorities. A vessel specification should state requirements for: general seaworthiness of the vessel for the region, anchoring systems, anchors, anchor lines and anchor winches, thrusters, positioning and survey equipment, dynamic positioning equipment and reference system, alarm systems, including remote alarms when required, cranes and lifting appliances, cable management and installation equipment and any other requirement due to the nature of the operations.

Cable Installation and Marine Operations

- Marine operations shall be planned to allow for safe and practical installation steps and developed into method statements and procedures.
- The rules to be applied for marine operations shall be defined.
- Exclusion zones should be established for areas surrounding the installation activities
- Day shapes or navigation lights, compliant with local regulations, shall be visible at the appropriate times of the day.
- Information on construction activities should be posted on “Notice to Mariners”.
- An installation manual shall be developed and agreed upon.
- The installation manual should include the installation sequencing and methodologies for the individual installation steps. The applicable, operational limiting conditions shall be defined
- Interfaces should be established with other parties that may be affected by the operations or may affect the operation.
- The responsibilities of all parties and lines of communication should be established.
- Operational limitations shall be established based on the intended vessel’s capabilities, the planned, installation techniques, the applicable weather windows and suitable contingencies.
- The installation operation shall be classified as weather restricted operation or unrestricted operation. An unrestricted operation is a temporary condition or permanent condition.
- For weather restricted operations, operational limiting conditions for whole or partial operations shall be established and agreed.
- The operational limiting conditions shall be based on detailed load effect analyses, vessel station keeping capability and Failure Modes and Effects Analysis (FMEA)/Hazardous Operations (HAZOP) data, and shall refer to objective, critical values determined by measuring devices.
- Continuous monitoring and recording of the measuring devices required for control of the operational limiting conditions shall be performed during all phases of installation activities.
- For weather-restricted operations, planning of activities shall be based on an operation reference period.
- Further, the operational criteria shall account for uncertainties in both weather forecasts and monitoring of environmental conditions.
- Regular weather forecasts from a recognized meteorological center shall be available on-board the cable installation vessel, and should be supplemented by historical environmental data and local knowledge.
- Start of weather restricted operations is conditional on an acceptable weather forecast for the required weather window.

- If the operational limits are about to be exceeded, preparations for stopping the work shall commence. If the critical condition is weather dependent only, and if weather forecasts indicate that the weather condition will subside, the installation may continue, subject to agreement.
- The decision to resume cable lay shall be based on comparison of forecasted (and, if applicable, measured) sea-state with the limiting (design) sea-state.
- With the explosion in inter-windmill and transformer tower-to-shore export cables, there has been a dramatic increase in capable crew and vessels to lay cable. Conversely, the highest incidents and insurance claims have been from human error, damaging cables. The learning curve has been expensive. Most vessels have multinational crews, language barriers and turnover. In comparison to interconnection of 100 windmills in the North Sea, this project is easy. In comparison to the Gulf of Mexico, or US inland bays and rivers, this project is very difficult.
- Other papers elaborate on cable handling equipment that does not work. Sheaves too small, inadequate traction on linear cable engines. Turntables that cannot handle an unanticipated vessel roll, towers unstable, insufficient cable float bags, and so on.

Conclusions

Many reports and interviews with installers talk about extremely detailed specifications, requirements for project execution plans down to the smallest detail. These very detailed specifications, however, often do not provide much flexibility for field changes and implementing on-site lessons learned. In order to make the installer accountable, you need to engage the installer in the planning. The Bureau of Ocean Energy Management (BOEM) and various other regulatory agencies may be demanding in their requirements to provide detailed specifications. Agencies may be inflexible in response to requests to change a method or procedure. During the permitting process, the owner needs to gain the trust of the agencies and try to have frank discussions about flexibility. I have found that conflict can arise from the fact that agency field staff have limited autonomy or experience and feel that they need to check with higher ranking or more experienced agency staff when questions arise. In contrast, the installers have full autonomy, and are empowered make all the decisions in the field. This can lead to a lack of understanding and trust between the installer and agency staff.

As a final note, any offshore project is dependent on the smallest of details. We often reminisce that the project can come to a screeching halt over one bolt or one fitting. Personal logs are full of these examples.

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Attachment 11-10: Mooring and Anchoring Study

Glosten and Associates provided a study of mooring and anchoring design considerations and lessons learned for wave energy converters.

PREPARED FOR: CH2M Sacramento,California			BY: Ken FitzGerald PROJECT MANAGER
 1201 WESTERN AVENUE, SUITE 200 SEATTLE, WASHINGTON 98101-2953 T 206.624.7850 GLOSTEN.COM			CHECKED: Benjamin B. Ackers, PE PRINCIPAL
			APPROVED: John L R Edgar, PE PRINCIPAL-IN-CHARGE
DOC:	REV: -	FILE: 16082.02	DATE: 28 November 2016

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Introduction

The CalWave Energy Test Center concept can be considered a second-generation test facility for ocean renewable devices. The evolution of the ocean renewable technology and the experiences of earlier demonstration sites provide direction and efficiency in defining the interfaces between Test Center operators, prospective developers and permitting agencies. Key efforts in the development of the Test Center include:

- Understanding the range and complexities of possible devices and how they may be accommodated and cultivated as a growing Test Center client base.
- Understanding the level and content of Test Center input required by developers to tailor energy generation for site conditions and provide design input for sound mooring and structural systems.
- Developing vetting programs for tenant developer designs and plans to manage risks to other tenants, Test Center infrastructure, future permitting efforts, and the wider health of the ocean renewable sector.

This report will discuss each of these Test Center efforts in detail. Section 1 describes the potential devices, moorings, and export lines that could be installed at the test site. Section 2 describes the engineering and design codes and practices for permanent installations and temporary installation works. Section 3 discusses the risks for system developers, and how to mitigate them.

Bottom-founded devices are excluded from this review, and while some moored ocean current generators may be categorized within the reviewed typologies, they are given light treatment due to the relatively low current speeds expected at the site.

CalWave Site Characteristics

The site conditions off Pt Arguello are dominated by a "profound oceanographic and faunistic boundary between true Subarctic and Equatorial Waters," (Reference 3). The area is characterized by seasonal variations of current direction, upwelling, and prevailing winds.

The following key characteristics define the CalWave Test Center site.

- Depth: 90 – 110 m
- Bottom condition: Sandy silt exceeding 1 m sub-bottom thickness (Reference 3)
- Energy design wave (annual means per Reference 1):

  South Central Site

  Hs: 2.36 m
  Ts: 11.0s

  South-By-Southeast Site

  Hs: 2.08 m
  Ts: 10.8s
- Design current: ~ 0.25 m/sec (Reference 2)
- Design wind (NOAA station PTGC Pt Arguello):

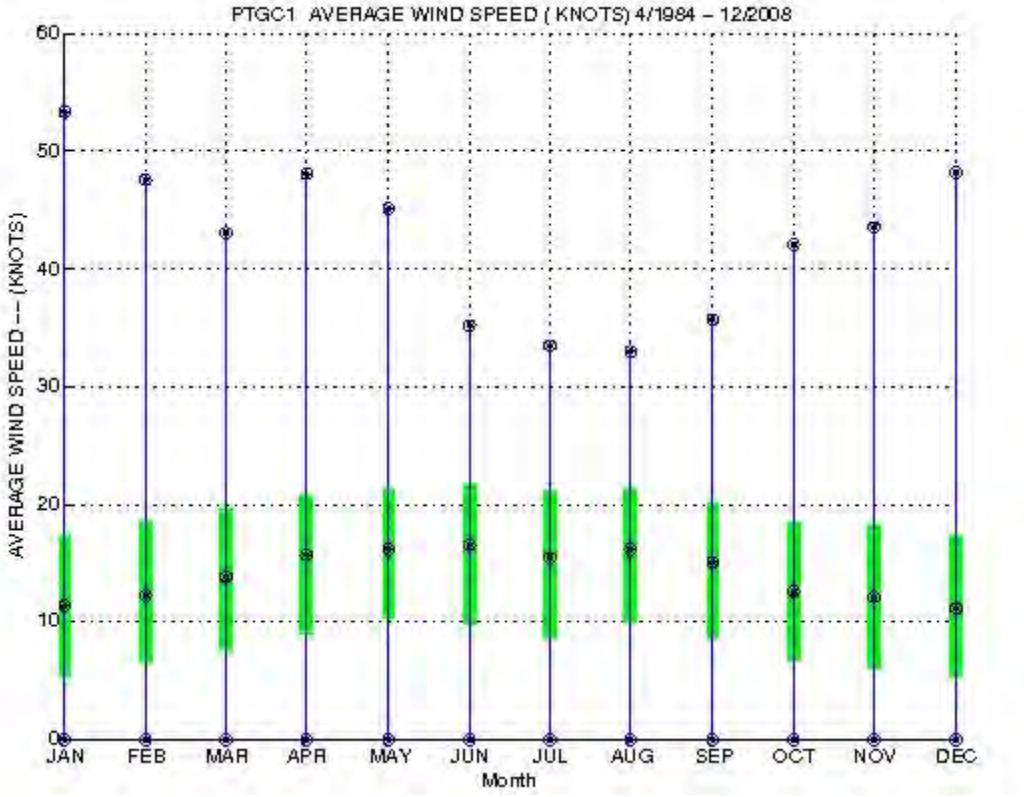


Figure 1 Pt Arguello maximum, 75th percentile, median, 25th percentile, minimum wind speeds

Section 1: Installation Device Typologies

This section will describe the range and complexity of possible devices within the Test Center client base. Installed devices at the CalWave site will fall into one of four categories, described below in the Floating System Categories section. The Mooring Typologies section will cover the

mooring types that may be used by these devices. The Power Export Conductors section will cover the types of conductors the systems may employ for power transfer.

Floating System Categories

The range of floating offshore systems to be considered in planning an ocean renewable test site includes renewable energy devices and other systems required for temporary offshore construction, installation, and on-going site operations. The long-term relevancy of the site in supporting future ocean renewables requires a flexible definition of allowable offshore systems. These floating systems may be divided into four categories: surface buoys, sub-surface buoys, floating foundations, and temporary installation vessel moorings.

Surface Buoys

Oceanographic buoys are typically the first systems installed in an offshore test facility. They may remain in place as a permanent fixtures of the site, or come and go as needed by the site operators and tenants. Two oceanographic buoy systems define the possible range of this class of device: the 10/12 m discus oceanographic buoy, and the 3 m discus oceanographic buoy, which is the standard meteorological buoy.

10/12 m discus oceanographic buoy:

- Diameter: 10-12m
- Height: 8 m
- Displacement: Up to 100 mt
- Mooring: Single point all-chain catenary moorings in less than 100 m
- Anchor: Drag embedment or deadweight
- Initially designed as replacement for USCG light ships
- Discontinued from USCG and NOAA service by ~ 2005

Figure 2 10 m discus Large Navigational Buoy (LNB); photo from globalsecurity.org/military/intro/buoys.htm

6 m NOMAD oceanographic buoy:

- Length: 6 m
- Height: 3.1 m
- Depth: 9 m
- Displacement: 5200 kg
- Mooring: varies (chain/wire/synthetic, catenary and spring buoy)
- Anchor: typically deadweight

Figure 3 6 m NOMAD oceanographic buoy; photo from ndbc.noaa.gov

Surface buoy WECs are characterized by relatively compliant position-keeping moorings designed to limit mooring load effects on the WEC buoy. Three existing characteristic designs for surface buoy WECs include the Fortum Wello Penguin, Seatricity's Oceanus 2, and the Triton by Oscilla Power.

Fortum Wello Penguin

- Beam: 30 m
- Draft: 7 m
- Displacement: 1600 mt
- Mooring: three-point mooring, subsurface spring buoys, chain and wire
- Anchors: drag embedment anchors with clump weights, pull tested with tug
- Electrical export power cable

Figure 4 Fortum Wello Penguin wave energy converter; photo from wello.eu/en/penguin

Seatricity Oceanus 2

- Draft: 1 m
- Diameter: 12 m
- Displacement: 12 mt
- Mooring: four-point subsurface spring buoys
- Anchors: deadweight
- Water pressure export hose

Figure 5 Seatricity Oceanus 2; photo from Seactricity.com

Oscilla Power Triton

- Multi-point catenary mooring
- Buoy length: ~30 m
- Heave plate diameter: ~30 m
- Mooring: surface buoys, chain and wire or synthetic
- Anchors: drag embedment or deadweight anchors
- Electrical export power cable

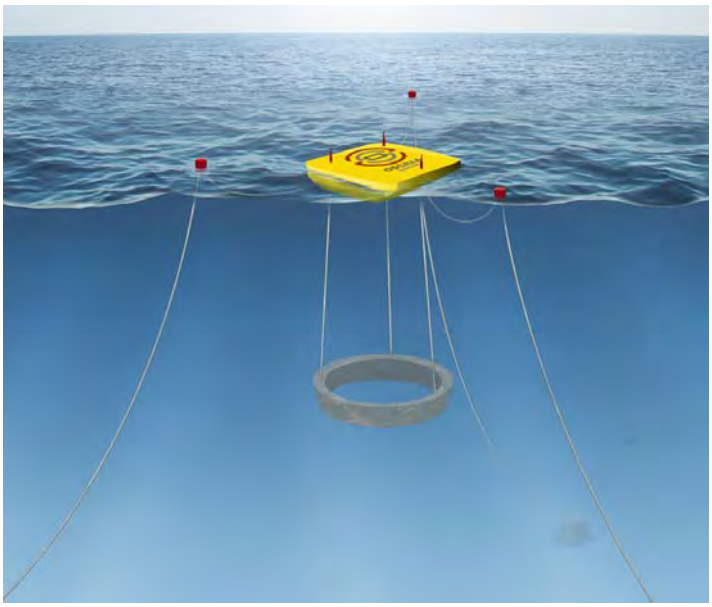


Figure 6 Oscilla Power Triton; photo from oscillapower.com/triton-wec/

Subsurface Buoys

Subsurface buoy WECs may use a high tension mooring line as part of the power take off or as part of a midwater foundation for the device. These high tension vertically loaded lines may be anchored with deadweight, plate anchors, vertically loaded drag embedment anchors, and piles (suction, driven or drilled). Deepwater applications of these anchors routinely exceed 1000 m depths. Two examples of subsurface buoy WECs include the Carnegie CETO 6 and the M3 Wave NEXUS.

Carnegie CETO 6

- Buoy diameter: 20 m
- Mooring: single-point high-vertical-load, synthetic line
- Anchors: pile
- Electrical export power cable
- Optional water pressure export hose

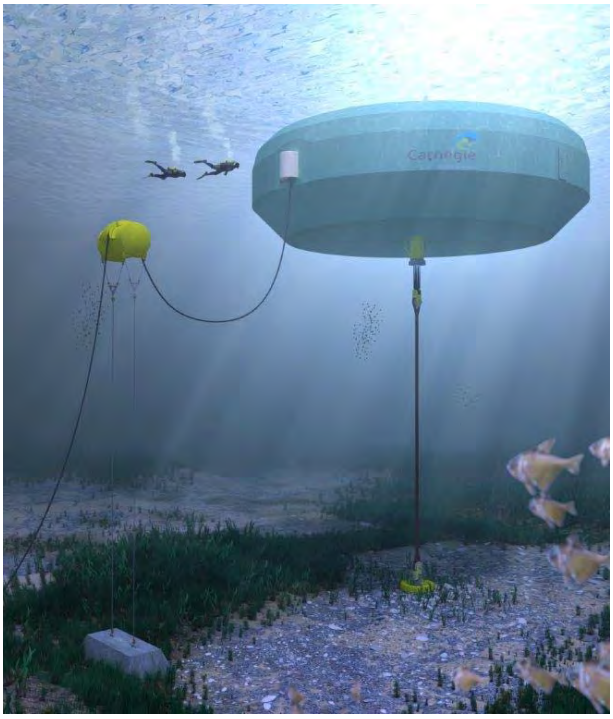


Figure 7 Carnegie wave energy CETO 6; photo from carnegiewave.com

M3 NEXUS

- Buoy length ~75 m
- Electrical export power cable
- Mooring: multi-point vertical load, synthetic or wire
- Anchors: pile, deadweight

Figure 8 M3 wave energy APEX/NEXUS; photo from tidalenergytoday.com/2015/08/26

Floating Foundations: Wind Turbines and Hybrids

Floating foundations represent a class of large ocean energy structures deployed to provide foundations for renewable generators. Wind turbines are currently the most common application for floating foundations. Offshore thermal energy conversion platforms require large floating

foundations, and conceptual hybrids combining tidal generators and wind turbines with WECs have been proposed. Three floating foundations representing potential test site devices include the Statoil Hywind spar, Principle Power's semi-submersible Windfloat, and the PelaStar tension leg platform.

Spar Wind Turbines

Statoil Hywind

- Draft: 100m
- Displacement: 5500 mt
- Spar float diameter: 8.3m
- Blade tip height: ~180 m
- Turbine height: 65m
- Rotor diameter: 83m
- Mooring: three-point, 3000 m chain catenaries
- Anchors: suction pile

Figure 9 Statoil Hywind spar; photo from Hywind

Semi-Submersible Wind Turbines

Principal Power Windfloat

- Draft: 20m
- Turbine height: 80m
- Rotor diameter: 120m
- Mooring: three-point catenary chain and synthetic mooring
- Anchors: drag embedment anchors

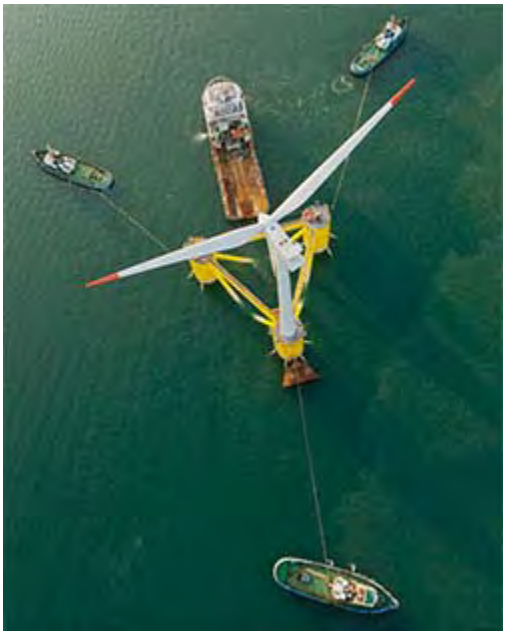


Figure 10 Principle Power Windfloat semisubmersible; photo from windfloatpacific.com

Tension Leg Platform Wind Turbines

PelaStar

- Displacement: ~4000 mt
- Submerged hull diameter: 60 m
- Draft: ~30 m
- Blade tip height: ~180 m
- Mooring: five-point high-vertical-load, synthetic lines
- Anchors: pile

Figure 11 Pelastar tension leg platform; photo from pelastar.com

Temporary Installation Moorings

The installation of a floating renewable device and the associated subsea cables and hoses often requires that the vessels moor on the test site temporarily during anchor installation, device hook-up/commissioning, maintenance, survey, and servicing.

These temporary moorings could be required to support the following types of vessels for a duration of hours to weeks:

1. Crane or drill barge with shipboard winches and drag embedment anchors in a multi-point wire rope mooring spread.
2. Submersible heavy lift ship or barge moored with pre-installed temporary moorings.
3. Dive support vessels with conventional shipboard multi-point mooring spread.
4. Survey, installation, and commissioning vessels on shipboard or pre-installed temporary moorings.

It is important to recognize that the area impact of a temporary service mooring may exceed the footprint of the permanent device it is supporting. For instance, a crane barge with a conventional wire catenary mooring serving a single-point subsurface buoy WEC could require a mooring spread extending over a diameter of 1000 m on the site. The extent of temporary moorings should be considered when planning the WEC location setbacks from anchoring boundaries unless temporary moorings are exempt from the boundaries.

Device Typology Summary

Table 1 Device examples and characteristics

Moored Structure Type	Developer	Device Name	Type	Key Dims	Disp (mt)	Mooring Type	Watch circle/ mooring Dia (m)	Anchors	Power export and telemetry
				Surface Buoys					
Oceanographic Buoy	Various	10/12m Discus	Disk Marker/Met-buoy	10-12m Dia	<100	All chain catenary	~1000	Deadweight	Radio
Oceanographic Buoy	Various	6m NOMAD	Vessel form met-buoy	6m x 3.1m	~5.2	Chain/wire/synthetic. Catenary, spring buoy	< 1000	Deadweight	Radio
Wave Energy Converter	Fortum Wello	Penguin	Vessel form buoy	50m x 30m	1600	Three-point chain and wire, subsurface spring buoys	< 1000	Drag embedment	Power cable with data
Wave Energy Converter	Seatricity	Oceanus 2	Octagonal torus	12m Dia, 1m draft	12	Four-point chain/wire/synthetic, subsurface spring buoys	< 1000	Deadweight	Water pressure flowline and radio
Wave Energy Converter	Oscilla Power	Triton	Vessel form buoy with heave plate	30m buoy length, 30m Dia heave plate	TBD	Three-point, surface buoys, TBD	< 1000	TBD	Power cable with data
				Subsurface Buoys					
Wave Energy Converter	Carnegie Wave Energy	CETO 6	Oblate spheroid	20m Dia, 5 m depth	~ 1000	Single-point, synthetic	<150	High-vertical-load piles or 3500 mt deadweight	Power cable with data or water pressure flowline and radio
Wave Energy Converter	M3 Wave	NEXUS	Rectangular paired buoy	75 m long, 20m wide	variable	Four-point synthetic tension leg	<200	High-vertical-load piles or deadweight	Power cable with data
				Floating Foundations					
Floating Wind Turbine	Statoil	Hywind	Spar	100m draft, 180m height off water, 8.3m spar Dia	5,500	Three-point all chain catenary	< 6,000	Suction piles	Power cable with data
Floating Wind Turbine	Principal Power	6 MW Windfloat	Three column semi-sub	20m draft, 170m height off water, ~75m triangle	6,000	Three-point wire and chain catenary	< 6,000	Drag embedment	Power cable with data
Floating Wind Turbine	PelaStar	PelaStar	Five arm tension leg platform	30m draft, 180m height off water, 60m submerged hull Dia	4,000	Four-point synthetic tension leg	< 100	High-vertical-load piles	Power cable with data

Mooring Typologies

The mooring arrangements for the moored devices under consideration can be classified within five categories: soft catenary, semi-taut, high vertical load, multi-point catenary, and single-point catenary. Moorings are a controlling system of WEC performance in power generation, cost of energy, position holding, and survivability. Many surface buoy generators benefit from minimizing mooring reactions at the anchor line connection. Other concepts such as the CETO 6 use the anchor line as a power take-off element within the generating machinery. In general, demonstration device developers often de-emphasize mooring design, hardware and geometry while concentrating on power-take-off efficiency.

Compliant Catenary

Soft catenaries are surface WEC moorings with low load contributions to the position mooring attachments resulting in large un-restrained watch circles. These moorings attempt to limit influences on WEC motion from the position-keeping moorings to maximize WEC motions that provide energy to the power takeoff. Multiple mooring lines provide low-load corrections to the watch circle position. Surface spring buoys decouple the mooring reactions from the catenary weight and aid in installation.

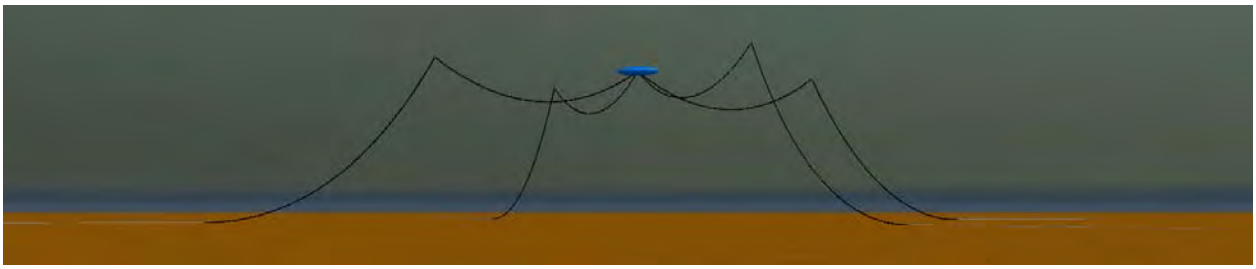


Figure 12 Soft catenary surface buoy mooring

Semi-taut

Semi-taut moorings are surface and subsurface WEC moorings providing increasing watch circle restraint and high mooring attachment loads. Subsurface spring buoys to maintain line tension often augment the watch circle restoring force of the catenary.

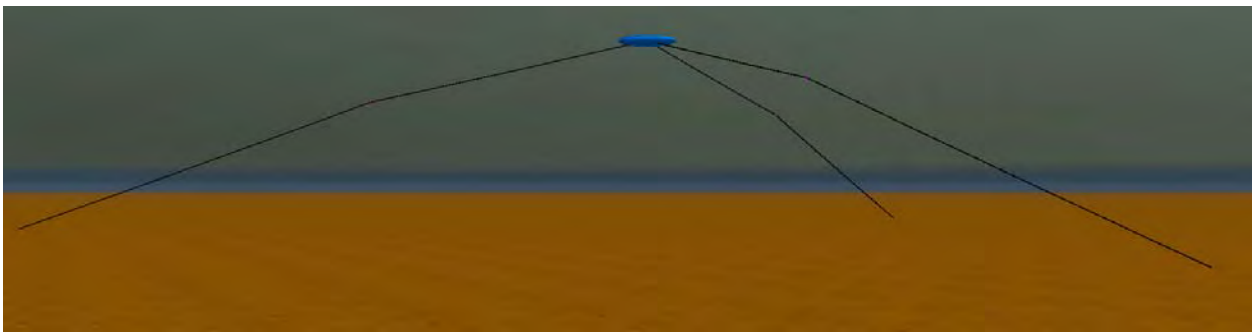


Figure 13 Semi-taut mooring with subsurface spring buoys

High Vertical Load

High vertical load moorings are vertical tendons under extreme tension, holding the floating structure within a very tight watch circle. The anchor zone diameter is often smaller than the watch circle of the floating structure.

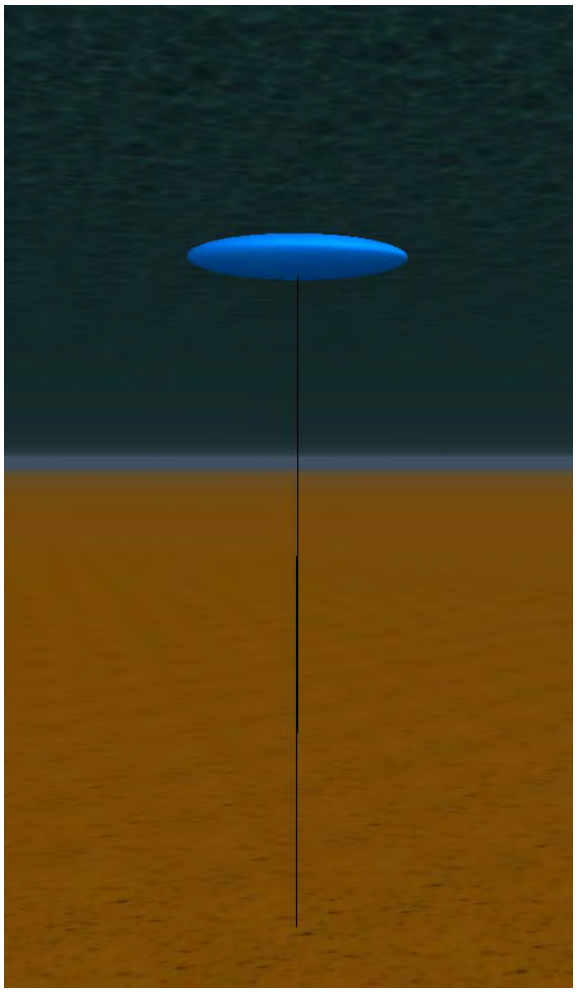


Figure 14a High vertical load mooring: Subsurface single-point

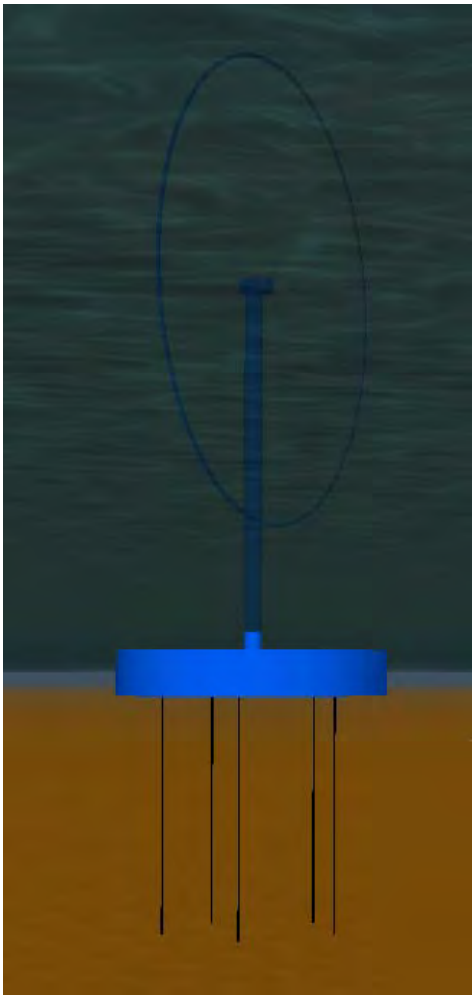


Figure 15b High vertical load mooring: Floating foundation tension leg platform

Multi-point Catenary

Multi-point catenaries have long anchor lines, using distributed catenary weight for position restoration forcing. Catenary weight may be augmented or replaced by point-load clump weights.

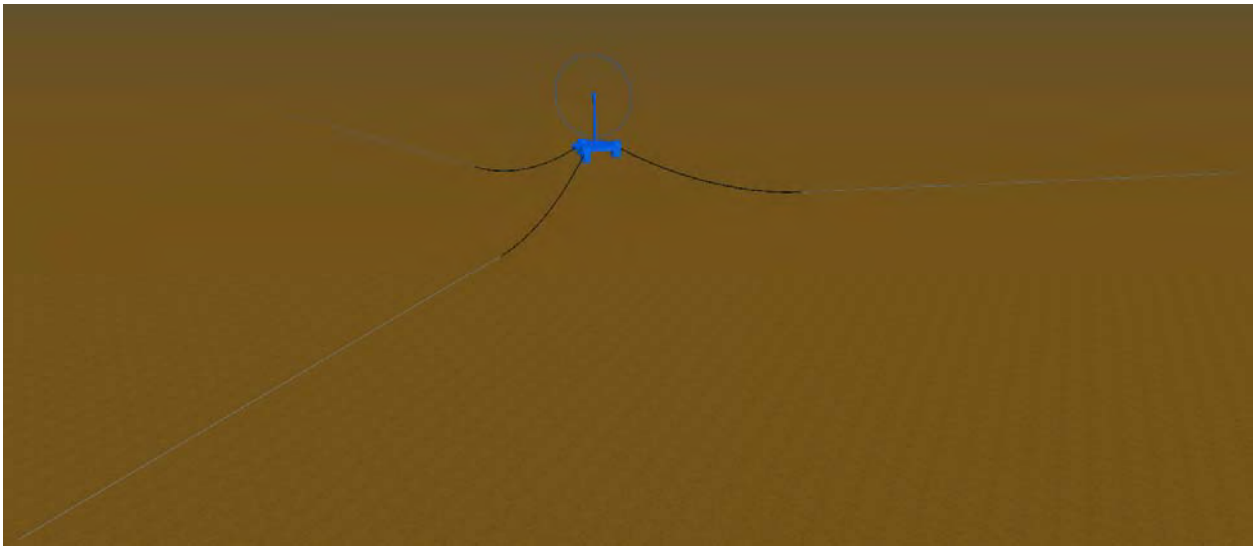


Figure 15 Floating foundation semi-submersible: catenary mooring

Single-point Catenary

Single-point catenaries are a single long anchor line using distributed catenary weight for position restoration forcing. Catenary weight may be augmented or replaced by point-load clump weights. The watch circle size increases rapidly with depth.

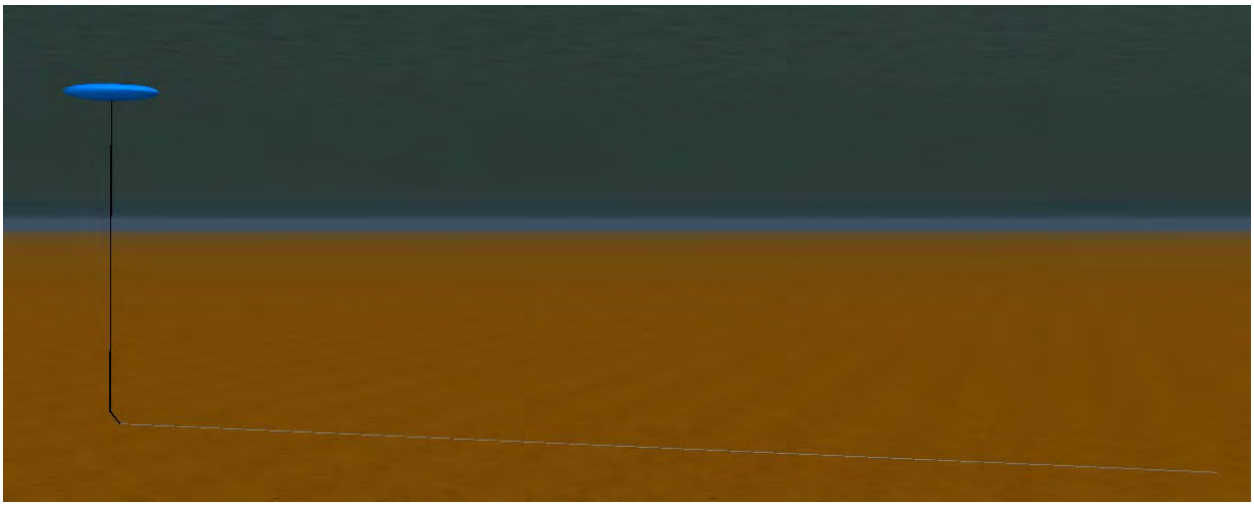


Figure 16 Surface buoy single-point catenary

The possible variations within each mooring category lead to a wide range of possible materials, anchors, and installation methods for a finalized design. Table 2 provides a summary of mooring options that could be implemented for each mooring category.

Table 2 Mooring options: components and installation

Demonstrator Mooring Type	Tension members			Anchors							
							Piles				
	Chain	Synthetic	Wire	Drag	Dead-weight	Plate	Suction	Driven	Torpedo	Drilled*	Micro*
Soft Catenary	●	●	●	●	●	●	●	●	●	-	-
Semi-taut	●	●	●	●	●	●	●	●	●	-	-
High Vertical Load		●	●		●	●	●	●		-	-
Multi-point Catenary	●	●	●	●	●			●	●	-	-
Single-point Catenary	●	●	●	●	●		●	●	●	-	-

* Hard bottom anchors not likely to be applicable off Pt Arguello

Installation Vessel Mooring Type	Installation Vessels				Installation Position Holding		
	Crane Barge	AHTS[1]	Fishing	Tug	Mooring spread	DP[2]	Hot-boat[3]
Soft Catenary	●	●	●	●	●	●	●
Semi-taut	●	●	●	●	●	●	●
High Vertical Load[4]	●	●			●	●	
Multi-point Catenary	●	●	●	●	●	●	●
Single-point Catenary	●	●	●	●	●		●

1 Oilfield Anchor Handling Tug Supply vessel

2 Dynamic positioning by thrusters

3 Manual maneuvering by the helm

4 Unlikely but could be a solution to limitations from permit boundaries

Mooring Area Extents

The final extent and shape of an anchor spread footprint is determined by the following typical variables:

- Slope of the bottom contours: Varying depths across the spread can result in asymmetrical mooring areas.
- Mooring geometry bias for site specific prevailing metocean directions
- Anchor installation corridors: the distance from anchor set-down to full anchor embedment.
- Anchor installation accuracy

Example Anchor Spread Extents

A soft catenary surface buoy mooring (Figure 17) optimized for a site with a sloping bottom could result in an asymmetric set of mooring leg lengths and anchor locations.

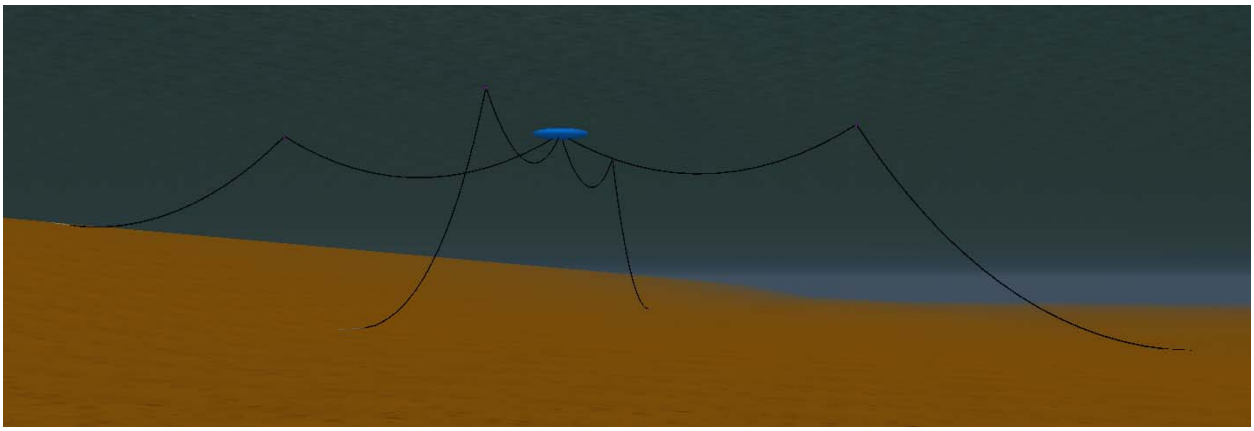


Figure 17 Example soft catenary surface buoy mooring on a sloping bottom: 40 to 100 m depth

The resulting mooring geometry optimized for static line load sharing could resemble Figure 18. While planning areas could be developed as circular mooring extents with margins for installation accuracy, the final actual mooring clearance requirement could be an ellipse.

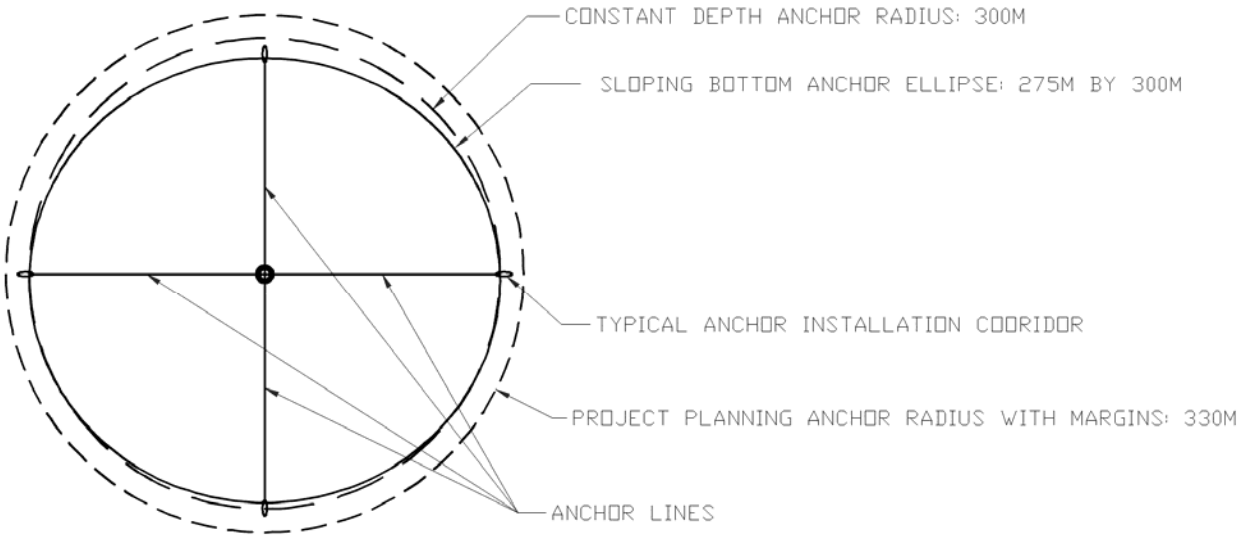


Figure 18 Example contributors to anchor spread shape and extent; plan view

Summary Anchor Spread Extents

Table 3 provides planning sizes of typical anchor spread diameters for the four primary classes of mooring.

Table 3 Typical anchor spread diameters for planning

Mooring Type	Anchor Spread Diameter (m), 100 m depth
Soft Catenary	< 1400
Semi-taut spring buoy	< 800
High-vertical-load	< 150
Multi-point Catenary	< 1400
Single-point catenary	~1000[a]

[a] Represents the watch circle for an all-chain single point mooring

Multiple interfaces between position moorings and power export conductors must be considered in the development subsea arrangements for the test site and tenant structures. These interfaces drive the designs and arrangements for dynamic conductors, static conductors, array conductors, subsea connectors, and cable protection systems.

Dynamic Conductors

Dynamic conductors carry floating device power through the water column to the seabed. These conductors are designed for the dynamic loads, fatiguing motions, and seabed touch-down wear associated with the moored device vessel motion. Distributed floatation along the midwater section of the conductor is often used to de-couple moored structure motion from the seabed conductor touch-down area. Dynamic conductors are effectively an element of the position mooring arrangement and must be designed with consideration of mooring line clashing and possible load sharing in the mooring spread.

Static Conductors

Static conductors remain stationary on the seabed and provide long power runs to shore or between stationary subsea components. The arrangement of the static conductors within the site must be developed to provide maximum flexibility in locating device and installation vessel mooring anchors and lines while avoiding damage to the conductors.

Array Cables

Array cables provide power networking between series of devices to decrease the amount of subsea cable required for a field of devices. Cable arrays add complexity to the seabed interferences between conductors and moorings.

Connectors

Subsea conductor connectors are often designed to be recovered to the surface for repairs and addition of new conductor lines. The seabed working space requirements for connector recovery and installation must be respected when installing test device moorings near or across conductor lines.

Protection: Armor, Trenching and Stabilization

Conductor protection may be applied to mitigate several risks to the subsea conductor line, including sediment scour, surf wear, anchor and mooring damage, fishing damage, and tampering. Cable protection may be applied in areas where mooring lines are known to cross the conductor.

Section 2: Engineering Design Codes and Practices

The technical methods and practices for the design of a Test Center demonstration device are governed by a collection of stakeholders with unique motivations.

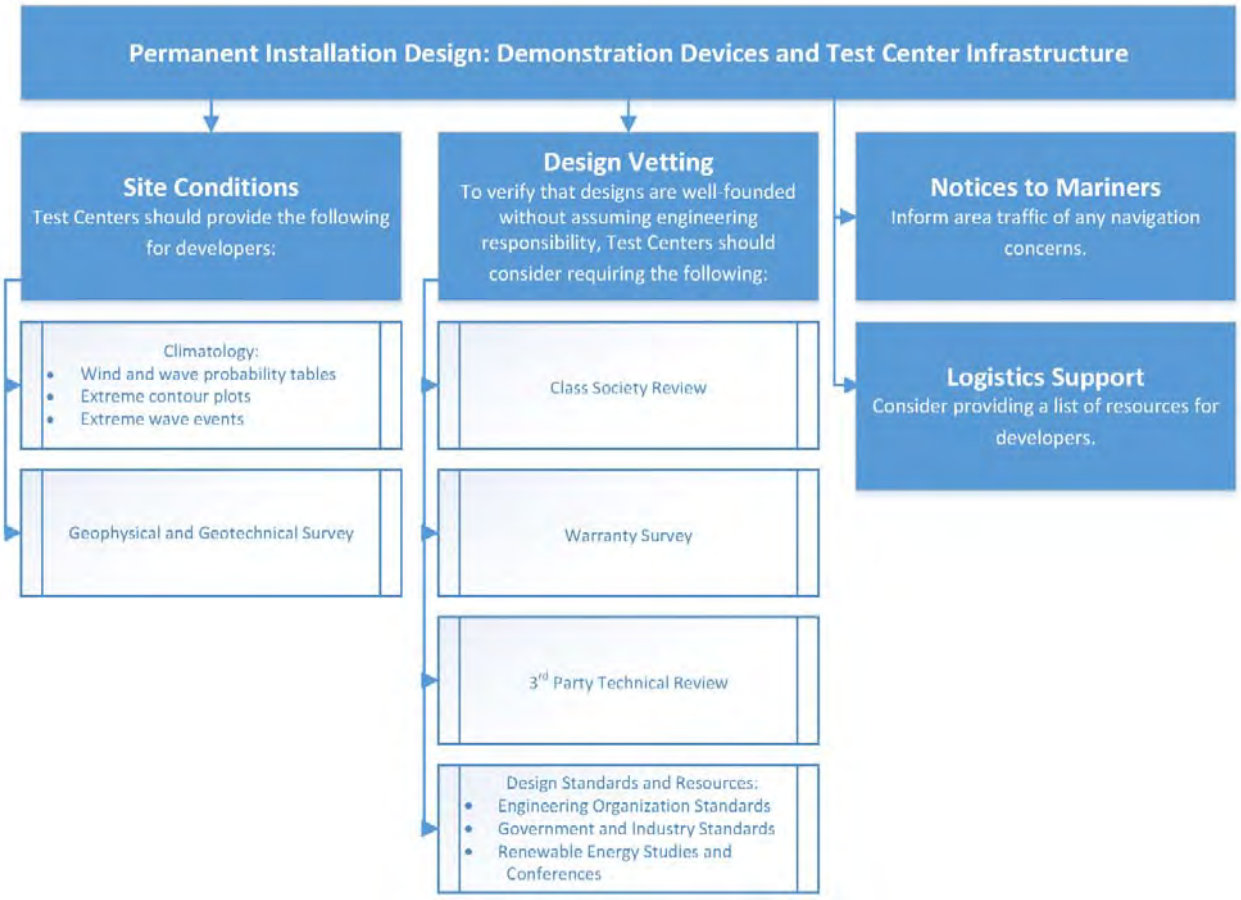
Test center operators are concerned with the risks tenant devices pose to other tenants, risk to the Test Center infrastructure, future permitting, the Test Center brand/reputation, and the long-term viability of the ocean renewable industrial sector. A significant failure by a tenant developer could have consequences beyond the developer's interests.

Government agencies may review designs and operational plans for safety, environmental impacts and prior to allowing deployments on leased seabed areas. Insurance carriers and development funders may require due-diligence reviews, compliance with Classification Society design codes or vetting by warranty surveyors.

The following section discuses design considerations that Test Centers should be aware of for all renewable device installations, and some specific concerns for temporary installation works.

Permanent Installation Design: Demonstration Devices and Test Center Infrastructure

The best-practice design of a renewable device project begins with a clear set of Test Center inputs and design compliance expectations.



Site Condition Basis for Mooring Design

The Test Center should provide a rigorous and exhaustive set of site condition data to each developer. This design basis should be specifically framed in terms of site mooring conditions in addition to renewable energy power generation conditions.

Structural Design Climatology

Mooring and device feasibility climatology must be provided to define the metocean loads influencing structural fatigue, position keeping, and energy generation. The ideal set of structural climatology will include:

- High definition joint probability tables relating wind speed, wind direction, significant wave height, wave direction, and peak period over a range of values for each variable. The variable ranges within this dataset should be based on metbuoy hindcasts but will be generated by numerical models to provide the appropriate level of fidelity in mooring numerical models for structural design.
- Extrapolated long term extreme contour plots defining the envelope conditions for structural design over the life of the installation.
- Design values for extreme wave events in a range of return periods between 1 and 500 years. These values are required to define ultimate load limit cases for system survival design.

Geophysical and Geotechnical Survey

Anchor selection and installation can be a key driver of device demonstration design, cost, and feasibility. The expense of a rigorous geotechnical survey to provide engineering values for

subbottom geology is often beyond the financial reach of device developers. The lack of this data is a known impediment to de-risking renewable devices and has negative impacts on developer funding. The Test Center could mitigate the risks of allowing tenant installations without strong geotechnical input in anchor design by commissioning a full geotechnical survey of the site.

At a minimum, the Test Center should provide a rigorous geophysical survey data suite including shallow sediment characterizations, subbottom acoustic reflectivity, sidescan coverage and high density bathymetry. These data products should be provided to developers in georeferenced drawings with site boundaries and features included and CAD native format versions made available.

Logistics Support

While the Test Center is unlikely to contract installation, operations, and maintenance efforts for demonstration developers, it is helpful to understand the logistics of the local marine construction sector. Executing marine installations and offshore work is often a weak area within developer teams. The Test Center could commission a survey of regional marine construction resources by subject matter experts in offshore work, to provide assistance to developers in identifying resources and locations for offshore work.

Notice to Mariners, Notation on Charts, and Outreach

The curators of the test site will mitigate some risks to the site infrastructure and demonstration tenants by disseminating accurate and frequent information to the marine community active in the adjacent waters. Notices to Mariners through the USCG inform commercial concerns of new structures, lights, and activity in the test site. Notations on nautical charts describe areas for mariners to avoid and describe new structures and lights in the Test Center. Informing small-scale commercial fisheries and recreational boaters of new navigational concerns in the Test Center may require targeted outreach to marines, periodicals, and digital media.

Site Developer Process and Vetting

Each device demonstration project carries risks to the environment, adjacent tenants, and the test site infrastructure. These risks begin with developer surveys in the Test Center waters and continue through the installation of the device, the operational period of tenancy, and the removal of the device. The Test Center's involvement in managing these risks should include verification that well-founded designs and plans are in place, but the Test Center should not assume developer engineering responsibility for a demonstration project. Demonstration project risks may be documented, evaluated, and controlled by subjecting the project designs and plans to design standards and class society and consultant reviews. These reviews need not be required for installation, but may be used by the Test Center on a case-by-case basis to screen designs.

Classification and Design Societies

The standard method of risk mitigation for commercial marine industry designs revolves around detailed engineering review and approval of design packages by classification societies such as DNV GL, Lloyds, and the American Bureau of Shipping. These societies maintain and publish extremely comprehensive design guides. They review and approve individual designs at significant cost with large staffs of subject matter expert engineers.

Various levels of review are available for purchase. Reviews may not include approval statements in the case of novel and new technologies for demonstration. While prescribed mooring design codes and methods may be readily applicable to ocean renewable demonstrators,

designers of devices may use sections of design codes meant for conventional projects through agreement and negotiation with the reviewing society.

Design Standards and Operational Planning Resources

Engineering Organizations

Second tier design guidance is available from standards organizations such as IEC, ASTM, ISO, PIANC, OCIMF, and EN. These organizations do not review designs but provide design standards for engineering design. Available standards vary in the level of useful detail. Referenced standards should be reviewed by the Test Center operators and other stakeholders to verify that these resources support a meaningful level of engineering care.

Government and Industry Organizations

Operational plans and marine practices may be developed with input from a wide range of government and industry resources such the USCG, OSHA, IMCA, BS, USACE, and UNOLS.

Lessons Learned

Numerous sources of information on WEC risks and mitigations are consolidated within the proceedings of renewable energy conferences and open source studies by government bodies (BOEM, The Crown Estate), public-private agencies (ORE Catapult), and commercial safety consultants.

Third Party Technical Review

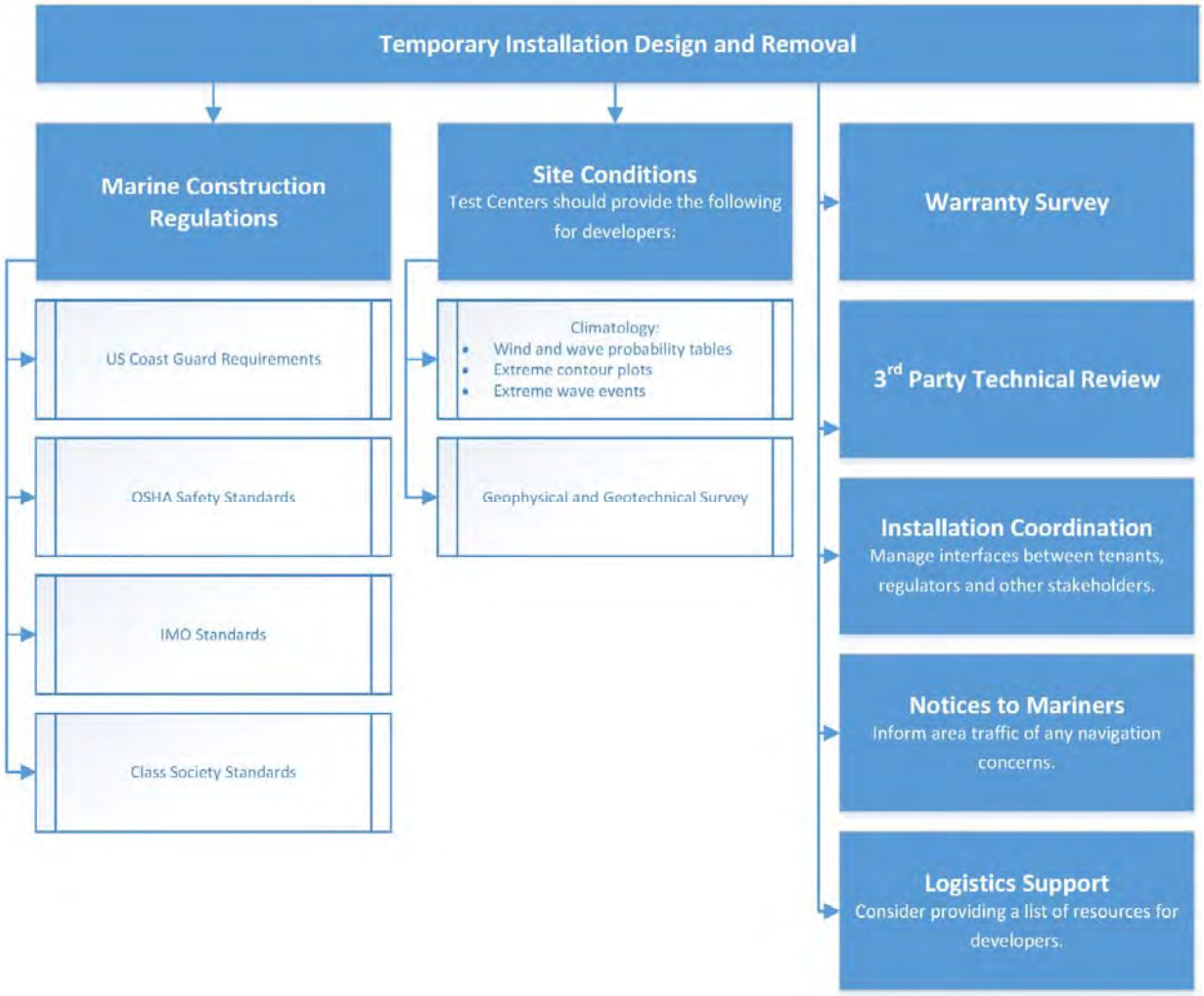
Marine engineering consultants may provide third-party reviews of demonstrator designs in lieu of classification society approval. These reviews should be conducted by consultants with experience and expertise in the engineering details of similar projects. Third party reviewers may be potential competitors of developers and this can cause alarm over conflicting interests and releases of intellectual property.

Warranty Survey

Consultants specializing in third party review are common within the offshore oil and special projects sectors. These warranty surveyors are senior subject matter experts in the planning and execution of marine projects, typically from an operational background. They often draw heavily on design compliance codes and professional seamanship rather than performing engineering quality assurance. Final inspection by a warranty surveyor or an equivalent field engineer is typically the last opportunity for review of the intended marine practice and to verify that mitigation hardware, fail-safes and backups are in place before deployment.

Installation and Removal Temporary Works

The installation and removal efforts for a device demonstration project require a distinct set of designs and plans.



Site Condition Basis for Temporary Mooring Design

Mooring designs for installation and removal vessels working in the Test Center require the same metocean site inputs that are required for the demonstration device. The periods of climatology interest and statistical values used may differ; for instance, a temporary installation mooring might be based on short seasonal statistical return periods rather than a multi-decade return period for a permanent design. Statistical likelihoods of metocean exceedances may be investigated to estimate schedule operability and costs of the offshore work.

Accurate as-built georeferenced drawings of the site infrastructure, tenant structures, moorings and export lines must be considered in designing the temporary moorings. In some cases, the restricted mooring footprint for construction work in an active test site can require a high level of engineering to ensure that interferences are managed and compromised mooring geometries are feasible.

Test Center Compliance for Temporary Works

The Test Center must coordinate all work in the test site waters to ensure that interferences between tenant systems and the site infrastructure are managed. Plans for undertaking marine construction work in the test site must be comply with the level of care communicated to developers and expected by the test site operators. Operational risks should be documented with mitigations and contingencies in place. Work schedules, durations, and contracts should be clear and well vetted to avoid incomplete efforts with risks to the Test Center and other tenants.

Notice to Mariners

The Test Center Notice to Mariners should be used to inform commercial shipping that temporary works are underway, with associated closest point-of-approach and wake advisories.

Marine Construction Regulations

Marine construction vessels and temporary works are regulated by several key agencies and organizations. Compliance with these regulations is managed internally by marine construction contractors but should be verified by the Test Center during work plan reviews.

- US Coast Guard:
  - Inspections
  - Manning
  - Load Line
  - Stability
  - The Jones Act
  - Oil Pollution Act
  - Emissions: Engine exhaust and discharges
- OSHA: Safety
- International Maritime Organization: Safety of Life at Sea
- Classification Societies: Classed vessel project vessel modifications, temporary accommodations, temporary overboarding deck gear.

Third Party Technical Review

Review of temporary marine construction moorings and plans is common within the marine construction industry. Marine construction operators may contract specialty ocean engineering firms to develop and vet standard arrangements developed by construction engineers and mariners. End clients also retain specialized firms as owner's representatives for quality assurance and to satisfy funders and insurers.

Warranty Survey

Warranty survey is often carried out for ocean transportation of special project components and could bring value to operational reviews of installation and removal.

Section 3: Developer Risk Mitigations

The specific risks associated with the installation, operation, and removal of a demonstration project depend on the sensitivity of the final device and its moorings to individual failures. These risks and the associated consequences should be individually evaluated for each project through a formal risk assessment process. At a minimum, a recurrent set of common risk drivers should always be considered.

Weather

Weather risks for work at sea are a primary concern for the safety, financial, engineering, and environmental success of an offshore demonstration. Extreme event weather risks are managed in the design phase by setting rigorous design values based in hindcast statistics. Marine construction weather impacts to safety, budget, and schedule are also mitigated by selecting appropriate operational limits based on monthly hindcast statistics, but additional weather planning is required including: go-no-go criteria, safe-hold points, short-term forecasting, stand-by budget and schedule.

Mooring Component Failure

Causes of mooring component failure can be seeded into a project during the design, installation, and maintenance phases. Mitigations to these known risks should be understood by the developer tenant and vetted by the Test Center.

Fatigue

Premature component fatigue may result from several sources:

- Missing climatology and mooring analysis.
- Misunderstood material properties.
- Quality issues with documented material properties.
- Structural assembly methods.

These risks are mitigated through rigorous engineering by experienced designers using high-quality metocean and device motion data.

Chafe

Catastrophic chafe of mooring and export lines is often a result of missing expertise in moored and subsea arrangements, lack of maintenance, and poor seabed/mooring interface design. Design efforts to minimize chafe include understanding line interface geometry through the complete range of device motions, and selecting line protection and maintenance intervals to mitigate known areas of concern.

Anchors

Anchor failures may result from a wide range of complications (Table 4).

Table 4 Anchor failures and mitigations

Anchor Type	Anchor Failure Mode	Mitigation
Drag embedment, Pile	Dragging	• Designing with accurate mooring loads
Drag embedment, Plate, Pile	Incomplete embedment or penetration	• Designing with accurate geotechnical input and anchor design • Pull Test Plan to develop the required embedment and penetration • Documented penetration data during installation • ROV or instrument verification of as-installed anchor position and elevation
Drag embedment, Pile	Bottom current scour exposes anchor	• Regular maintenance survey • Scour protection mats and material
Plate	Dragging	• Designing with accurate mooring loads • Corrosion management for sub-bottom hardware
Deadweight	Uplift and dragging	• Designing with accurate mooring loads • Designing with accurate anchor material properties

Export Cable and Flowline Failure

Subsea electrical cables and seawater flowlines are high-value components in a Test Center and require special treatment for long-term protection.

Moisture, Corrosion

Failed cable splices and damaged sheathing are key sources of electrical cable failure. Cable material selection and installation contracting by known specialty contractors is one mitigation for these failures.

Flowlines are susceptible to corrosion and erosion. Design and material selection care should be applied to pipe flow systems and corrosive areas of two-phase flow.

Fatigue

Terminations of dynamic of cables and flowlines are susceptible to extreme fatigue conditions. Cables and flowline internal construction must also be designed for the special fatigue environments of the mid-water span from a floating device to the seabed. Dynamic cables and flowlines may be numerically modeled to provide a basis for fatigue life estimates.

Scour, Strumming and Abrasion

Scouring of seabed export lines can expose the lines to mooring and biological damage. Exposed spans of line between bathymetric high points can lead to line strumming, abrasion at the touchdown points, and lowered fatigue life. The following export line armoring and burial methods are used to mitigate these hazards:

- Conduit casing.
- Deadweight mats.
- Sub bottom burial.
- Gravel berm burial.

Vessel Allision

The risks of a vessel striking a stationary installation (allision) are largely managed by the Test Center through notifying the marine community of new restrictions to formerly navigable waters, and through monitoring the site using methods such as AIS, cameras, acoustic instruments, and shore radar.

Device developers must be required to include navigational aids such as lights, radar reflectors, and AIS transmitters in device designs.

Project Vessels

Vessels alliding with moored devices is a common source of device and mooring damage. These events are possible during installation, servicing, and recovery, and usually result from:

- Operations in excessive weather conditions.
- Inadequate maneuvering capability.
- Poor or incomplete deployment planning.

Allisions by non-project vessels may include vessels in transit or engaged in fishing or recreation.

Commercial Vessels

Commercial vessels in transit are responsive to Notices to Mariners and updated chart annotations. These vessels are often on recurring routes and have the opportunity to become accustomed to new navigation restriction in an offshore Test Center.

The commercial fishing vessel community includes wide variations in the level of resources and care applied to watch standing and new areas of navigational restriction. Multi-national corporations or local artisanal owner-operators may operate these vessels. In general, fishing concerns are less likely to be aware of Notices to Mariners and chart updates. Interest in fishing near the Test Center could develop among local commercial fishing concerns if the Test Center became a known site of fish aggregation. Uninvited fishing vessel mooring to scientific and special-purpose buoys is a common historical concern in the ocean science sector and could contribute to allisions and damage.

Recreational Vessels

Recreational vessels are notoriously unaware of official Notices to Mariners or updates to navigational charts. Watch standing is irregular and new areas of navigational restriction may not be understood or respected. Recreational fishing, diving, and uninvited mooring on devices in the Test Center is a source of allisions and damage that is difficult to mitigate.

Device Collision

A demonstrator drifting at sea after a mooring failure presents a risk of collision with other vessels in transit. This could be a liability for the demonstration device developer and the Test Center. This risk is mitigated through rigorous mooring design resulting from site-specific metocean input and well documented device mooring loads.

Entanglement

Vessel anchor entanglement is the most common risk for moorings and export lines in a Test Center. Entanglement by project vessels during installation, servicing, or removal is the most likely occurrence of this risk. Mitigations include using dynamic positioning, hotboat maneuvering, and careful planning of temporary works.

Cetaceans and Plankton Sharks

Concern over entanglements by cetaceans, basking sharks, and whale sharks is commonly raised in planning a moored buoy Test Center. These species are known to suffer entanglements with fishing gear. Test Center device moorings are likely to be larger diameter lines with fewer entrapment features than a fishing system, but the likelihood of large marine animal entanglement with new and unusual renewable device moorings is currently unclear.

Trawl Gear

Fishing trawl gear is very likely to entangle device moorings and structures in a Test Center. Such an event would damage both demonstrator and fishing gear and would only occur under a navigational misunderstanding by the fishing vessel.

Survey Gear

Survey streamers and towed systems could easily become entangled in Test Center demonstrator systems. These survey systems would likely be associated with Test Center data collection of sidescan, subbottom, seismic, magnetomer or acoustic data. The primary mitigation of this risk is to provide georeferenced as-built drawings of all tenant and Test Center installed hardware to survey contractors. Survey plans and proposed tracklines should be submitted to the Test Center for review in advance of the data collection.

Attachment 11-11: Benchmarking: UK Wave Hub, Camp Rilea and BIMEP

Representatives from the United Kingdom's "UK Wave Hub" visited the CalWave team and the conceptual wave energy test site location at VAFB over several days.

UK Wave Hub presented information on a wide variety of aspects of their existing wave energy test facility in Cornwall, UK including permitting and technical design elements, operational and management strategies, and critical lessons learned based on their development, construction, and operational experiences over a twelve-year timeline.

The Commercial Director from the UK Wave Hub testing facility presented material on a variety of information regarding the Wave Hub facility including lessons learned, its historical timeline, permitting obstacles, technical design considerations and construction challenges, the operations and maintenance procedures of the facility, its WEC developer contracting/berthing lease and power purchase agreement models, and risk mitigation strategies and insurance structures. Much of this information is still being internalized and considered by the CalWave team and it is likely that future reports will incorporate further lessons learned from this initial consultation visit. The UK Wave Hub commercial director which highlights many, but not all, of the topics covered. Below is an outline of the presentation (attached):

Wave Hub Presentation

- Wave Hub History (2003 First Project Review – 2011 Site Open)
- Site Overview
- Original Drivers for Funding and Constructing the Facility
- Infrastructure and Installation Funding Sources
- Initial Installation Management
- The Business Case for the Facility/Economic Impact
- Current Ownership and Governance

A risk and insurance presentation was given by a UK firm Renewable Risk Advisors and Power Point content are attached:

- **UK Wave Hub Marine Energy Insurance and Associated Risks for Test Sites and Early State Technologies July 2016.**

This presentation covered a variety of risk mitigation and insurance issues including construction and operation issues, submarine cable issues, health and safety concerns, devices lost in transit, impacts from the fishing industry and pleasure craft, commissioning and reliability concerns, and many others; as well as how to reduce this uncertainty, mitigate the risk, and properly insure a project like CalWave. This presentation contained highly specialized risk management information for early state offshore renewable energy technologies which can be directly applied to the CalWave project.

CalWave's Chief Engineer is also Program Manager for the Camp Rilea site in Oregon. His presentation from the Oregon Wave Energy Trust Conference and Hydrovision Conference is attached.

CalWave's electrical engineer with Omega Power Engineers held meetings on May 19, 2016 with Yago Torre-Enciso, Director of Bimep (Biscay Marine Energy Platform, S.A.) and their outside electrical engineer regarding the Bimep project in Spain. This information has been considered while developing the conceptual CalWave^{sm} design. BIMEP provided a power point with additional facility information.

Calwave presentation

Marine energy Insurance and associated risks for test sites and early stage technologies

July 2016

Renewable Risk Advisers

What did marine projects look like to insurers?

=

OR
EVEN

Uncertainty, lack of experience, underfunded projects and poor loss experience → greater cost and more restricted insurance, but opportunity.

Why? What have we seen?

- Issues with cables for offshore renewables in construction and operation;
- Devices lost in transit – towing, sea fastening;
- Impacts from trawlers and pleasure craft;
- Health & Safety concerns;
- Uncertain replacement times;
- Survivability in ocean environment
- (later stage) commissioning and reliability concerns.

How to reduce that uncertainty?

- Planning, budgeting and risk management;
- Factoring in intervention cost and time;
- Understanding weather risks;
- Independent oversight;
- Maximise the “tried and tested”
- Prudent contractual allocation of risk;
- Building partnerships with contractors / suppliers;
- Understanding spares & replacement times

Some key variables

- How schedules, budgets, design & methods affect risk, insurance availability and cost…
- … and contractor and supplier selection & input, & spares and replacement strategies?
- Key concerns? Transit, cables, PTO equipment, lost revenue, breakdown, liability …?
- Critical risk management measures … contingency planning, cable protection, interface management, extreme weather modes?

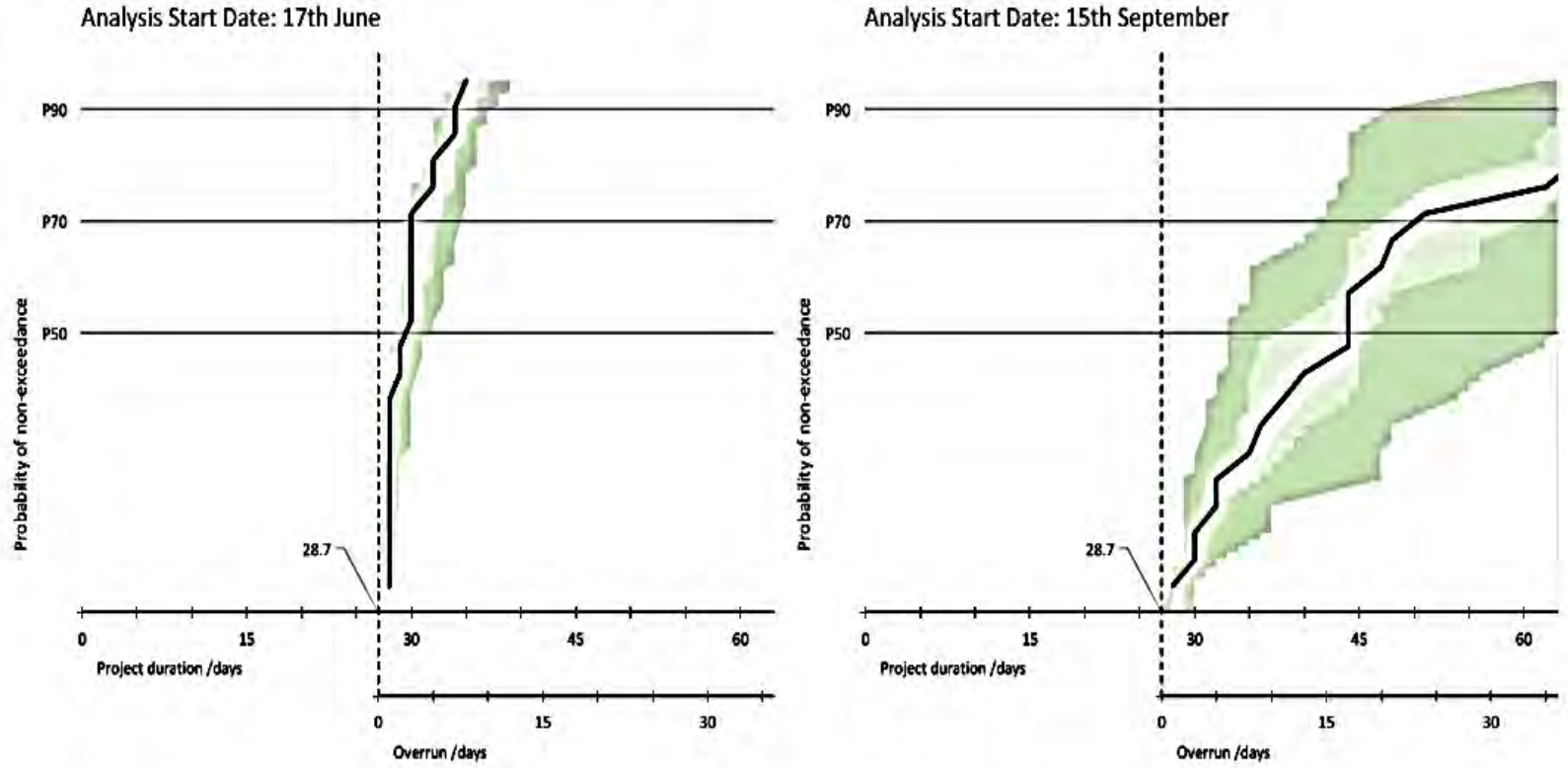
What due diligence is needed?

- Variable sub size and perception of risk;
- Marine Warranty Surveyor?
- Moorings, seaworthiness and deployment risk analysis
- Debris removal cost analysis
- More? NB: Allow time for iterative process with insurers.

A Note on Weather delay risk analysis:

Analysis Results

Probability of non-exceedance	Days overrun (Start date1: 17th June)	Days overrun (Start date 2: 15th Sept.)
50%	2.2	17.0
70%	3.2	20.3
90%	6.6	52.9



What cover might a test site itself need?

- Third party liability insurance
- Specialist Employers / Workers' Comp
- Removal of Wreck insurance
- Goods in transit to site;
- Cover for assets in construction and operation
- Loss of revenue / contingent business interruption
- Plus vetting contractors' insurances.

What insurance should clients be required to hold?

- Third party Liability, including to test site assets
- Removal of wreck
- Other legally required covers including EL / WCA
- Others, replacement cost etc.optional
- Minimum suite of contractor insurances: Hull, Protection & Indemnity and as above;

(useful to recommend local brokers).

Any questions?

Michael Bullock
mjb@renewablerisk.com
+44 7584 572 070

Renewable Risk Advisers

Attachment 11-12: Risk Management

Leidos provided the CalWave risk management approach that integrates risk, configuration control and contingency management. The approach is a foundation of complex acquisition programs.

Approach to Project Risk Management

Effective risk management will be critical to the success of the CalWave Program and the facility to be constructed. This planning will require close attention to current risk, vigilance to emerging risk, constant monitoring of risk, and the contingency against that risk.

The CalWave Program Team intends to use recognized and accepted techniques and analyses in our approach to risk management. The CalWave Program Risk Management Plan (RMP) will be fully developed during Phase III and will be based on a critical process approach to identify, assess, analyze, and track risk throughout the project.

The CalWave Program Team has made an initial effort to link identified risk elements to the WBS (see CalWave Program Risk Register). The Team intends to conduct a risk workshop early in Phase III to review and refine this preliminary Risk Register and lay the groundwork to complete the final RMP.

Risk Management Plan

The final RMP will build on this preliminary register and will include the following:

- Methodology
- Roles and Responsibilities
- Budgeting for Identified Risks
- Timing
- Risk Categories
- Definitions of Risk Probabilities and Impact
- Probability and Impact Matrix
- Stakeholders' Risk Tolerances
- Risk Reporting Processes
- Risk Tracking Processes.

The following outline was used to provide the framework for a bottom-up risk and contingency estimate tied to the Draft Program WBS. The preliminary Risk Register shows risks that the Team foresees at this time, with risk level, cost estimate, handling strategy, and after-handling risk and costs.

Change Control and the associated Configuration Control will be vital. Changes will be managed in accordance accepted program and project management practices and DOE guidelines. The CalWave Program team will implement Change Control supports Configuration Management, Contingency Management, Risk Management and Quality Control.

Risk Management Plan Outline (to be fully developed in Phase III)

1.0 Introduction

2.0 Project Summary

3.0 Definitions

3.1 Risk Probabilities - the probability of a particular risk occurring is divided into four levels: Very Unlikely, Unlikely, Likely, Very Likely. Each identified risk item is assigned a probability of occurrence: Very Unlikely: 10% chance of occurrence; Unlikely: >10, but <40% chance; Likely: >40%, but <80% chance; Very Likely: 80% chance of occurrence.

3.2 Risk Consequences - the consequence to the project of any risk occurring is divided into the following five levels:

- Negligible - Having minimal or no consequence
- Marginal - Small consequence, minor redesign, cost estimates marginally exceed budget (<5% increase)
- Significant - Significant impact, some redesign, cost estimates significantly exceed budget (5%–10%), significant schedule slip
- Critical - Technical goals cannot be achieved, serious threat causing major redesign, cost estimates exceed budget by 10%-15%, excessive schedule slip
- Crisis - Project cannot be completed within scope, cost, or schedule constraints; cost estimates unacceptably exceed budget (>15%); catastrophic threat to project, environment, or people.

3.3 Risk Level Matrix - The Risk Level Matrix (Figure 11-12-1) gives a qualitative level of risk associated with each combination of probability and consequence.

Probability	Consequence				
	Negligible	Marginal	Significant	Critical	Crisis
Very Likely	Low	Moderate	High	High	High
Likely	Low	Moderate	High	High	High
Unlikely	Low	Low	Moderate	Moderate	High
Very Unlikely	Low	Low	Low	Moderate	High

Figure 11-12-1: Risk Level Matrix

3.4 Handling Strategies - handling strategies can have the following effects on risk level:

- Accept - No effect on risk level - the project accepts the risk level as is, but takes steps to reduce costs.
- Reduce - Risk is reduced - the project handling strategy will reduce this risk by one level (high becomes moderate; moderate becomes low).
- Transfer - Risk is transferred to another part of the project or away from the project altogether.
  At present, no risks are transferred in the Risk Register.

3.5 After-Handling Risk Level - After-handling risk level is defined as the risk level for a particular risk after handling strategies have been applied.

3.6 After-Handling Cost Estimates.

- Best Case - all events occur perfectly, and the risk results in zero impact to the project. This case is unrealistic.
- Expected Case - this is the CalWave Program assessment of the expected outcome, assuming that the handling strategy has been moderately effective.
- Worst Case - this is the cost estimate for a risk item, assuming that handling strategy has no effect. This measure is not always assigned a zero probability.

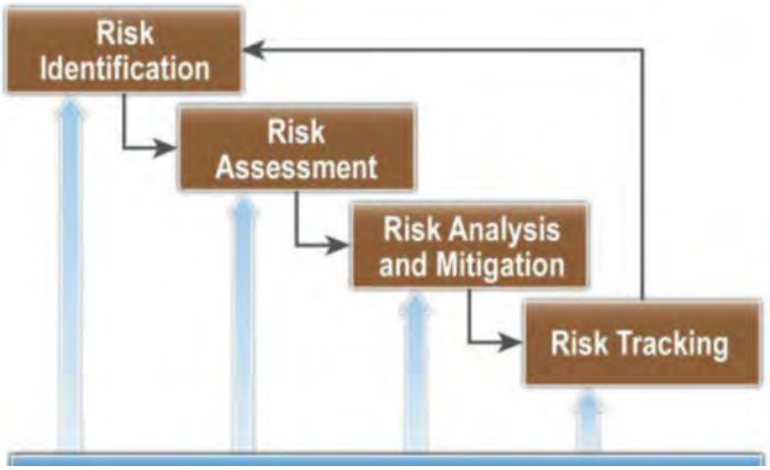


Figure 11-12-2: Risk Management

4.0 Risk Management Strategy and Approach

4.1 Risk Strategy Overview - The CalWave Program Team will use a Critical Process Approach to identify, assess, analyze, and track risks. Figure 11-12-2 summarizes this process, which will involve an initial effort to identify and assess project risk through all phases, analyzing risks for scope, cost, and schedule implications; identifying and analyzing handling strategies; and tracking risks to update current risks and proactively identify emerging risk areas.

As the CalWave Program progresses, we expect some risk areas to retire and new risks to emerge. Full awareness of current risk and vigilance to emerging risk are keys to the success of the project.

4.2 Organization - The PM has overall responsibility for risk management. The PM uses the knowledge and experience of the entire team, and collaborative relationships to identify current and emerging risk areas, quantify risk, and identify handling strategies and expected outcomes.

During development of the RMP, the PM may delegate responsibility for some elements of plan development or risk management to other team members. The PM will remain the single point of contact for risk management, will interface directly with DOE and oversight entities, and will retain overall responsibility for risk and contingency management throughout the project.

5.0 Risk Management Process and Procedures - Risk and contingency management will proceed in accordance with CalWave Risk and Contingency Management Process, using standard risk management methods.

5.1 Risk Planning - During Phase III, as part of the Risk Workshop, the team will re-evaluate the preliminary register for completeness; add or remove risks, as appropriate; conduct more detailed evaluations of identified risks for cost and schedule impact; and update the Risk Register and RMP. The Team expects to engage a third-party risk management consultant to assist with this workshop.

5.2 Risk Assessment - Level and Consequence - Based on DOE guidance, program/project management best practices, team experience, and risk history of similar projects, the team will identify and assign to likely risk areas a before-handling risk probability and worst-case cost consequence based on the categories defined in RMP section 3.

5.3 Cost Assessments - Initial cost estimates for risks are based on either estimates of project burn rates for delays (primarily, personnel and administrative costs) or estimates of costs, based on the experience of similar projects.

5.4 Schedule Assessments - Schedule risks are incorporated into this preliminary plan by converting schedule into cost. The plan addresses schedule risks as additional costs associated with delays.

5.5 Risk Phasing - All risks must be tied to the project WBS at the lowest practicable level, while keeping the number of risks manageable. In some cases, risks may be assigned at high WBS levels and later refined to lower levels.

It is expected that risks will retire and new risks will emerge, as the project moves through various phases. For example, risks associated with design in Phase III will retire as the project moves into Phase IV and beyond.

The initial Risk Register will attempt to account for risks across all phases, but likely will not anticipate emergent risk areas.

5.6 Risk Monitoring - The program management team will meet at least quarterly throughout the program and supporting projects to assess and update current-phase risks; retire risks, as appropriate; review and update risks in upcoming phases; and identify, evaluate, and incorporate emerging risks. Cognizant DOE personnel will be invited to attend these risk monitoring reviews, either in person or by teleconference/web conference.

5.7 Risk Management Documentation and Reports - The two primary project risk management documents will be the final the RMP and the Risk Register. Overall responsibility for these documents rests with the PM. The PM may designate another member of the project team to help manage the RMP. Document archive and version control will be the responsibility of the PM.

At the conclusion of each Quarterly Risk Review, the project will issue an updated Risk Register, noting retired and emergent risks, and update the RMP. These will be submitted to DOE and the CalWave Oversight Council and circulated within the program.

How Project Changes will be Handled

Changes will be managed in accordance accepted program and project management practices and DOE guidelines. The CalWave Program team will implement Change Control that supports both Contingency Management, and Risk Management.

Change Control and Contingency Management Plan (C^3MP)

Effective management of changes in scope, schedule, cost, and quality are linked and are keystones of successful program and project management. CalWave will leverage our Risk Management, Contingency Management and Configuration Management to accomplish Change Control.

Figure 3-8 illustrates the CalWave Program Team's conceptual framework for managing contingency with risk management and configuration control.

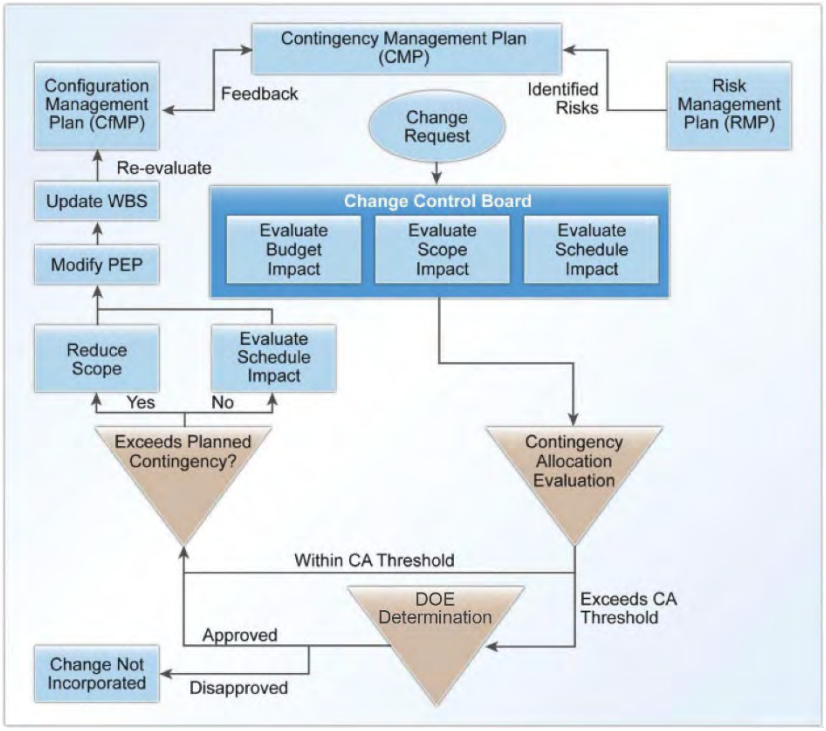


Figure 11-12-3: Contingency Management Framework

Each of the three elements plus quality informs the others, and the system controls scope, cost, and schedule. Contingency will be managed in accordance with accepted program project and management practices and DOE guidelines.

The CalWave Program Team expects contingency to follow the arc of the entire program and supporting project, with establishment of contingency in schedule and cost in Phase 3.0, based on the Risk Management Workshop.

As the project moves into Phases 4.0 and 5.0, contingency will be used to mitigate identified risks as they arise and to handle emergent risks.

Likely, the program will manage contingency in two parts:

1. Contingency against risk for the entire project, which will include risk elements common to all CalWave Test Berths

2. Separate, smaller contingency margins for each individual CalWave Test Berth, which are identified as Scope Margin. In this way, contingency against configuration changes for additional features will not be expended too early in the project

As the project reaches delivery for each CalWave Test Berth, unexpended contingency may be used to reduce downstream risks for operations and maintenance.

As the CalWave Program progresses, a Risk Reduction Opportunity matrix will be established that tracks and prioritizes these opportunities. If and when contingency funds are available, the team may elect to take advantage of these opportunities to reduce downstream risks or add deferred features.

As risks are retired, inclusion of the additional features may be possible, such as the NREL Grid Emulator.

Configuration Management Plan

The *Configuration Management Plan* (CfMP) describes guidelines for management of changes in the facility configuration that may affect cost, schedule, and performance during the CalWave Program.

The details of the plan's control of CalWave configuration changes will be described in the final PEP for the CalWave Program during Phase 3.0. Generally, configuration management will follow program phases. The plan's requirements are:

- Phase 3: Permitting, including Preliminary Design and Final Design - Early in Phase 3, a preliminary configuration management system will be implemented to control and document changes to CalWave configuration during design. This likely will be an informal process but will include documenting requests for change; publishing minutes of design review meetings; documenting changes to the CalWave specifications, test reports, and project memos; documenting specific decisions; and documenting other necessary information to provide an accurate, well-documented history of design development.
- Phase 4: Construction - It is expected that changes to specifications, contract, or drawings made during Phase 3 will result from bidders' questions and value engineering. It is likely that these changes will apply to contract language only and will not affect the facility configuration. These changes will be documented in contractual documents and managed by CalWave as part of the solicitation and contracting process.
- Phase 5: Test - It is expected that changes to specifications, contract, or drawings made during Phase 5 will result from needs determined during the testing program and will be associated with test instrumentation.
- Phase 6: Operations - It is expected that changes to specifications, contract, or drawings made during Phase 6 will result from needs determined during the operational employment of the site and will be associated with the balance between CalWave equipment and services, in contrast with equipment and services that will be the responsibilities of the WEC developers.

Change Control Board (CCB)

The CalWave Program Team envisions a three-level change approval process to apply the correct levels of delegation, control and oversight.

- Low level changes below a to-be-determined (TBD) dollar amount, preliminarily $10K, will be delegated to the CalWave PM for approval
- Medium-level changes above TBD ($10K prelim.) and below TBD ($50K prelim.) will require approval by the PM and Change Control Board (CCB)

- High-level changes (above TBD; $50K prelim.) will require approval by the PM, CCB, and DOE. All changes will be prepared, estimated, and negotiated by the EPC and then moved through the configuration control system, as appropriate, to the level of change requested

The CCB will be established early in Phase 3.0, shortly after contract award. The CCB is envisioned to be comprised of one representative from the CalWave Consortium, one representative from the NREL, and one consultant from outside the CalWave Program with appropriate experience, and the PM. The PM will call meetings, chair the meetings, and publish minutes. After the modifications are approved, the authorized Contracts Representative will execute contract modifications.

Approach to Quality Assurance/Control

Quality Assurance (QA) and Quality Control Plan

QA will be a clearly defined contract requirement for the EPC and will be developed with other terms for the contract during Phase 3.0. If extraordinary quality is expected in some aspects of the construction, such as submarine cable connectors, the EPC contract will clearly state these specific requirements. If not otherwise explicitly stated in the specifications or contract, normally applicable EPC guidelines will apply, including engineering society standards and International Electrotechnical Commission (IEC) standards. Quality-related references routinely will be used in many areas of the specifications, drawings, and the eventual contract.

How Communications Will Be Maintained Among Project Team Members

Communications between all persons actively involved in the CalWave Program will be facilitated by strong working relationships and a spirit of teamwork and aided by modern technology, especially video and Internet conferencing. Content and schedule for required deliverables and reports for each phase will be specifically defined across the program, and within specific projects.

Within Phases 3.0 and 4.0, we expect to prepare the information and materials essential to successfully progress through in-depth CDR, PDR, and FDR milestones. This will include, at each review, an updated PEP.

An essential deliverable for completing the PDR milestone will be an up-to-date analysis of feasibility and costs associated with acquiring the submarine cables and chartering installation vessels.

During Phase 4.0 (Construction) and Phase 5.0 (Test) we expect to:

- Hold higher-level Program Team videoconference calls at a fixed time, weekly
- Hold more detailed Construction Project Team videoconference calls at a fixed time, weekly
- Hold more detailed Test Project Team videoconference calls at a fixed time, weekly
- Hold more detailed budget videoconference calls at a fixed time, weekly
- Submit end-of-week program summary reports
- Hold SOC telephone conferences monthly and as needed
- Require EPC project office reports weekly
- Compile invoices monthly
- Hold event-specific meetings with suppliers/EPC, such as quarterly management reviews.

Phase 6.0 (Operations) reporting will follow major milestones.

Attachment 11-13: Cost Estimating

Cost estimating efforts focused on the Primary Site, and the Conceptual Design of the South Base Configuration Baseline, near Vandenberg Dock. Refinements were made as the Preliminary Design Stage was initiated. Cost comparisons were used to estimate the alternatives.

- Cost estimating during the Feasibility Study collected best estimates.
- In the Conceptual Design Stage, the estimates were adjusted as more was learned about the geophysical, geotechnical and bathymetric influences on Horizontal Directional Drilling and submarine power cable.
- Multiple estimating methods were used.
- As we initiated the Preliminary Design Stage, Omega Power Engineers developed an estimate of costs based on key vendor estimates and an independent input from Cal Poly.
- Both quantitative and qualitative inputs were considered.

Findings:

1. The most tangible, quantitative input is that the major cost drivers will depend on the results of detailed bathymetry, and geophysical and geotechnical surveys. In particular the distance from the shore landing to the "daylight" spot in 10 to 12 meters depth and the hardness of substrate material.
    a. These surveys are the critical path in the next phase.
2. The most consistent qualitative input is the high degree of uncertainty for submarine cable cost and related expenses for logistics and installation.
    a. Most qualified cable manufacturers are foreign entities.
    b. Most cable installation ships are foreign-flagged.
    c. The market is active, so cable manufactures resist providing quotes until the requestor has a funded project.
3. The CalWave Team considers the following estimates to be realistic at the ROM level of estimating. The estimates are believed to be accurate at a rounding level of $100K.
    a. "Accuracy" does not imply precision on a program that is in the early Preliminary Design.
    b. "Precision", such as several decimal places, does not imply accuracy in an early stages

Summary:

Primary Site – South Base with Shore Station at Surf (40MW):

- The CalWave Team preliminary cost estimate of the baseline configuration is $82M.

Primary Site – South Base with Shore Station at Surf (40MW):

- The CalWave Team preliminary cost estimate of the modified baseline configuration is $79M.

Alternate Site – Platform Irene with Shore Station at Surf (25MW):

- The CalWave Team conceptual cost estimate of the platform configuration is $75M.

Basis of Estimates: Primary Site – South Base with Shore Station at Surf (40MW):

The cost estimates have consistently shown a Rough Order of Magnitude (ROM) cost of the CalWave Conceptual Baseline (South Base Configuration) to be $82M with four (4) years from initiation of Phase 3 (Permitting) through Construction, Test and Certification. A cost factor is access through Base Security.

Source of requirements			CalWave Conceptual Baseline South Base Configuration
Level of implementation			Preliminary Estimates
Basis of Design			Design to Concept
Planned Period of Performance (60 months)			Mar 2017 to March 2022
Initial Operating Capability with 1 Berth (IOC)			September 2021
Full Operating Capability with 3 berths (FOC)			November 2021
Enhanced Operating Capability with 4 berths (EOC)			February 2022
Berths			4 Berths
Cables			5 Cables 4 plus Spare Bore & Cable
HDD Bores			5 HDD Bores (15,473 ft)
Cable Length (total)			Cables (16 miles)
Excavation BOE			Full Excavation
Shore Station BOE			Full Shore Station
Addequate Space			
			Modular Buildings
Operating Voltage/System Rating			35 kV Operating/35 kV System
Export Voltage(s)			12 kV & 70kV Export
70kV Features			70 kV Substation
Capacity per Cable (MW)			up to 10 MW per cable at 35kV
System Capacity (MW)			40 MW
Upgrade paths			Upgrade path to 50MW
Facility Life-Span			30 years
Remobilization Requirements for Full Capability			No Remobilization
CONSTRUCTION COSTS (ROM)			$59.00
NON-CONSTRUCTION COSTS SUB-TOTAL (ROM)			$22.70
TOTAL COST: Preliminary Stage – Pre PAD (ROM)			$82M
			CalWave Conceptual Baseline South Base Configuration
Initial Operating Expenses (ROM)			
First Two Years Operations			**$5M**

Table -11-13-1

Primary Site – South Base with Shore Station at Surf (40MW): Moving the offices to Surf will save costs by reducing access time and will add costs for remote operation. Estimated cost: $79M.

Alternate Site – Platform Irene with Shore Station at Surf (25MW): Using the existing 25MW cable from Platform Irene to Surf save costs for cables, HDD and marine operations. Adapting the South Base Configuration to the Platform Configuration will require engineering and permitting. Expanding the Surf Substation and adapting designs for platform weight and structural limits will add costs. Moving the offices to Surf saves cost by reducing access time. Will add costs for remote operation. Adherence to electrical design standards for offshore (safety critical) installations will add cost. Estimated cost: $75M.

See Comparison Table in Attachment 11-13-1

See Basis of Estimate Workbook in Attachment 11-13-2

See Construction Cost Estimate in Attachment 11-13-3

See Phase 1 Report in Appendix 1 (Summary Table below).

CalWave Phase 1 Summary of ROM Estimated CalWave Costs through Construction (Costs in $1,000s)

Alternative	Platform Irene Alternative	South Base Conceptual Baseline	Cost Difference (PI minus South Base)
Permitting[a]:			
Field Studies	$2,350	$2,350	$0
Obtain Permits	$1,200	$1,200	$0
Compliance Plans and Monitor Construction	$450	$450	$0
Subtotal Permitting	$4,000	$4,000	$0
Stakeholder Engagement/Public Involvement:	$1,600	$1,600	$0
Engineering:			
Preliminary Engineering (for planning, permitting, surveys)	$2,000	$1,400	$600
Final Engineering Design including RFPs and bid review	$4,000	$3,100	$900
EPC Design and Construction Management	$9,000	$6,500	$2,500
System Integration, Test, and Validation	$1,400	$1,000	$400
Subtotal Engineering	$16,400	$12,000	$4,400
Construction:			
Shore Station (Civil, Electrical, Network, Architecture)	$6,000	$14,600	-8,600
Horizontal Directional Drill	$0	$3,000	-3,000
Subsea Cabling	$10,000	$12,000	-2,000
Marine and Cable Construction	$23,000	$22,000	1,000
Fees	$11,000	$13,400	-2,400
Subtotal Construction	$50,000	$65,000	-$15,000
Total	**$72,000**	**$82,600**	**-$10,600**

Source of requirements			CalWave Conceptual Baseline South Base Configuration	CalWave Modified Baseline South Base and Surf	CalWave Platform Configuration with Surf Substation and Offices
Level of implementation			Preliminary Estimates	Preliminary Estimates	Conceptual Estimates
Basis of Design			Design to Concept	Design to Concept	
Planned Period of Performance (60 months)			Mar 2017 to March 2022	Mar 2017 to March 2022	
Initial Operating Capability with 1 Berth (IOC)			September 2021	September 2021	
Full Operating Capability with 3 berths (FOC)			November 2021	November 2021	
Enhanced Operating Capability with 4 berths (EOC)			February 2022	February 2022	
Berths			4 Berths	4 Berths	4 Berths
Cables			5 Cables 4 plus Spare Bore & Cable	5 Cables 4 plus Spare Bore & Cable	5 Cables 4 plus Spare J-Tube & Cable
HDD Bores			5 HDD Bores (15,473 ft)	5 HDD Bores (15,473 ft)	n/a
Cable Length (total)			Cables (16 miles)	Cables (16 miles)	Cables (4 miles)
Excavation BOE			Full Excavation	Full Excavation	Surf Substation Expansion
Shore Station BOE			Full Shore Station	Split Shore Station	Split Shore Station
Adequate Space					
			Modular Buildings	Modular Buildings	Modular Buildings
Operating Voltage/System Rating			35 kV Operating/35 kV System	35 kV Opearting/35 kV System	Platform Voltage
Export Voltage(s)			12 kV & 70kV Export	12 kV & 70kV Export	Platform Export Voltage (~25kV)
70kV Features			70 kV Substation	70 kV Substation	
Capacity per Cable (MW)			up to 10 MW per cable at 35kV	up to 10 MW per cable at 35kV	up to 10 MW per cable at 35kV
System Capacity (MW)			40 MW	40 MW	~25 MW
Upgrade paths			Upgrade path to 50MW	Upgrade path to 50MW	Possible upgrade path
Facility Life-Span			30 years	30 years	Platform Life
Remobilization Requirements for Full Capability			No Remobilization	No Remobilization	
CONSTRUCTION COSTS (ROM)			$59.00	$56.50	$42.40
NON-CONSTRUCTION COSTS SUB-TOTAL (ROM)			$22.70	$22.40	$32.70
TOTAL COST: Preliminary Stage – Pre PAD (ROM)			$82M	$79M	$75M
			CalWave Conceptual Baseline South Base Configuration	CalWave Modified Baseline South Base and Surf	CalWave Platform Configuration with Surf Substation and Offices
Initial Operating Expenses (ROM)					
First Two Years Operations			**$5M**	**$5M**	**$8M**

			CalWave Conceptual Baseline South Base Configuration	CalWave Modified Baseline South Base and Surf	CalWave Platform Configuration with Surf Substation and Offices
Cost Basis in 2016 US$M			US$ Millions	US$ Millions	US$ Millions
Site Civil: Excavation & Foundations	Year 3		$0.20	$0.20	$0.10
Site Architectural: Offices & Security	Year 4		$0.25	$0.25	$0.30
Site Systems: Networks/Control/Telemetry	Year 4		$0.10	$0.10	$0.20
Site: Electrical Facilities	Years 3-4		$14.00	$12.00	$18.00
Horizontal Directional Drill ~16,000 ft	Year 3	393	$6.10	$6.10	$0.00
HDD Marine Operations	Year 3		$1.40	$1.40	$0.00
Subsea Cabling: 5 cables @3.2nm=16 nm	Year 3		$7.00	$7.00	$2.80
Cable Installation & Marine Operations and	Year 3		$12.45	$12.45	$4.00
Sub-Total Construction Costs			$41.50	$39.50	$25.40
Risk, Contingency & Configuration Tradeoffs-Top Level		$5.00	$8.00	$8.50	$9.00
HDD Ops Reserve	Years 3-4	$0.50			
HDD Marine Ops Reserve	Years 3-4	$0.50			
Subsea Cable Cost Reserve	Years 3-4	$1.00			
Cable Installation and Marine Operations Reserve	Years 3-4	$1.00			
Remoted Operations Reserve	Years 3-4	$0.50			
Platform Transportation Reserve	Years 3-4	$1.00			
Platform Engineering Reserve	Years 3-5	$1.00			
Surf Substation Reserve	Years 3-6	$1.50			
Performance Bond ~1%			$0.50	$0.50	$0.50
Engineering Procurement Construction 20% to 25%			$9.00	$8.00	$7.50
CONSTRUCTION COSTS SUB-TOTAL (ROM)			$59.00	$56.50	$42.40
NON-CONSTRUCTION COSTS SUB-TOTAL (ROM)			$22.70	$22.40	$32.70
TOTAL COST: Preliminary Stage – Pre PAD (ROM)			$82M	$79M	$75M
			CalWave Conceptual Baseline South Base Configuration	CalWave Modified Baseline South Base and Surf	CalWave Platform Configuration with Surf Substation and Offices
Initial Operating Expenses (ROM)					
First Two Years Operations			**$5M**	**$5M**	**$8M**

			CalWave Conceptual Baseline South Base Configuration	CalWave Modified Baseline South Base and Surf	CalWave Platform Configuration with Surf Substation and Offices
Program Management & Operations			$6.28	$6.00	$7.50
Grant and Contract Administrator	Years 1-5	$2.00			
Office Space	Years 1-5	$0.10			
Project Development	Years 1-5	$0.75			
Program/Project Management	Years 1-5	$1.50			
Site Staffing (Core) Years 4 and 5	Years 4-5	$0.90			
Risk and Contingency Management Program	Years 1-5	$0.20			
Configuration Control Program	Years 1-5	$0.20			
Economic Analysis Support	Years 1-5	$0.18			
Risk Management Support	Years 1-5	$0.15			
EPRI: Program/Project Management Support	Years 1-5	$0.30			
Engineering (ROM)			$7.00	$7.00	$11.50
Preliminary Engineering	Years 1-3	$1.15			
Owner's Engineer (Final Design)	Years 4-5	$0.60			
Arch/Civil/CMgmt Support	Years 1-5	$1.00			
Electrical Engineering	Years 1-5	$0.45			
PG&E: Engineering Support	Years 1-5	$0.60			
NREL Facility Design Support	Years 1-3	$0.25			
NREL Test Operations Planning Support	Years 1-3	$0.35			
NREL Test Engineer and Test Technician	Years 3-5	$1.35			
NREL Commissioning and Certification	Years 4-5	$0.35			
NREL Test Bus/GridSimulator/Support	Years 1-5	$0.20			
EPRI Power Quality	Years 1-5	$0.20			
Sandia: Reference Model/WECSim Support	Years 1-5	$0.25			
EPC Consultant Support	Years 1-5	$0.25			
Platform Engineering	Years 1-5	$2.00			
Platform Access	Years 1-5	$1.50			
Platform Consultant	Years 1-5	$1.00			

			CalWave Conceptual Baseline South Base Configuration	CalWave Modified Baseline South Base and Surf	CalWave Platform Configuration with Surf Substation and Offices
Geotechnical/Geophysical/Bathymetric (ROM)			$2.30	$2.30	$2.80
Near-shore Bathymetry	Year 1	$0.35			
Shore-side Geotech/Geophysical	Year 1	$0.40			
Offshore Geotech/Geophysical/Bathymetry	Year 1	$0.50			
Scripps: Wave Measurement: 1 buoy 4 yrs	Years 1-4	$0.25			
Wave Resource Analytics	Years 1-5	$0.80			
Platform Conditions and Resource Monitoring	Years 1-4	$0.50			
Permitting & Environmental (ROM)			$5.25	$5.25	$8.25
Field Studies	Years 1-2	$2.50			
Obtain permits	Years 1-2	$1.50			
Compliance & Monitoring	Years 1-5	$0.25			
Marine Science Support	Years 1-5	$0.35			
Marine Environmental Support	Years 1-5	$0.25			
EPRI: Adaptive Management	Years 1-5	$0.40			
Platform Studies and Permitting	Years 1-5	$3.00			
Stakeholder & Outreach (ROM)			$1.85	$1.85	$2.60
Stakeholder Program	Years 1-5	$1.75			
EPRI: Outreach Support	Years 1-5	$0.10			
Additional Stakeholder Work - Platform	Years 1-5	$0.75			
NON-CONSTRUCTION SUB-TOTAL (ROM)			$22.70	$22.40	$32.70
TOTAL Estimate - Preliminary - Draft PAD			$82M	$79M	$75M
			Rough Order of Magnitude	**Rough Order of Magnitude**	**Rough Order of Magnitude**

	CalWave Conceptual Baseline South Base Configuration	CalWave Modified Baseline South Base and Surf	CalWave Platform Configuration with Surf Substation and Offices
Initial Operating Expenses (ROM) First Two Years Operations	**$5M**	**$5M**	**$8M**

Initial Operating Expenses (ROM)

First Two Years Operations			$5M	$5M	$8M
Core Staff: Site Dir, BusMgr, SiteEng, Admin, Supplies, Services	Years 6-7	$1.30			
On-Call Staff: ProjDev; OpsMgr; ElecTechs	Years 6-7	$1.00			
PG&E: Engineering Support	Years 6-7	$0.20			
NREL Detachment: Test Eng/Test Tech + Remote Support	Years 6-7	$1.50			
EPRI Detachment: DepPM; Power Quality; Adaptive Mgmt	Years 6-7	$0.50			
Sandia Detachment: Analytics Support	Years 6-7	$0.50			
Marine Transportation	Years 6-7	$1.00			
Marine Operations	Years 6-7	$2.00			

Source of requirements			CalWave Conceptual Baseline South Base Configuration
Level of implementation			Preliminary Estimates
Basis of Design			Design to Concept
Planned Period of Performance (60 months)			Mar 2017 to March 2022
Initial Operating Capability with 1 Berth (IOC)			September 2021
Full Operating Capability with 3 berths (FOC)			November 2021
Enhanced Operating Capability with 4 berths (EOC)			February 2022
Berths			4 Berths
Cables			5 Cables 4 plus Spare Bore & Cable
HDD Bores			5 HDD Bores (15,473 ft)
Cable Length (total)			Cables (16 miles)
Excavation BOE			Full Excavation
Shore Station BOE			Full Shore Station
Addequate Space			
			Modular Buildings
Operating Voltage/System Rating			35 kV Opearting/35 kV System
Export Voltage(s)			12 kV & 70kV Export
70kV Features			70 kV Substation
Capacity per Cable (MW)			up to 10 MW per cable at 35kV
System Capacity (MW)			40 MW
Upgrade paths			Upgrade path to 50MW
Facility Life-Span			30 years
Remobilization Requirements for Full Capability			No Remobilization

Cost basis in 2016 US$M			US$ Millions
Site Civil: Excavation & Foundations	Year 3		$0.20
Site Architectural: Offices & Security	Year 4		$0.25
Site Systems: Networks/Control/Telemetry	Year 4		$0.10
Site: Electrical Facilities	Years 3-4		$14.00
Horizontal Directional Drill ($6.08M/15,473 ft) = $393/ft	Year 3	393	$6.10
HDD Marine Operations	Year 3		$1.40
Subsea Cabling: 5 cables @3.2nm=16 nm @ $0.4M/nm	Year 3		$7.00
Cable Installation & Marine Operations and	Year 3		$12.45
Sub-Total Construction Costs			$41.50
Risk, Contingency & Configuration Tradeoffs-Top Level		$5.00	$8.00
HDD Ops Reserve	Years 3-4	$0.50	
HDD Marine Ops Reserve	Years 3-4	$0.50	
Subsea Cable CostReserve	Years 3-4	$1.00	
Cable Installation and Marine Operations Reserve	Years 3-4	$1.00	
Remoted Opeartions Reserve	Years 3-4	$0.50	
Platform Transportation Reserve	Years 3-4	$1.00	
Platform Engineering Reserve	Years 3-5	$1.00	
Surf Substation Reserve	Years 3-6	$1.50	
Performace Bond ~1%			$0.50
Engineering Procurement Construction 20% to 25%			$9.00
CONSTRUCTION COSTS			$59.00

Program Management & Operations			$6.28
Grant and Contract Administrator	Years 1-5	$2.00	
Office Space	Years 1-5	$0.10	
Project Development	Years 1-5	$0.75	
Program/Project Management	Years 1-5	$1.50	
Site Staffing (Core) Years 4 and 5	Years 4-5	$0.90	
Risk and Contingency Management Program	Years 1-5	$0.20	

Configuration Control Program	Years 1-5	$0.20	
Economic Analysis Support	Years 1-5	$0.18	
Risk Management Support	Years 1-5	$0.15	
EPRI: Program/Project Management Support	Years 1-5	$0.30	
Engineering (ROM)			$7.00
Preliminary Engineering	Years 1-3	$1.15	
Owner's Engineer (Final Design)	Years 4-5	$0.60	
Arch/Civil/CMgmt Support	Years 1-5	$1.00	
Electrical Engineering	Years 1-5	$0.45	
PG&E: Engineering Support	Years 1-5	$0.60	
NREL Facility Design Support	Years 1-3	$0.25	
NREL Test Operations Planning Support	Years 1-3	$0.35	
NREL Test Engineer and Test Technician	Years 3-5	$1.35	
NREL Commissioning and Certification	Years 4-5	$0.35	
NREL Test Bus/GridSimulator/Support	Years 1-5	$0.20	
EPRI Power Quality	Years 1-5	$0.20	
Sandia: Reference Model and WECSim Support	Years 1-5	$0.25	
EPC Consultant Support	Years 1-5	$0.25	
Platform Engineering	Years 1-5	$2.00	
Platform Access	Years 1-5	$1.50	
Platform Consultant	Years 1-5	$1.00	
Geotechnical/Geophysical/Bathymetric (ROM)			$2.30
Near-shore Bathymetry	Year 1	$0.35	
Shore-side Geotech/Geophysical	Year 1	$0.40	
Offshore Geotech/Geophysical/Bathymetry	Year 1	$0.50	
Scripps: Wave Measurement (CDIP) one buoy 4 yrs	Years 1-4	$0.25	
Wave Resource Analytics	Years 1-5	$0.80	
Plaform Conditions and Resource Monitoring	Years 1-4	$0.50	

Permitting & Environmental (ROM)			$5.25
Field Studies	Years 1-2	$2.50	
Obtain permits	Years 1-2	$1.50	
Compliance & Monitoring	Years 1-5	$0.25	
Marine Science Support	Years 1-5	$0.35	
Marine Environmental Support	Years 1-5	$0.25	
EPRI: Adaptive Management	Years 1-5	$0.40	
Platform Studies and Permitting	Years 1-5	$3.00	
Stakeholder & Outreach (ROM)			$1.85
Stakeholder Program	Years 1-5	$1.75	
EPRI: Outreach Support	Years 1-5	$0.10	
Additional Stakeholder Work - Platform	Years 1-5	$0.75	
NON-CONSTRUCTION SUB-TOTAL (ROM)			$22.68

TOTAL Estimate - Preliminary Design Stage - Draft PAD	$82

Rough Order of Magnitude

Initial Operating Expenses ROM)			
First Two Years Operations			$5.00
Core Staff: Site Dir/BusMgr/SiteEng/Admin/Supplies/Services	Years 6-7	$1.30	
On-Call Staff: ProjDev; OpsMgr; ElecTechs	Years 6-7	$1.00	
PG&E: Engineering Support	Years 6-7	$0.20	
NREL Detachment: Test Eng/Test Tech + Remote Support	Years 6-7	$1.50	
EPRI Detachment: DepPM; Power Quality; Adaptive Mgmt	Years 6-7	$0.50	

Sandia Detachment: Analytics Support	Years 6-7	$0.50	
Marine Transporation	Years 6-7	$1.00	
Marine Opeartions	Years 6-7	$2.00	

CalWave Modified Baseline South Base and Surf Preliminary Estimates Design to Concept	CalWave Platform Configuration with Surf Substation and Offices Conceptual Estimates
Mar 2017 to March 2022	
September 2021	
November 2021	
February 2022	
4 Berths	4 Berths
5 Cables 4 plus Spare Bore & Cable	5 Cables 4 plus Spare J-Tube & Cable
5 HDD Bores (15,473 ft)	n/a
Cables (16 miles)	Cables (4 miles)
Full Excavation	Surf Substation Expansion
Split Shore Station	Split Shore Station
Modular Buildings	Modular Buildings
35 kV Opearting/35 kV System	Platform Voltage
12 kV & 70kV Export	Platform Export Voltage (~25kV)
70 kV Substation	
up to 10 MW per cable at 35kV	up to 10 MW per cable at 35kV
40 MW	~25 MW
Upgrade path to 50MW	Possible upgrade path
30 years	Platform Life
No Remobilization	

US$ Millions	US$ Millions
$0.20	$0.10
$0.25	$0.30
$0.10	$0.20
$12.00	$18.00
$6.10	$0.00
$1.40	$0.00
$7.00	$2.80
$12.45	$4.00
$39.50	$25.40
$8.50	$9.00
$0.50	$0.50
$8.00	$7.50
$56.50	$42.40

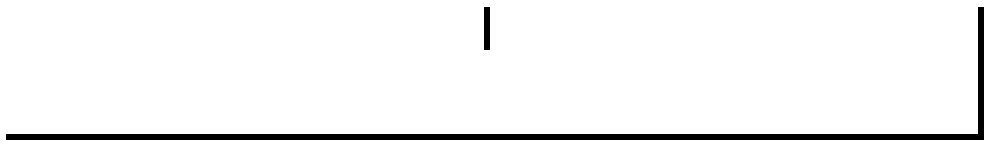
$6.00	$7.50

$7.00	$11.50
$2.30	$2.80

$5.25	$8.25
$1.85	$2.60
$22.40	$32.65

$79	$75
Rough Order of Magnitude	**Rough Order of Magnitude**

$5.00	$8.00



CONSTRUCTION COST ESTIMATE SUMMARY

OMEGA POWER ENGINEERS

Title:	Preliminary Stage Construction Cost Estimate-Class 2-3			**Based on**
Facility:	Calwave Shore Elect Facilities	**Estimated By:**	R Connett	**20% Design**
Project #	Omega Project No 1505	**Date:**	2/2/2017	**Sheet: 1of 27**

DESCRIPTION	PRIME CONTRACTOR MATERIAL %	PRIME CONTRACTOR MATERIAL TOTAL	PRIME CONTRACTOR LABOR %	PRIME CONTRACTOR LABOR TOTAL	PRIME CONTRACTOR EQUIPMENT TOTAL	SUBCONTRACTOR MATERIAL %	SUBCONTRACTOR MATERIAL TOTAL	SUBCONTRACTOR LABOR %	SUBCONTRACTOR LABOR TOTAL	SUBCONTRACTOR EQUIPMENT TOTAL	TOTAL
DIRECT COSTS		11,490,373		1,290,349	116,375		8,225,497		6,291,114	6,224,759	
Sales Tax-Material *	8%	919,230			9,310	0	658,040			497,981	
Labor Burdens (incuded):			-	-				-	-		
SUBTOTAL		12,409,603		1,290,349	125,685		8,883,536		6,291,114	6,722,740	
Overhead *	10%	1,240,960	0	129,035	12,569	0	710,683	0	503,289	537,819	
SUBTOTAL		13,650,563		1,419,383	138,254		9,594,219		6,794,403	7,260,559	
Profit *	6%	819,034	0	85,163	8,295	0	575,653	0	407,664	435,634	
SUBTOTAL		14,469,597		1,504,546	146,549		10,169,872		7,202,068	7,696,193	
Prime Commission on Sub *						0	610,192	0	432,124	461,772	
SUBTOTAL		14,469,597		1,504,546	146,549		10,780,065		7,634,192	8,157,964	42,692,913
Contingency (10% contractor, 10% owner)										20%	8,538,583
SUBTOTAL											51,231,495
Performance Bond *										1%	512,315
SUBTOTAL											51,231,495
Prof Services: Owner's Eng & Const Mgmt										10%	5,123,150
SUBTOTAL											56,354,645
Escalation * **YEAR:** 2018 (2 years)										3.6%	2,047,026
TOTAL ENGINEERING & CONSTRUCTION COST											$58,401,671
										Rond off to:	

Labor Cost & Burdens Calculation:

National Cost (Means) 7 person crew, per day:	$	3,767	
Per labor-hour:	$	67.26	Includes benefits, supv, truck, 2T crane, small tools & consumables
Cost Adj for San Luis Obispo labor, (Means):		1.064	
Adjusted Hourly Rate:	$	71.57	
Average hours worked per day:		10	
Equiv. rate for 10 hour day:		78.72	Average cost per hr w/ OT
Reporting location @ V'Berg gate - add 1hour:	$	87.47	Cost includes travel time thru AFB
% of crew as travellers		50%	
Per Diem allowance for traveller labor (daily)	$	100.00	
Equivalent uplift per hour:	$	5.00	
ALL IN HOURLY RATE:	**$**	**92.47**	**Per hour**

MARINE OPERATIONS ESTIMATING TOOL BOX (Rev 0)

Marine Operations ROM for HDD Support 9/12/2016 Data Source: Williams & CalWave

Assumptions:

Mobilizatio Shore Site core samples

(M-6) Offshore CPT survey

(M-6) Survey of 10 meter curve

(M-6) Mapping of seaweed

(M-6) Detailed bore engineering

(M-3) Shore Site excavation

(M-3) HDD staging area prep

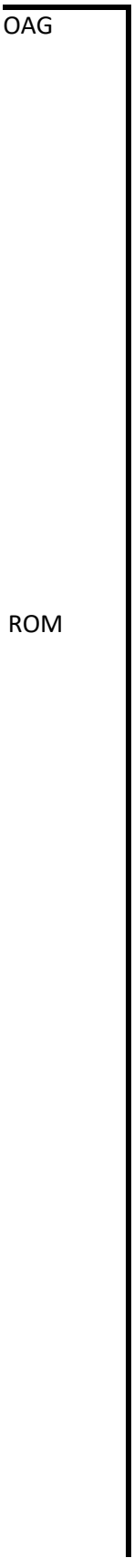
(M-0) Mobilize one "maxi" drill rig for first bore

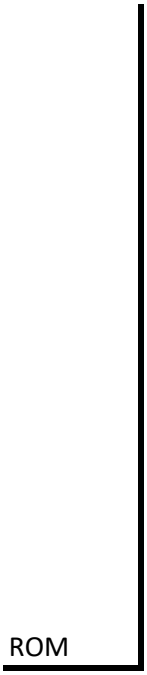
(M+1) Go-NoGo decision on number of bores

(M+1) Mobilize second "maxi" drill rig for subsequent bores

			Days	Day Rate	Extended
Hydrographic craft to confirm 10 meter curve and mark seaweed					
Craft Mob/Demob			1	$2,000	$2,000
Confirm 10 meter curve			2	$2,000	$4,000
Map seaweed			2	$2,000	$4,000
Craft contingency days			5	$2,000	$10,000
Dive Support Vessel and Divers (10 meter depth) to dig "sump pits" as a precaution					
Vessel and Dive Team			5	$6,500	$32,500
Dive Vessel	5 bores	3 days/bore	15	$3,300	$49,500
Vessel contingency days			10	$3,300	$33,000
Dive Spread (shallow water)			15	$450	$6,750
Dive Spread (shallow water) contingency days			10	$450	$4,500
Divers Mark Exits	5 bores	1 day/bore	5	$8,415	$42,075
Divers Dig Sump Pits	5 bores	2 days/bore	10	$8,415	$84,150
Diver contingency days (Saturday)			6	$10,890	$65,340
Diver contingency days (Sunday)			4	$12,595	$50,380
Small craft (or remotely operated craft)					
Development			1	$10,000	$10,000
Mob/Demob			5	$5,000	$25,000
Towed flourometer			90	$1,500	$135,000
Dive Support Vessel and Divers to tend pipe					
Vessel and Dive Team Mob/Demob			5	$6,500	$32,500

Dive Vessel	5 bores		10	$3,300	$33,000
Vessel contingency days			10	$3,300	$33,000
Dive Spread (shallow water)			10	$450	$4,500
Dive Spread (shallow water) contingency days			5	$450	$2,250
Divers Hook up and Te	5 bores	2 days	10	$8,415	$84,150
Diver contingency days (Saturday)			6	$10,890	$65,340
Diver contingency days (Sunday)			4	$12,595	$50,380
Vessel to tow HDD pipe offshore and tend					
Tow Vessel Mob/Dem			5	$6,500	$32,500
Tow Vessel	5 bores	3 days	15	$2,500	$37,500
Tow Vessel contingency days			5	$2,500	$12,500
					$943,815

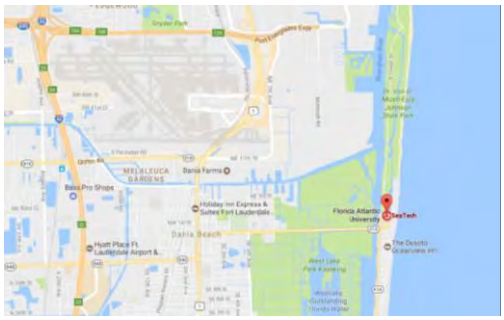

OAG
ROM


ROM

3rd Marine Hydrokinetic Instrumentation Workshop

February 28 –March 1, 2017

Location:
Florida Atlantic University, SeaTech Campus
ST250 Auditorium
101 North Beach Road
Dania Beach, Florida 33004
GPS: 26.0548311,-80.1132756



DOE's third MHK sensors and instrumentation will focus on identifying measurement needs, determining gaps in measurement capabilities, and defining solution pathways for those gaps as relevant for resource assessment, laboratory and field testing, and operation of MHK technologies.

Summary of Findings for CalWave(Vandenberg AFB) and OMD(Camp Rilea):

Day 1:

The CalWave Final Report is satisfactory as written.

Instrumentation, measurement, and modelling is a highly dynamic field that must involve the Test Center and the WEC Developers. The CalWave teaming with NREL, as led by Dr Al LeVecchi, will provide access to state of art and state of practice. Lead on instrumentation and measurement is Dr. Rick Driscol. CalWave team member Columbia Power Technologies is working with NREL. CalWave should consider teaming with PNNL for environmental monitoring.

OMD is teamed with NNMRC (OSU, UW, UAF) for academic input. OMD should consider teaming with NREL and with PNNL.

MHK Data Repository: We should coordinate with DOE Sponsor to upload the CalWave Final Report. This puts the information into the DOE Open Energy Information (OpenEI) framework.

Modular Ocean Instrumentation System (MOIS) – Data acquisition and data logger system. Supplement to WEC SCADA including motion and load cells. Latest generation used on NWAI Azura WEC at WETS.

Importance of Meteorological and Oceanographic (METOCEAN) support. For RFPs: OGP HSE Guidelines for MetOcean Studies. http://ww.iogp.org/pubs/447.pdf and ISO 19901-1

See Agenda next page. Presentations will be available online.

Tuesday, February 28		
8:30 – 9:00	Opening Remarks	
Welcome and Introduction		Erik Mauer, DOE
Review of Prior Workshops		Erik Mauer, DOE
Workshop Overview		Rick Driscoll, NREL
9:00 – 10:00	DOE Testing Instrumentation Projects	
MHK Instrumentation Database and Community		Rick Driscoll, NREL
MOIS and NWTC Component Testing		Eric Nelson, NREL
Tidal Turbulence Measurement System		Levi Kilcher, NREL
Environmental Instrumentation Workshop		Genevra Harker-Klimes, PNNL
MHK Activities in Canada		Fabian Wolk, Rockland Scientific
10:20 – 12:00	State-of-the-art in Measurement Technology and Testing	
Field Testing of Wave Energy Systems		Terry Lettenmaier, NWEI
Field Testing: VolturnUS 1:8 Floating Offshore Wind Turbine		Curtis Libby, Univ of Maine
Real Time Wave Field Measurement and Forecasting		Bill Milewski, APS Corp.
Resource Assessment and Forecasting		Robert Raye, StormGeo
Scaled Testing of Tidal Turbines, Lab Instruments		Martin Wosnik, UNH
12:00 – 1:00	Catered Lunch with Industry Presentations	
Signature ADP, Kevin Frost, Nortek		
Canada-UK projects in Turbulence Measurement and Methodology in Tidal Channels and Laboratory, Fabian Wolk, Rockland Scientific		
The “Living Bridge” Tidal Energy Project, Martin Wosnik, UNH		
1:00 – 3:00	Breakout 1 – Gap Identification, Characterization and Prioritization	
Findings of the Pre-Workshop Survey		Rick Driscoll, NREL
Break into groups		
Group 1: Field Measurement: Wave		Terry Lettenmaier
Group 2: Field Measurement: Current		Levi Kilcher
Group 3: Laboratory Measurement: Wave and Current		Eric Nelson
4:30 – 5:15	Groups Document and Prioritize Findings	
6:30 – 8:30	No-Host Dinner	

Wednesday, March 1		
8:00 – 8:30	Hot Breakfast Buffet	
8:30 – 10:00	Breakout Session Reporting and Discussion	
Group 1: Field Measurement: Wave		Terry Lettenmaier
Group 2: Field Measurement: Current		Levi Kilcher
Group 3: Laboratory Measurement: Wave and Current		Eric Nelson
10:00 – 10:20	Break (Coffee and Tea)	
10:20 – 12:00	Breakout Session 2 – Solution Pathways	
Group 1: Field Measurement: Wave		Terry Lettenmaier
Group 2: Field Measurement: Current		Levi Kilcher
Group 3: Laboratory Measurement: Wave and Current		Eric Nelson
12:00 – 1:00	Catered Lunch with Industry Presentations	
TRDI ADCPs, Darryl Symonds, Teledyne RD Instruments Comparison of Fault Detection Techniques for an Ocean Turbine, Pierre , FAU		
1:00 – 3:00	Breakout Session 2 Continued	
3:00 – 3:20	Break (Coffee and Tea)	
3:20 – 4:00	Groups Document and Prioritize Findings	
4:00 – 5:30	Breakout Session Reporting and Discussion	
Group 1: Field Measurement: Wave		Terry Lettenmaier
Group 2: Field Measurement: Current		Levi Kilcher
Group 3: Laboratory Measurement: Wave and Current		Eric Nelson

Wave Energy Electrical Infrastructure Planning

Oregon National Guard

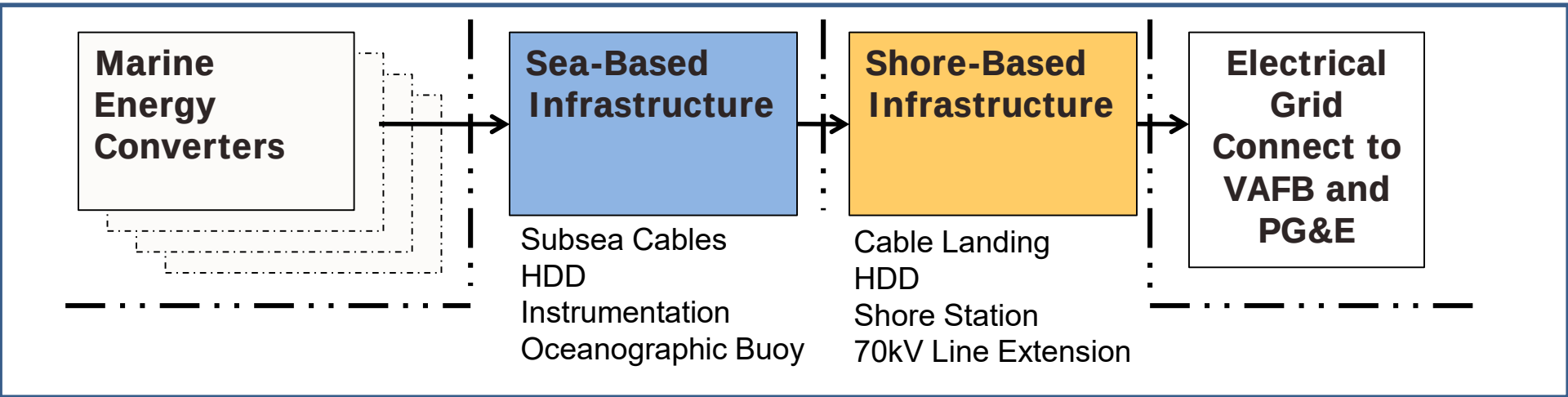
CalWave℠

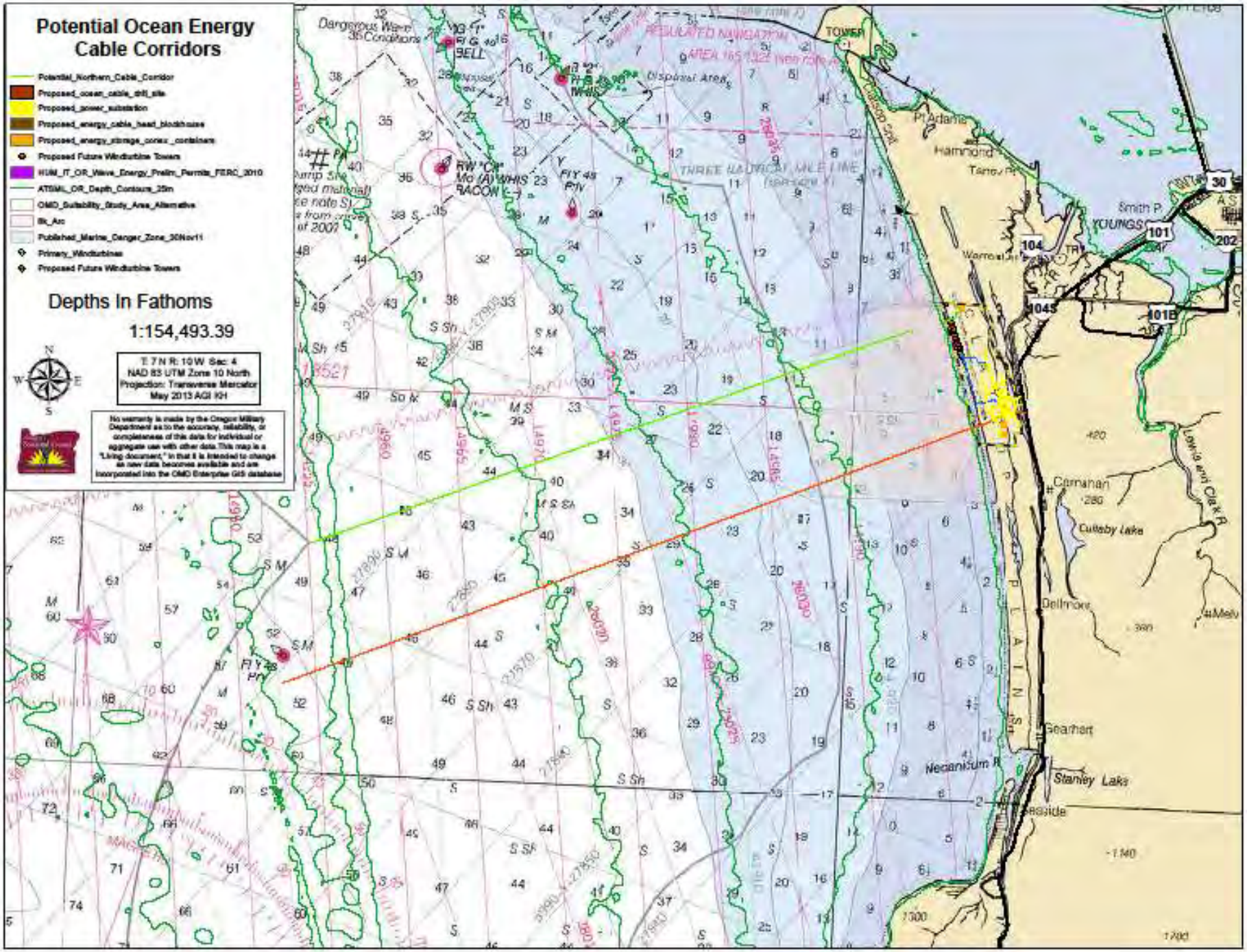
Cal Poly San Luis Obispo

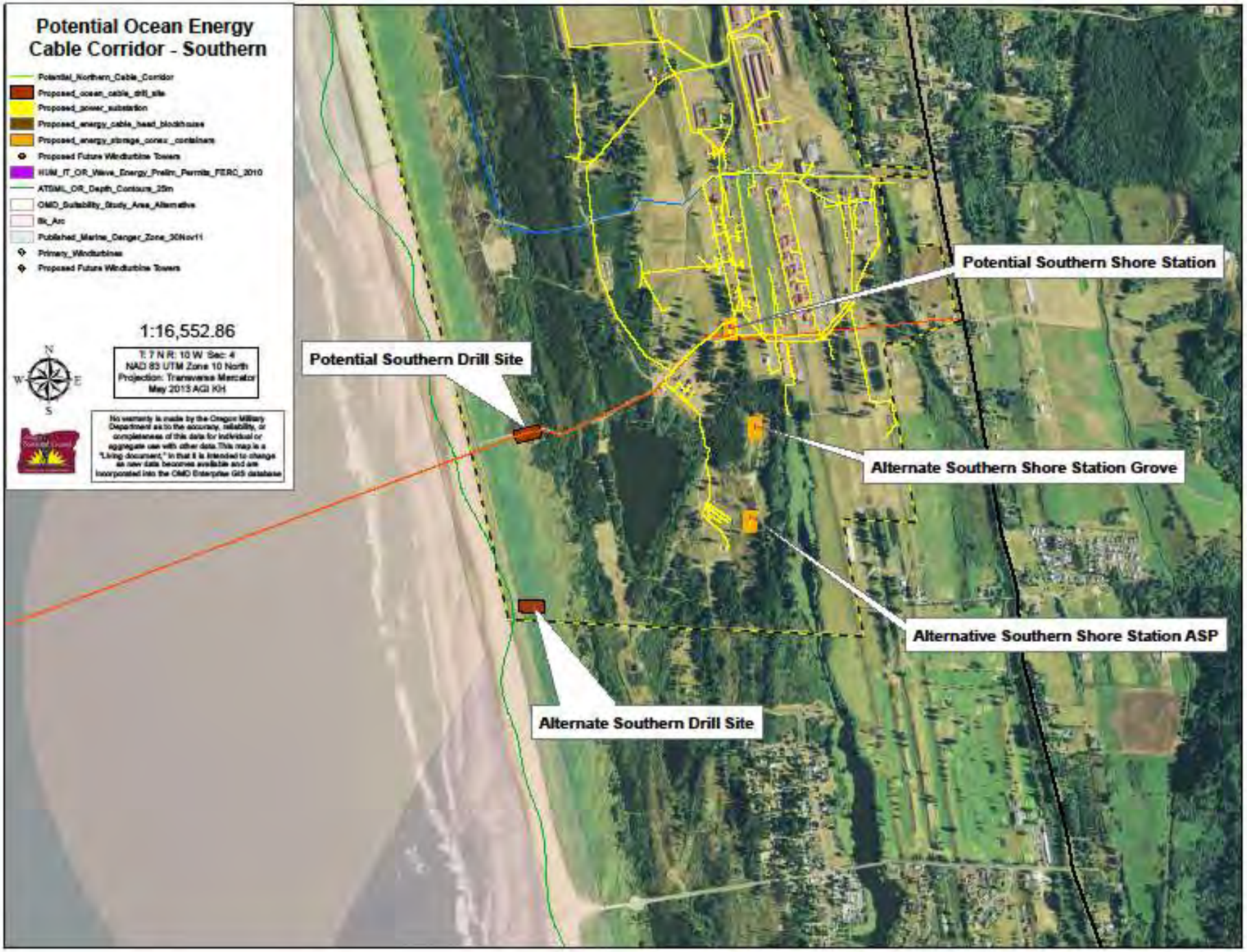
U.S. Department of Energy

Topics

- Requirements-Driven
  - Why Wave Energy?
  - Offshore Siting
  - On-shore Siting
  - Grid Integration
- Spiral Design
  - SubSea Cabling
  - Distribution vs Transmission
  - Grid Compliance and Power Conditioning




Potential Ocean Energy Cable Corridors
Potential_Northern_Cable_Corridor
Proposed_ocean_cable_drill_site
Proposed_power_substation
Proposed_energy_cable_head_blockhouse
Proposed_energy_storage_conex_containers
Proposed Future Windturbine Towers
HUM_IT_OR_Wave_Energy_Prelim_Permits_FERC_2010
ATSML_OR_Depth_Contours_25m
OMD_Suitability_Study_Area_Alternative
8k_Arc
Published_Marine_Danger_Zone_30Nov11
Primary_Windturbines
Proposed Future Windturbine Towers
Depths In Fathoms
1:154,493.39
T 7 N R: 10 W Sec: 4
NAD 83 UTM Zone 10 North
Projection: Transverse Mercator
May 2013 AGI KH
No warranty is made by the Oregon Military Department as to the accuracy, reliability, or completeness of this data for individual or aggregate use with other data. This map is a "living document," in that it is intended to change as new data becomes available and are incorporated into the OMD Enterprise GIS database.
Dangerous Wreck
Pt Adams
Hammond
Warrenton
Smith P.
YOUNGS
Cullaby Lake
Delmoor
Gearhart
Neacanicum R.
Stanley Lake
Seaside
Camanan
Lewis and Clark R.
PLAIN
30
101
202
104
1045
101B


Potential Ocean Energy Cable Corridor - Southern
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Proposed Future Windturbine Towers
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OMD_Suitability_Study_Area_Alternative
Bk_Arc
Published_Marine_Danger_Zone_30Nov11
Primary_Windturbines
Proposed Future Windturbine Towers
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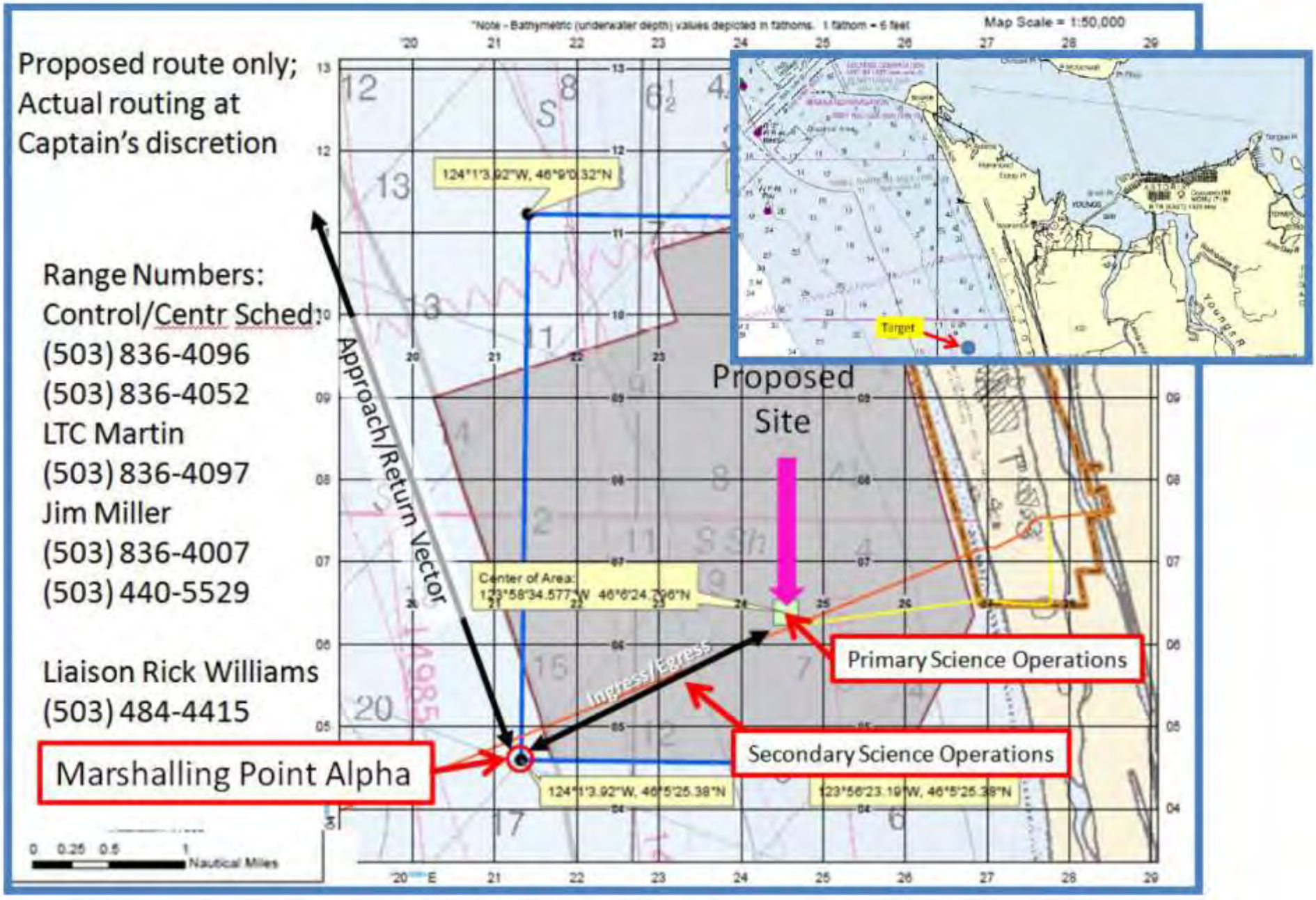
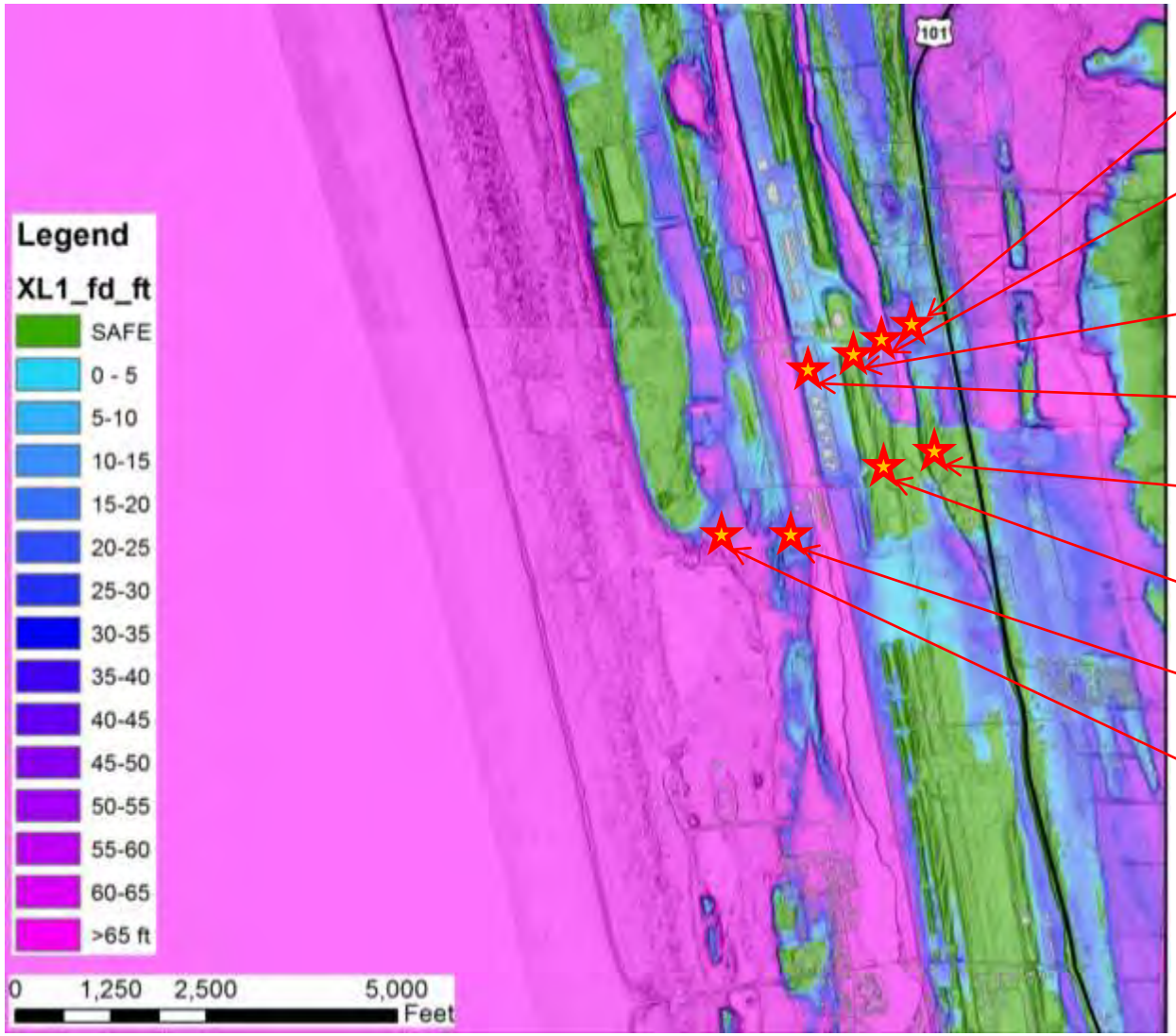
NAD 83 UTM Zone 10 North
Projection: Transverse Mercator
May 2013 AGI KH
N
W
E
S
No warranty is made by the Oregon Military Department as to the accuracy, reliability, or completeness of this data for individual or aggregate use with other data.This map is a "Living document," in that it is intended to change as new data becomes available and are incorporated into the OMD Enterprise GIS database
Potential Southern Shore Station
Potential Southern Drill Site
Alternate Southern Shore Station Grove
Alternative Southern Shore Station ASP
Alternate Southern Drill Site


Proposed route only;
Actual routing at
Captain's discretion
Range Numbers:
Control/Centr Sched:
(503) 836-4096
(503) 836-4052
LTC Martin
(503) 836-4097
Jim Miller
(503) 836-4007
(503) 440-5529
Liaison Rick Williams
(503) 484-4415
Marshalling Point Alpha
Approach/Return Vector
Ingress/Egress
Proposed
Site
Primary Science Operations
Secondary Science Operations
Target
Map Scale = 1:50,000
0 0.25 0.5 1
Nautical Miles

Draft List: Camp Rilea Locations for DOGAMI Analysis



North Entrance to Camp & Iron OP

Entrance to Camp (Patriot Way)

Emergency Generator Pad

Ridgeback above AAFES

Range Operations & Warrior Hall

Alternate Emergency Entry/Egress

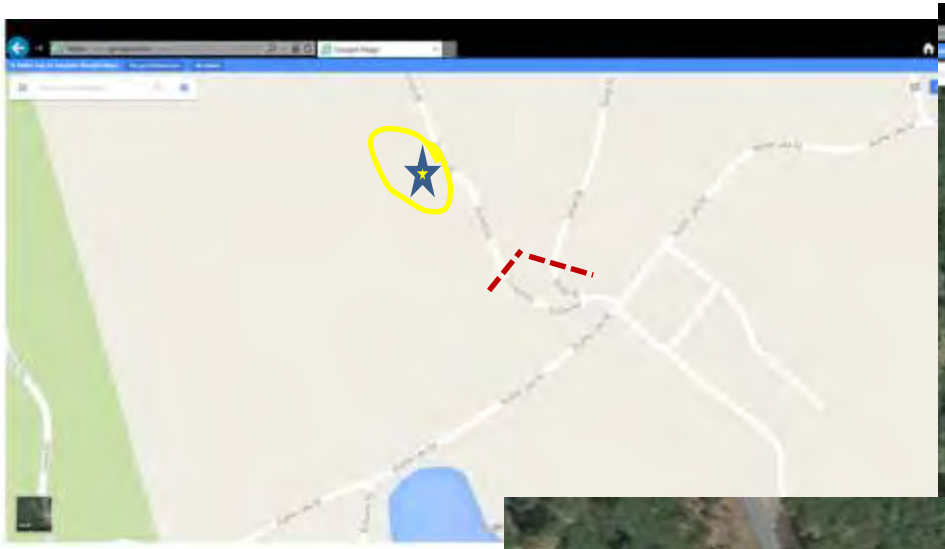
Ridgeback above Ponds

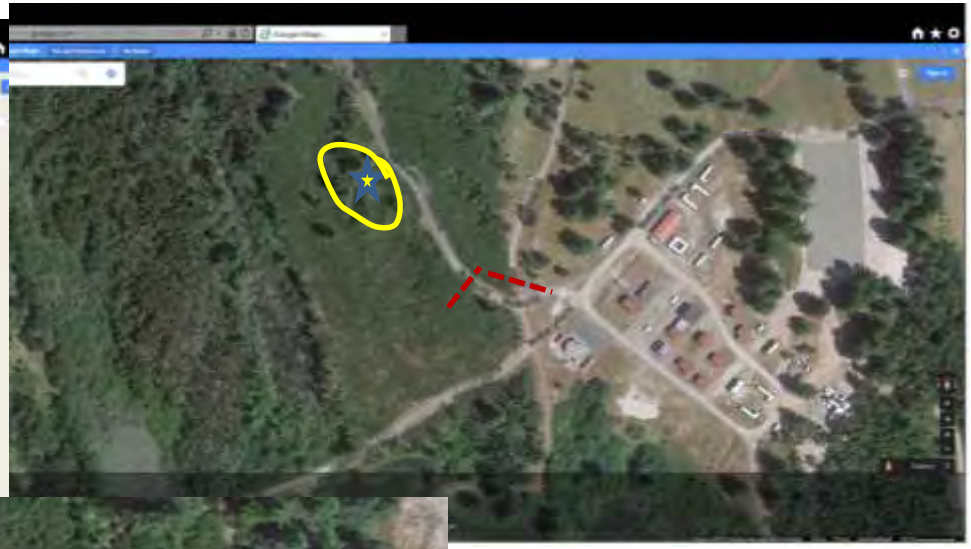
Existing Staging Area

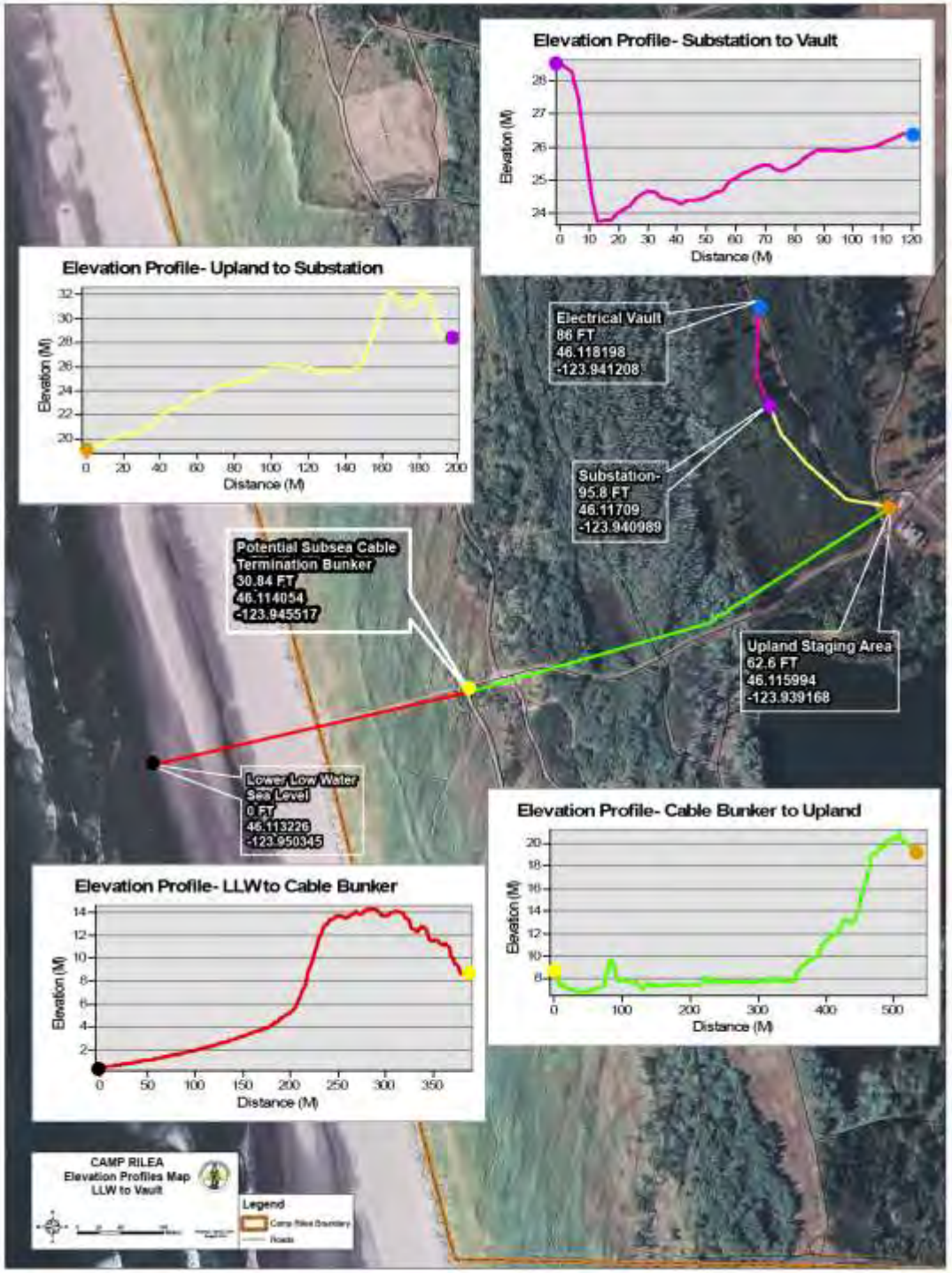
MOUT Site

Camp Rilea Electrical Infrastructure Planning

Potential Shore Station: West side Gunline Road, first rise north of shoot house



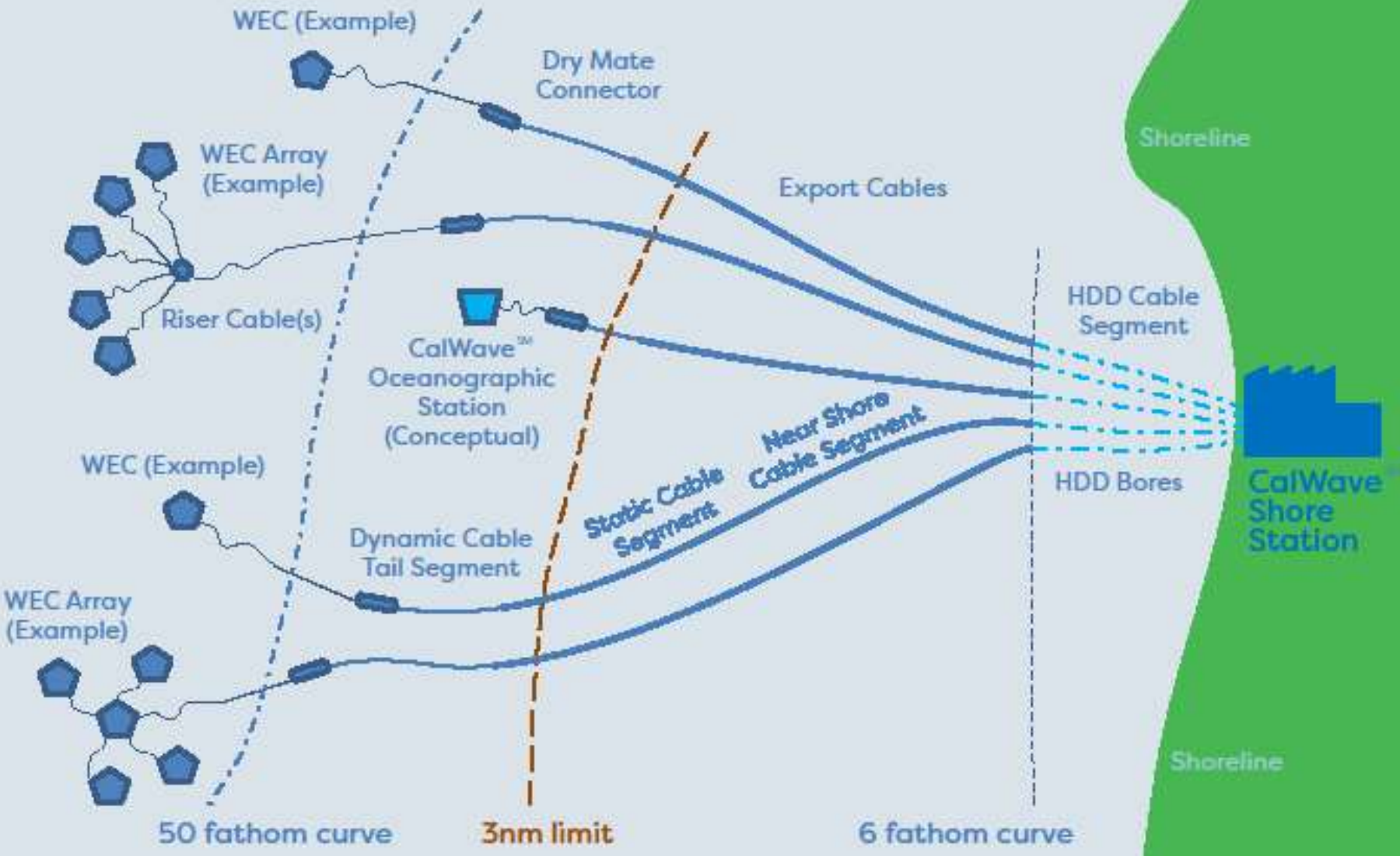



Elevation Profile- Substation to Vault
Elevation (M)
Distance (M)
Elevation Profile- Upland to Substation
Elevation (M)
Distance (M)
Electrical Vault
86 FT
46.118198
-123.941208
Substation-
95.8 FT
46.11709
-123.940989
Potential Subsea Cable Termination Bunker
30.84 FT
46.114054
-123.945517
Upland Staging Area
62.6 FT
46.115994
-123.939168
Lower Low Water Sea Level
0 FT
46.113226
-123.950345
Elevation Profile- Cable Bunker to Upland
Elevation (M)
Distance (M)
Elevation Profile- LLWto Cable Bunker
Elevation (M)
Distance (M)
CAMP RILEA
Elevation Profiles Map
LLW to Vault
Legend

CalWave^{SM} Area

CalWave℠ System Concept

CalWave℠ is envisioned to have 4 test berths, each with a "home run" cable to the shore station. Each WEC Array will operate independently.



Why Wave Energy?

- California features a high-energy wave climate and deep water close to shore and major population centers.
- Phase-out of Once-Through-Cooling (OTC) power plants and retirement of Diablo Canyon will provide greater than 12,200 MW of unused coastal substation capacity for ocean renewable energy projects.
- State RPS goals increased to 50% by 2030; wave energy could be part of attaining that goal.
- Wave energy generation profile is highly predictable and complementary to intermittency of terrestrial wind and solar energy.

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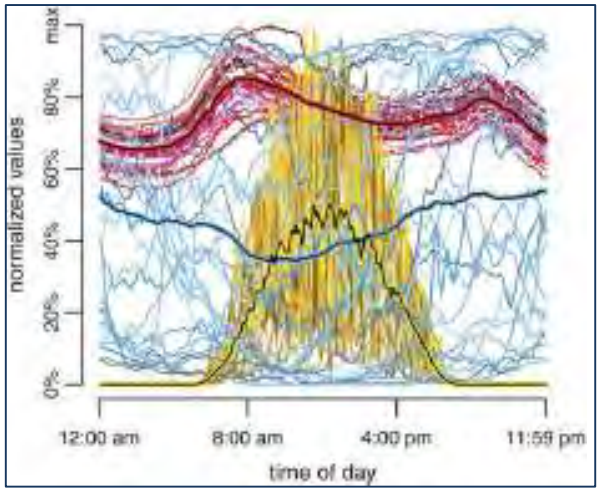
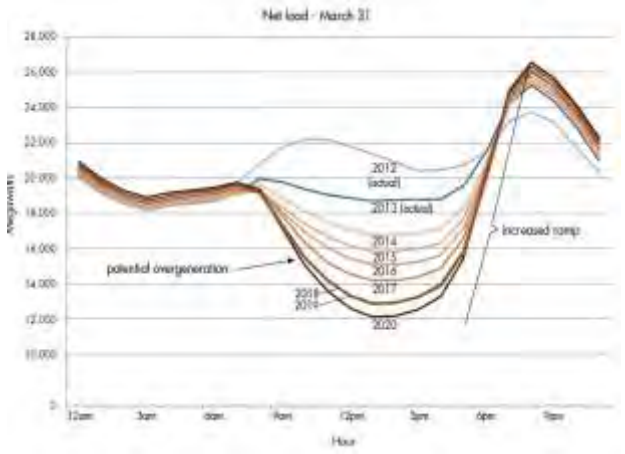
The Challenge of Integrating Renewables



Daily Profile, for 30 days: Electrical Demand (red), Wind Energy Supply (blue), Solar Insolation (yellow)

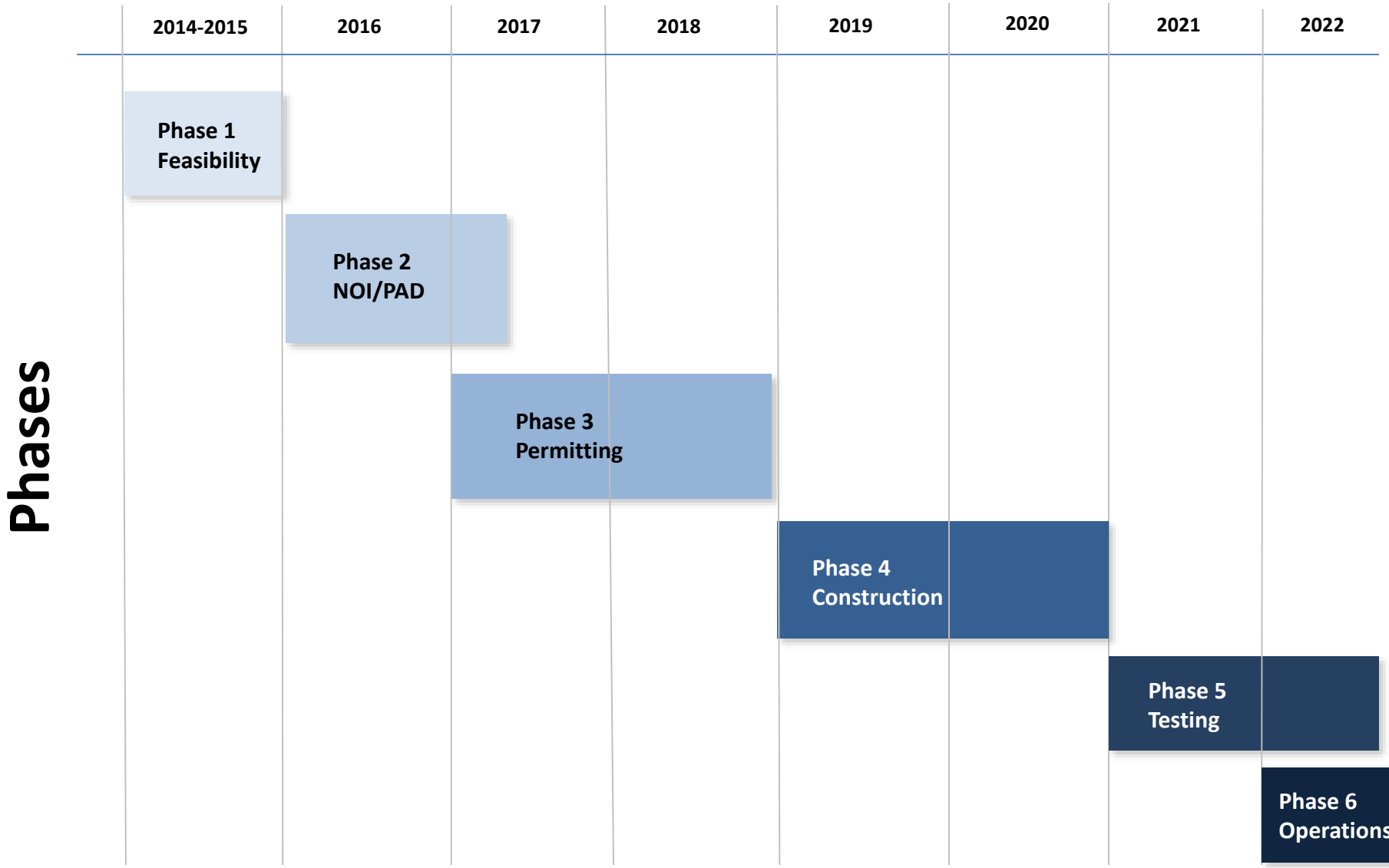
Source: Barnhardt, et al. 2013. "The energy implications of curtailing versus storing wind- and solar-generated electricity". Energy and Environmental Science.



The "Duck Curve" showing high ramp rates

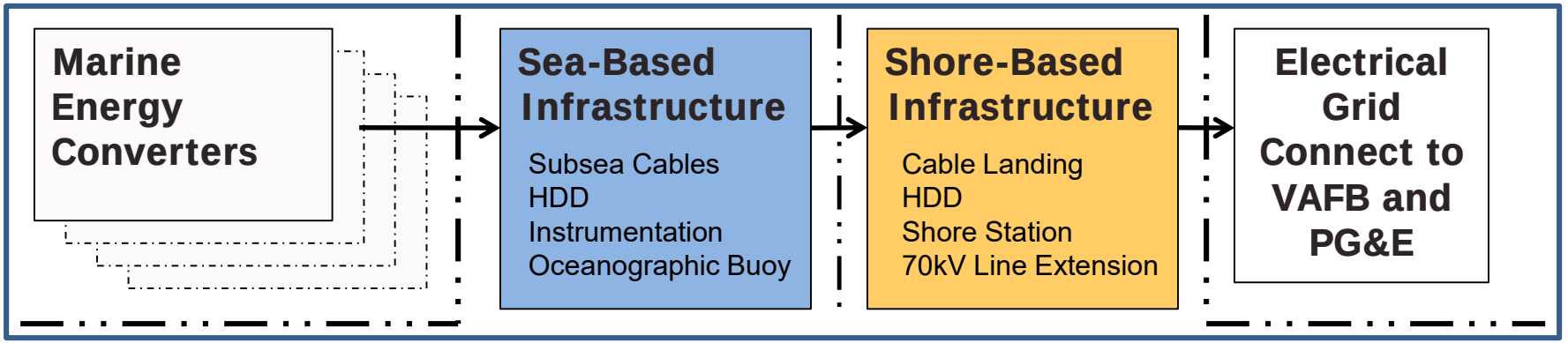
- Traditional grid (central control):
  - Large central generating stations and long-distance transmission
  - Predictable "base load" power resources
  - Easily dispatched to balance load
  - Must be balanced every 4 sec
- Modern grid (sharing economy):
  - "Geographically-distributed" resources, including renewables and consumer rooftops
  - Dramatic increase of intermittent renewables – wind and solar – with high ramp rates.
  - Increasingly variable loads
  - Plus, major reductions in baseload power plants
  - And, still must be balanced every 4 sec
  - Marine renewables are more predictable and forecastable – approaching base load

CalWave^{SM} Timeline

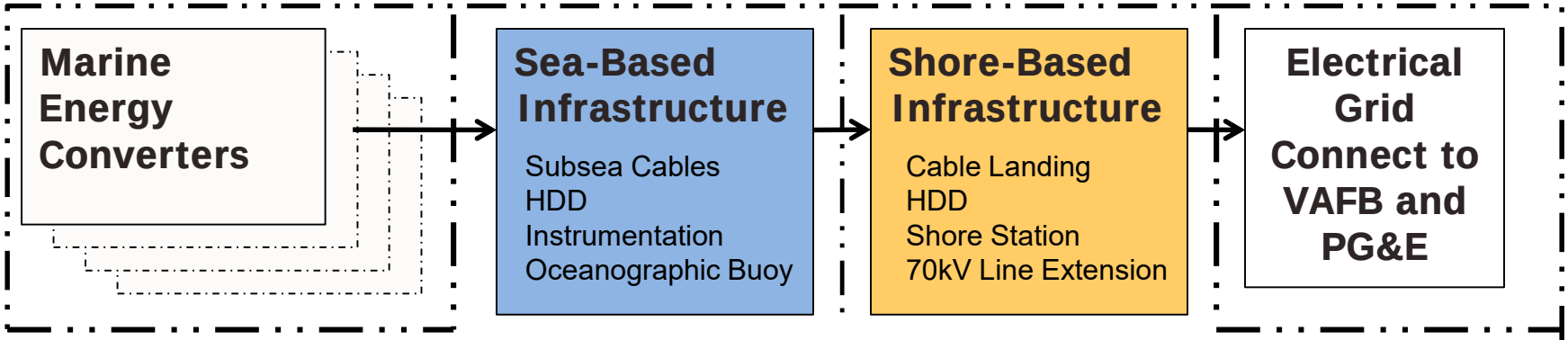


CalWave^{SM} System Design Concept

-Top-Level Requirements
-System Block Diagram
-Types of Wave Energy Converters
-Mooring and Anchoring
-Power Conditioning
-Grid Connection
-Base Facilities



CalWave^{SM} System Block Diagram



CalWave^{SM} Functional Task Areas

Design & Planning	Resource adaptation, conceptual design, preliminary design, prototyping, detailed design, implementation planning
Regulatory & Permitting	Site evaluation and selection, environmental analysis, outreach, and agency interaction
Implementation, Operations and Maintenance	Procurement, fabrication, logistics, installation, commissioning, project operations, maintenance, monitoring, adaptive management, and decommissioning
Financial & Business Management	Business planning, finance, project management, cost accounting and control
Marine Energy Converters (MECs) interface	MEC technology development, installation planning, device operation and maintenance.

CalWave^{SM} System Design

CalWave^{SM} will provide Test Center infrastructure that enables mature Marine Energy Converters (MECs), also known as Wave Energy Converters (WECs), to operate in open ocean fully-energetic conditions.

The CalWave^{SM} System design is:

"requirements-driven"

"technology-neutral"

"vendor agnostic"

Boundary Systems:

WEC System Base Facilities VAFB-PG&E Grid

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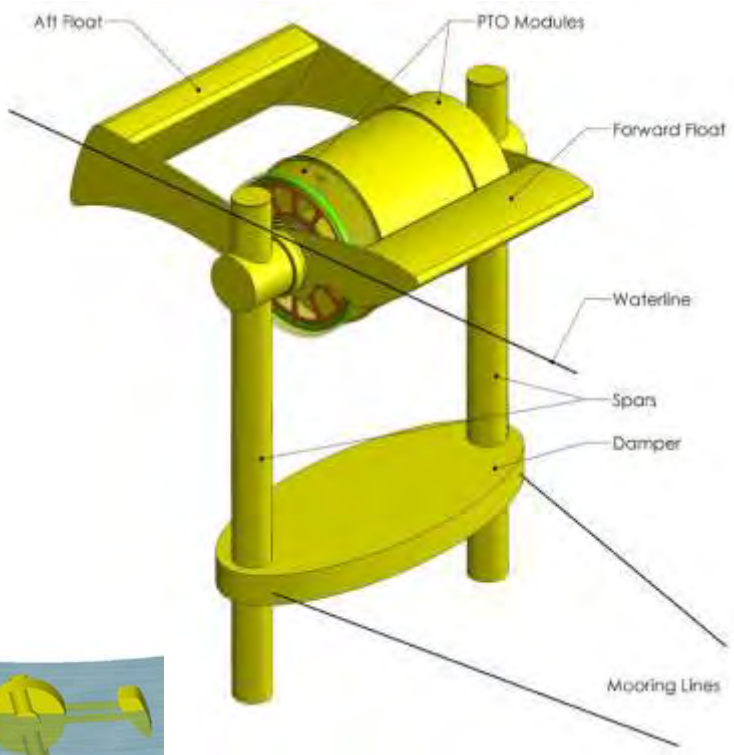
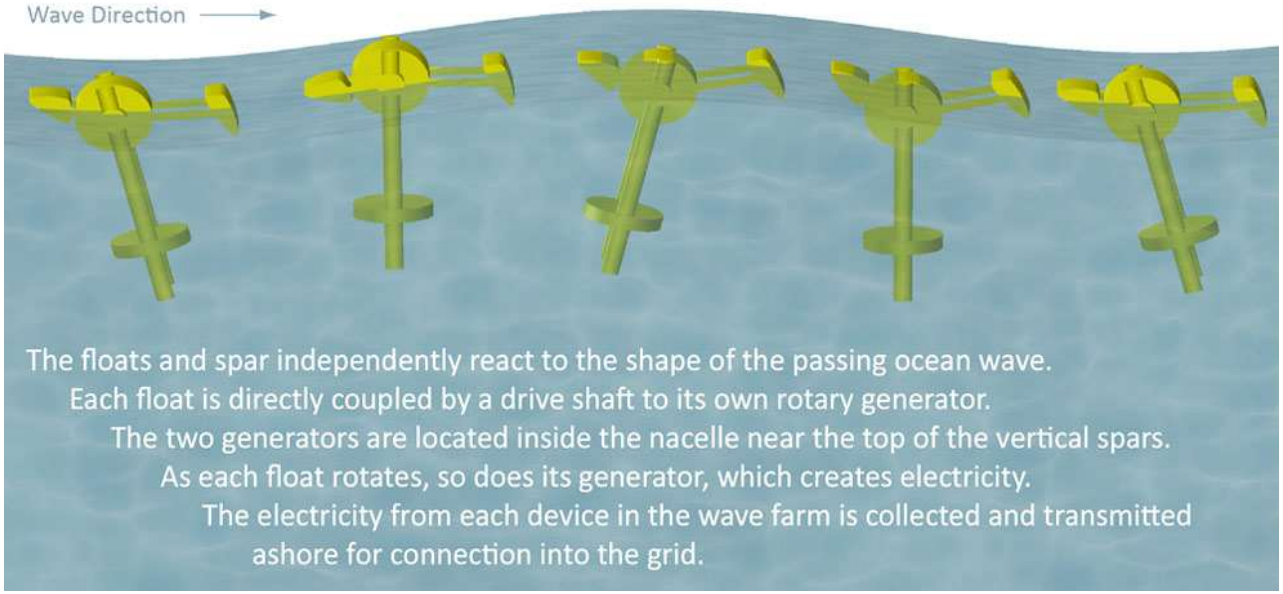
Examples of Wave Energy Converters

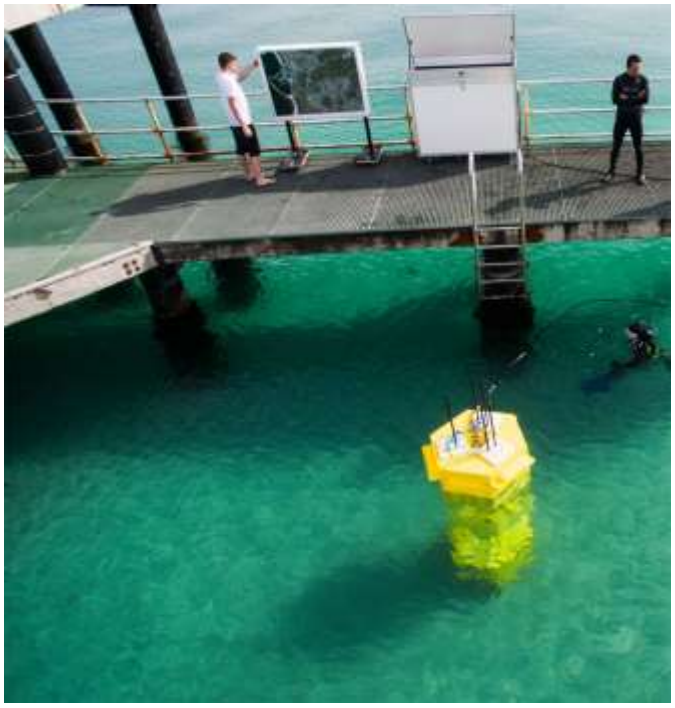
- Columbia Power StingRAY point absorber

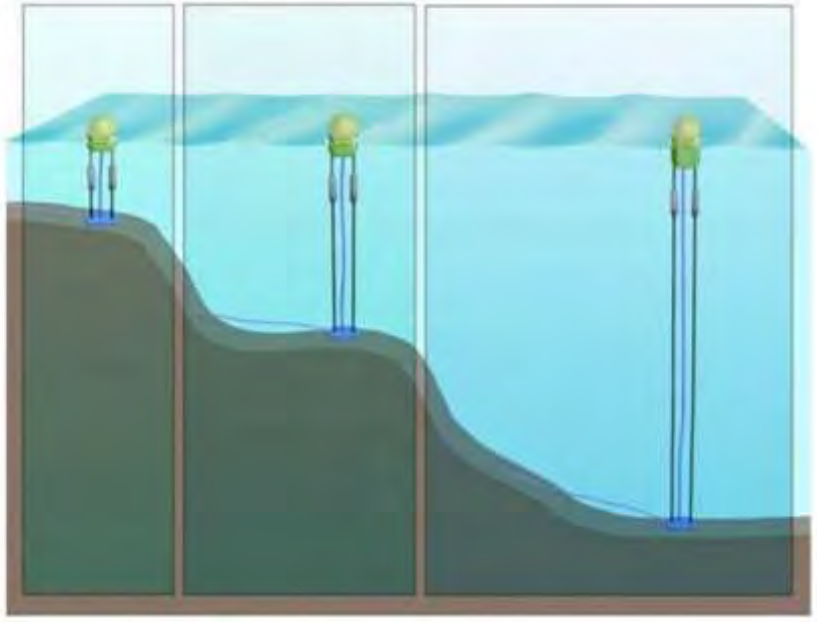




Examples of Wave Energy Converters

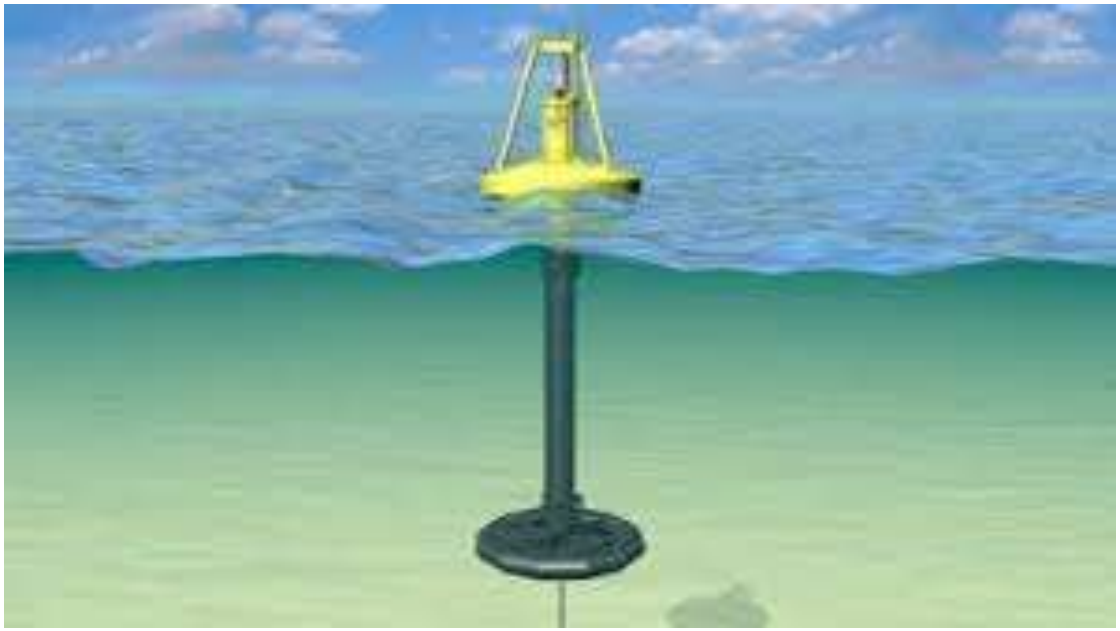
- Protean™ point absorber





Examples of Wave Energy Converters

- Ocean Power Technology point absorber



Examples of Wave Energy Converters

- Fred Olsen BOLT Lifesaver point absorber

- Azura: multi-mode, point absorber

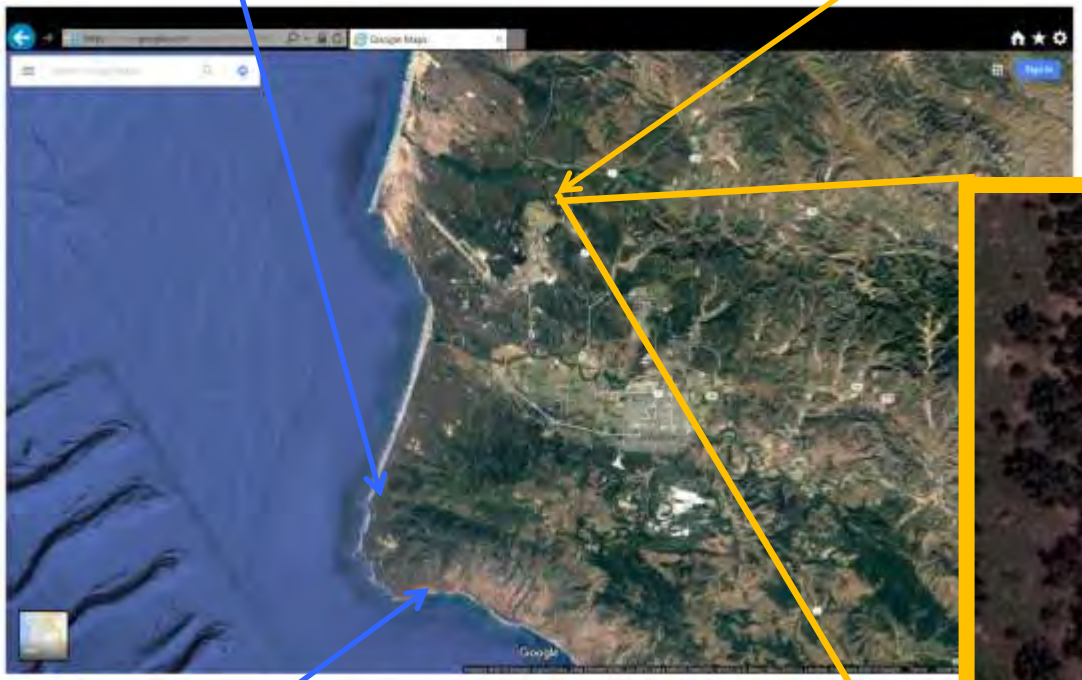
- Seatricity Oceanus 2 Pump Type point absorber

- Ocean Energy Floating Oscillating Water Column

VAFB-PG&E Electrical Grid Interface

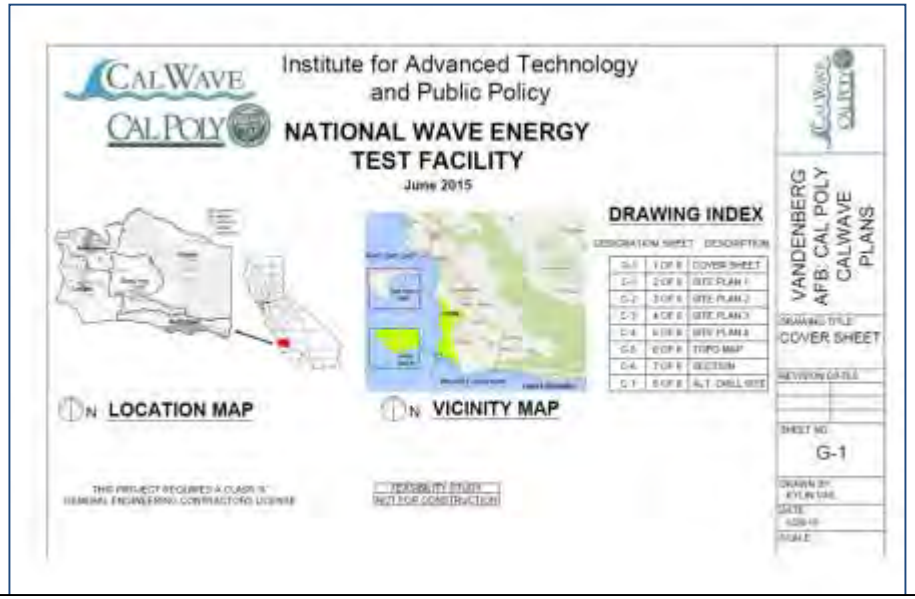
VAFB Substation N

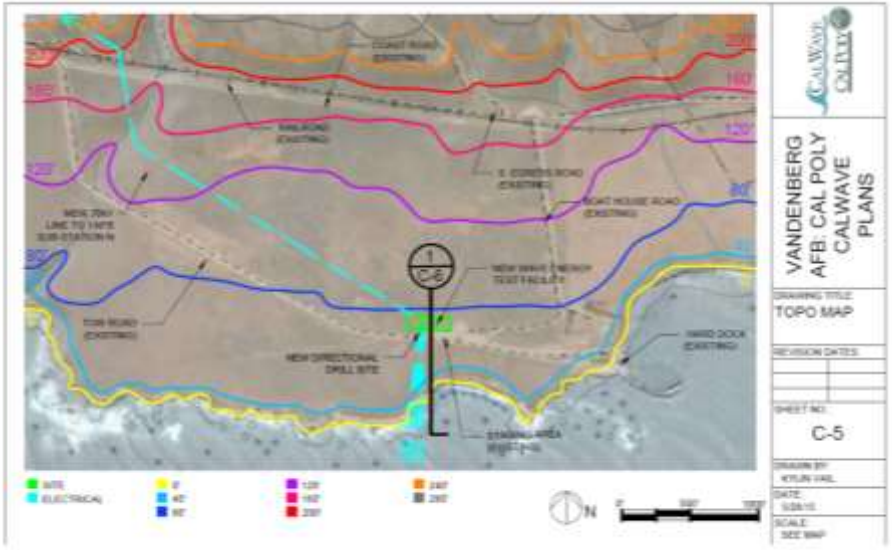
PG&E Substation serving VAFB

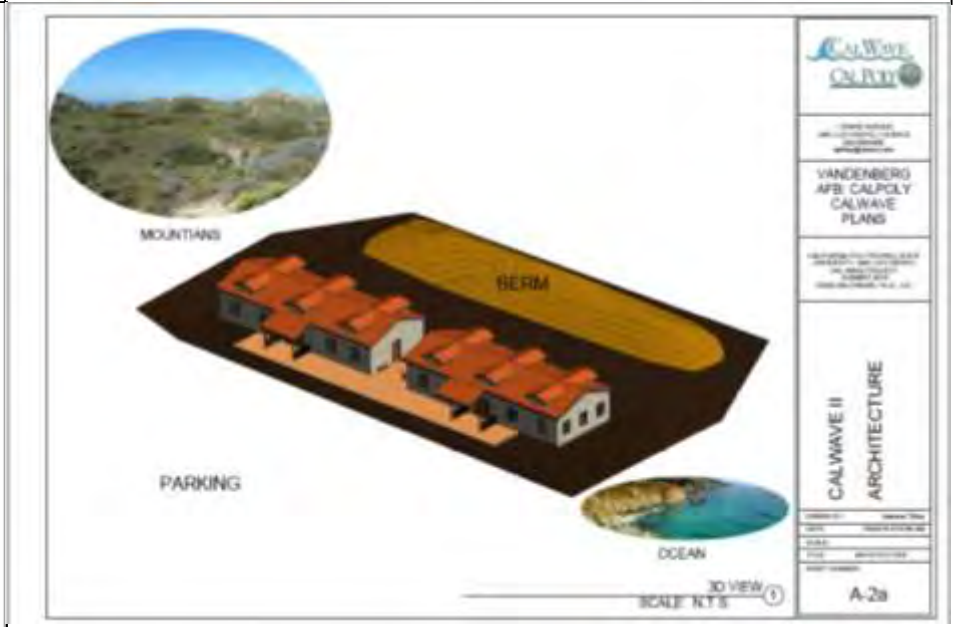


Vandenberg Dock

Vandenberg Base Facilities Interface







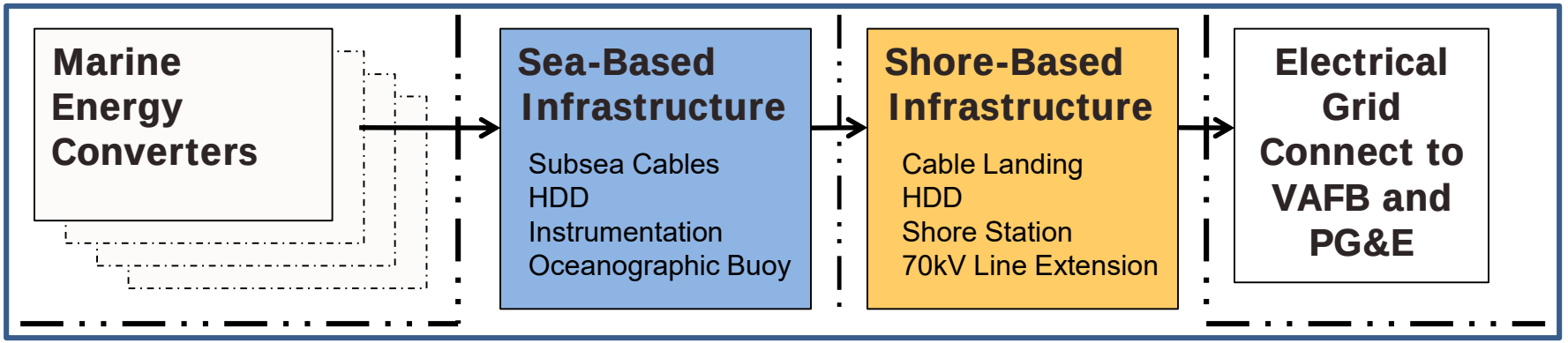
Draft CalWave^{SM} Project Description

-CalWave^{SM} Offshore Sites in BOEM Lease Blocks

-CalWave^{SM} System Design Concept

-CalWave^{SM} Subsea Cable Routes

-CalWave^{SM} Onshore Siting

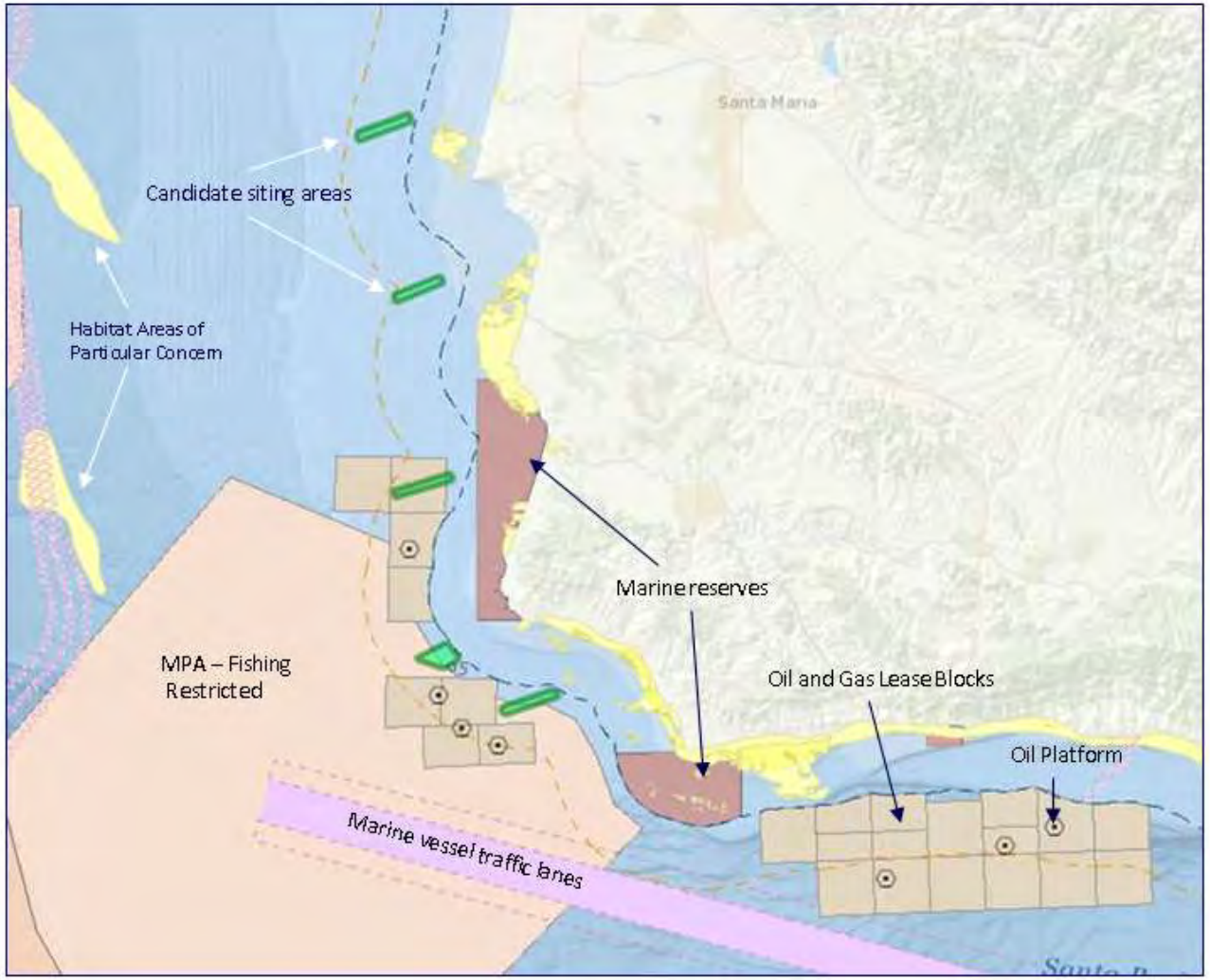


Proposed CalWave^{SM} Sites

In April 2015, the CalWave^{SM} Team presented a concept with five alternative offshore sites & four alternative cable landing and substation sites.

Since then, the proposed project description uses BOEM lease blocks and the south-based cable landing and substation site.

Resources and Siting Considerations



Source: Bureau of Ocean Energy Management, MarineCadastre.gov National Viewer, 2014

Potential Use of Offshore Infrastructure

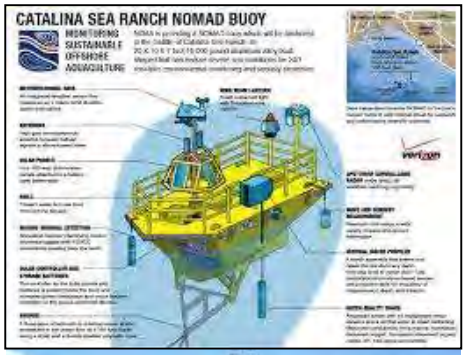
Platform Irene has an existing 25MW subsea cable to Surf Substation

- In concept, the WEC array dynamic cables would connect to Platform Irene.
- Looking forward, the collaborative use -- or repurposing -- of offshore oil & gas platforms would provide offshore substations.
- Some of these platforms have existing cables to shore.

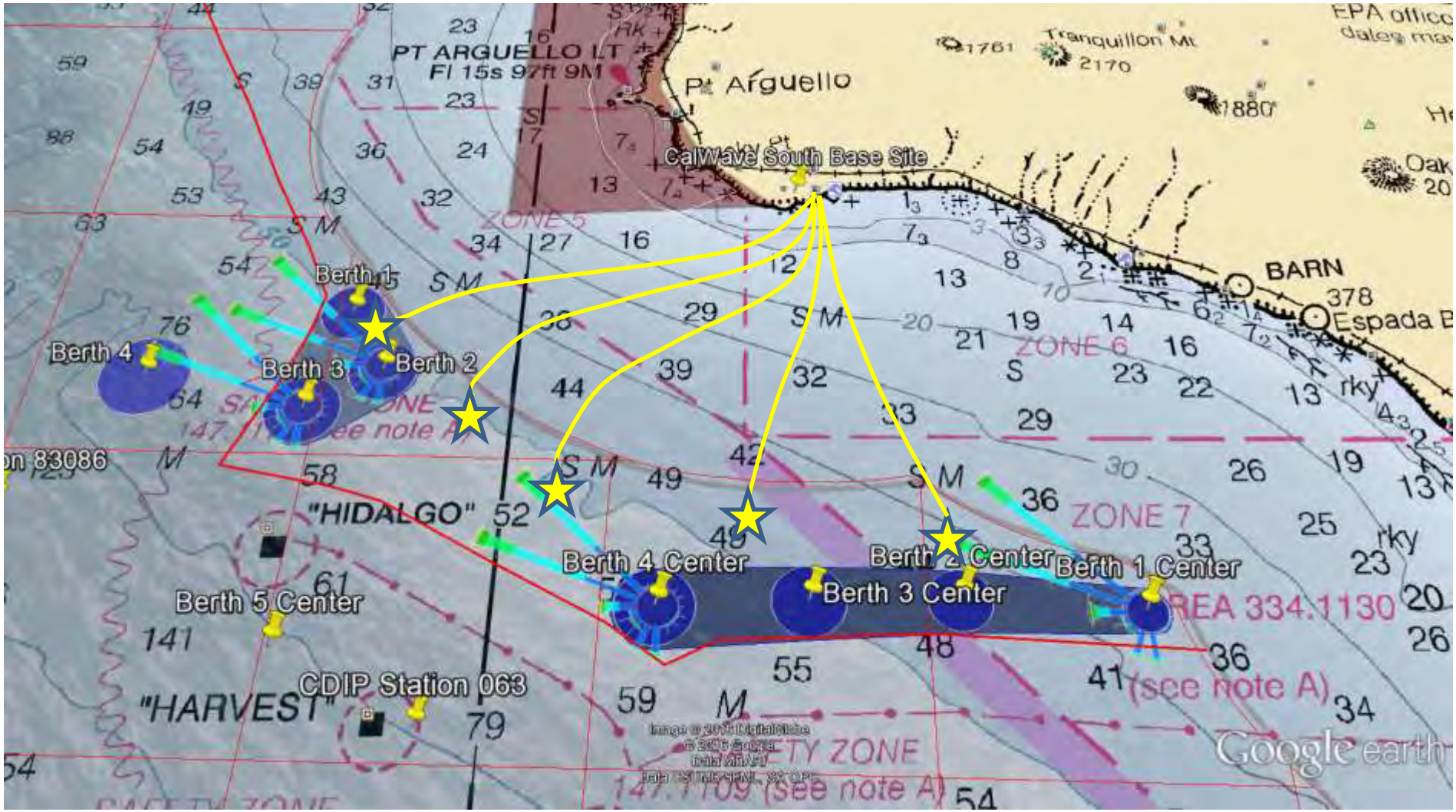
CalWave^{SM} Oceanographic Station Concept

The CalWave^{SM} Team is considering an oceanographic buoy south of VAFB dock.

- The buoy would allow measurement of wave resource meteorological instrumentation, telemetry relay, and terminus for the spare cable.
- Would allow WEC checkout enroute to the open ocean Berths.
- Options include surplus NOAA buoys, such as: 12m discus, or 10m discus.
- Intention: Work with Scripps, NOAA, USC, IOOS, and developers to explore requirements



Conceptual Cable Routes



West Cable

Southwest Cable

CalWave Oceanographic Station (Spare) Cable

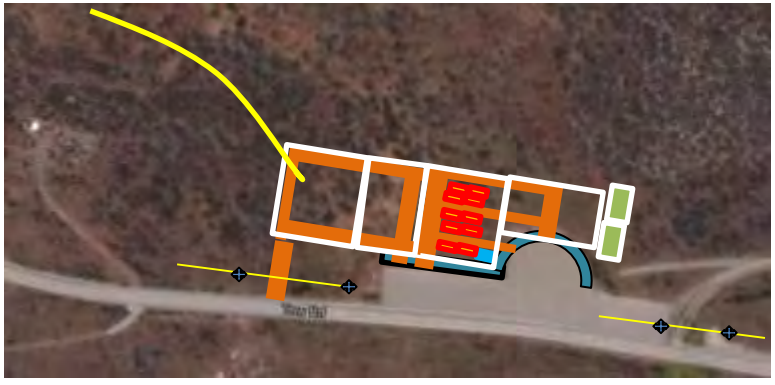
South Cable

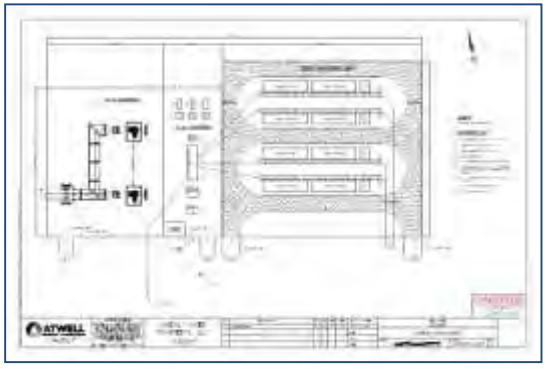
Southeast Cable

Onshore Cable Landings

The Feasibility Study identified South Base Site that leverages existing roadways, staging areas, 12kV line, and 70kV substation.

The Team has made significant progress in the Conceptual Design Stage:



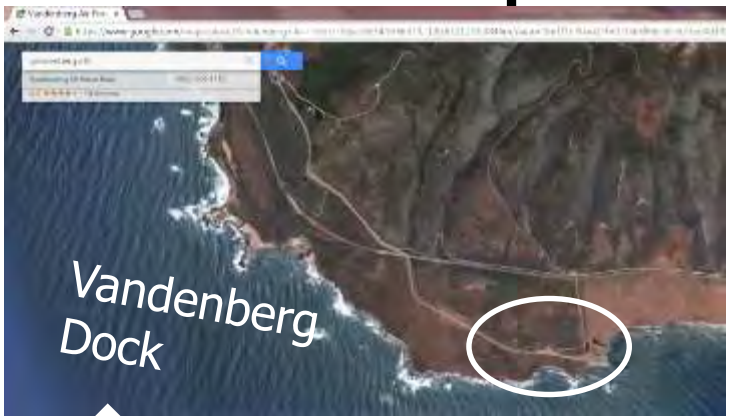


CalWave^{SM} Systems Approach

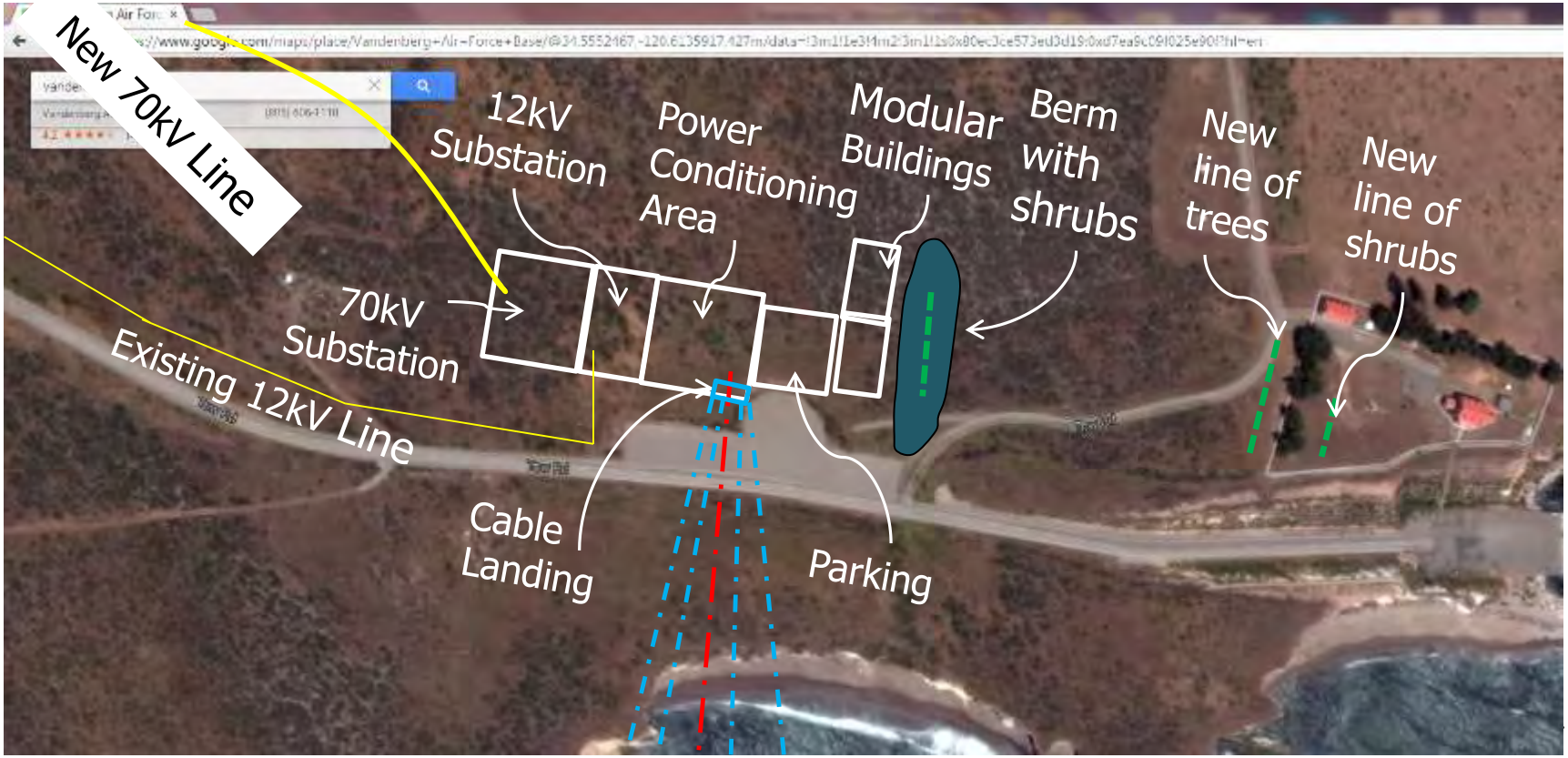
CalWave^{SM} Systems Approach:

- Establish shore station footprint, retain excess fill on site
- Setup Horizontal Directional Drilling (HDD) from shore, "daylight" ~40fsw
- Deploy cable ship, pull export cables ashore from HDD launch site
- Surface lay export cables (or bury if required) from ~40ft curve to ~4nm
- Test export cables and dry-mate connectors
- (Option) Install Calwave^{sm} Oceanographic Station
- WEC Developer responsible for mooring, anchoring and riser cables
- Connect WEC array to subsea export cable
- Connect shore-end cable to WEC developer's power conditioning equipment
- WEC developer responsible for power conditioning to meet grid integration requirements

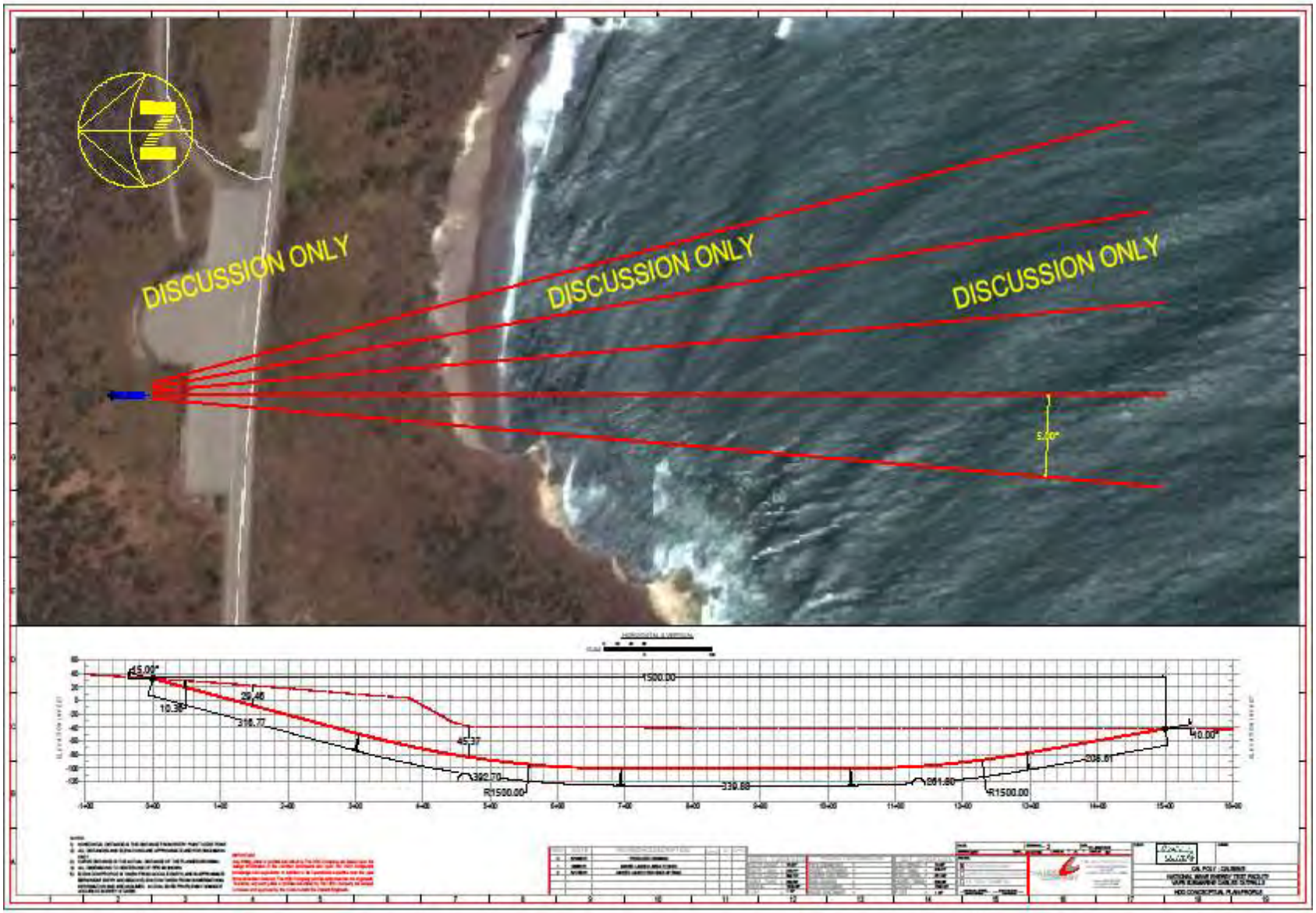
Conceptual Shore Station Site Plan



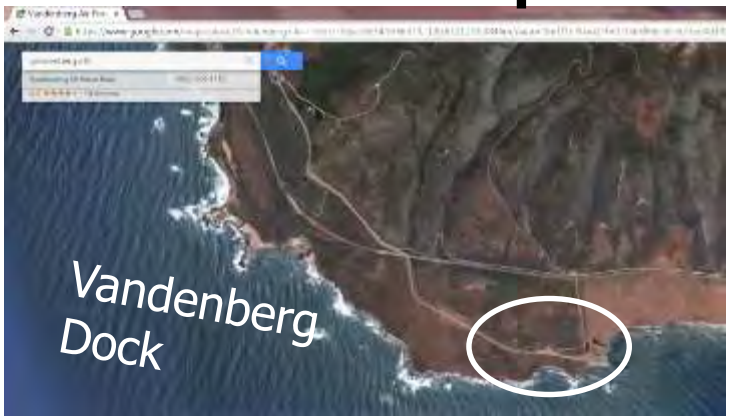
Primary HDD Upland Launch Location



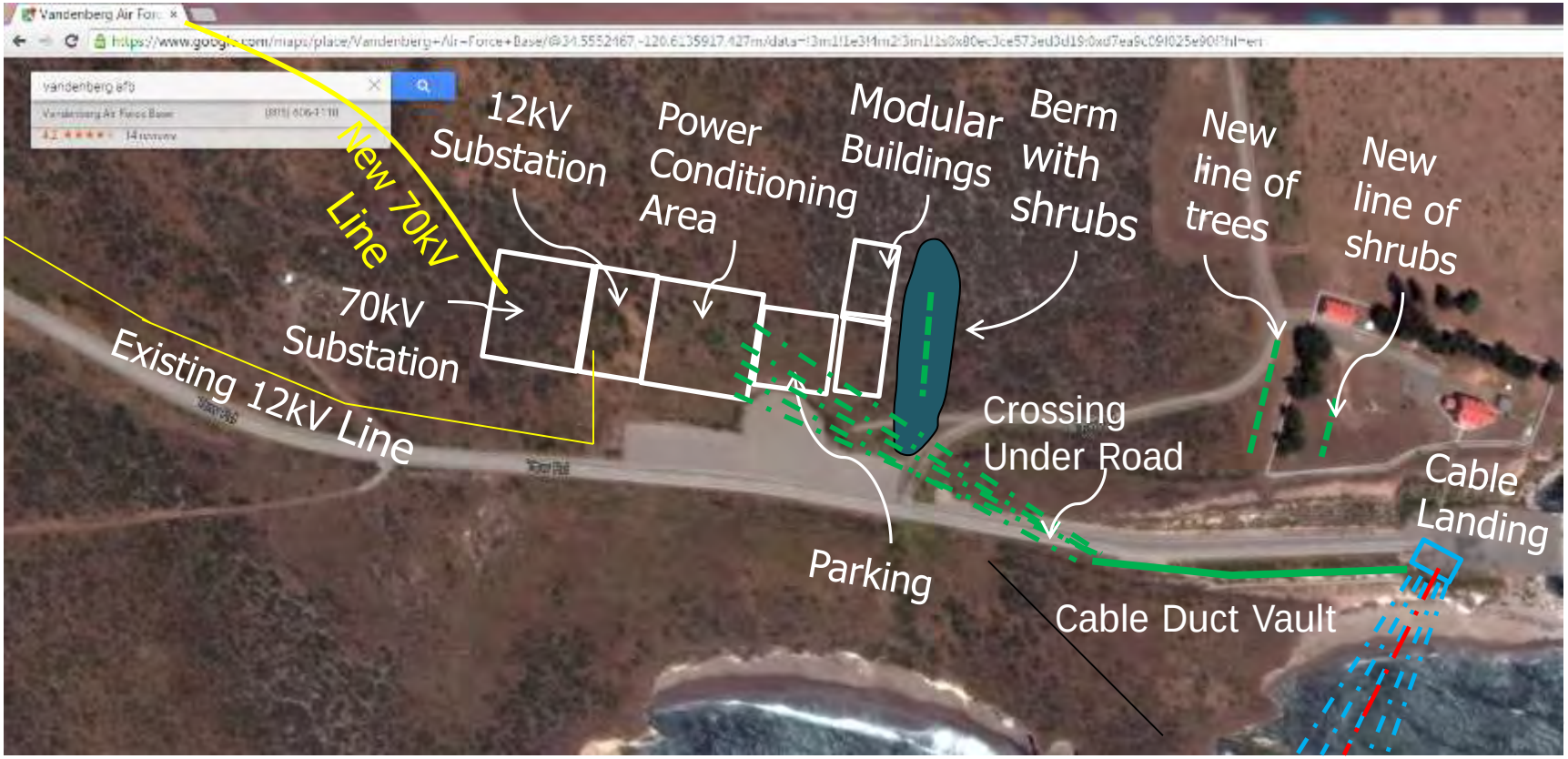
Onshore HDD Concepts - Upland



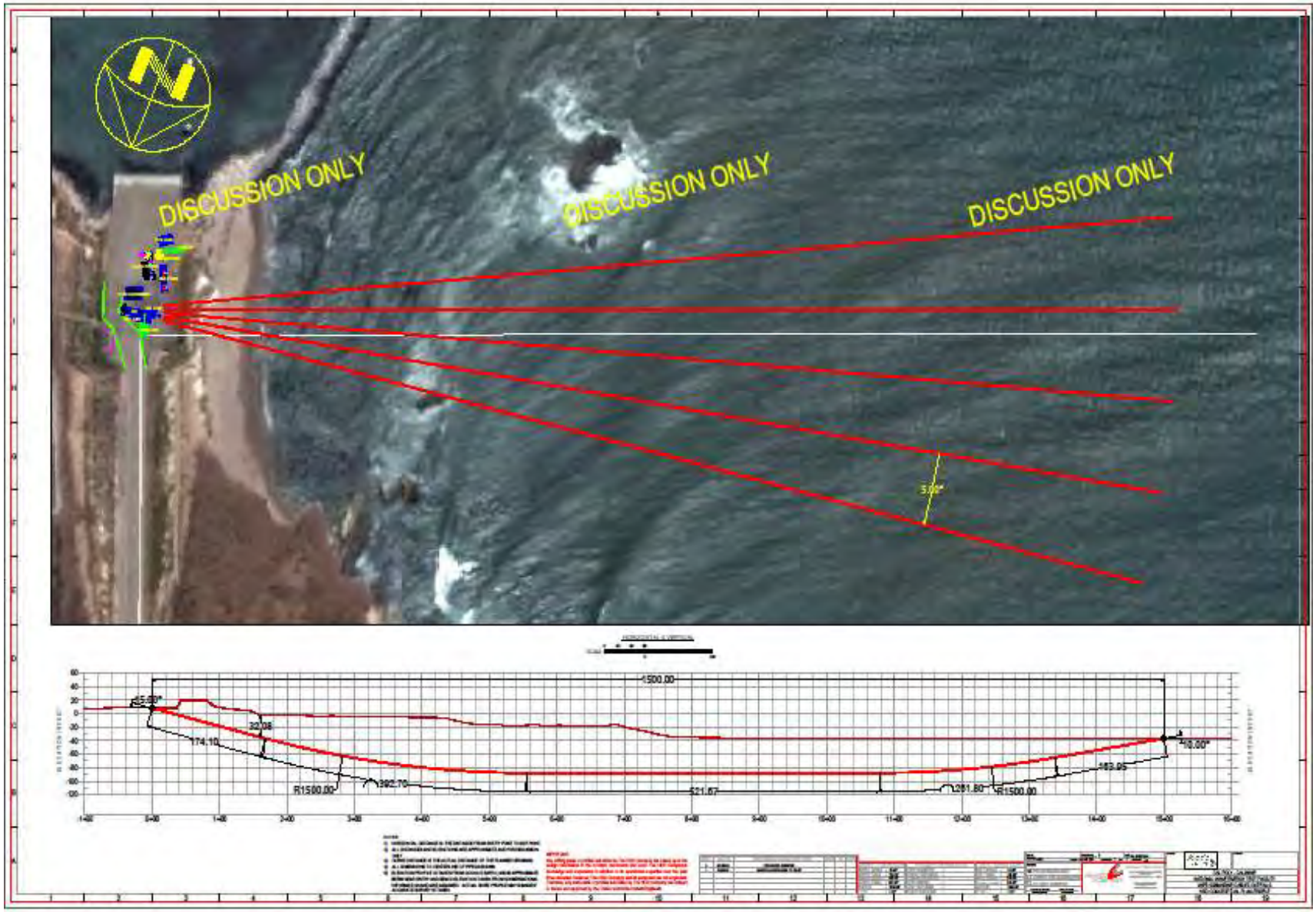
Conceptual Shore Station Site Plan



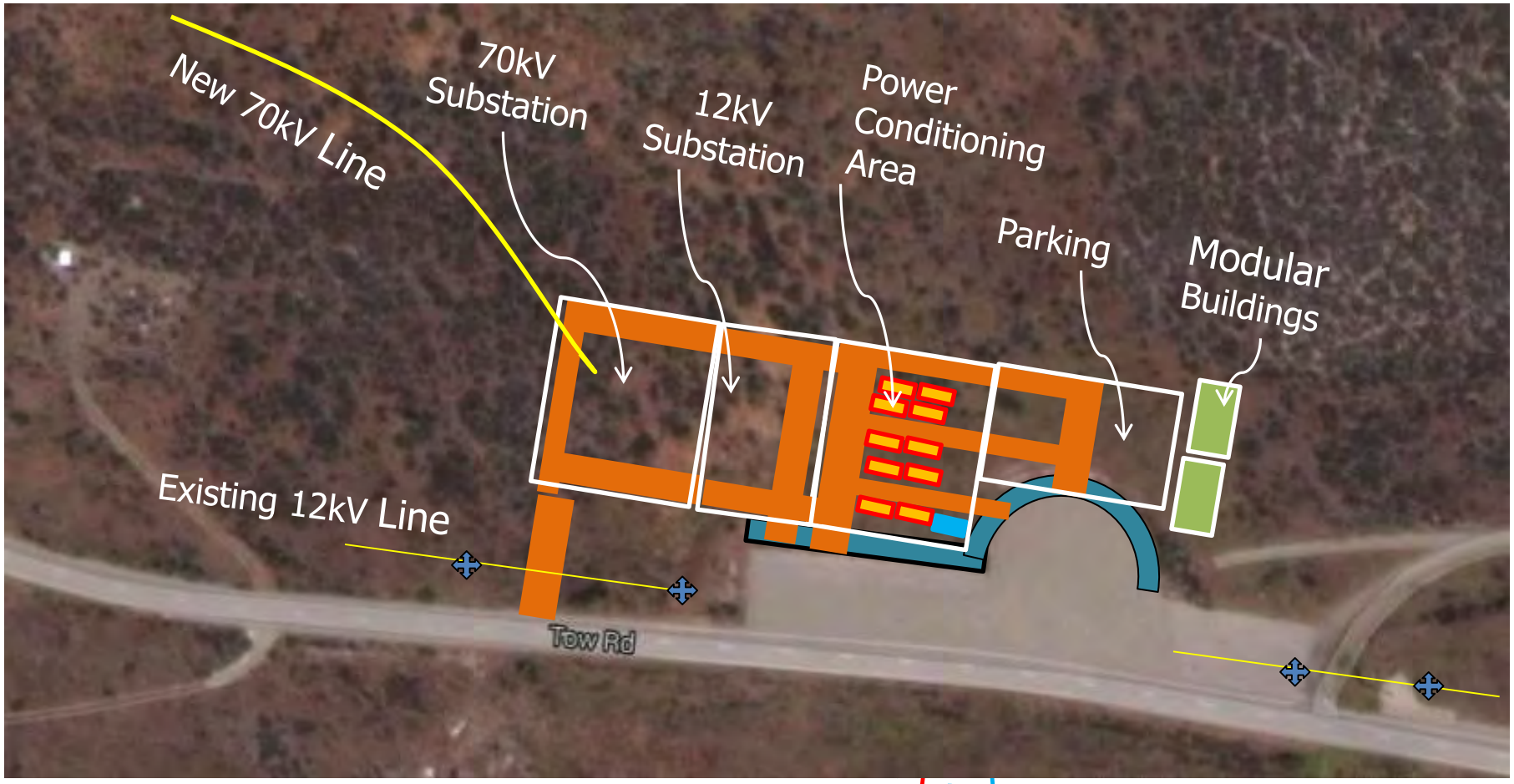
Alternate HDD Dock Launch Location



Onshore HDD Concepts - Dock



Conceptual Shore Station Site Plan



Two (2) 40 ft ISO Containers per circuit

Parking/Drainage Buffer

Suitable for trucks

Onshore HDD Concepts

Horizontal Directional Drill Equipment Setup

Shore Station Topography

General Notes:

Survey Basis: The Horizontal coordinate system is NAD83, Realization 2011 Epoch 2010.00 California State Plane Zone 5 (405). The orthometric heights are based on NAVD88. Units are U.S. Survey Feet. This Survey is based on OPUS Static Positioning of Point 5. RTK Checks were made on PID DZ1221 and DZ0837. Control Information is shown below.

Control Points:

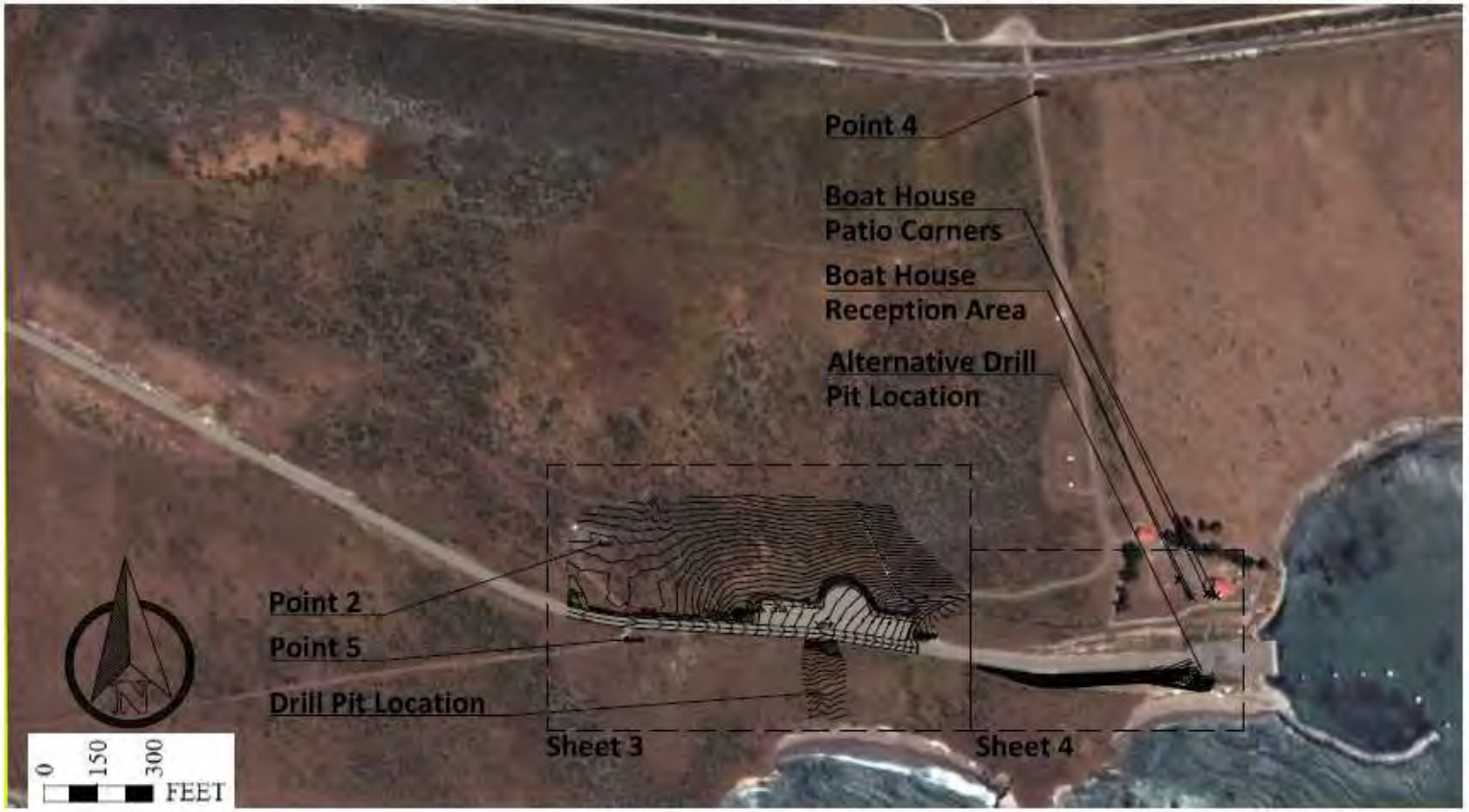
Point ID: 2
Description: PID DZ1221 Vandenberg VLBI STA 7223 3 1/2" Survey Disk stamped VLBI STA 7223 1983 DET 1 G SS

	Measured (sFt):	Published (sFt)
North:	2,035,003.008	2,035,003.19
East:	5,773,985.00	5,773,984.99
Ortho Ht:	80.77	80.88

Point ID: 4
Description: PID DZ0837 N 1214 Bench Mark Disk Stamped N 1214 1970

	Measured (sFt):	Published (sFt)
North:	2,036,283.72	2,036,292 (hand held GPS)
East :	5,775,344.30	5,775,340 (hand held GPS)
Ortho Ht:	159.62	159.59

Point ID: 5
Description: Set 5/8" Rebar capped "Survey Control"
Measured (sFt):
North : 2,034,715.209
East : 5,774,047.156
Ortho Ht: 79.1930



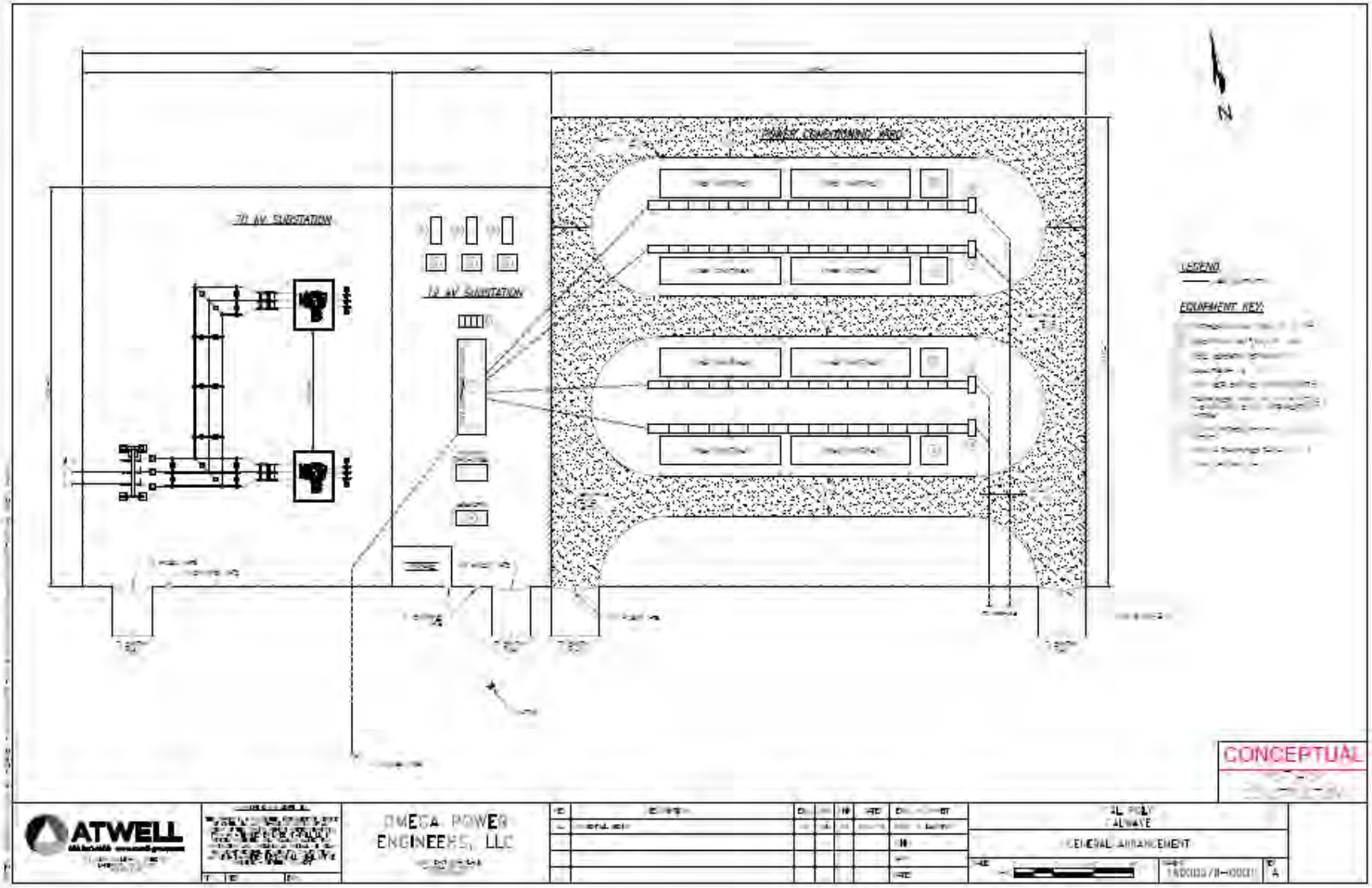
TOPOGRAPHIC MAP

GENERAL VICINITY

Scott Smith

2 of 4

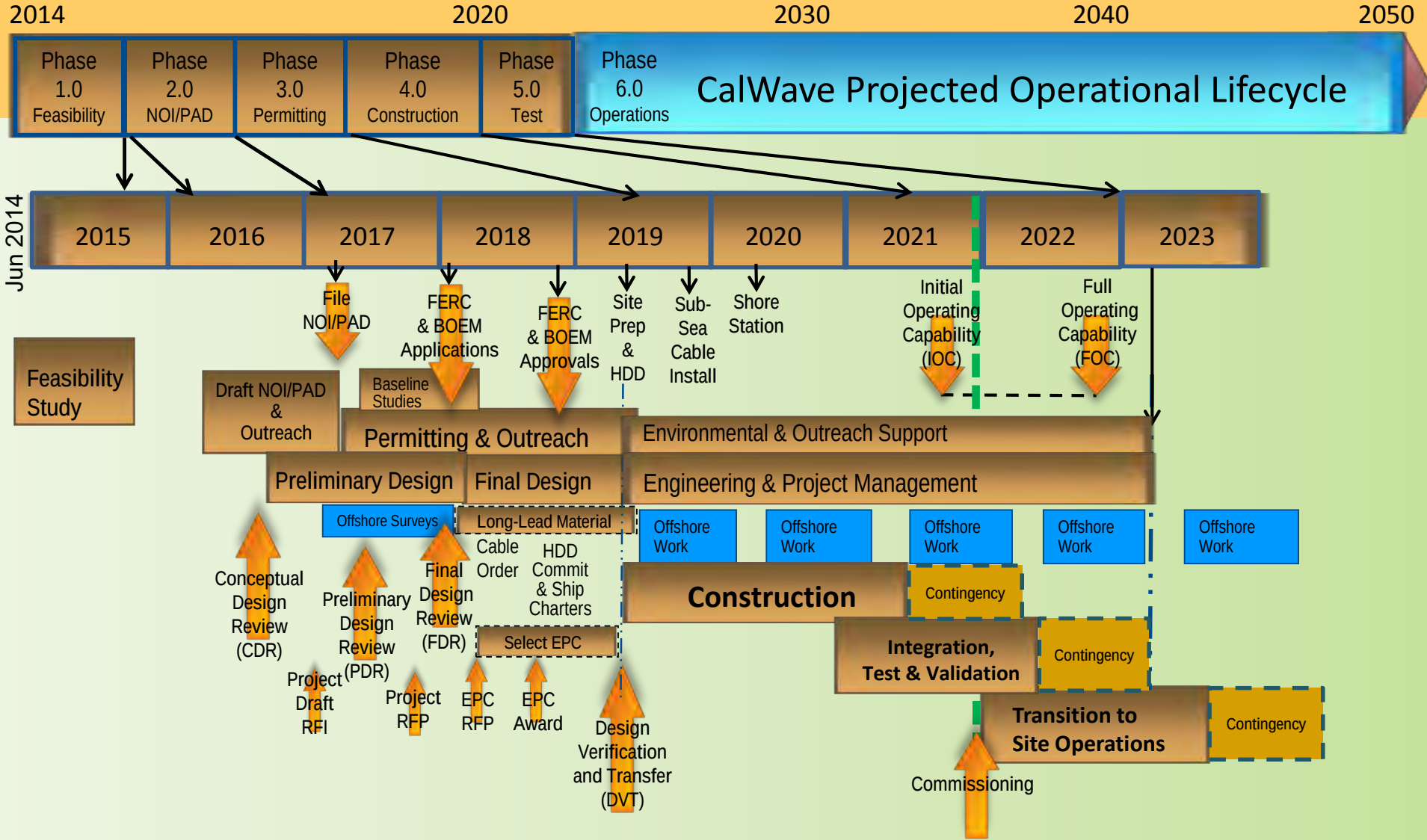
Conceptual Electrical Arrangement



CalWave
Cal Poly
Institute for Advanced Technology and Public Policy

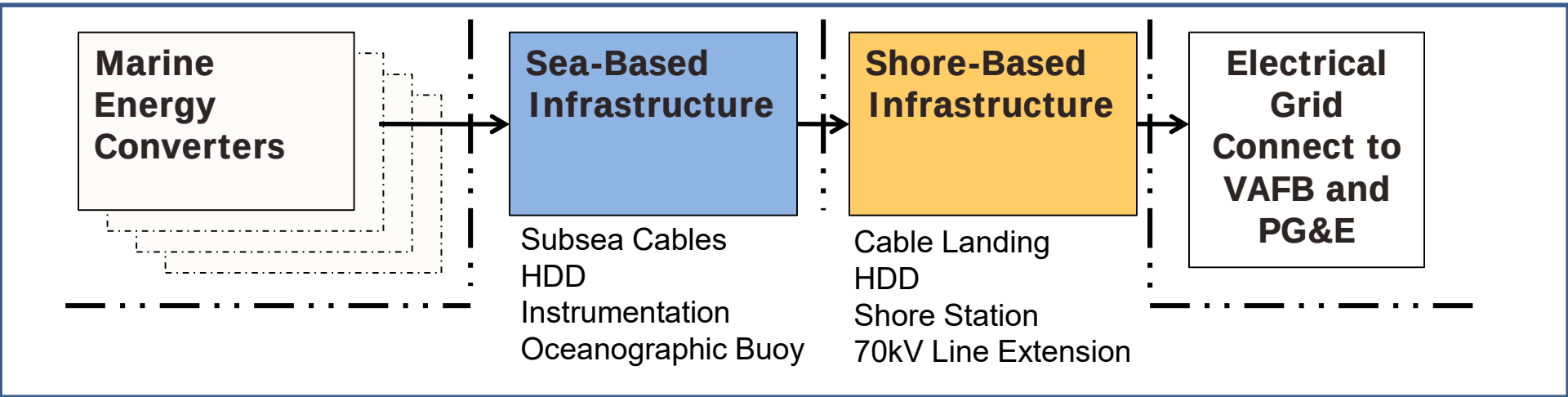
NATIONAL WAVE ENERGY TEST FACILITY

June 2015



Questions, Answers, & Discussion

- Requirements-Driven
  - Why Wave Energy?
  - Offshore Siting
  - On-shore Siting
  - Grid Integration
- Spiral Design
  - SubSea Cabling
  - Distribution vs Transmission
  - Grid Compliance and Power Conditioning



Contact CalWave℠

calwave@calpoly.edu

Dr. Sam Blakeslee, Principal Investigator

Bill Toman, Project Manager
(President, Protean Wave Energy, Inc)
707-731-9261 (m)

Rick Williams, Chief Engineer
(Leidos Maritime Solutions)
503-484-4415 (m)

ATTACHMENT 12-1

SOPO TASK 12 PERMITTING FINAL REPORT

Task 12.5 Draft Pre-Application Document

For the

California Wave Energy Test Center (CalWave)

DOE Award Number: DE-EE0006517.0005

Prepared for:

Cal Poly Corporation
Institute of Advanced Technology and Public Policy
California Polytechnic State University
San Luis Obispo, California

Prepared by:

CH2M Hill Engineers, Inc.
2485 Natomas Park Drive, Suite 600
Sacramento, CA 95833

February 2017

Department of Energy Award Number: DE-EE0006517.0005

Principal Investigator:

Sam N. Blakeslee, Institute of Advanced Technology and Public Policy, California Polytechnic State University (Cal Poly), San Luis Obispo

Project Manager:

William I. Toman, Institute of Advanced Technology and Public Policy, Cal Poly, San Luis Obispo

Principal Co-Authors:

Douglas M. Davy, CH2M
Richard B. Williams, Leidos Maritime Solutions
William I. Toman, Pacific Marine Renewables

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Acronyms and Abbreviations

AC	Alternating Current
AFB	Air Force Base
AUV	Autonomous Undersea Vehicle
BA	Biological Assessment
BMP	best management practice
BOEM	Bureau of Ocean Energy Management
CalCOFI	California Cooperative Oceanographic Fisheries Investigations
Cal Poly	California Polytechnic State University, San Luis Obispo
CalWave	California Wave Energy Test Center
CCC	California Coastal Commission
CDFW	California Department of Fish and Wildlife
CDP	Coastal Development Permit
CEQA	California Environmental Quality Act
CFR	Code of Federal Regulations
CG	Coast Guard
CSLC	California State Lands Commission
CWA	Clean Water Act
cyd	cubic yards
CZMA	Coastal Zone Management Act
DC	Direct Current
DOD	Department of Defense
DOE	Department Energy
EFH	Essential Fish Habitat
EA	Environmental Assessment
EERE	Energy Efficiency and Renewable Energy
EIR	Environmental Impact Report
EIS	Environmental Impact Statement
EMEC	European Marine Energy Center
EMF	electric and magnetic fields
ESA	Endangered Species Act
FAD	Fish Attraction Device
FCMA	Fishery Conservation and Management Act
FMP	Fisheries Management Plan
FERC	Federal Energy Regulatory Commission
HABS/HAER	Historic American Building Survey/Historic American Engineering Record
HAPC	Habitat Area of Particular Concern
HDD	horizontal directional drill
HMPE	high modulus polyethylene
ICPC	International Cable Protection Committee
ICSE	International Council on System Engineering

IOP	Initial Operating Capability
ISO	International Organization for Standardization
LiMPETS	Long Term Monitoring Program and Experiential Training for Students
MEC	Marine Energy Converter
METOC	meteorology and oceanography
MHK	marine hydrokinetic
MMPA	Marine Mammal Protection Act
MOU	Memorandum of Understanding
nm	nautical mile
NEPA	National Environmental Policy Act
NHPA	National Historic Preservation Act
NMFS	National Marine Fisheries Service
NNMREC	Northwest National Marine Renewable Energy Center
NOAA	National Oceanic and Atmospheric Administration
NOAA-NMFS	National Oceanic and Atmospheric Administration-National Marine Fisheries Service
NMFS	National Marine Fisheries Service
NOI	Notice of Intent
NOI/PAD	Notice of Intent/Pre-Application Document
NREL	National Renewable Energy Laboratory
OCS	Outer Continental Shelf
OEERE	Office of Energy Efficiency and Renewable Energy
OWET	Oregon Wave Energy Trust
PAD	Pre-Application Document
PFMC	Pacific Fisheries Management Council
PG&E	Pacific Gas and Electric Company
PMP	Project Management Professional
PNNL	Pacific Northwest National Laboratory
ROM	Remotely Operated Vehicle
ROV	Remotely Operated Vehicle
RPL	Route Position List
RWQCB	Regional Water Quality Control Board
SOPO	Statement of Project Objectives
SWRCB	State Water Resources Control Board
TRL	Technology Readiness Level
TP	Test Protocol
USACE	United States Army Corps of Engineers
USC	United States Code
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
VAFB	Vandenberg Air Force Base
WEC	wave energy converter
YOY	young-of-year

SECTION 1

Introduction

This document is intended as part of the Final Report for the California Wave Energy Test Center (CalWave) project, Phase II, specifically, as an attachment to the report for the Permitting task (Task 12) of the CalWave Statement of Program Objectives (SOPO). CalWave is funded by the U.S. Department of Energy (DOE) Office of Energy Efficiency and Renewable Energy (EERE) and cost-share partners and is part of an effort to advance the development of marine hydrokinetic energy (MHK) technology. This phase of work, called CalWave Phase II, involves developing conceptual designs, a stakeholder engagement program, and permitting roadmap for the project. It is funded as a continuation of the DOE Feasibility Study grant (DE-EE0006517.0005). The CalWave program is led by the California Polytechnic State University at San Luis Obispo (Cal Poly) Institute of Advanced Technology and Public Policy. The purpose of CalWave Phase II is to:

- Finalize the siting of the offshore wave energy test berths
- Finalize the siting of the shore station
- Progress project design from conceptual to preliminary phases
- Prepare a cable route desktop study
- Evaluate available environmental baseline information
- Identify environmental permitting issues and agencies
- Conduct stakeholder engagement meetings, including meetings with regulatory agency personnel and a project advisory group of stakeholders
- Prepare a regulatory roadmap for permitting CalWave

SOPO Task 12 involves permitting CalWave. Subtasks are to evaluate environmental baseline information, participate in stakeholder engagement activities, and prepare the regulatory roadmap for permitting the project. This report has been prepared in the format of a Federal Energy Regulatory Commission (FERC) Pre-Application Document (PAD). The final PAD will initiate licensing of CalWave before the Federal Energy Regulatory Commission (FERC) during a future phase (Phase III) of CalWave. Its purpose is to inform FERC, other regulatory agencies, and the public regarding the location and design of the CalWave project and any regulatory issues to be discussed further and resolved during the licensing proceeding. The final PAD will thus serve as a master permitting document for permitting CalWave. Preparing the CalWave Phase II report in the format of a PAD will enable a rapid startup to Phase III work with a final PAD while also providing a suitable format for a portion of the report to the United States Department of Energy on Phase II permitting activities.

1.1 Project Objectives

The primary objective of the CalWave program is to design, permit, construct, and operate a long-duration (20- to 30-year design life), fully energetic, grid-connected, open-ocean facility national wave energy testing facility for advanced wave energy converters (WECs), located on the Central California coast offshore of VAFB. Advancing MHK technology will foster the development of a robust and competitive MHK industry in the U.S. that will become cost-competitive with other forms of electricity generation. Subsidiary objectives include:

- Provide affordable access for MHK technology developers to world-class test facilities for emerging wave energy components and systems
- Reduce technical and financial risks of MHK technology deployment
- Reduce the cost of testing for individual developers and the industry as a whole
- Reduce the time-to-market of commercially-ready systems

1.2 Project Elements

The CalWave Project consists of the following major elements, described in greater detail in Section 3.0:

- Four WEC device test berth locations for WEC/WEC Array demonstration and evaluation on the Outer Continental Shelf (OCS), between 3 and 4 nautical miles (nm) offshore of Vandenberg Air Force Base (VAFB), in 90 to 110 meters (50 to 60 fathoms) of water depth. The diameter of each circular test berth will be approximately 0.6 to 0.7 nm (1,100 to 1,300 m), depending on the water depth and resulting extent of mooring cables. The extent of the test berth area will be approximately 6 square nautical miles, plus transit lanes.[1]
- WECs of various designs, within the scale and design limits described in Section 3.3.2, that WEC developers bring to CalWave for testing
- WEC anchoring devices and mooring cables, 2 to 6 inches in diameter, within the scale and design limits described in Sections 3.3.4 and 3.3.5 that the WEC developers provide for their WEC devices
- WEC umbilical electrical cables connecting the WEC device(s) with the power cable, as described in Section 3.3.6
- Submarine electrical power cables extending from a shore station to the test berth locations. The cables will be rated at 12.5 MW and extend to for approximately 3.25 nautical miles to water depth of approximately 90 meters (50 fathoms). The cables will be approximately 4.25 inches in diameter and will be laid on the seafloor surface. The cables will terminate at a dry-mate connector to which the WEC test berths will connect. There will be four cables to serve the four test berths plus a fifth, spare, cable that will also be used for pre-deployment checkout and data collection.
- A shore station near Vandenberg Dock, consisting of an operations building for test center staff and operations and monitoring equipment and a control building with office space for WEC developer staff and monitoring equipment
- Four modular buildings at the shore station containing power conditioning equipment, where power will be received from the individual WEC test berths and conditioned to grid standard
- One modular building housing electrical switchgear and associated controls
- A substation with transformers that will step WEC power output from the WEC output voltage (will vary) to 12 kV for transmission to the VAFB distribution grid
- A substation with transformers that will step WEC power output from 34.5 kV to 70 kV for transmission to the VAFB distribution grid
- A 70 kV generator tie-line upgrade extending from the shore station to VAFB's transmission grid at a substation (Substation "N") that will convey WEC power at 70 kV to the VAFB grid. The upgrade will consist of approximately 10.8 miles (57,190 feet) of overhead 70 kV transmission line mounted on 52 transmission structures. The transmission structures will consist of laminated wood poles 110 feet height for spanning over roadways in two locations, and 48 concrete poles approximately 70 feet in height for the remainder of the line.

1.3 Project Development History

The CalWave Phase I Feasibility Study, completed in July 2015, was sponsored by the U.S. Department of Energy (DOE) and cost-share partners through DOE's funding, #DE-EE0006517. It evaluated offshore test sites along the California coast for establishment of a national wave energy testing facility appropriate for

[1] The BOEM Lease Block Administrative Area may be larger than the test berth area to conform to the square pattern of aliquots and may approach nine (9) square nautical miles.

the testing of WEC devices under conditions that approach full-scale, grid-connected operation. The Feasibility Study identified a candidate shore-station site for the facility on Vandenberg Air Force Base (VAFB) near Point Arguello and the Vandenberg Dock, and five alternative sites for WEC test berths. There were no obstacles identified that would prevent successful development of the facility.

This phase of work (called CalWave Phase II) is funded by a continuation of the Feasibility Study grant (DE-EE0006517.0005). The project is led by the California Polytechnic State University at San Luis Obispo (Cal Poly) Institute of Advanced Technology and Public Policy.

SECTION 2

Process Plan and Schedule

18 CFR § 5.6 (d)(1) - Process plan and schedule

Time frames for pre-application consultation, information gathering, and studies

Proposed location and date for scoping meeting and for the site visit § 5.8 (b)(3)(viii)

2.1 Permitting Background

The CalWave project has been under study since the Phase I Feasibility Study began in August of 2014. Investigation of the Point Arguello area as a potential site for a wave energy test center began even earlier as part of Pacific Gas and Electric Company's (PG&E's) WaveConnect program in the Fall of 2009.[2] During the Feasibility Study Phase, which was completed in September of 2015, the project team held meetings with regulatory agencies and other stakeholder and evaluated several siting alternatives, eliminating all but two of these, both reachable from a shore station site at VAFB's Vandenberg Dock. During the (current) Phase II, the permitting team has participated in the following Stakeholder engagement (pre-application consultation activities):

- California Energy Commission Integrated Energy Policy Report Workshop on Marine Renewables, held May 25, 2016 in Sacramento, California. The workshop was attended by a number of the applicable CalWave regulatory agencies including California Department of Fish and Game, State Lands Commission, Coastal Commission, National Oceanic and Atmospheric Administration National Marine Fisheries Service, and United States Department of Fish and Wildlife. CalWave was represented at the meeting by William I. Toman, who presented on the project in general and Doug Davy on CalWave and MHK permitting.
- Meeting and site visit with VAFB environmental specialists regarding environmental resources near the shore station and along the 70 kV upgrade line, and to determine the location of the cable shore landing, June 16, 2016.
- Meeting near the Bureau of Ocean Energy Management offices in Camarillo, California attended by the key regulatory agencies Federal Energy Regulatory Commission, California Department of Fish and Game, State Lands Commission, California Coastal Commission, National Marine Fisheries Service, United States Department of Fish and Wildlife, U.S. Coast Guard, U.S. Army Corps of Engineers, and others on July 11, 2016. Agency staff heard presentations on the development of the project description and regulatory permitting issues and provided feedback and commentary.
- Meeting with a designated Advisory Group of stakeholders, held in San Luis Obispo, California on October 10. The Advisory Group included representatives from local economic development groups, labor, commercial and recreational fishers, offshore industrial service businesses, universities, Native American tribes, regulatory agencies, elected representatives, local government, and non-governmental agencies such as Surfrider Foundation, Nature Conservancy, and Environmental Defense Center. Those attending heard presentations regarding the development of the project description and regulatory permitting issues and provide commentary and feedback.

[2] Several members of the CalWave development team also served on the development team for WaveConnect.

- Meeting near the Bureau of Ocean Energy Management offices in Camarillo, California on October 10 attended by the key regulatory agencies (including Federal Energy Regulatory Commission, California Department of Fish and Game, State Lands Commission, California Coastal Commission, National Marine Fisheries Service, United States Fish and Wildlife Service, U.S. Coast Guard, U.S. Army Corps of Engineers). Agency staff heard presentations on the development of the project description and regulatory permitting issues and provided feedback and commentary.

2.2 Time Frames for Pre-Application Consultation

The following schedule for pre-application consultation (Table 2.2-1) assumes that CalWave Phase III is funded in December, 2016 and work can begin by March 1, 2017. Dates are estimated and approximate.

Table 2.2-1. Time Frames for Pre-Application Consultation

Event	Agency	Date	Notes
CalWave Agency Meeting	Multiple	12/8/2016	Final Phase II meeting
Pre-application consultation with regulatory agencies	Multiple	3/1/2017 to 6/30/2017	Develop baseline data, define regulatory issues, and identify studies that may resolve regulatory issues
Conduct environmental field studies	Multiple	3/1/2017 to 3/1/2018	Conduct environmental field studies
File Lease Application	BOEM	3/30/2017	File application for Research Lease
Respond to BOEM Request for Information	BOEM	4/30/2017	CalWave provides any additional information needed by BOEM Staff
BOEM issues Request for Competitive Interest	BOEM	5/30/2017	Public announcement by BOEM
BOEM makes Determination of No Competitive Interest	BOEM	6/30/2017	Assumes that there will be no competitive interest[3]
File Notice of Intent (NOI), PAD, and Study Plans	FERC	7/1/2017	Request FERC Alternative Licensing Process

2.3 Scoping Meeting

We propose to hold the FERC Scoping Meeting in July of 2017 in Lompoc, California, which is the municipality nearest to the project site.

[3] It is currently assumed that there will be no competitive interest for a lease of this type. If there were competitive interest, BOEM would enter an auction process and the BOEM interest determination process would take longer.

SECTION 3

Project Location, Facilities, and Operations

§ 5.6 (d)(2) - Project location, facilities, and operations

(i) Contact information for applicant's agents (name, address and phone numbers)

(ii) Maps of land use within project boundaries (township, range and section, state, county, river, river mile, and closest town) and, if applicable, Federal and Tribal lands, and location of proposed facilities

(iii) Detailed description of proposed facilities

(A) Composition, dimensions, and configuration of dams, spillways, penstocks, powerhouses, tailraces, etc.

(B) Reservoir area, gross and usable capacity, and elevation.

(C) Number, type and capacities of turbines and generators, and installed (rated) capacity of proposed turbines or generators

(D) Transmission line numbers, lengths, voltage, and interconnections (including diagrams)

(E) Energy production (estimate of dependable capacity, average annual, and average monthly energy production)

(iv) Current and proposed project operation

(v) Description of proposed physical and operational changes to project

3.1 (i) Contact Information for Applicant's agents

Principal Investigator:

Sam N. Blakeslee, Institute of Advanced Technology and Public Policy, California Polytechnic State University (Cal Poly), San Luis Obispo
Sambee@outlook.com
(805) 756-1694

Project Manager:

William I. Toman, Pacific Marine Renewables
witomanium@gmail.com
(707) 731-9261

3.2 (ii) Maps of Land Use within Project Boundaries

CalWave test berths will be located on the OCS between 3 and 5 nautical miles from the shores of VAFB. The shore station will be located on federally owned land of VAFB. The shore station will be located at the intersection of Boat House Road and Tow Road on VAFB near Vandenberg Dock, at 34.555° North Latitude/120.614 West Longitude (UTM Zone 10S, 718,916m E/3,826,330m N), Santa Barbara County, California. The generator tie line will connect the Shore Station with VAFB Substation N.

The CalWave Test Berth Operational Area will be limited to six (6) square nautical miles, plus transit lanes if requested. The BOEM Lease Block Administrative Area may be larger, than the test berth area to conform to the square pattern of aliquots and may approach nine (9) square nautical miles. CalWave will seek a Research Lease of OCS submerged lands from BOEM for the following full or partial aliquots:

South Group

- Lease block 6474: 6474 I, L, P
- Lease block 6475: 6475 E (partial), I, J (partial), M, N

South by Southeast Group

- Lease block 6526: 6526 E, F, G, I, J, K

The aliquots are found in two groups; one for the South test berth site (4 full and 2 partial aliquots) and one for the South by Southeast site 6 aliquots.

Maps of the project location are provided as Figures 3.2-1, 3.2-2, and 3.2-3.

3.3 (iii) Detailed Description of Project Facilities

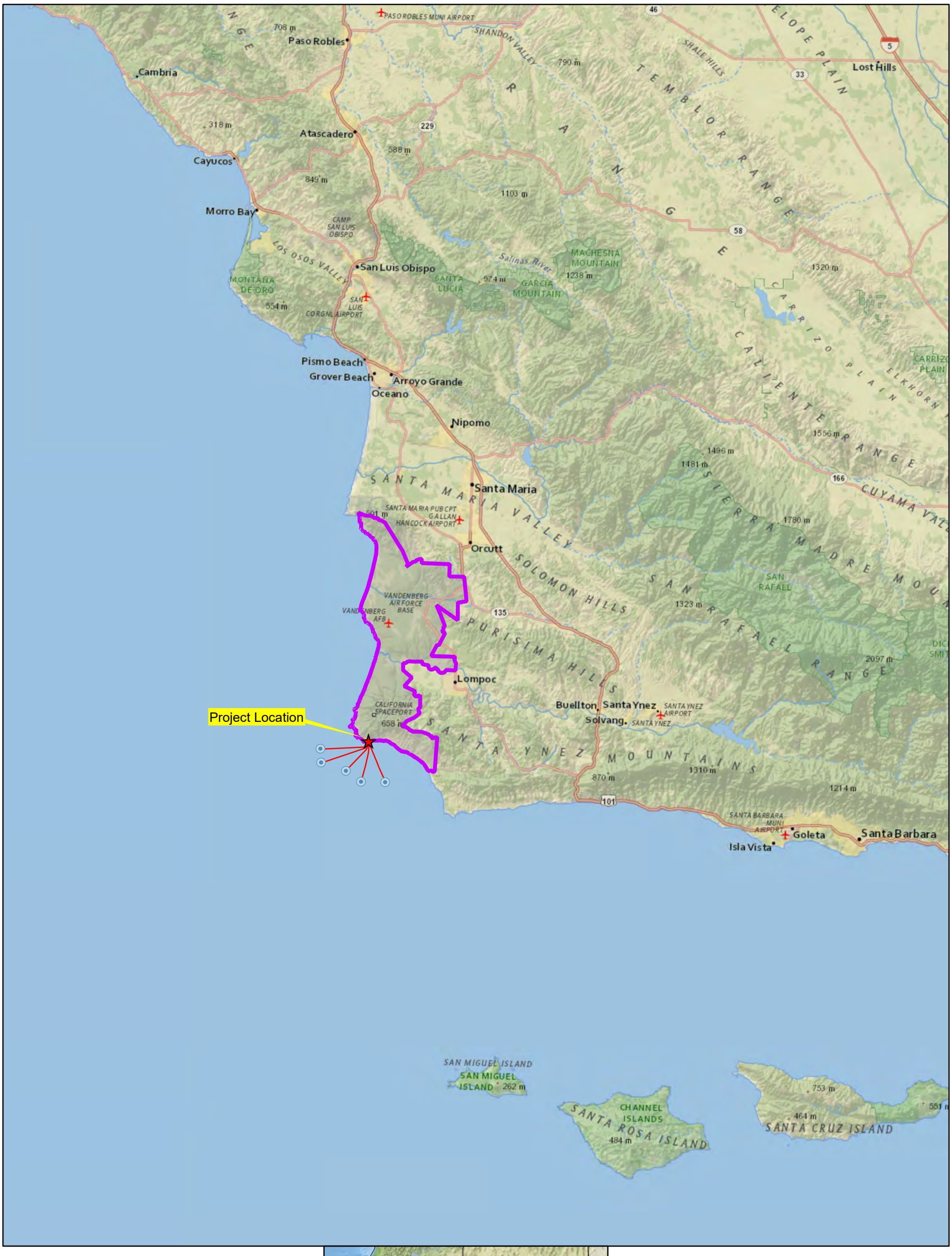
FERC guidelines require the following information be provided in the PAD:

(A) Composition, dimensions, and configuration of dams, spillways, penstocks, powerhouses, tailraces, etc.
(B) Reservoir area, gross and usable capacity, and elevation.
(C) Number, type and capacities of turbines and generators, and installed (rated) capacity of proposed turbines or generators
(D) Transmission line numbers, lengths, voltage, and interconnections (including diagrams)
(E) Energy production (estimate of dependable capacity, average annual, and average monthly energy production)

Because the CalWave test center will involve MHK devices instead of hydroelectric facilities, it will not have dams, spillways, penstocks, powerhouses, tailraces, or a reservoir. Energy production can be estimated in general terms, but cannot be specified precisely. Because of these differences, we have organized this project description by CalWave project element.

In addition, because CalWave is a facility designed to test MHK technology, including newly developed designs, it is not feasible to provide a detailed description of each specific device that will test at CalWave. Also, because the WEC developers will bring their own anchoring and mooring systems, it is not possible to provide specific details about each individual anchor and mooring set that will be used for the WECs tested. Rather, for the WECs and their anchoring and mooring systems, this PAD provides a permitting "envelope" (bounding box, or bookends) that describes the basic types of WECs and anchoring/mooring systems that we expect to be tested there. The permitting envelope describes the general types of WECs that will be allowed under the permit (pre-permitted) and describes their scale and likely environmental effects. WECs of a type not described in the project description/permitting envelope would not be considered permitted equipment, but could be permitted with a streamlined supplemental analysis (and focused supplemental National Environmental Policy Act (NEPA) document and license amendment) that would focus only on the differences between the unpermitted WEC type and those types within the envelope.

Similarly, several anchoring and mooring designs are described in this project description as permitted within the permitting envelope. In addition, the scale of the system is described. WECs requiring mooring systems outside of the envelope boundaries would not be considered pre-permitted, but may require additional review.



LEGEND

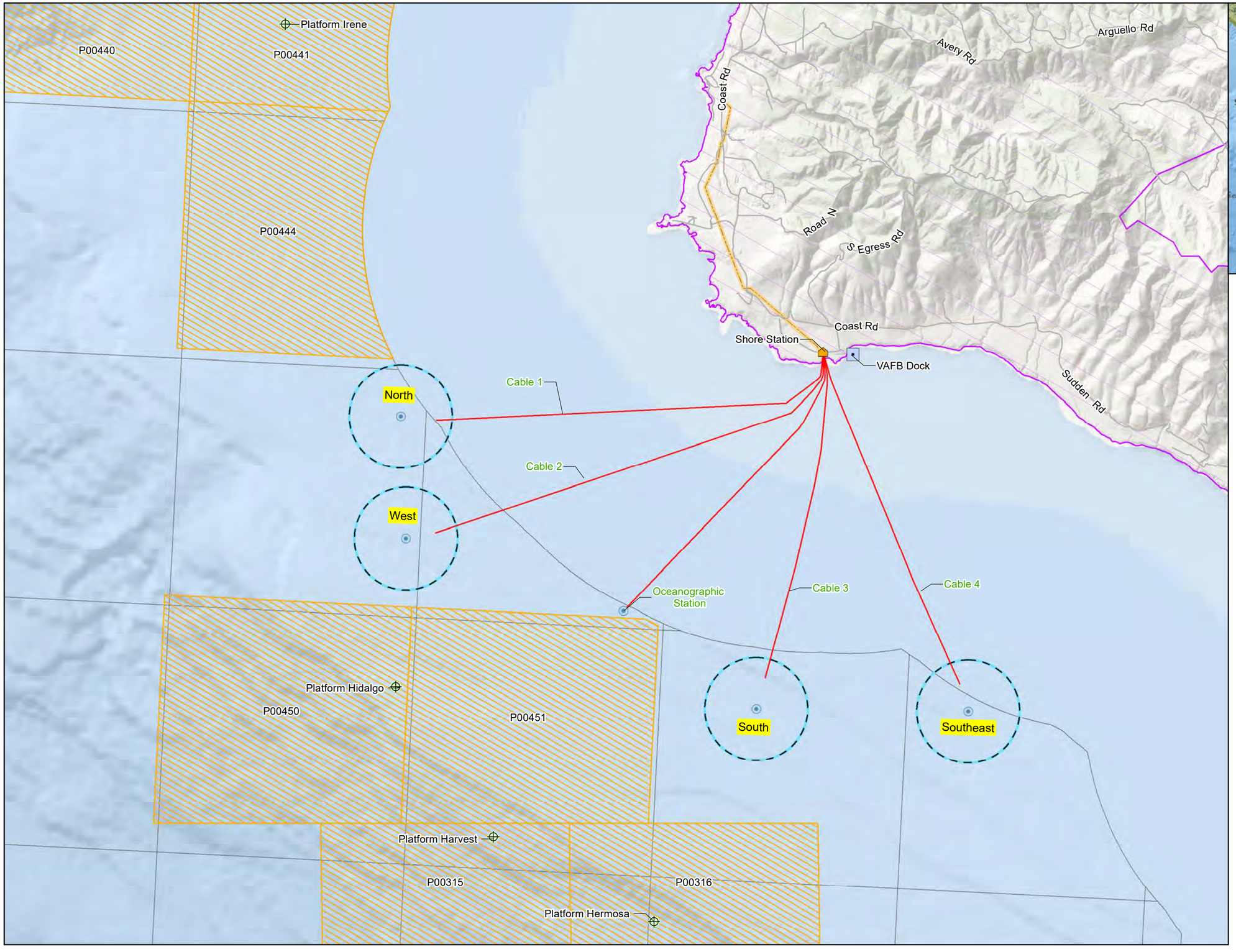
- Berth Locations
- Shore Station
- Cable Route
- Vandenberg Air Force Base

N

0 10 20

Miles

Figure 3.2-1
Project Vicinity
California Wave Energy Test Center (CalWave^{sm})



LEGEND

- Berth Locations
- Shore Station
- VAFB Dock
- Platform
- Transmission Line
- Santa Maria Lease Blocks
- Cable Route
- Test Berth
- BOEM Pacific Oil and Gas Leases
- Vandenberg Air Force Base

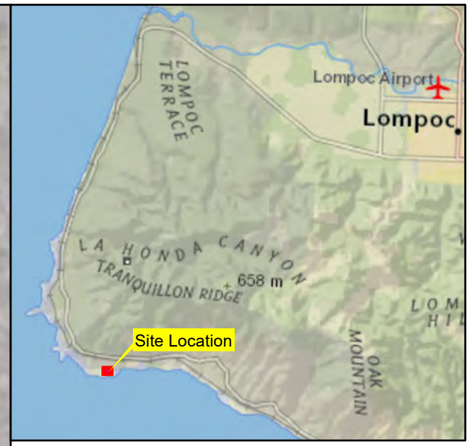
Service Layer Credits: Esri, DeLorme, GEBCO, NOAA NGDC, and other contributors
Content may not reflect National Geographic's current map policy. Sources: National Geographic, Esri, DeLorme, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.

N

0 6,000 12,000
Feet

Figure 3.2-2
Project Location
California Wave Energy Test Center (CalWave℠)

ch2m



LEGEND

- 70 kV Transmission Line (Future)
- 12kV Distribution Line (Existing)
- Proposed Structure

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Content may not reflect National Geographic's current map policy. Sources: National Geographic, Esri, DeLorme, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.

N

0 75 150
Feet

Figure 3.2-3
Shore Station Components
California Wave Energy Test Center
(CalWave^{sm})

ch2m

3.3.1 Test berths

CalWave will support four test berths for WEC/WEC Array demonstration and evaluation, each served by a dedicated submarine electrical cable from shore. The test berth areas will be defined as a roughly circular area that is defined by the areal extent of the mooring system on the sea floor. This extent is determined by the slope of the mooring cables and the water depth. For example, if a single WEC were moored over a flat seabed in 100 meters (55 fathoms) of water depth and used a 6:1 catenary mooring, the test berth would extend on the seafloor across a circle 1200 meters in diameter and covering about 113 hectares. In actuality, the seafloor slopes, so the berth area would extend further than the idealized perfect circle into deeper water and extend less towards shore and shallower water depths. The resulting true test berth would be an ellipse.

The sea surface area within which the WECs would move is the 'watch circle' within which the resistance of the mooring cables or anchors allows the WEC to move. For a 6:1 catenary mooring in 100 meters of depth, for example, the watch circle would be approximately 100 to 300 meters in diameter.

For the purposes of this project description, it is expected that the approximate centers of the test berth circles will be at the following locations:

- North: 34.531797 N lat/120.69693 W long
- West: 34.5214605 N lat/120.702035 W long
- South: 34.516 N lat/120.701 W long
- Southeast: 34.485022 N lat/120.614248 W long

3.3.2 WEC devices

CalWave will be designed to test WECs, devices that harness the energy in ocean waves to generate electricity, which are moored to the seafloor in water approximately 90 to 110 meters (50 to 60 fathoms) deep. Devices to be tested at CalWave will generate electricity for transmittal through subsea cables to the shore station on VAFB. Currently, the CalWave project plan does not provide for near-shore devices that would use ocean energy to pump water ashore to generate electricity using shore-based turbines or for other purposes. Such devices could be permitted at CalWave in the future under a separate leasing agreement and set of permits and authorizations.

3.3.2.1 Permitted Devices

The major types of WECs for which CalWave has been designed are as follows:

Point Absorber

Description. A point absorber is a floating or subsurface moored structure that converts the up-and-down motion of an ocean wave or swell as it passes the device into motion in an electrical generating device. Most point absorbers do this by exploiting the difference in momentum between a lighter weight structure on or near the surface that moves up and down with the ocean wave that is connected with a heavier base or counterweight that extends vertically down into the water column and is more resistant to motion than the surface buoy. Point absorbers may be entirely mechanical, with the surface/near surface structure moving relative to the base, or may be hydraulic, with the lighter surface structure driving a hydraulic ram, or pumping water back and forth through a small turbine wheel (hose pump). Point absorbers can be partly or entirely submerged. Generally speaking, the surface or near-surface expression of a point absorber is small, relative to the subsurface expression and the distance between wave crests. They can depend

entirely on the up and down motion of the counterweight/base or can deploy wings adjacent to the surface structure to create a back and forth motion in the base.[4]

Submerged pressure differential devices are point absorbers mounted on the sea floor significantly below the water surface. They depend on the subsurface movement of ocean waves to alternatively increase and decrease pressure, creating an up and down motion in a device attached to the sea floor-mounted base. This type of device is generally placed in shallow water near shore and will not be considered for CalWave at this time.

Scale. Point absorbers are constructed at a variety of scales but, generally speaking, the larger the structure and its counterweight, the more power can be generated per device. The scale of the device, however, is governed by the substructure/counterweight, which may extend for tens of meters below the surface. For the purposes of CalWave permitting, the largest expected point absorber would be 30 meters in diameter and would extend 15 meters above the water line, and 60 meters below the surface. By way of comparison, standard marker buoys are up to 15 m in diameter and 15 meters above the water line.

Shape and Structure. On the water surface, point absorbers resemble marker buoys, having a superstructure housing for equipment and mast for radio transmission and visibility marking. The superstructure may be round or square/rectangular in shape. Generally, the base is fixed to the end of a long, vertical spar that extends into the water.

Mooring and anchoring needs. Can be a multi-point catenary or single-point mooring, depending on the scale of the device. Drag-embedment or dead weight anchors most likely at CalWave.

Examples. Ocean Power Technologies' PowerBuoy - http://www.oceanpowertechnologies.com/, Columbia StingRAY - http://columbiapwr.com/
Oscilla Power Triton - http://oscillapower.com/triton-wec/

Floating Oscillating Water Column

Description. An oscillating water column (OWC) is a moored, floating structure like a barge that contains one or more openings on its bottom surface, to the sea. The openings entrap a column of water with a column of air on top of it that is open to the surface. Waves passing the device alternatively push and pull the water and air column up and down and the motion of the air moving up and down is harnessed to create electricity. As the wave peak passes the device, the water column rises and pressurizes the air, pushing it up through an air-driven turbine mounted on the barge deck. As the wave peak recedes, the water column drops back down in the opening, dropping air pressure above the water column and drawing air back down through the turbine. The turbine is rotates in the same direction regardless of air flow direction (Wells turbine).

Scale. OWCs can be mounted as multiple units on a buoy or barge structure. Although shore-mounted OWCs are not included in the CalWave testing project description currently, they can also be mounted on the shore or in a breakwater. An individual OWC open column designed to maximize the wave energy harnessed would be no more than half the average wave length in diameter or width, but could be considerably smaller.

Shape and Structure. A barge containing multiple OWCs could be created at a variety of scales and shapes. We expect that the largest OWC device to be tested at CalWave, would be no larger than 60 meters in diameter.

[4] For example, Columbia Power Technologies' StingRAY, which has two spars connected to a counterweight damper that moves back and forth, rather than up and down.

Mooring and anchoring needs. Can be a multi-point catenary or single-point mooring, depending on the scale of the device. Devices of this type deployed in shallow water on the sea floor or in a breakwater would not be tested at CalWave. Drag-embedment or dead weight anchors are most likely at CalWave.

Example. Oceanlinx - http://oceanlinx.com/.

Rotating Mass

Description. Rotating mass WECs convert the back-and-forth, rocking motion of a moored vessel as a wave passes, to a circular motion around a rotating axis. A generator is attached to the axis and converts the rotating motion to electrical power. There are two main subtypes: eccentric weight and gyroscopic.

In an eccentric weight rotating mass WEC, an asymmetrical (lop-sided) weight is mounted on a vertically aligned axle and enclosed within a vessel. As waves pass the vessel, the axle rocks forward in the direction the wave is moving, then back in the opposite direction, causing the eccentric weight to swing back and forth on the axle with the tilting vessel, and rotate around the axis. Mechanical design features ensure that the eccentric weight rotates in a single direction so that the axle moves in a circular path, rather than back and forth.

The gyroscopic rotating mass device works in a similar way, except the rotating device is a spinning disk mounted within in a moveable frame (gyroscope). The tilting back and forth of the vessel as waves pass keeps the gyroscopic disk rotating due to its angular momentum, and this rotating motion is used to drive a generator.

Scale. The rotating mass would be housed within a vessel, the narrow dimension of which would be less than half the wave length of the prevailing wave to achieve the most efficient conversion of energy. For the sake of CalWave permitting, we assume that the vessel would be no larger than 50 by 70 meters, with no more than 20 meters of draft.

Shape and Structure. Rotating mass WECs are generally vessel-form buoys. The Wello Penguin, for example, is 29 by 16 meters with 9 meters draft and is asymmetrical, formed to a shape that enhances motion of the rotating mass.

Mooring and anchoring needs. Can be a multi-point catenary or single-point mooring, depending on the scale of the device. Drag-embedment or dead weight anchors most likely at CalWave.

Example. Wello Penguin - http://www.wello.eu/en/.

Linear Attenuator

Description. A linear attenuator is a long and narrow structure, often a cylinder, which is moored in alignment with the direction of the waves. As the wave passes, it moves the each end the cylinder up and down relative other parts of the cylinder and drives hydraulic rams which, in turn, drive turbine generators. The best known linear attenuators are segmented attenuators, meaning that the cylinder contains several segments that are hinged to one another and move separately.

Another type of linear attenuator uses a flexible, water-filled hose that lies on the ocean surface. Passing waves cause the tube to flex and water to flow down the tube from the wave crest in both directions. The wave thus creates a water pressure pulse (bulge wave) that travels the length of the tube to a low-head hydroelectric turbine mounted at the down-wave end of the tube.

Scale. The best-known and most advanced development of a linear attenuator is Pelamis P2, which is 180 m long by 4 m in diameter.

Shape and Structure. Linear attenuators are long and narrow cylindrical tubes. The Pelamis P2 consists of five tube sections and four flexible joints. The Oceantec and Anaconda devices are unsegmented. Anaconda is a flexible hose.

Mooring and anchoring needs. Standard 2-point catenary mooring attached to the upwave end of the cylinder, allowing the tail (downwave end) of the device to pivot in alignment with wave direction. The Oceantec device uses a 4-point mooring. Anaconda uses a single-point mooring.

Examples. The Pelamis P2.[5] Oceantec - http://www.oceantecenergy.com/

Bulge Wave Anaconda - http://www.bulgewave.com/

3.3.2.2 Other Devices

The following are device types for which CalWave is not currently requesting authorization. The following descriptions are offered for information only and these devices are not considered further. It is possible that, at some future time, these device types could be permitted for CalWave under a supplemental filing and amendment to the license.

Overtopping device

An overtopping device is essentially a floating water storage reservoir that is filled as waves break over its outer edge. The additional water creates pressure that pushes the water downward through a low-head hydroelectric turbine and back to the sea.

3.3.3 Mooring types permitted

Moorings that might be used for WECs are of two basic types:

Single-point moorings use a single cable of metal chain or steel wire or synthetic[6] rope to attach the device directly to an anchor on the sea floor. Single-point moorings are simple and inexpensive, but do not provide either the stability or security of multi-point moorings.

Multi-point moorings use several metal chain or steel wire or synthetic rope cables to connect the WEC to an anchor on the sea floor. Generally speaking, multi-point moorings used in the industry are either 3- or 4-point catenary moorings. Catenary (chain) refers to the arc that the mooring line describes between two points. Multipoint moorings are described in terms of their scope (ratio of horizontal run to vertical rise) and material. Typical scopes for a multi-point catenary mooring are between 3:1 and 6:1, with 6:1 being the widest mooring scope expected to occur at CalWave.

Catenary moorings may have submerged buoys or floats that help to control the extent of movement (watch circle) of the device or to minimize the amount of drag that the mooring cable itself could exert (which could otherwise dampen wave action and electricity generation). Although the cables are anchored, the resistance of mooring cables in the water provides considerable stability to the moored device.

3.3.4 Anchoring types permitted

Basic anchoring types that might be used by CalWave WECs include the following:

- Dead weight
- Drag-embedment

[5] The Pelamis is no longer being manufactured. The Pelamis P2 technology is owned by Wave Energy Scotland. The device was tested at the European Marine Energy Center Wave Center (EMEC) in Orkney, Scotland, UK. Of the two P2 devices constructed, one has been dismantled, and the other is owned by EMEC.

[6] Materials may include polyester, nylon, polypropylene, polyethylene, high modulus polyethylene (HMPE), and aromatic polyamine (aramid).

- Pile
- Plate

- **Dead weight anchors** use a large metal or concrete mass that is placed on the sea floor and constraints movement of the anchored device by the resistance of the weight alone and its mooring cables. This type of anchor may be effective on hard (rocky) bottom but is not as effective on a sloping seafloor and is relatively costly to transport, maneuver into placed, and remove. The seafloor coverage of such a device as used at CalWave would be less than 80 square meters.
- **Drag-embedment anchors** are metal structures having a flap or fluke that are placed on the seafloor and dragged laterally until the flap deploys, causing resistance and the burrowing of the anchor into the sediments on the sea floor. Drag-embedment anchors can be used where there will be lateral tension from a single direction as is the case, for example, with a multi-point catenary mooring. They require soft or sandy bottom for embedment. Drag-embedment anchors are deployed under the seafloor and installation requires disturbance of up to 50 square meters of seafloor.
- **Pile anchors** are large cylinders that are pounded into soft sediment or mud. The piles tend to be 1 to 3 meters in diameter and 10 to 30 meters in length. Installation methods include pile driving and suction pumping. Pile anchors are expensive to fabricate and to install and are unlikely to be used at CalWave due to their expense.
- **Plate anchors** are large metal structures that are installed in the sea floor by pile driving, water jetting, augering, shooting (ballistic) and that hold by friction. In some cases, plate anchors are driven vertically into the seafloor and then tilted to a more horizontal position, increasing resistance and holding capacity. Seafloor disturbance would be less than 30 square meters.

Deadweight and drag embedment anchors are the most likely to be used with WECs at CalWave, given the soft bottom conditions and cost considerations.

3.3.5 Umbilicals, connecting equipment, marking and lighting

Umbilicals are a distinct category of cable and are also known as “riser cables”. These cables must be designed to support the vertical load of the cable in the water column, from the WEC to the bottom, and musts also have features that allow for movement. In some cases, a mid-column buoy is used to decouple surface motion from the riser cable.

Connecting Equipment is a category of features associated with the structural connection between the WEC and the mooring lines attachment point(s) and the structural/electrical connection of umbilicals. Another category could include telemetry for data transfer.

Marking is dictated by US Coast Guard directives and based on international treaty. Typically, WECs are painted yellow for visibility.

Lighting is also dictated by US Coast Guard directives and based on international treaty. Typically, WECs are lighted with a yellow flashing light with specific characteristics (color, pattern, repetition, encoded signal and visible range) such as “yellow, flashing, 3 second, Morse Code UNIFORM, 2 nautical mile).

3.3.6 Cable runs

The test berths will be served by submarine electrical cables. Each berth will have a dedicated cable to the shore station and there will be a spare cable that can also be used for WEC checkout before committing to a test berth mooring, for a total of 5 cables, each approximately 4.25 inches in diameter. From the shore station, the cables will extend underground for approximately 1,000 meters using horizontal directional drilling (HDD) technology, to surface in approximately 10 meters of water depth. The cables will be surface-

laid from the HDD exit point to the connector end, which will be located approximately 3.25 nm from shore in approximately 90 meters (50 fathoms) of water. Each cable will be equipped with an acoustically activated pop-up buoy that will allow retrieval of the dry-mate connector at the test berth end.

3.3.7 Shore Station support facilities

Facilities at the shore station will include an office building for test facility staff with four offices, a reception area, and a conference room and a separate building for WEC test customer staff, including 6 offices, a control room, and a conference room. The shore station will also include bays for power conditioning equipment adjacent to the HDD exit point of the transmission cable.

Shore electrical facilities include switchgear buildings, diesel generator, load banks (10MW), and interconnection facilities to the local 12.5 kV distribution system for shore power. The initial configuration for export via the 12.5 kV system can accommodate approximately 6 MW of power. Once the 70 kV upgrade and 70 kV substation are built, the power export capability will increase to 50 MW.

3.3.8 Generator tie-line and switchyards

CalWave will interconnect with the existing VAFB 12.5 kV distribution system for station power, as well as to provide wave energy generated power to the grid. CalWave will have two substations on shore (12.5 kV and 70 kV), and a planned five-mile-long generator tie-line to connect to the VAFB 70 kV ring bus at VAFB Sub-Station 'N'.

3.3.9 Ports, harbors, piers, and docks

The Vandenberg Dock in the South Base area is the primary docking support facility for CalWave and is adjacent to the proposed shore station. The dock was designed by CalWave teammate Glosten Associates and built to accommodate M/V Delta Mariner, a large transport vessel used to deliver rocket boosters to the Space Launch Complexes at Vandenberg.

Several highly capable docks and piers are also available near the project site. It is expected that maintenance and service vessels would deploy from these ports:

- Port Hueneme is only deep water harbor between Los Angeles and the San Francisco Bay area and is the U.S. Port of Entry for California's Central Coast region. It is located about 75 nm from the CalWave test berths. This pier has the capability to host very large vessels and is home to large cranes and dockside storage facilities and a variety of marine operations services for the oil and gas industry. Oil platforms near VAFB and the CalWave test berths are supported by vessels from Port Hueneme.
- Morro Bay harbor and boatyard are about 51 nm from the CalWave test berths
- Santa Barbara Harbor and boatyard, about 54 nm from the CalWave test berths
- Port San Luis Boatyard, 38 nm from the CalWave test berths
- Cal Poly Pier in Port San Luis (former Union Oil offloading pier), approximately 38 nm from the CalWave test berths
- Ellwood Pier (personnel transfers, operated by Venoco for the for oil and gas industry) about 35 nm from the CalWave test berths
- Casitas Pier in Carpentaria: (operated by Venoco for oil and gas industry), about 56 nm from the CalWave test berths

3.4 Project Operation

CalWave is a test facility for WECs and project operation profiles will follow the testing needs of up to four different WEC testing customers. A secondary operational goal will be to provide electrical generation resources to VAFB.

CalWave program staff will manage shore station operations. WEC development customers will install their own devices, umbilicals, and anchors and mooring lines. WEC developers will also arrange for WEC operations and maintenance support as part of gaining operational testing experience with their devices.

WEC development phases will include the following:

- Fabrication and assembly
- Staging at the supply port chosen near CalWave
- Transit to the test area and checkout using the cable spare
- Installation at the test berth

Example modes of operation for each test berths will be as follows:

- Construction/Maintenance: No WEC connected
- Standby: WECs connected, no control power from shore, no power generation
- Ready: WECs connected, control power applied from shore
- Operating: WECs connected, control power applied from shore, generating to Test Bus and Load Banks
- Demonstration: WECs connected, control power applied from shore, generating a maximum output to Power Conditioning, Test Bus and Load Banks
- Certification: WECs connected, control power applied from shore, generating a maximum output to Power Conditioning, Test Bus and VAFB Grid (6MW to 10 MW)
- Reliability Phase: WECs connected, control power applied from shore, generating a maximum output to VAFB Grid up to facility rating (6MW to 40 MW)

CalWave program staff positions will include the following:

- Site Director
- Operations Manager
- Safety and Quality Manager
- Test Engineer
- Site Engineer
- Electrical Technician
- Environmental Technician
- Project Developer
- Business Manager
- Administrative Assistant

3.5 Physical and Operational Changes

CalWave will be a newly licensed project and so will not involve physical and operational changes to an existing, licensed facility.

SECTION 4

Existing Environment and Resource Impacts

§ 5.6 (d)(3) - Existing environment and resource impacts (based on existing, relevant and reasonably available information)

(A) Description of existing environment (See following Sections)

(B) Summaries of existing data or studies

(C) Potential adverse impacts and issues related to project construction, operation, or maintenance

(D) Existing or proposed resource protection and mitigation measures (facilities, operations, and management activities)

Sections 4.2 through 4.13 describe the existing environment, by discipline, summarize existing data and studies, outline potential adverse impacts and issues related to project construction, operation, and maintenance, and describe possible resource protection and mitigation measures that could be used to reduce environmental effects.

4.1 Geology, Topography, and Soils

§ 5.6 (d)(3)(ii) - Geology, topography, and soils (descriptions and maps)

(A) Description of geological features, including bedrock lithology, stratigraphy, structural features, glacial features, unconsolidated deposits, and mineral resources

(B) Description of soil types, occurrence, physical and chemical characteristics, erodability and potential for mass soil movement, and soil characteristics

(C) Description of reservoir shorelines and stream banks, including

(1) Steepness, composition, and vegetative cover

(2) Existing soil instability

4.1.1 (A) Geological Features

4.1.1.1 Topographic and Physiographic Setting

The CalWave project is sited on a narrow coastal plain between Tranquillon Ridge and the Pacific Ocean coastline southeast of Point Arguello and northwest of Point Conception. The local topography is characterized by ridge crests reaching up to 2,000 feet in elevation, steeply sloping to a series of uplifted, sloping marine terraces, with a broader, flatter marine terrace adjacent to coastal bluffs. The CalWave shore station site and 70 kV upgrade line are located on the broad lower marine terrace adjacent to the coastal bluffs (Figure 4.1-1)

This section of coastline is located at the western end of the Transverse Ranges physiographic province, a series of mountain ranges that trend in and east-west direction throughout Southern California. Point Arguello is located at the northern margins of the California Continental Borderland province, which extends south to Cedros Island off the coast of Baja California, Mexico (Hanson, et al. 1994). The section of coastline beginning at Point Pedernales, 3 km north of Point Arguello, and extending south to San Clemente Island in the Santa Barbara Channel, is known in particular for a series of well-preserved, elevated marine terraces on lower ridge slopes adjacent to the coastline. These are associated with rapid tectonic uplift of the western Transverse Ranges.

4.1.1.2 Regional Geology[7]

Older alluvium (Qoa) mantles uplifted marine platforms immediately north of the site area. At least three wave-cut terraces are developed along this portion of the coast. The lowest occurs at an elevation of 50 to 150 feet and forms a broad but much dissected coastal plain north and east of Point Conception, and also near Point Arguello. The CalWave shore station site is sited on this terrace and it is apparent as the lower terrace seen in Figure 4.1-1. A higher terrace, at an elevation of 200 feet, is well developed against Burton Mesa north of the project site, but is preserved only as small remnants elsewhere. Isolated remnants of a still higher terrace occur at an elevation of about 500 feet on the seaward slopes of the hills northeast of

[7] This section is a summary of Section 2.1 Geology and Seabed Conditions, from a technical report commissioned for CalWave titled *CalWave Desktop Study for the Submarine Export Power Cables, Final Report* (Fugro Pelagos Inc. 2016). The entire report is included as Appendix 4.1A.

Point Conception and Point Arguello. Figure 4.1-2 shows the development and configuration of the marine terraces.

The CalWave shore station site is underlain by Quaternary alluvial (Qa) deposits of sand, silt and gravel, of varying thickness, which overlie a wave-cut marine platform (Johnson 1984, 1989; Woodring and Bramlette 1950). The underlying marine platform ranges in elevation from 15 to 60 m above present sea level. Dissected remnants of older uplifted platforms are locally preserved nearby at higher elevations within the Transverse Ranges. Figure 4.1-3 shows the surficial geology within two miles of the shore station.

Rock underlying beneath the alluvium at the shore station site belongs to an upper member of the Miocene-aged Monterey Formation. This formation consists of hard, laminated, platy, siliceous; soft, thin-bedded; and phosphatic shales and limestone beds inter-bedded with soft, thin-bedded shale and limestone (Dibblee 1950, 1988). Measured sections of the Monterey Formation north of Point Conception are reported to be as much as three to four thousand feet thick.

The terrace deposits consist of unconsolidated alluvium comprised of sands, silts and gravels that vary widely in their thickness. Along the coastline at the shore station site, the alluvium is approximately 10 feet to 15 feet thick (Figure 4.2-4), while nearby at the Vandenberg Dock, the alluvium appears to be 30- to 40-feet thick, as observed in the road cut for the dock. This is an indication that alluvium may also be thicker upslope of the beach at the shore station site.

The Monterey Formation is often tightly folded or crumpled (Figure 4.1-5), and in many places is shattered or fractured extensively. The weaker portions of the Monterey Formation are readily eroded by both marine and non-marine processes. The coastal exposures of Monterey Formation at the CalWave site dip south southwesterly at 12° to 15°. A folded section of the Monterey Formation is mapped just offshore of the landing sites where the axis of an anticline and adjacent syncline can be traced onshore beneath the alluvial mantle.

Although not well documented, the geologic conditions similar to those onshore prevail offshore. The Miocene Monterey Formation underlies a seabed covered, for the most part, by a veneer of unconsolidated marine sediment. From the information that is available from seismic reflection profiles, the Monterey generally dips southwest 12° to 16° and the folded and faulted strata continue offshore. The Miocene-aged Tranquillon Volcanic Formation conformably underlies the Monterey Formation.

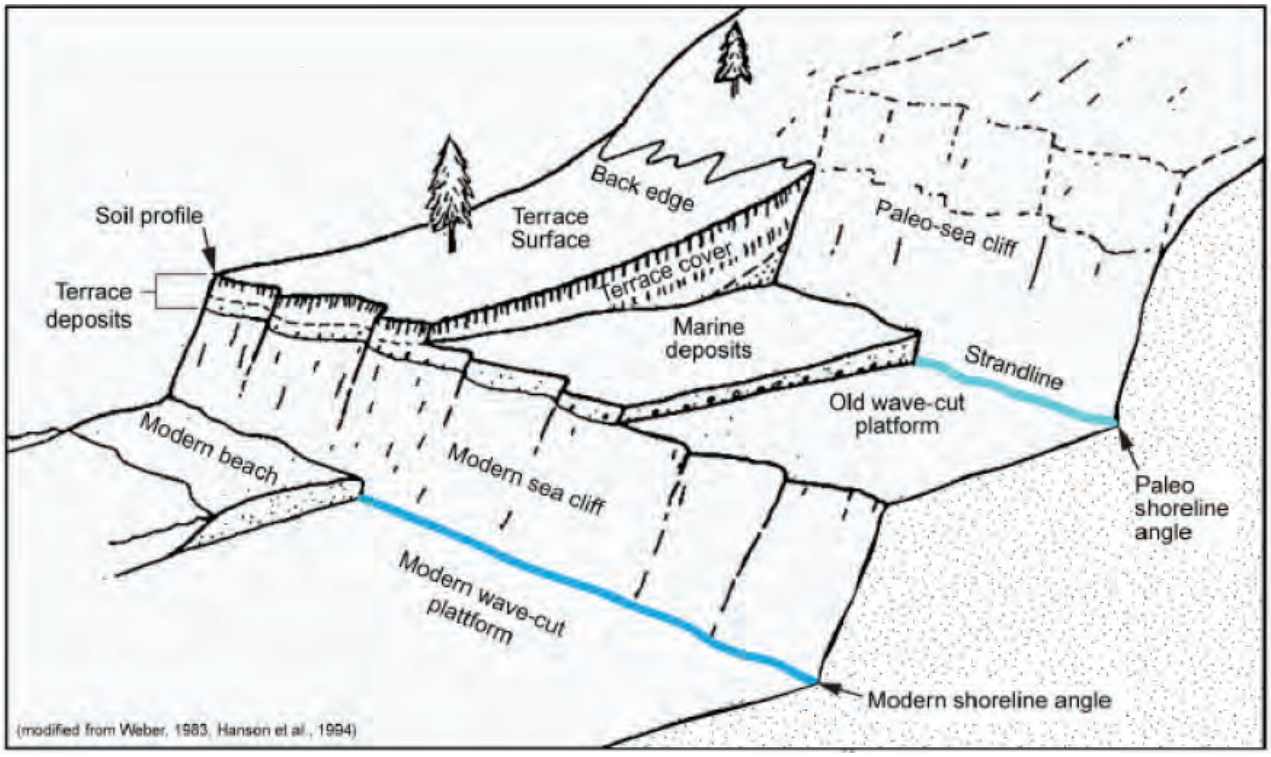
The Monterey Formation is ubiquitous beneath the terrace deposits and extending offshore. Water depths within the project area range from 0.0 feet at the shoreline to nearly 95 m (310 feet or 52 fathoms) at the south and south by southeast tests berth sites.

With the exception of the shallow water <20 m (<65 feet) areas, the seabed is relatively smooth, with the Monterey Formation rock covered in soft sediment out to the continental shelf topographic break at about 100 m (328 feet or 55 fathoms). To the south-southeast of the Vandenberg Dock, however, rock outcrops extend out to 130 feet (40 m). Near the southeast test berth site, a large outcrop is found between the 50 m (165 feet or 28 fathoms) and the 70 m (230 feet or 38 fathom) contour (Figure 4.1-6).

The seafloor slopes between 0.3° and 0.5° to the south-westward. The thickness of unconsolidated Quaternary sediment in the project area ranges from 0 (bedrock outcrop) to almost 50 m (165 feet) off Point Arguello (Cummings, D. and Johnson, T.A., 1994). The erosional bedrock surface covered by these sediments is irregular nearshore because of differential erosion, but the farther offshore, the bedrock is relatively planar and uniform. The sediments were deposited on bedrock cut by a Pleistocene erosional surface that has been dated by Payne et al. (1979) as 30,000 to 40,000 BP and by PS Associates (1987) as 11,000 BP.

Figure 4.1-1. View east from the Coast Guard Station near the CalWave[sm] shore station site, showing the lower marine terrace, higher, uplifted terraces (middle-ground left), Tranquillon Ridge, and Tranquillon Peak (left, with cloud).

Figure 4.1-2. Marine terrace development along the coast of southwestern California (after Webber, 1983)



Geology

- Ke - Dark gray, hard but fratured miscaceous shale with thin interbeds of hard, olive-gray arkosic sandstone, minor pebbe conglomerate, and thin, dark gray carbonate strata; locally pebbly at base
- kh - Gray clay shale or claystone, pervasively sheared; contains clcareous concretions (may be part of Franciscan assemblage)
- Qa - Valley and floodplain deposits of silt, sand and gravel
- Qoa - Remmants of weekly consolidated stream terrace and alluvial fan deposits of silt, sand and gravel
- Qos - Older dune sand deposits, in places weakly consolidated
- Tm - Upper shale unit: white weathering, thin, bedded, hard, brittle cherty siliceous shale with black flinty lamine; Mohnian Stage
- Tr - Poorly bedded gray clay shale or claystone; Saucesian and upper Zermorrian Stages
- Ttr - Gray-white to tan, rhyolitic to andesitic flow breccia

LEGEND

- Proposed Structure
- VAFB Dock
- Transmission Pole
- Transmission Line

Source:
Dibblee, T.W., Jr., 1950, Geology of southwestern Santa Barbara County, California . California Division of Mines, Bulletin 150.

N

0 1,700 3,400

Feet

Figure 4.1-3
Surficial Geology Within Half Mile of Transmission Line
California Wave Energy Test Center (CalWave^{sm})

Figure 4.1-4. The ocean bluff and beach south of the shore station, overlying the approximate location of the subsea cable bore.

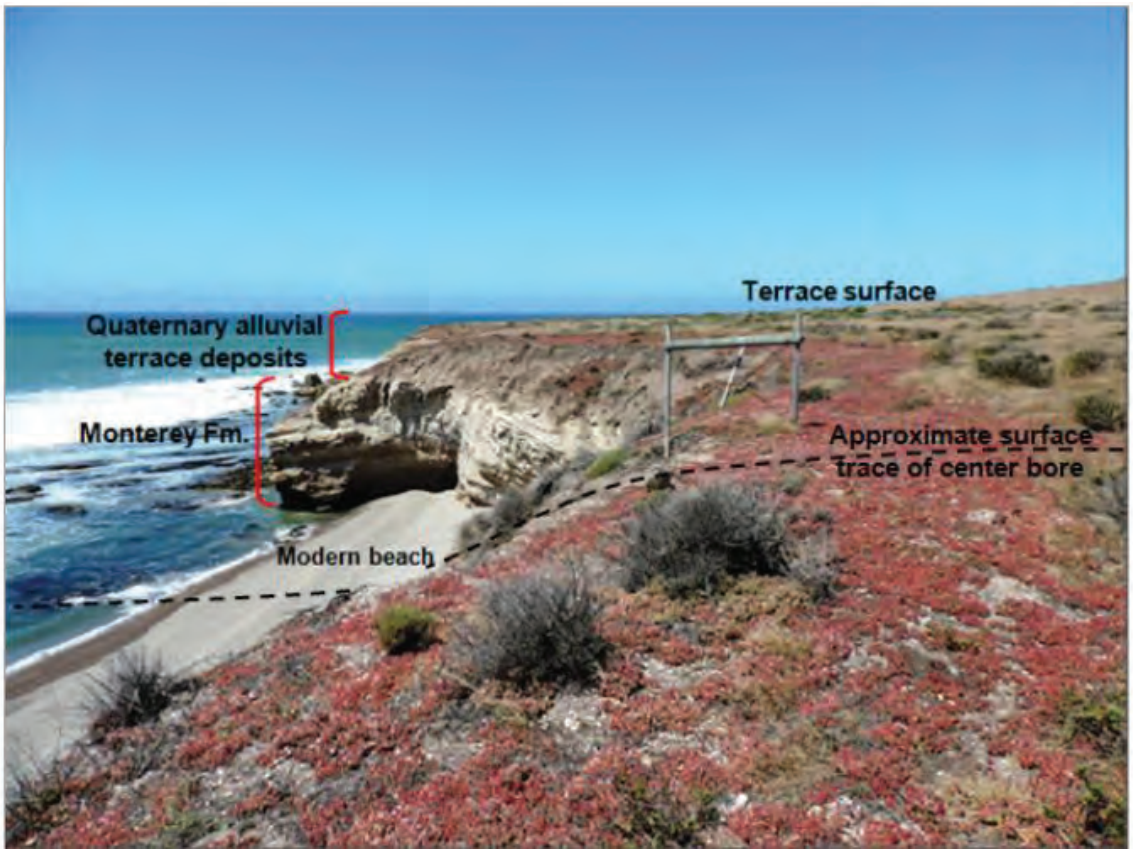
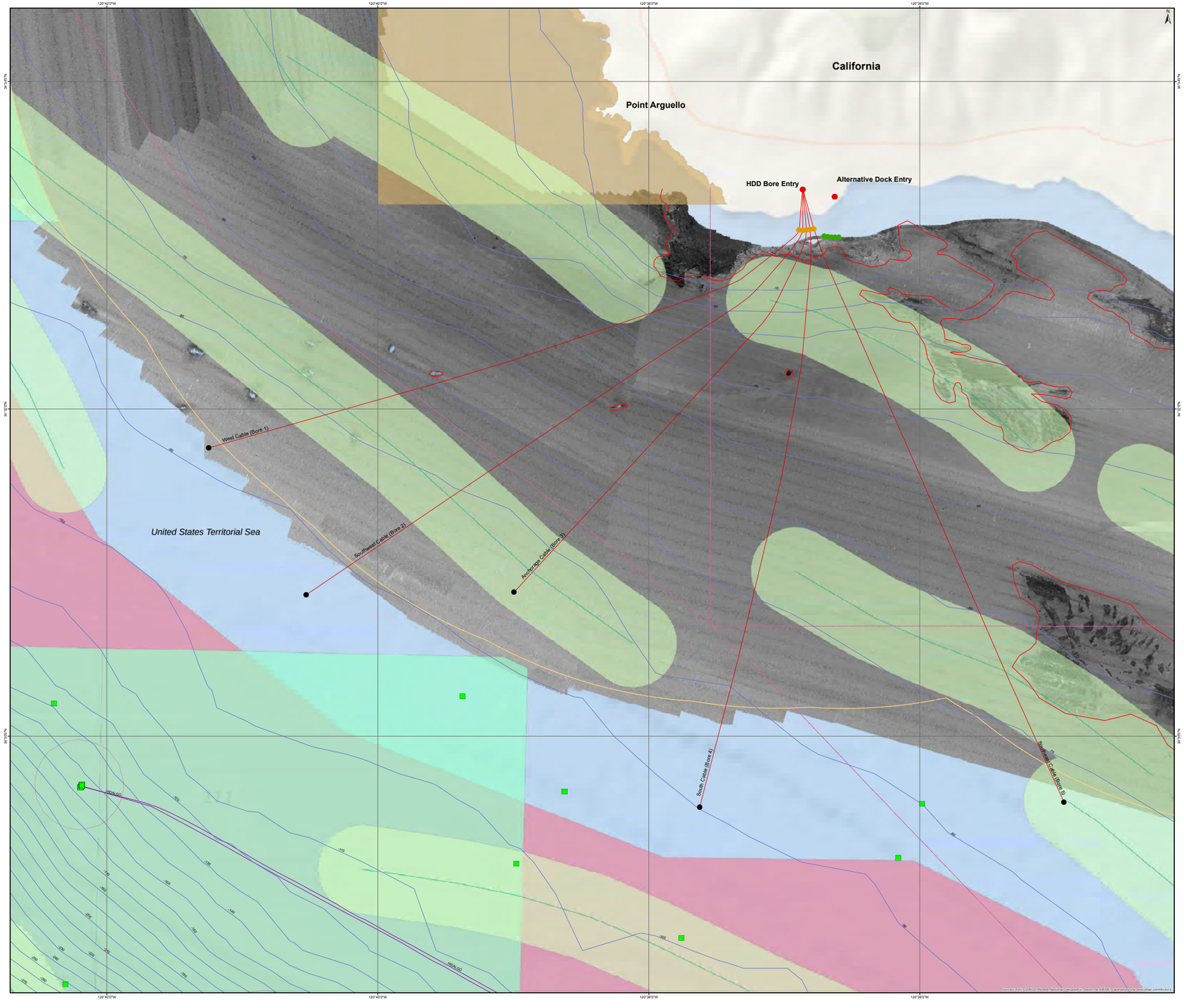


Figure 4.1-5. Tightly folded Monterey Formation rocks in an outcrop at the Vandenberg Dock.

Figure 4.1-6. Offshore geological outcrops - rocky vs. soft bottom



Legend

- HDD Bore Entry
- HDD Bore Exits
- Alternate Dock Entry
- Alternate Dock Exit
- SubSea Cable Terminus Positions
- Pacific Well Locations
- Proposed Primary Routes
- Bathymetric Contours (10m)
- State Boundary 3nm Limit
- Military Protected Area
- Restricted Areas
- BOEM Pacific Pipelines
- In-service telecommunications cable
- Out-of-service telecommunications cable
- Rock Outcrop Areas
- Quarternary Faults
- Fault Activity Buffer
- BOEM Pacific Leases
- Point Conception Essential Fish Habitat Conservation Area
- Vandenberg State Marine Reserve

Notes:

1. Bathymetry contours are from SRTM30 data
2. Maritime and territorial boundaries compiled from General Dynamics GMBD 2008 Spring edition.
3. Color background base map is from ArcGIS Online Base Maps.
4. Cables compiled from Fugro Cable Database, other in-house sources, and National Oceanic and Atmospheric Administration (NOAA) online sources.
5. Coastline, hazards, obstructions, wrecks, and restricted areas gathered from NOAA online sources.
6. Marine Protected Areas compiled from NOAA published data.
7. California state boundary 3nm limit provided by BOEM online sources.
8. Previous Side Scan Sonar data downloaded from Seafloor Mapping Lab, CSU Montery Bay. Imagery provided by CSMP (Southern CAL:H11953)
9. Fault activity data provided by USGS.

GEODETIC PARAMETERS:

Projection	Mercator	False Easting	0 m
Spheroid and Datum	WGS84	False Northing	0 m
Semi Major Axis	6378137.00 m	Latitude of Origin	0°N
Inverse Flattening	298.257223563	Longitude of Origin	0°W

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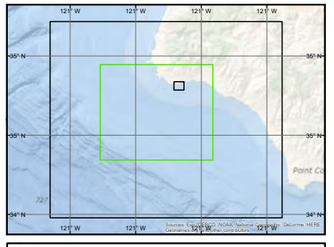

CH2M HILL
2485 Natomas Park Drive, Suite 600
Sacramento, CA, 95833-2937, USA

FUGRO PELAGOS, INC.
3574 Ruffin Road
San Diego, California 92123 USA
Tel: (858) 292 8922
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CALWAVE Desktop Study

Desktop Study

Offshore Lease Area Overview

SCALE: 1:17,000

0 0.15 0.3 0.6 0.9 1.2 1.5 1.8 Kilometers

Issue:	Date:	Description:	Drawn:	Chkd:	Appr:
0	29 July 2016	Draft	AM	RW	RW
1	9 Nov 2016	Final	AM	RW	RW

Issue: FINAL

Chart: CALWAVE_DTS_003_17K

4.1.1.3 Seismicity

Faults are planes of fractures or planes of weakness in the earth's crust where one side has moved relative to the other. They are recognized and mapped by sheared and displaced rock units and by the distinctive landforms created by repeated rupture of the earth's surface. Earthquakes generated by rupture and displacement of rocks along these faults cause significant damage to manmade structures and can be life threatening. The resulting and sometimes violent shaking poses a serious hazard.

Studies of historic earthquakes generated along these faults provide basic background for projecting future seismic hazards and losses. A listing of historic earthquakes occurring within 150 km (93 miles) of the CalWave site with a magnitude of 4.5 or greater is provided in Table 4.1-1 and are mapped in Figure 4.1-7

Table 4.1-1. Earthquakes within 150 km of CalWave with magnitude of 4.5 or more, 1916-2016.

Location	Magnitude	Year	Depth (km)
Central CA offshore	6.9	1927	10.0
Santa Barbara Channel	6.8	1925	10.0
Greater Los Angeles	6.5	1922	10.0
18 km NNW of Cambria	6.5	2003	11.5
28 km NW of Cambria	6.2	1952	6.0
Central CA offshore	6.0	1969	10.0
18 km N of Shandon	6.0	2004	8.6
Central CA offshore	5.8	1969	10.0
11 km NNE of San Miguel	5.8	1934	6.0
13 km WNW of Grapevine	5.5	1952	6.0
9 km SSW of Carpinteria	5.5	1941	9.6
8 km N of Cholame	5.5	1966	6.0
27 km S of Santa Barbara	5.1	1978	18.0
9 km SSE of Santa Cruz Island	5.1	1973	16.9
20 km ENE of Santa Cruz Island	5.1	1968	0.2
10 km NW of Cholame	4.9	2004	0.7
12 km ENE of Santa Cruz Island	4.9	1945	0.1
6 km of Isla Vista	4.8	2013	7.1
1 km WSW of Port Hueneme	4.8	1957	6.0
12 km SW of Parkfield	4.8	1934	6.6
18 km S of Santa Cruz Island	4.8	1954	6.5
41 km WNW of San Miguel Island	4.7	1949	6.0
18 km N of Pine Mountain Club	4.7	1981	6.6
10 km N of Cambria	4.7	2003	6.5
27 km SSW of Lompoc	4.7	1959	6.0
17 km NNW of Santa Cruz Island	4.7	1941	6.0
28 km SW of Avila Beach	4.7	1980	6.0
27 km SW of Lompoc	4.7	1934	6.0
19 km NE of Santa Cruz Island	4.6	1968	21.0

Table 4.1-1. Earthquakes within 150 km of CalWave with magnitude of 4.5 or more, 1916-2016.

Location	Magnitude	Year	Depth (km)
103 km WSW of VAFB	4.6	1969	6.0
10 km N of Cambria	4.6	2003	5.1
10 km NNE of Pine Mountain Club	4.6	1954	9.6
33 km NW of Santa Barbara Island	4.6	2002	6.8
20 km ESE of Maricopa	4.6	2005	9.3
17 km WNW of Grapevine	4.6	1975	24.1
44 km WNW of San Miguel Island	4.5	1936	6.0
14 km NNE of Pine Mountain Club	4.5	1952	8.4
18 km S of Frazier Park	4.5	1942	20.0
19 km S of Santa Barbara	4.5	1941	9.7
8 km NNW of Los Olivos	4.5	1984	5.0
87 km WSW of VAFB	4.5	1962	6.0

The map depicts regions of active faults that will experience stronger more frequent shaking. The CalWave site is located in a region that is more distant from known active faults and can be expected to experience lower levels of shaking less often. For example, the USGS maps peak ground acceleration in the Pt. Arguello area at less than 0.15 g (gravitational force), compared with 0.40 to 0.60 further east along the Santa Barbara Channel. This correlates with a USGS Instrumental Intensity (Modified Mercalli) scale rating of VI, for which perceived shaking is rated as "Strong" and potential damage is rated as "Felt by all, many frightened. Some heavy furniture moved; a few instances of fallen plaster. Damage slight" (USGS 2016: https://earthquake.usgs.gov/learn/topics/mercalli.php).

All offshore faults were based on interpretation of seismic reflection profile records and are shown as solid lines where faults are well defined, dashed where inferred and queried where uncertain. The age of these unnamed offshore faults is reported as <1,600,000 years with slip rates of <0.2 mm/year and having lengths ranging from 2.5 km to 679 km. The offshore faults are approximate in location as mapped by McCulloch (1989).

Table 4.1-2 lists some of the major onshore earthquake faults located near the project area.

Table 4.1-2. Major onshore earthquake faults in the project area.

Name	Age	Type	Jennings ID	Source
Santa Ynez River	Late Quaternary	Reverse	299	Sylvester and Darrow (1979)
Honda	Late Quaternary	Certain	300	Sylvester and Darrow (1979)
Pacifico	Late Quaternary	Concealed	301	Diblee (1988)
Los Alamos	Holocene	Concealed	302	Guptill, et al (1981)
Garey	Quaternary	Approx. loc.	303	Buchannan-Banks, et al (1978)
South Branch Santa Ynez	Late Quaternary	Concealed	321	Diblee (1988)

Figure 4.1-7. Earthquake faults in the project region. (Source: California Geological Survey, Geologic Data Map No. 6, Compilation and Interpretation by: Charles W. Jennings and William A. Bryant)

Figure 4.1-8. Earthquakes of M>4.5 within a 150 km (93 mile) radius of the CalWave site (1916 – 2016) Image source: Google™ Earth.

Figure 4.1-8 maps the locations of earthquake epicenters (from Table 4.1-1) of M ≥4.5 within a 150 km (93 mile) radius of the CalWave site from the period 1916 to 2016. There are 41 earthquakes mapped and noted in the data set of which seven have a magnitude ≥6.0.

4.1.1.4 Sediment Transport Offshore Point Arguello

The long-shore transport of sediment in the area of the project site is generally in a southward direction north of Point Arguello and in an eastward direction between Point Conception and Gaviota. Estimates of the net transport southward around Point Conception range from zero to 180,000 yd^3/year.

4.1.2 (B) Soil Types

Soils along the Vandenberg AFB coastal plain are characterized by coastal sand dunes and alluvium washed down from adjacent ridges and uplifted marine terraces. The shore station site, as stated above, is underlain by sandy and gravely soils deposited on top of these ancient wave-cut terraces.

Soils of the shore station site belong to the Arguello series (Weir 1950, Cole et al. 1958) and consist mainly of Arguello shaly loam, gently sloping and sloping. Arguello soils occur on older alluvial fans and stream terraces in the coastal plain. These soils contain angular fragments of the underlying Monterey shale. Table 4.1-3 summarizes characteristics of the Arguello shaly loam soils.

Table 4.1-3. Characteristics of the Arguello shaly loam soils.

Characteristic	Value	Characteristic	Value
Surface soil	Dark gray, moderately compact, slightly to medium acid, with shale fragments	Percent sand	33-39
Subsoil	Dark gray, moderately compact, slightly to medium acid, with shale fragments	Percent silt	30-36
Parent material	Medium-textured stratified, slightly acid, gravelly older alluvium	Percent clay	29-32
Agricultural uses	Range, hay, lima beans, tomatoes	Capability Class	III

Engineering properties of the soils and near the shore station site are not published in the existing soil surveys because these were prepared during the 1950s, when soil survey reports were compiled mainly to inform agriculture. The southern portion of VAFB (Point Arguello south) within which the shore station is sited was acquired by VAFB in 1968 and subsequent surveys of the Santa Barbara coastal area have not included VAFB.

That said, significant hazards due to soil characteristics (liquefaction, expansive soils) do not appear to be evident with the Arguello soils.

4.1.3 (C) Reservoir Shorelines and Stream Banks

CalWave is an MHK facility and so does not have a reservoir and does not involve changes to stream banks.

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4.2 Water Resources

§ 5.6 (d)(3)(iii) - Water resources (quality and quantity)

(A) Drainage area

(B) Adjusted minimum, mean, and maximum recorded flows at powerplant intake or diversion

(C) Monthly flow duration curve and critical stream flow used to determine the project's dependable capacity

(D) Existing and proposed water uses and upstream or downstream requirements

(E) Existing instream flow uses and water rights

(F) Relevant federally-approved water quality standards

(G) Project effects on seasonal variation of water quality data, including

(1) Water temperature and dissolved oxygen

(2) Other physical and chemical parameters

(H) Existing or proposed lake and reservoir information (surface area, volume, maximum depth, mean depth, flushing rate, shoreline length, substrate composition)

(I) Gradient for affected downstream reaches

This section is not applicable for MHK facilities as they do not involve installation of facilities in a stream or river basin.

4.3 Fish and Aquatic Resources

§ 5.6 (d)(3)(iv) - Fish and aquatic resources: description and impacts

(A) Identification of existing fish and aquatic communities

(B) Identification of essential fish habitat

(C) Temporal and spatial distribution of fish and aquatic communities and trends with respect to:

(1) Species life stage composition

(2) Standing crop

(3) Age and growth data

(4) Spawning run timing

(5) Extent and location of spawning, rearing, feeding, and wintering habitat

The following sections summarize existing information on fish and other aquatic wildlife communities in the vicinity of the proposed CalWave Project.

4.3.1 Phytoplankton and Zooplankton

Planktonic organisms off the Central California coast are an important part of the food web for fish and other aquatic resources in the region. Plankton are made up of a diversity of plant and animal organisms that float in the water column and move with the current. Because these species are unable to move against the current, their occurrence is dependent on seasonal currents and upwelling, which occurs in the region seasonally (Brink et al., 1984). Upwelling and other abiotic conditions facilitate high levels of primary production in the area (Dugdale and Wilkerson 1989).

Planktonic communities generally consist of phytoplankton and zooplankton. Phytoplankton are microscopic organisms that utilize carbon dioxide and light to photosynthesize organic material from the water column. These include single-celled organisms, such as cyanobacteria, as well colonial species of algae diatoms, such as diatoms. Diatoms (species: *Chaetoceros*) have been recorded as the most numerous type of phytoplankton on the coast of California (Bolin and Abbot 1963). Primary production is highest within approximately 50 km of the coast (Owen 1974). Phytoplankton biomass is high near Point Conception than other locations along the coast because of strong upwelling in the region (Owen 1974). Seasonal abundance of phytoplankton is highest in spring and summer, then decreasing fall, with the lowest levels occurring in winter (Palaez and McGowan 1986).

Zooplankton are small invertebrates such as copepods, isopods, salps, and doliolids, and also larger organisms such as jellyfish and ctenophores. In studies conducted at Diablo Canyon, 94 taxonomic zooplankton categories were identified (Icanberry and Warrick 1978). The major categories of zooplankton included calanoid copepods (nauplii and copepodites), thalicians, *Oikopleura* (sea squirts), *Euphausia* (largest genus of krill), calyptopis (larval stage of krill), copepodites cyclopoid and harpacticoid (crustacean larvae), and the copepod *Acartia tonsa*. Ichthyoplankton (fish eggs/larvae) also are considered part of the planktonic community in the project area (see Section 4.3.3 below). Research conducted at Diablo Canyon suggests zooplankton production is highest during spring and summer during periods of upwelling, when

phytoplankton occur in higher numbers (Icanberry and Warrick 1978, Smith 1974). Seasonal variations in zooplankton abundance influence the presence of other larger aquatic organisms, including fish and whales.

4.3.2 Benthic Invertebrates

Nearshore benthic invertebrate communities are an integral part of the marine food web. These invertebrates break down dead organic material that deposits in the sea floor and are themselves important food source for many fish, including commercial and recreational harvested species. In addition to supporting fisheries, benthic communities also include important commercial and recreational species, including the Dungeness crab (*Metacarcinus magister*). Benthic invertebrates range in size from microscopic macroinvertebrates to larger macroinvertebrates such as shellfish and crabs. Their distribution largely depends on the substrate type, depth, and water quality conditions. Substrate type strongly influences the type of benthic community present, depending on the substrate composition (rocky, silty, or sandy) and species diversity varies widely based on these site-specific conditions. In the offshore areas around Point Conception, which are dominated by soft substrate, Hyland et al. (1991) identified at least 866 species of benthic infauna, representing 15 phyla. Amphipods, polychaete worms, gastropods, and bivalves were the most common taxa found (Hyland et al. 1991). These soft-bottom areas tend to have reduced species diversity and abundance with increasing depth. In these coastal areas hard substrates generally are patchily distributed areas of exposed rock separated by soft mud and fine sands (Benech Biological and Remote Ocean System 1986; Steinhauer and Imamura 1990; SAIC and MEC 1995). Anthozoans are commonly found in hard-substrate areas, but there is a wide variety of taxa found on hard substrates and no particular taxon appears to be dominant (Hardin et al. 1994).

Artificial platforms also provide hard-substrate habitat for marine species and their use by invertebrate communities is well studied. In project area, fifteen platforms including Irene and Hidalgo were surveyed in 1997-2001, and 2004-2005 (Goddard and Love 2010). Large numbers of sea stars (*Patiria miniata*, *Pisaster* spp., and *Stylasterias forreri*), sea anemones (*Metridium* spp.), sea slugs (*Pleurobranchaea californica*), rock crabs (*Cancer* spp.), spot prawns (*Pandalus platyceros*), and a few sea urchins (*Strongylocentrotus fragilis*) were found on platforms. Large masses of a non-native bryozoan (*Watersipora subtorquata*) were present at one platform. Echinoderms (sea stars and brittle stars) were the most abundant taxa. Except for filter feeders, the dominant species were carnivorous or omnivorous and depended on mussels and other fouling organisms. Although these platforms provide hard substrate, these substrates are rare around Platforms Hidalgo, Harvest, and Hermosa (Steinhauer et al., 1994, SAIC and MEC 1995), and thus they provide unique, isolated habitats in these offshore areas. For instance, Page et al. (1999) found higher densities of large, highly mobile crab species on and under platforms compared to adjacent soft-bottom areas. These results suggest hard substrates are important to avoid while siting platforms, cables, and other energy-production infrastructure, and that unique habitats that can be created by placing structures in offshore areas.

4.3.3 Fish

At least 554 species of marine fishes occur in California coastal waters, either as year-round residents or seasonal visitors (Miller and Lea 1972). Species abundance, diversity, and composition reflect various habitat conditions such as water depth, substrate type, and water quality. Point Conception area is a recognized biogeographic transition zone between Oregonian Province (cool-temperature species) to the north and Californian or San Diegan Province (warm-temperate species) to the south (Horn and Allen 1978). Thus, there is a wide variety of fish species and communities in the offshore areas surrounding the project site. Several researchers have reported that demersal fish species distributions in the region are related to depth (e.g., Bence et al., 1992, Wakefield 1990, Cailliet et al., 1992). In general, overall abundance of commercially and recreational species appears to be highest within shallower depths of the region (Bence et al., 1992).

Epipelagic fish species occur in the wind-mixed surface waters up to a depth of approximately 150 m (Pearcy and Laurs 1966). In the region, Pacific mackerel (*Scomber japonicas*), Pacific herring (*Clupea pallasii*), northern anchovy (*Engraulis mordax*), rockfish (*Sebastes* spp.), medusafish (*Icichthys lockingtoni*), Pacific sardine (*Sardinops sagax*), Pacific saury (*Cololabis saira*), Pacific argentines (*Argentina sialis*) are common epipelagic fish species. Salmon (*Onchorhyncus* spp.) and albacore tuna (Thunnus alalunga) are epipelagic species that are fished commercially and recreationally. Epipelagic species such as albacore tuna (*Thunnus alalunga*) and salmon are important commercial and recreational fish species. Among approximately 140 epipelagic species captured in midwater trawls off central California, juvenile rockfish, Pacific herring, and northern anchovy were the most common species (Bence et al. 1992). Benthic, soft-substrate fishes characterizing the continental shelf in this region are California halibut (*Paralichthys californicus*), English sole (*Parophrys vetulus*), Pacific sanddab (*Citharichthys sordidus*), speckled sanddab (*Citharichthys stigmaeus*), white croaker (*Genyonemus lineatus*), stripetail rockfish (*Sebastes saxicola*), queenfish (*Seriphus politus*), and a several species of surfperch (*Embiotocidae*; Love 1996, Allen et al., 2007).

Rocky substrate areas support sculpins (*Cottoidea*), black rockfish (*Sebastes melanops*), lingcod (*Ophiodon elongatus*) and numerous other species. Surfperches, wrasses (*Labridae*), greenlings (*Hexagrammos* spp.), seabasses (*Latidae*), and damselfish (*Pomacentridae*) are common species at shallower rock outcrops (Schroeder et al., 2000, Stephens et al., 2006, Love and Schroeder 2007). Rockfish are strongly associated with the presence of rock outcrops (Love et al., 2009) but species composition varies by depth and other habitat characteristics. Rockfish, as a group, have historically been extremely abundant on the continental shelf and at depths down to approximately 270 m (Bence et al., 1992). However, significant declines have been reported for many rockfish species in recent years (Love et al., 1998, Ralston 1998). Rockfish assemblages appears to be variable based on fishing access. In a study comparing three differently fished areas (one open to all fishing, another open to only recreational fishing, and a de facto protected area [i.e., Platform Gail]), the open fishing area had the highest density of fish (7,212 fish per ha), but size structure and species composition were dominated by small fish. The recreational-only fishing area supported a density of 423 fish/ha, and similar species composition and size as the area open to all fishing. The protected area associated with Platform Gail had high density (5,623 fish/ha) and a size structure and species composition shifted towards larger fish. Similarly, two federally listed as overfished species (bocaccio [*Sebastes paucispinis*] and cowcod [*Sebastes levis*]) were shown to have a 32-fold and 408-fold higher density, respectively, in the protected area versus the recreational-only area, and an 8-fold and 18-fold higher density compared to the open fishing area (Schroeder and Love 2002). This suggests fishing access (either commercial and/or recreational/commercial) results in a bias of smaller rockfish and, with recreational access only, much lower densities of individual fish. The results also imply that catch and release fisheries can have damaging effects on rockfish populations.

In addition to naturally-occurring rock outcrops, artificial structures provide habitat for marine species associated with hard substrates. Love and York (2005) identified four general habitat types associated with offshore platforms: shallow and deep pipeline, and shallow and deep seafloor. Fish densities were about 7 times higher on the shallow pipeline versus shallow seafloor; rockfish composed 84% of observed fish species. Densities of cowcod in deeper parts of the pipeline were higher than was observed at over 80 natural outcrops and 10 platforms surveyed. There is variability in how age-classes utilize artificial structures; midwaters are “nursery” areas for young-of-year (YOY) fish, whereas platform bottoms are primarily used by subadult and adult rockfish (Love et al., 2003). Results from fish surveys conducted by Love et al., (1999), at the four platforms (Hidalgo, Harvest, Hermosa, and Irene) in the Santa Maria basin also indicate there is spatial and temporal variability of observed species at each platform. The number of species present at the platforms decreases from west to east, and the northernmost platform (Irene, located north of Point Arguello) was inhabited by the highest number of species. Of the species observed (21), 44% were rockfish. Sardines were the only pelagic species observed at Irene. Twenty species were

reported for Platform Hidalgo, 16 species at Platform Harvest, and 13 species at Platform Hermosa (Love et al., 1999).

In addition to supporting more common species, there is indication that oil platforms play a role in the recovery of important fish populations. For instance, four federally-declared overfished species have been observed at platforms in southern California (Love and Nishimoto 2012). For instance, densities of mature bocaccio are generally very low at both natural reefs and platforms, but the species appears to be more abundant at artificial platforms than reefs (Love et al., 2005), resulting in higher potential larval production around platforms than in natural areas. These habitats are so productive for some species; for instance, removing Platform Gail would be the equivalent of removing approximately 13 ha of productive habitat for cowcod and 30 ha for bocaccio. Artificial structures also have been observed supporting higher densities of invasive exotic species (e.g., caprellids), although native fish have been observed feeding heavily on the exotic species, and this food source may have had a positive effect on the condition of some fish species (Page et al. 2007). Oil platforms sometimes have "shell mounds" around them. Shell mounds are created when mussels and other invertebrates are dislodged from platforms during cleaning of the structures and during storms. Platform shell mounds support a high number and diversity of small fish and YOY fish. In a comparison of fish densities at Hidalgo Platform to the North Reef (located approximately 1000 m from the platform) fish assemblages were similar, but densities were generally higher at the platform. Also, YOY densities were generally 100 times greater at the platform than North Reef (Love et al., 2003). Another study (Love and Snook 1999) observed at least 35 fish species at oil and gas platforms, and 18 of these were rockfish.

Fish spawning in the project area varies by season, but with no discernible pattern within the California Current system (Kramer and Ahlstrom 1968, Ahlstrom et al., 1978). Fish larvae (ichthyoplankton) occur in the water column, and their presence is variable by season. In samples collected offshore California, ichthyoplankton were observed at their highest densities between January and March (Loeb et al., 1983). These high densities are attributed to the peak spawning seasons for northern anchovy, Pacific hake (*Merluccius productus*), Pacific mackerel, and the Pacific sardine (larvae of these species comprised up to 84% of samples). Generally, ichthyoplankton densities decrease from north to south and inshore to offshore between San Francisco and Baja California. In a summary of fish larvae data, Ahlstrom (1965) found that most of the larvae collected (90%) was compressed of twelve taxa. The most abundant was the northern anchovy, *Engraulis mordax.* Other common larval species were the Pacific hake, rockfish, flatfish, and the California smoothtongue (*Leuroglossas stilbius*). Anchovy and rockfish larvae were most abundant winter through spring.

The Magnuson-Stevens Fishery Conservation and Management Act requires federal agencies to engage in consultation on projects that may impact Essential Fish Habitat (EFH). EFH is defined as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity" (72 Fed. Reg. 19862). Marine habitats within the project area are designated as EFH for four Fishery Management Plans (FMP) by the Pacific Fisheries Management Council (PFMC). These FMPs include Pacific Coast Salmon, Pacific Coast Groundfish, Coastal Pelagic Species, and Highly Migratory Species (PFMC 2005). The habitat and trophic requirements of salmon species include offshore areas, as well as migratory corridors to spawning sites. The Pacific Coast Groundfish FMP manages over 80 species in a large and ecologically diverse area. Groundfish EFH includes all waters and substrates that extend to MHHW or the upriver extent of saltwater intrusion. The Coastal Pelagic Species FMP addresses northern anchovy, Pacific sardine, mackerel, and squid. The east-west boundaries of EFH includes marine and estuarine waters offshore to the limits of the exclusive economic zone and above the thermocline where sea surface temperatures range from 10-26 degrees Celsius. The Highly Migratory Species FMP addresses highly-mobile species such as tuna and sharks, and their habitat is defined broadly by water quality conditions that support those species.

4.3.4 Sea turtles

Although marine turtles are not common to the project area, four species are known to occur in the region: the green sea turtle (*Chelonia mydas*), the Olive ridley sea turtle (*Lepidochelys olivacea*), the leatherback sea turtle, (*Dermochelys coriacea*), and the loggerhead sea turtle (*Caretta caretta*) (Hubbs 1977, Smith and Houck 1983). Within the eastern North Pacific, the populations of all four species that occur off the California coast are listed under the U.S. Endangered Species Act.

Leatherback turtles are regularly observed off of the U.S. west coast, where they forage on soft prey, such as jellyfish, in the summer and fall (Benson et al. 2007). Small numbers of leatherbacks (approximately 150 to 170) appear off the California coast between Point Conception and Point Arena in summer and fall. They typically occur over the continental slope in deeper waters than closer to shore. Their presence in the region coincides with seasonal abundance of jellyfish, an important prey item (Shenker 1984; Suchman and Brodeur 2005; Benson et al., 2007; Graham 2009). Because California waters are important to the survival of Pacific leatherbacks, critical habitat for this species was designated off the U.S. west coast in January 2012, including 16,910 square miles off California's central coast. This area of critical habitat stretches from Point Arena to Point Arguello east (inshore) of the 3,000-m depth contour line (77 FR 4170).

Like leatherbacks, loggerhead sea turtles generally occur over the continental shelf. However, loggerheads primarily occur in warmer (subtropical to temperate) waters, and as such southern California is their northern limit of their distribution (Stebbins 2003, Mager 1984; MMS 1996). At the Diablo Canyon Nuclear Power Plant off central California all sightings and strandings have been of green turtles (NMFS 1997). However, like loggerheads, green sea turtles generally occur in warmer tropical waters and they are infrequent visitors to the area. Although strandings have been reported from as far north as Washington and Oregon, olive ridleys are infrequent visitors to the waters north of Mexico (Green et al., 1991; Houck and Joseph 1958; NMFS 1997).

4.3.5 Marine Birds

Numerous waterbird species utilize shoreline and coastal offshore habitats in the project region. These include nearshore and pelagic seabirds, as well as shorebirds that occur along the coastal habitats. Mason et al., (2007) identified 54 species off southern California during coastal and at-sea surveys (from Cambria to the Mexican border), representing 12 different families. Nearshore seabirds tend to occur close to shore in relatively shallow waters. Common nearshore seabirds that can be observed in the region include western grebes (*Aechmophorus occidentalis*), Clark's grebes (*A. clarkii*), surf scoters (*Melanitta perspicillata*), cormorants (*Phalacrocorax* spp.), Pacific and common loons (*Gavia* spp.), California brown pelicans (*Pelecanus occidentalis californicus*), and several gull species (*Laridae*; Mason et al 2007). Pelagic species mainly occur in deeper habitats away from the shoreline. Nearshore species generally occur in higher numbers in winter and low numbers in summer, although there a wide degree of seasonal variation, with some species more common in spring or fall (Mason et al., 2007).

Pelagic seabirds occur in deeper waters, typically farther from shore than the nearshore species described above. Seabirds such as albatross (*Diomedeidae*), shearwaters (*Procellariidae*), storm-petrels (*Hydrobatidae*), phalaropes (*Phalaropus* spp.), jaegers (*Stercorarius* spp.), and alcids become common in the deeper offshore parts the region mid-May through early June (Lehman 1994), but seabirds are most numerous August through mid-October when large numbers of sooty shearwaters (*Puffinus griseus*), stormpetrels, and jaegers occur in the region (Mason et al., 2007). Fluctuations in numbers of several of California's most numerous seabirds off of central and southern California, including in the Point Conception/Vandenberg area, appears to be related to sea surface temperatures. When temperature are high, cold-water species generally are scarce and warm water species are abundant; whereas when temperature are low, warm-water species are more common (Ainley et al., 1995).

The coastal and offshore areas in the region are also important breeding areas for many seabirds. Although some birds nest on the mainland, many seabrids nest in the Channel Islands. For instance, the Channel Islands support nearly half of the world's populations of ashy storm-petrels (*Oceanodroma homochroa*) and western gulls (*Larus occidentalis*) and approximately 80% of the U.S. breeding population of Scripps's murrelets (*Synthliboramphus scrippsi*). Additionally, the islands support the only major breeding population of California brown pelicans in the western U.S. and the largest concentration of double-crested cormorant (*Phalacrocorax auritus*) colonies in southern California. One of the largest breeding colonies of Cassin's auklets within the California occurs in the Channel Islands as well (Lehman 1994, Whitworth et al., 2009). On the mainland, the federally endangered California least tern (*Sterna antillarum browni*) colony is located at Purisma Point, and is one of only three colonies between Monterey Bay and Point Conception. In 2013 there was an estimated 15 breeding pairs at this colony (Robinette et al., 2013).

In addition to open-water seabirds, shorebirds also occur in the shallow intertidal areas along the California coast. Most of the shorebird species the region are those that are adapted to sandy shoreline habitats; these include sanderling (*Calidris alba*), willet (*Tringa semipalmata*), western snowy plover (*Charadrius nivosus nivosus*), black-bellied plover (*Pluvialis squatarola*), marbled godwit (*Limosa fedoa*), killdeer (*Charadrius vociferous*), and whimbrel (*Numenius phaeopus*) (Lehman 1994, McCrary and Pierson 2002). Black oystercatchers (*Haematopus bachmani*), however, are one of a few shorebirds that are associated with rocky shoreline and island habitats. Sanderlings, willets and western snowy plovers account for most (78%) of shorebirds observed during a multi-year study of sandy beaches in Ventura County that are similar to those in the project area (Rodriguez 2011). The onshore area between Point Sal and Point Conception is an important breeding site for the federally threatened western snowy plover (Robinette et al., 2013). Since 1997, a management plan has been implemented at the Vandenberg Air Force Base beaches to protect this species and its habitat. During 2010, 255 nests and 409 chicks were counted hatched on Vandenberg AFB lands. Western snowy plovers breed throughout the approximately 14 miles of coastal beaches at Vandenberg, with an average number of plover adults totaling approximately 240 individuals (Robinette et al., 2013).

In addition to California least tern and western snowy plover, there are several bird species listed under the Federal Endangered Species Act that occur in the project area. These include Cassin's auklet (*Ptychoramphus aleuticus*), Scripp's murrelet (*Synthliboramphus scrippsi*), Guadaulupe murrelet (*Synthliboramphus hypoleucus*), and marbled murrelet (*Brachyramphus marmoratus*). See Section 4.6 below for more information on endangered species with potential to occur in the project area.

4.3.6 Marine Mammals

The project area supports many types of marine mammals, including cetaceans (whales, dolphins, porpoises), pinnipeds (sea lions, seals), and a single species of fissiped (otter). In total, approximately 40 species have the potential to occur off southcentral California (Dohl et al., 1983, Bonnell and Dailey 1993, Takekawa et al., 2004). These include species that occur seasonally during migrations to or from calving or feeding areas; seasonal visitors foraging on a particular (usually abundant) food source; and year-round regional residents. For some species, the region represents the northernmost or southernmost extent of their range (Dohl et al., 1983, Bonnell and Dailey 1993) and their presence varies by season. Boreal marine mammals are usually observed in the project area from winter through early summer, whereas species typically found in warmer, subtropical waters to the south tend to occur in late summer and autumn. Boreal species, those that typically occur in the cooler North Pacific waters, include harbor porpoises (*Phoecoena phoecoena*) and Dall's porpoises (*Phocoenoides dalli*), and the northern fur seal (*Callorhinus ursinus*). Warm-water species include bottlenose dolphins (*Tursiops truncatus*), Guadalupe fur seals (*Arctocephalus townsendi*), and pilot whales (*Globicephala* spp.). The most common baleen whale, the California gray whale (*Eschrichtius robustus*), migrates along the California coastline biannually. These migrations occur close to shore, with the majority of observed individuals during aircraft surveys occurring

within 1.8 km of the coast (Herzing and Mate 1984, Reilly 1984, Rice et al., 1984; Rugh 1984, Dohl et al., 1983, Sund and O'Connor 1974).

The southern sea otter (*Enhydra lutris nereis*), a year-round resident of coastal south-central California, generally occurs in shallow coastal waters (Riedman and Estes 1990). Currently, sea otters occur from approximately Point Año Nuevo in the north to Coal Oil Point (Santa Barbara) in the south (USGS 2008). In a 2012 survey, 2,792 southern sea otters were counted in central California (USGS 2012). During the breeding season (typically June to November) many members of the southernmost part of its population (in the project vicinity) move northward towards the center of its range (Bonnell et al. 1983; Estes and Jameson, 1983). The species is experiencing a range increase, including at the southern edge of its range (in the Point Arguello area). Approximately 200 otters were observed in the area extending from Point Purisma to Point Conception during surveys (USGS 2005) and over 150 otters (predominately male) are regularly seen east of Point Conception during the winter and spring (USGS, 1999, 2005, 2010).

The California sea lion (*Zalophus californianus*), harbor seal (*Phoca vitulina*), northern fur seal (*Callorhinus ursinus*), and northern elephant seal (*Mirounga angustirostris*) occur regularly off the coast and have breeding colonies in the region (Bonnell et al., 1983). Approximately half of the U.S. west coast California sea lion population (approximately 100,000 individuals) breed on San Miguel Island (part of the Channel Islands). Pacific harbor seals also breed on San Miguel Island, as well as Santa Rosa Island and at Carpinteria on the coast. In 2014, 4,344 sea lions were observed in Channel Islands and 26,333 statewide.

Approximately 400-600 Pacific harbor seal haulout sites occur in California in a variety of habitats (Hanan 1996, Lowry et al., 2008). The majority of harbor seals in southern California (70%) have been observed at Santa Cruz, Santa Rosa, and San Miguel Islands (Lowry et al., 2008). As of 1999 the populations of Northern fur seal, California sea lion, harbor seal, and northern elephant seal have increased up to three-fold, while Steller sea lions no longer breed on the island; pinniped population dynamics at the island are likely influenced by El Nino events (DeLong and Melin 2000). In addition to these species, Steller sea lions (*Eumetopias jubatus*) and the Guadalupe fur seals (*Arctocephalus townsendi*), although extirpated as breeders in in the region, are regular visitors to the region.

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4.4 Wildlife and Botanical Resources

§ 5.6 (d)(3)(v) - Wildlife and botanical resources including invasive species

(A) Description of upland habitat(s) and plant and animal species that use the habitat(s).

(B) Temporal or special distribution of commercially, recreationally, or culturally important species

4.4.1 Habitats and Plant and Animal Species

The project area has topography and vegetative cover that provide habitat for many common wildlife species. Natural vegetation communities found in the project area are of two major types (Vandenberg Air Force Base 2011, 2012).

Central Coast Scrub/Maritime Scrub

Central coast scrub/maritime scrub occupies much of the narrow coastal strip along central California. Shallow-rooted, mesophyllic plant species that are often drought-deciduous and summer-dormant characterize this community. Native species including California sagebrush (*Artemesia californica*) and coyote brush (*Baccharis pilularis*) dominate this vegetation type. Herbaceous species such as grassland tarplant (*Deinandra increscens*) may be present in clearings between shrubs. Seacliff buckwheat (*Eriogonum parvifolium*), the host plant for the federally endangered El Segundo blue butterfly (*Euphilotes battoides allyni*), occurs within this plant community in generally sparse distribution.

Coastal Bluff/Dune Scrub

Native species in this habitat include seacliff buckwheat, coyote brush, dune lupine (*Lupinus chamissonis*), species of *Dudleya*, giant coreopsis (*Coreopsis gigantea*), and species of *Croton*. Equally important to this ecosystem are the small sections of open sand. Beach layia (*Layia carnosa*) (listed as federally and state endangered) is located in this habitat, within sandy openings in the central dune scrub vegetation community.

Table 4.4-1 lists some of the wildlife species likely to be present in the CalWave shore station vicinity.

Table 4.4-1 Wildlife Species Commonly Found in the Project Area

Species	Common Name	Range[1]	Habitat Characteristics[2]
Pseudacris cadaverina	California treefrog	Year-long range	Wide, but patchy, distribution along rocky, mountain streams of coastal southern California from central San Luis Obispo County south to the Mexican border. An interior range extension to the western edge of the desert occurs in San Bernardino and Riverside counties. It may be common in quiet, shaded pools and other favored habitat.
Haemorhous mexicanus	House finch	Year-long range	Coastal shrub and grassland vegetation. A common to abundant resident in a variety of open habitats, usually where trees and large shrubs are absent. Found from grasslands along the coast and deserts near sea level to alpine dwarf-shrub habitat above tree line.

Table 4.4-1 Wildlife Species Commonly Found in the Project Area

Species	Common Name	Range[1]	Habitat Characteristics[2]
Sturnus vulgaris	European starling	Year-long range	Coastal shrub and grassland vegetation. Most common in urban, cropland, pasture, and orchard-vineyard habitats. Generally absent from higher montane habitats in Cascade Range and Sierra Nevada. Uncommon elsewhere in such habitats. In deserts of Great Basin and southern California, generally restricted to urban, cropland, pasture, orchard-vineyard, desert riparian, and palm oasis habitats. Also occurs in Joshua tree woodlands. In winter, much of the population withdraws from higher elevations and east of Cascade Range and Sierra Nevada.
Aphelocoma californica	Western scrub-jay	Year-long range	Frequents scrub habitats, especially with oaks; chaparral, coastal scrub, hardwood, hardwood-conifer, valley foothill riparian, pinyon-juniper, and urban.
Melozone crissalis	California towhee	Year-long range	Frequents open chaparral and coastal scrub, as well as brush-land patches in open riparian, hardwood hardwood-conifer, cropland, and urban habitats. Commonly uses edges of dense chaparral and brushy edges of densely wooded habitats.
Chamaea fasciata	Wrentit	Year-long range	A common, characteristic resident of California chaparral habitat. Also frequents shrub understory of coniferous habitats from the coast to lower regions of mountains throughout cismontane California.
Anaxyrus boreas	Western toad	Year-long range	Widely distributed in California, the western toad is present everywhere except the deserts and highest mountains. Throughout its range, the western toad can be scarce or common, depending on habitat quality. The western toad occurs in most California habitats except the deserts. It is uncommon in the high Sierra and in densely forested areas.
Sceloporus occidentalis	Western fence lizard	Year-long range	This adaptable lizard is found throughout California except in true desert, where it is restricted to riparian and high mountain locations.
Elgaria multicarinata	Southern alligator lizard	Year-long range	Generally common in suitable habitats, the southern alligator lizard is widespread in northern and central California west of the Sierra-Cascade crest and in southern California west of the desert regions.

Table 4.4-1 Wildlife Species Commonly Found in the Project Area

Species	Common Name	Range[1]	Habitat Characteristics[2]
			Occurs most commonly in valley-foothill habitats, mixed chaparral, and in open areas of mixed conifer forest.
Plestiodon skiltonianus	Western skink	Year-long range	In central and southern California, the western skink is restricted to the Coast Ranges and southern mountains exclusive of desert regions. Found in a variety of habitats, this lizard is most common in early successional stages or open areas within habitats in which it occurs. Heavy brush and densely forested areas are generally avoided.
Pituophis catenifer	Gophersnake	Year-long range	Gophersnakes are found throughout California, including the Channel Islands, and are absent only from the high mountains of the Sierra Nevada. They are found in all habitats and are generally absent only from densely forested habitat stages in the Sierra Nevada.
Phrynosoma coronatum	Coast horned lizard	Year-long range	Occurs in valley foothill hardwood, conifer and riparian habitats, as well as in pine-cypress, juniper and annual grassland habitats. Occurs in the Sierra Nevada foothills from Butte Co. to Kern Co. and throughout the central and southern California coast.
Sylvilagus bachmani	Brush Rabbit	Year-long range	This species is an abundant, yearlong resident of dense, brushy areas, and of early successional stages of oak and conifer habitats. Occurs throughout the length of the state west of the Sierra Nevada, excluding the dry Central Valley and southern arid regions.
Lepus californicus	Black-tailed jackrabbit	Year-long range	Common throughout the state, except at the highest elevations. Abundant at lower elevations in herbaceous and desert-shrub areas and open, early stages of forest and chaparral habitats.
Thomomys bottae	Botta's pocket gopher	Year-long range	Abundant, yearlong resident the length of the state. Optimal habitats are perennial meadows, and grass and forb stages of most riparian-deciduous and conifer forests. Less common in mature stages of forest habitats.
Sorex trowbridgii	Trowbrige's shrew	Year-long range	This shrew is most common in redwood, Douglas fir, ponderosa pine, montane hardwood-conifer, and mixed conifer forests with well-developed shrub understories and litter layers. Also occurs in montane riparian, valley foothill

Table 4.4-1 Wildlife Species Commonly Found in the Project Area

Species	Common Name	Range[1]	Habitat Characteristics[2]
			hardwood and hardwood-conifer, red fir, and chaparral habitats.

Notes

[1]Range: Based on California Department of Fish and Game range maps. These range maps are based on available occurrence data and professional knowledge. They represent current, but not historic or potential, range. Range types include migration, winter, summer and yearlong.
California Department of Fish and Wildlife (CDFR). "Life History and Range." 2017.
https://www.wildlife.ca.gov/Data/CWHR/Life-History-and-Range

[2]Habitat : Based on California Department of Fish and Wildlife life history accounts. Life history accounts include species in the California Wildlife Habitat Relationships System.
CDFR. "Life History and Range." 2017. https://www.wildlife.ca.gov/Data/CWHR/Life-History-and-Range

The proposed project site is largely undeveloped open space that has limited access due to its designation as a military base. Potential construction activities for the transmission line will limited in both areal extent and duration such that the wildlife present would be expected to move about and temporarily relocate during the construction period. Although some individual may be negatively impacted, there is sufficient additional adjacent habitat available that no significant negative effects to any species would be expected.

4.4.2 (A) Commercially, recreationally, or culturally important species

Please see Section 4.10, Socioeconomics, for a detailed discussion of the spatial distribution of commercially important species and Section 4.7, Recreation, for a discussion of recreationally important species. Wildlife and botanical resources are of importance to Native Americans though specific consultations regarding this topic have not yet taken place as part of government-to-government consultation.

4.4.3 (B) References Cited

Vandenberg Air Force Base. 2011. Final Draft Environmental Assessment for Repairs and Replacement of Overhead Electrical Line, Feeders N1, N3, and N6 Vandenberg Air Force Base, California. Department of the Air Force, August 2011.

Vandenberg Air Force Base. 2012. Finding of No Significant Impact/Finding of No Practicable Alternative for Replacement of Overhead Electrical Line, Feeders K1 and K7 Vandenberg Air Force Base, California. Department of the Air Force, Environmental Assessment, September 2012.

4.5 Floodplains, Wetlands, Riparian, and Littoral Habitat

§ 5.6(d)(3)(vi) Description of floodplains, wetlands, riparian, and littoral habitat

(1) List of plant and animal species using the habitat

(2) Map of wetlands, riparian and littoral habitat

(3) Acreage estimate for each type of land including variability connected to project operations

4.5.1 Description of floodplains, wetlands, riparian, and littoral habitat

The following section describes the floodplains, wetlands, riparian, and littoral habitats within the proposed site. Figure 4.5-1 shows the wetland area identified in the National Wetland Inventory (NWI) within one-half mile of the transmission right of way. Table 4.5-1 lists species likely to occur in these areas near CalWave.

Table 4.5-1 Wildlife Species Found in Project Area Wetland Habitats

Species	Common Name	Range[1]	Habitat Characteristics[2]
Lithobates catesbeiana	American bullfrog	Yearlong range	Highly aquatic, bullfrogs are found in quiet waters of ponds, lakes, reservoirs, irrigation ditches, streams, marshes, and other permanent water. This species occurs near permanent or semi-permanent water in a variety of California habitats.
Aneides lugubris	Arboreal salamander	Yearlong range	This species is only found on the surface during moist periods, when it can be common. Occurs primarily in valley-foothill hardwood, valley-foothill hardwood-conifer, and mixed conifer habitats, but is also known from Douglas fir and redwood habitat types. May be found in chaparral in southern California.
Anaxyrus californicus	Arroyo toad	Yearlong range	During the breeding season, individuals take daytime cover under clumps of vegetation and surface objects near water. During the remainder of the year, they leave their breeding sites and seek cover in moist niches in buildings, wells, rotting logs or burrows. Although not restricted to wetland habitats, this species always selects moist refuges. Associated with permanent or temporary water of all kinds in all California habitats, except dry desert types.
Batrachoseps nigriventris	Blackbelly Slender Salamander	Yearlong range	Suitable habitat for this salamander consists of relatively small, semi-mesic areas (e.g., swales, drainages, etc.), with an overstory of trees or shrubs and abundant rocks, litter, or woody debris

Table 4.5-1 Wildlife Species Found in Project Area Wetland Habitats

Species	Common Name	Range[1]	Habitat Characteristics[2]
Rana draytonii	California Red-legged Frog	Yearlong range	The California red-legged frog inhabits quiet pools of streams, marshes, and occasionally ponds. Occurs in the vicinity of quiet, permanent pools of streams, marshes, and occasionally ponds. Highly aquatic. Prefers shorelines with extensive vegetation. Usually escapes to water 1 m (3 ft) deep or more, at the bottom of pools.
Spea hammondii	Western spadefoot	Yearlong range	Recently metamorphosed juveniles seek refuge in the immediate vicinities of breeding ponds for up to several days after transformation. They hide in drying mud cracks, under boards and other surface objects. Breeding and egg laying occur almost exclusively in shallow, temporary pools formed by heavy winter rains. Grasslands with shallow temporary pools are optimal habitats for the western spadefoot.
Anaxyrus borea	Western Toad	Yearlong range	The western toad occurs in most California habitats except the deserts. Standing water is essential for reproductive success. Breeding and egg-laying normally occur in quiet waters less than 30 cm (12 in) deep (Stebbins 1954). Almost any source of standing water can be used for reproduction, including lakes, ponds, vernal pools, roadside ditches, irrigation canals, permanent and intermittent streams, and rivers. The presence of predatory fishes may reduce tadpole survival.
Actinemys marmorata	Western Pond Turtle	Yearlong range	The western pond turtle is uncommon to common in suitable aquatic habitat throughout California. Associated with permanent or nearly permanent water in a wide variety of habitat types. Individuals normally associate with permanent ponds, lakes, streams, irrigation ditches or permanent pools along intermittent streams.
Megaceryle alcyon	Belted kingfisher	Yearlong range	Valley foothill riparian and montane riparian habitats are preferred, but feeds in marine, estuarine, lacustrine, and riverine habitats as well. Requires riparian and aquatic habitats. All stages of growth along streams in wooded areas are used. Earthen banks nearby required for nesting. Preferred foraging areas have clear, slow moving, shallow water.

Table 4.5-1 Wildlife Species Found in Project Area Wetland Habitats

Species	Common Name	Range[1]	Habitat Characteristics[2]
Scapanus latimanus	Broad-footed mole	Yearlong range	Optimal habitats are annual and perennial grassland, pasture, montane and valley foothill riparian, and aspen. Prefers moist, friable soils. Avoids flooded soils. Most common in moist meadows and near streams.
Thamnophis hammondii	Two-striped garter snake	Yearlong range	Historically common, it is associated with permanent or semi-permanent bodies of water in a variety of habitats. Associated with permanent or semi-permanent bodies of water bordered by dense vegetation in a variety of habitats.

Notes

[1]Range: Based on California Department of Fish and Game range maps. These range maps are based on available occurrence data and professional knowledge. They represent current, but not historic or potential, range. Range types include migration, winter, summer and yearlong.
California Department of Fish and Wildlife (CDFR). "Life History and Range." 2017.
https://www.wildlife.ca.gov/Data/CWHR/Life-History-and-Range

[2]Habitat : Based on California Department of Fish and Wildlife life history accounts. Life history accounts include species in the California Wildlife Habitat Relationships System.
CDFR. "Life History and Range." 2017. https://www.wildlife.ca.gov/Data/CWHR/Life-History-and-Range

The presence and significance of the floodplain, wetland, riparian and littoral habitats on the project site are well documented as the shoreline and upland portions of proposed project would generally be sited in an area of VAFB that already have electrical transmission facilities that have been the subject of NEPA environmental assessments for potential upgrades. As seen on Figure 4.5-1, the project area includes areas of estuarine and marine deep water, estuarine and marine wetland, as well as some limited areas of freshwater forested and shrub wetland and also riverine wetland that are found along stream courses. No on-site, project specific wetland delineation studies have been conducted, but the review of aerial photography of the site and the NWI wetland mapping provide a reliable initial assessment of the presence and location of wetland features on the site.

The proposed shore station will be located on an upland area that has no wetland areas nearby. The shore station will be located more than 500 feet from the estuarine and marine wetland located along the ocean shoreline. The transmission line will be installed underground via HDD from the store station to the ocean out beyond any estuarine and marine wetland thus avoiding potential impacts to those wetlands.

The upland portion of the electric transmission line from the shore station to the interconnection with the existing VAFB distribution grid will be a pole-supported overhead line. Depending on the final routing and engineering, this overhead portion of the transmission will cross up to eight riverine and freshwater forested/shrub wetlands associated with site topographic drainages. Despite the fact that these drainages will be crossed by the transmission lines, no impacts to the wetland habitats are expected due to the ability to locate the support poles well outside of any jurisdictional areas. Thus the transmission line will span the identified wetland areas without encroaching on them.

4.5.2 References Cited

Vandenberg Air Force Base. 2011. Final Draft Environmental Assessment for Repairs and Replacement of Overhead Electrical Line, Feeders N1, N3, and N6 Vandenberg Air Force Base, California. Department of the Air Force, August 2011.

Vandenberg Air Force Base. 2012. Finding of No Significant Impact/Finding of No Practicable Alternative for Replacement of Overhead Electrical Line, Feeders K1 and K7 Vandenberg Air Force Base, California. Department of the Air Force, Environmental Assessment, September 2012.

National Wetlands Inventory (NWI) from U.S. Fish and Wildlife Service, December 2016.

Honda Canyon Rd
Honda Ridge Rd
Sky Screen Rd
Diosa Rd
North Rd
Luner Rd
Road N
Coast Rd
S Egress Rd
Tow Rd
Shore Station
VAFB Dock

Source:
National Wetlands Inventory (NWI) from U.S. Fish and Wildlife Service December 2016.

Map Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

LEGEND

- Proposed Structure
- 0.5 Miles from Transmission Line
- VAFB Dock
- Transmission Pole
- Transmission Line

NWI Wetland Type

- Estuarine and Marine Deepwater
- Estuarine and Marine Wetland
- Freshwater Emergent Wetland
- Freshwater Forested/Shrub Wetland
- Freshwater Pond
- Other
- Riverine

N

0 1,700 3,400
Feet

Figure 4.5-1
National Wetlands Inventory (NWI)
Within Half Mile of Transmission Line
California Wave Energy Test Center (CalWave℠)

ch2m:

4.6 Rare, Threatened and Endangered Species

§ 5.6 (d)(3)(vii) - Rare, threatened, and endangered species

(A) Description of listed rare, threatened and endangered, candidate, or special status species in the project vicinity.

(B) Identification of habitat requirements

(C) References to known biological opinion, status reports, or recovery plans pertaining to a listed species

(D) Extent and location of federally-designated critical habitat or other habitat for listed species

(E) Temporal and spatial distribution of the listed species

4.6.1 (A and B) Description of Special Status Species and Identification of Habitat Requirements

The following sections describe special status species in project area including rare, threatened, and endangered species in terms of major habitat categories (marine, terrestrial).

4.6.1.1 Marine Species

Table 4.6-1 (following pages) shows the special-status marine species that could occur in the project region. The table indicates whether the species is likely to occur in the project area (or would be rare or extremely rare) and whether there is critical habitat for that species (if critical habitat has been designated), for shallow waters and offshore waters.

Table 4.6-2 (follows Table 4.6-1) is a subset of Table 4.6-1 showing species that are both listed as threatened, endangered, or fully protected (California) and also likely to occur in the CalWave project areas. These are the species that will elicit the most regulatory concern. The following is a brief narrative discussion of the regulatory/permitting issues most likely to arise regarding the listed species found in Table 4.6-2.

Birds. The least tern and California pelican are California State fully protected, meaning that the CDFW would not issue a permit to take this species. Impacts to these species would be likely to occur mainly if shore facilities were to disrupt a nesting colony. (This also applies to the western snowy plover, which is federally listed as threatened and a California Species of Special Concern). Literature review for this phase of work indicates that the nearest least tern nesting colony is located at Point Purisima in Vandenberg Air Force Base (Robinette, D.P, R. Ball, J. Miller, and J. Howard 2013). This location is shoreward of the CalWave siting area (closest to, but not directly shoreward of the North Central and South Central prospective sites) but not in a location that would be near CalWave shore-side facilities if the North Central or South Central site were chosen. Vandenberg has 13.8 miles of beaches suitable for snowy plover nesting. Based on information from VAFB staff (Rhys Evans, personal communication 2016) none of the nesting beaches are near the CalWave shore station.

With diving feeders such as least terns and Scripps' murrelets, there could be concern that diving birds could encounter lost fishing gear tangled in mooring cables. Studies indicate that least terns forage in the vicinity of Platform Irene. The potential for this impact to occur would be low and could be mitigated by cable maintenance procedures to clear lost fishing gear, if needed.

Fish. Listed fish species likely to be present are all anadromous salmonids. It is unlikely that CalWave would cause concern over these species because CalWave would not affect terrestrial stream habitat for salmonids (given reasonable measures during 70 kV upgrade construction) and, in their marine phase, salmonids roam widely in the pelagic zone.

In previous cases of marine development, agencies have expressed concerns that MHK or similar devices could be fish attraction devices (FAD) where predators of salmonids would congregate, feeding on young salmon entering the ocean from the mouths of streams, for projects relatively near shore and near a stream outlet. The Santa Ynez and Santa Maria rivers and San Antonio Creek are the only large salmonid-bearing streams that enter the ocean near the CalWave project site. The South and South by Southeast test berth sites are 10 and 15 nm, respectively, from the mouth of Santa Inez River. Smaller streams enter the ocean from the Tranquillon Ridge near these sites. It is unknown without further consultation with NOAA-NMFS, whether these streams or those previously listed would pose a significant issue with regards to salmonids.

Marine Mammals (cetaceans). Several listed whale species are present in the project area and will likely be a cause of some level of regulatory agency concern. These include the humpback, blue, fin, sei, sperm, and northern right whale. A recent 15-year satellite tracking study of 170 tagged blue whales, for example (Irvine, et al. 2014), documents a "home range" area around the western Channel Islands and extending north past and including much of the CalWave siting area and a "Core Area" that is a smaller area and on the margins of which the southern portion of the CalWave siting area is located. For these large whale species, one of the major management concerns has to do with vessel strikes, particularly with large vessels.

Sea Otter. The southern sea otter has been relatively rare in the project area, but has expanded its range south of Point Conception in recent years. Sea otters feed on the bottom and in kelp forests and so spend most of their time within 1 km of shore and in shallower water and are known to occur in the Vandenberg Dock harbor cove (United States Air Force 1978, 1983, United Launch Alliance 2014). Regulatory issues would have mostly to do with disturbance of feeding grounds during cable laying and horizontal directional drilling near shore.

Black Abalone. Critical habitat for the black abalone has been designated as consisting of rocky shore habitats in the Vandenberg project area including the shoreline adjacent to the CalWave shore station. Impacts to this species should be relatively easy to avoid by horizontal directional drilling.

Leatherback turtle. Critical habitat for the leatherback turtle has been defined for a large ocean area, starting at an east-west line extending west from Point Arguello. The South and South by Southeast test berth sites lie outside of this area, however. Key issues for this species would involve any potential for turtles to suffer vessel strike or become entangled in fishing gear that catches on WEC mooring cables, as well as potential effects on the leatherback turtle's preferred jellyfish prey.

Table 4.6-1. Special-Status Species that Could Occur in Shallower or Deeper Waters off of Vandenberg AFB or be Affected by the CalWave Project

Species[a]	Status[b]	Critical Habitat[c]		Likely to Occur[d]	
		Inshore Waters	Offshore Waters	Inshore Waters	Offshore Waters
Marine Birds and Shorebirds					
Brant (*Branta bernicla*)	SSC	--	--	Y	N
Ashy storm-petrel (*Oceanodroma homochroa*)	SSC	--	--	Y	Y
Black-footed albatross (*Phoebastria nigripes*)	BCC	--	--	U	U
Black storm-petrel (*Oceanodroma melania*)	SSC	--	--	Y	Y
California least tern (*Sternula antillarum browni*)	E, E, CFP	--	--	Y	Y
Cassin's auklet (*Ptychoranphus aleuticus*)	SSC	--	--	Y	Y
California brown pelican (*Pelecanus occidentalis californicus*)	DE, CFP	--	--	Y	Y
Double-crested cormorant (*Phalacrocorax auritus*)	SSC	--	--	Y	Y
Hawaiian petrel (*Pterodroma sandwichensis*)	FE	--	--	U	U
Light-footed clapper rail (*Rallus longirostris levipez*)	E, E, CFP	--	--	Y	N
Marbled murrelet (*Brachyramphus marmoratus)*	FT, SE	N	N	U	U
Pink-footed shearwater (*Puffinus creatopus*)	BCC	--	--	Y	Y
Black-vented shearwater (*Puffinus opisthomelas*)	BCC	--	--	Y	Y
Short-tailed albatross (*Phoebastris albatrus*)	FE	--	--	U	U
Scripps' murrelet (*Synthliboramphus scrippsi)*	FC, ST	--	--	Y	Y
Tufted puffin (*Fratercula cirrhata*)	SSC	--	--	Y	Y
Western snowy plover (*Charadrius nivosus nivosus*)	FT, SSC	--	--	U	Y
Fish					
North American green sturgeon southern DPS (*Acipenser medirostris*)	FT	N	N	U	U
Central California Coast coho salmon ESU *(Oncorhynchus kisutch)*	FE, SE	N	N	Y	Y
Southern Oregon/Northern California Coast Coho salmon ESU *(O. kisutch)*	FT, ST	N	N	Y	Y
California Coast Chinook salmon ESU (*Oncorhynchus tshawytscha*)	FT	N	N	Y	Y
Sacramento River winter-run Chinook salmon ESU (*O. tshawytscha*)	FE, SE	N	N	Y	Y

Table 4.6-1. Special-Status Species that Could Occur in Shallower or Deeper Waters off of Vandenberg AFB or be Affected by the CalWave Project

Species[a]	Status[b]	Critical Habitat[c]		Likely to Occur[d]	
		Inshore Waters	Offshore Waters	Inshore Waters	Offshore Waters
Central Valley spring-run Chinook salmon ESU (*O. tshawytscha*)	FT, ST	N	N	N	N
Northern California steelhead DPS (*Oncorhynchus mykiss*)	FT	N	N	Y	Y
Central Valley steelhead DPS (*O. mykiss*)	FT	N	N	Y	Y
Central California Coast steelhead DPS (*O. mykiss*)	FT	N	N	Y	Y
South-Central California Coast steelhead DPS (*O. mykiss*)	FT	N	N	Y	Y
Southern California steelhead DPS (*O. mykiss*)	FE	N	N	Y	Y
Southern eulachon DPS (*Thaleichthys pacificus*)	FT	N	N	N	N
Tidewater goby (*Eucyclogobius newberryi*)	FE, SSC	N	N	U	U
Longfin smelt (*Spirinchus thaleichthys*)	FC, ST	--	--	N	N
Marine Mammals – Cetaceans					
Gray whale (*Eschrichtius robustus*)	DE, MMPA	--	--	Y	Y
Bryde's whale (*Balaenoptera edeni*)	MMPA	-	-	U	U
Humpback whale (*Megaptera novaeangliae*)	FE, MMPA	--	--	Y	Y
Blue whale (*Balaenoptera musculus*)	FE, MMPA	--	--	Y	Y
Killer whale – Eastern North Pacific Southern Resident (*Orcinus orca*)	FE, MMPA	N	N	U	U
Killer whale –Eastern North Pacific Transient (*Orcinus orca*)	MMPA	--	--	Y	Y
Minke whale (*Balaenoptera acutorostrata*)	MMPA	--	--	Y	Y
Fin whale (*Balaenoptera physalus*)	FE, MMPA	--	--	Y	Y
Sperm whale (*Physeter macrocephalus*)	FE, MMPA	--	--	U	Y
Sei whale (*Balaenoptera borealis*)	FE, MMPA	--	--	U	U
North Pacific right whale (*Eubalaena japonica*)	FE, MMPA	N	N	Y	Y
Harbor porpoise (*Phocoena phocoena*)	MMPA	--	--	Y	Y
Dall's porpoise (*Phocoenoides dalli*)	MMPA	--	--	Y	Y
Pacific white-sided dolphin (*Lagenorhynchus obliquidens*)	MMPA	--	--	Y	Y

Table 4.6-1. Special-Status Species that Could Occur in Shallower or Deeper Waters off of Vandenberg AFB or be Affected by the CalWave Project

Species[a]	Status[b]	Critical Habitat[c]		Likely to Occur[d]	
		Inshore Waters	Offshore Waters	Inshore Waters	Offshore Waters
Risso's dolphin (*Grampus griseus*)	MMPA	--	--	Y	Y
Northern right whale dolphin (*Lissodelphis borealis*)	MMPA	--	--	Y	Y
Common bottlenose dolphin (*Truncatus truncatus*)	MMPA	--	--	Y	Y
Striped dolphin (*Stenella coeruleoalba*)	MMPA	--	--	U	U
Short-beaked common dolphin (*Delphinus delphis*)	MMPA	--	--	Y	Y
Long-beaked common dolphin (*Delphinus capensis*)	MMPA	--	--	Y	Y
Short-finned pilot whale (*Globicephala macrorhynchus*)	MMPA	--	--	U	U
Baird's beaked whale (*Berardius bairdii*)	MMPA	--	--	Y	Y
Beaked whales (*Mesoplodon* spp.)	MMPA	--	--	U	Y
Cuvier's beaked whale (*Ziphius cavirostris*)	MMPA	--	--	Y	Y
Marine Mammals – Pinnipeds					
Harbor seal (*Phoca vitulina richardsi*)	MMPA	--	--	Y	Y
Steller sea lion Eastern DPS (*Eumetopias jubatus*)	DE, MMPA	--	--	Y	Y
California sea lion (*Zalophus californianus*)	MMPA	--	--	Y	Y
Guadalupe fur seal (*Arctocephalus townsendi*)	FT, ST, MMPA	--	--	U	U
Northern elephant seal (*Mirounga angustirostris*)	MMPA	--	--	Y	Y
Northern fur seal (*Callorhinus ursinus*)	MMPA	--	--	Y	Y
Mammals – Mustelids					
Southern Sea Otter (*Enhydra lutris nereis)*	FT	--	--	Y	U
Invertebrates					
Black abalone *(Haliotis cracherodii)*	FE	Y	Y	Y	N
White abalone (*Haliotis sorenseni)*	FE	--	--	N	N
Reptiles					
North Pacific Ocean Loggerhead turtle DPS (*Caretta caretta*)	FE	--	--	U	U

Table 4.6-1. Special-Status Species that Could Occur in Shallower or Deeper Waters off of Vandenberg AFB or be Affected by the CalWave Project

Species[a]	Status[b]	Critical Habitat[c]		Likely to Occur[d]	
		Inshore Waters	Offshore Waters	Inshore Waters	Offshore Waters
Green turtle (*Chelonia mydas*)	FT	N	N	U	U
Leatherback turtle (*Dermochelys coriacea*)	FE	Y	Y	U	U
Olive Ridley turtle (*Lepidochelys olivacea*)	FT	--	--	U	U

[a] DPS = Distinct Population Segment; ESU=Evolutionarily Significant Unit

[b] FC = Federal Candidate for listing; FE = Federally listed as endangered; FT = Federally listed as threatened; BCC = Bird of Conservation Concern; MMPA = Protected by the Marine Mammal Protection Act
SE = California state-listed as endangered; ST = California state-listed as threatened; CFP = California Fully Protected Species; SSC = State Species of Special Concern; DE = Delisted

[c] Y = critical habitat occurs in project area

N = critical habitat not in project area

-- = critical habitat not designated for species

[d] Y = likely to occur in CalWave project area
U = potentially within species' range but unlikely to occur in project area (e.g., rare in area and/or found generally farther offshore). Marine mammals in this category could be affected by noise and vibration from project activities.

N = outside of species' range

Table 4.6-2. Listed (Candidate, Threatened, or Endangered) Marine Species likely to Occur in CalWave Area

Species name	Federal status	State Status	Habitat	Potential or Impact at CalWave
Birds:				
California least tern (*Sternula antillarum browni)*	Endangered	Endangered - Fully protected	Nests at Purisma Point, dive-feeder	Does not nest near CalWave shore station – impact unlikely
California brown pelican (*Pelecanus occidentalis californicus*)	Delisted	Delisted - Fully protected	Colony nesting, skim feeder	Present, but impact unlikely
Scripps' murrelet (*Synthliboramphus scrippsi*)	Candidate	Threatened	Nests on Channel Island, dive-feeder	May feed near test berths, potential for entanglement in derelict fishing gear
Western snowy plover (*Charadrius nivosus nivosus*)	Threatened	Special Concern	Nests on VAFB beaches, shore feeder	Does not nest in south VAFB, impact unlikely
Fish:				
Salmon (5 Evolutionarily Significant Units)	Endangered /threatened	Endangered /threatened	Pelagic species, ranges widely	May be present at test berth sites but impact unlikely
Steelhead (5 Distinct Population Segments)	Endangered /threatened	-	Pelagic species, ranges widely	May be present at test berth sites but impact unlikely – spawns on VAFB streams, but not near shore station.
Marine Mammals				
Humpback whale (*Megaptera novaeangliae*)	Endangered	-	Migratory species, common in project area	Vessel strike hazard
Blue whale (*Balaenoptera musculus*)	Endangered	-	Active near Channel Islands	Vessel strike hazard
Fin whale (*Balaenoptera physalus*)	Endangered	-	More common in deeper water, but present in project area	Vessel strike hazard
Sperm whale (*Physeter macrocephalus*)	Endangered	-	More common in deeper water, but present in project area	Vessel strike hazard
North Pacific right whale (*Eubalaena japonica*)	Endangered	-	More common in deeper water, but present in project area	Vessel strike hazard
Sei whale (*Balaenoptera borealis*)	Endangered	-	More common in deeper water, but present in project area	Vessel strike hazard

Table 4.6-2. Listed (Candidate, Threatened, or Endangered) Marine Species likely to Occur in CalWave Area

Species name	Federal status	State Status	Habitat	Potential or Impact at CalWave
Other Mammals:				
Southern Sea Otter (*Enhydra lutris nereis*)	Threatened	-	Lives and feeds near shore in kelp forest	Present in VAFB Dock cove, but impact unlikely
Invertebrates:				
Black abalone (*Haliotis cracherodii*)	Endangered/Critical Habitat (rocky shores)	-	Rocky shoreline	Present near shore station but impacts can be avoided
Reptiles:				
Leatherback turtle (*Dermochelys coriacea*)	Endangered/Critical Habitat (north of Pt. Arguello)	-	Present near test berths	Potential for entanglement in derelict fishing gear

4.6.1.2 Listed Terrestrial Species

Terrestrial species are, initially at least, of less immediate regulatory concern than marine species because: (1) impacts and mitigation measures are relatively well known for most areas, and (2) the project footprint on land is small, consisting of the horizontal directional drilling pit, shore facilities, and 70 kV upgrade line for approximately six miles. Potential impacts to listed terrestrial species should be relatively easy to avoid by moving facilities such as 70 kV upgrade line poles out of the way. Table 4.6-3 shows the terrestrial species that are either federal or state threatened or endangered and that are known to occur in the vicinity of the project's shore facilities (USGS quadrangles surrounding the Tranquillon Mountain Quadrangle, where Vandenberg Dock is located). Based on discussions with VAFB environmental staff (Evans, 2016), many of these species will likely be eliminated from further consideration based on detailed habitat analysis and determinations that the project would be unlikely to affect, or could avoid them. Once the final 70 kV route is determined, field surveys will help in adjusting the route to avoid impacts.

4.6.1.3 Special-Status Species Summary

Conflicts with terrestrial species habitats appear to be relatively easy to avoid even if the species and habitat are present. For marine species, analysis of project effects for MHK projects has in the past been hampered by lack of experience with the technology and corresponding uncertainty about the potential effects of the MHK devices. The presence of listed marine species such as leatherback turtle and the large cetaceans (blue, fin, humpback, sperm, and sei whales) in the project area and in particular of critical habitat for the leatherback turtle in portions of the siting area could be cause for regulatory concern. On the other hand, it is difficult to see how the deployment of MHK devices in the chosen location could cause significant impacts or obstacles to these species or pose issues that could not be resolved by implementing prudent measures to observe and avoid cetaceans.

4.6.2 (C) References to Biological Opinion, Status Reports, Recovery Plans

The final PAD will contain a detailed list of Biological Opinions, Status Reports, and Recovery Plans for species determined to be affected.

4.6.3 (D) Extent and Location of Critical Habitat

There is critical habitat in or near the project area for two marine species:

Leatherback turtle (*Dermochelys coriacea*)—Critical habitat for the endangered leatherback turtle is found to the north of the project area. The NMFS designated critical habitat for this species in 2012 (50 CFR 226) in an area to the north of an east-west line extending due west from Point Arguello to the base of the Santa Lucia escarpment (roughly 90 km) and extends northward over the entire Central California coast. Neither the CalWave cables nor test berths are within the critical habitat zone, which is defined mainly by the availability food species, which consist mainly of jellies and other soft-bodied invertebrates.

Black abalone (*Haliotis cracherodii*)—Critical habitat for the black abalone was designated by NMFS in 2011 (76 FR 66806) as consisting of rocky intertidal and subtidal areas in central California from Point Conception north to Point Arena and along the Channel Islands and Palos Verdes Peninsula. The shoreline areas adjacent to the CalWave shore station is critical black abalone habitat. The project will seek to avoid any disruptions to this habitat by using horizontal directional drilling techniques to route the subsea cables from the shore station to a depth of 10 meters or so.

4.6.4 (E) Temporal and Spatial Distribution

Please see the previous sections and tables for this information.

Table 4.6-3. Threatened or Endangered Terrestrial Species from the Project Area*

Common Name	Scientific Name	Federal Status	State Status	Potential CalWave Shore Station Impact**
Amphibians				
California tiger salamander	*Ambystoma californiense*	Threatened	Threatened	Not known to occur at VAFB
California red-legged frog	*Rana draytonii*	Threatened	None	Known north of 70 kV line, but avoidable by spanning drainage
Birds				
Bald eagle	*Haliaeetus leucocephalus*	Delisted	Endangered, fully protected	Not known to nest at VAFB
Belding's savannah sparrow	*Passerculus sandwichensis beldingi*	None	Endangered	Not known to occur at VAFB
Tricolored blackbird	*Agelaius tricolor*	None	Candidate	Avoidable by spanning wetlands
Little willow flycatcher	*Empidonax traillii brewsteri*	None	Endangered	Not known to occur at VAFB
Southwestern willow flycatcher	*Empidonax traillii extimus*	Endangered	Endangered	Known from Santa Ynez Valley, North Base, not found near shore station
Crustaceans				
Vernal pool fairy shrimp	*Branchinecta lynchi*	Threatened	None	Known occurrences on North Base
Fish				
Unarmored threespine stickleback	*Gasterosteus aculeatus williamsoni*	Endangered	Endangered – fully protected	Known north of 70 kV line, but avoidable by spanning drainage
Tidewater goby	*Eucyclogobius newberryi*	Endangered	Species of Special Concern	Not known to occur at VAFB
Invertebrates				
El Segundo blue butterfly	*Euphilotes battoides allyni*	Endangered	None	Known occurrences on North Base and further inland in South Base
Plants				
Surf thistle	*Cirsium rhothophilum*	None	Threatened	Not known to occur at VAFB
La Graciosa thistle	*Cirsium scariosum var. loncholepis*	Endangered	Threatened	Known from Santa Ynez Valley, not found near shore station, 70 kV line
Gaviota tarplant	*Deinandra increscens ssp. villosa*	Endangered	Endangered	Known occurrences at VAFB north and east of the 70 kV line

Table 4.6-3. Threatened or Endangered Terrestrial Species from the Project Area*

Common Name	Scientific Name	Federal Status	State Status	Potential CalWave Shore Station Impact**
Beach layia	*Layia carnosa*	Endangered	Endangered	Known occurrences at VAFB north of the 70 kV line
Lompoc yerba santa	*Eriodictyon capitatum*	Endangered	Rare	Known occurrences at VAFB inland on North Base mesa, not near 70 kV line or shore station
Beach spectaclepod	*Dithyrea maritima*	None	Threatened	Not known to occur at VAFB
Seaside bird's-beak	*Cordylanthus rigidus ssp. littoralis*	None	Endangered	Not known to occur at VAFB
Vandenberg monkeyflower	*Mimulus fremontii var. vandenbergensis*	Endangered	None	Known occurrences at VAFB inland on North Base mesa, not near 70 kV line or shore station

* California Natural Diversity Database list from 9 quadrangles surrounding and including Tranquillon Mountain USGS 7.5-minute quadrangle. Note: Because of its coastal position, there are only six quadrangles surrounding the Tranquillon Mountain Quadrangle.

**Presence-absence information from VAFB Environmental Staff (Evans, 2016). Will require confirmation from field surveys of the final route.

Note: Species already listed as marine (salmonids, snowy plover, brown pelican, etc.) in Table 4.6-2 are not listed here also.

Source: California Department of Fish and Wildlife. https://map.dfg.ca.gov/bios/?tool=cnddbQuick, accessed January 12, 2017.

4.6.5 References Cited

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4.7 Recreation and Land Use

§ 5.6 (d)(3)(viii) - Recreation and land use

(A) Description and illustration of existing recreational facilities, uses, location, ownership, capacity and management

(B) Recreational use of lands and waters compared to facility or resource capacity

(C) Existing shoreline buffer zones

(D) Current and future recreation needs from existing state or regional plans

(E) Existing shoreline management policies

(F) Project's location within or adjacent to a river segment that is:

(1) Designated or under study for inclusion in the National Wild and Scenic River system

(2) A state-protected river segment

(G) Description of project lands under study for inclusion in the National Trails System or as a Wilderness Area

(H) Regionally or nationally important recreation areas

(I) Non-recreational land use and management within the project boundary

(J) Recreational and non-recreational land use and management adjacent to the project boundary

4.7.1 (A) Existing recreational facilities and uses

The test berth locations are to the south and southwest of Vandenberg AFB (VAFB) and would be accessed by marine vessel from the VAFB dock and from other regional ports such as Morro Bay, Port San Luis, Santa Barbara, and Port Hueneme. There are no existing offshore recreational facilities in this area.

The shore station site and surrounding area are located on VAFB, which is not open to the public, though it is open to authorized military personnel for recreation. The Vandenberg Dock and adjacent cove are used for fishing, surfing, and other recreational activities by military personnel with authorization. The Coast Guard Station building adjacent to the proposed shore station site is used by military personnel for social events, but also is not open to the public.

4.7.1.1 Public Parks

To the north of the test berth and shore station sites there is a public access corridor in the geographic center of the VAFB property to Ocean Park Beach which is operated by Santa Barbara County. This park is located about 13 miles west-northwest of Lompoc, California off Highway 246. It provides the only public beach access in the region. Ocean Beach Park is open from 8:00 AM to sunset. However, it is closed to the

public from March 1st through September 30th because of Snowy Plover nesting season.[8] From Ocean Beach, the South test berth would be about 12 miles to the south-southwest. The Land Use element of the Santa Barbara County General Plan identifies Ocean Park has having nature walks, walking, informal recreation, and family picnicking.[9] There would be no line of site from this park to the South by Southeast test berth.

To the south of the test berth and shore station sites, the nearest publicly accessible land is also a recreational facility, Jalama Beach County Park, 6.85 miles southeast from Vandenberg Dock. Land between Vandenberg Dock and Jalama Beach is grazing land and open space that is not open to the public and not actively used by the Air Force. The park features a parking area, general store, grill, and 107 campsites that accommodate tents, trailers, and recreational vehicles. From the park, the nearest berth at the South by Southeast site would be approximately 5.5 nautical miles to the west-southwest.

4.7.12 Surfing and Kitesurfing

Surfing is a popular outdoor sport along the Central California Coast. The nearest publicly accessible surfing spots are Surf Beach and Jalama Beach County Park. Additional locations on VAFB are used by surfers with a military identification and pass, as stated above, but these areas are not open to the public. Table 4.7A-1 lists the characteristics of known surfing spots within 12 air miles of the CalWave shore station.

Table 4.7-1. Surfing spots within 12 miles of the CalWave Shore Station, listed north to south

Name	Miles/ direction from Shore Station	Public access?	Break/Conditions	Experience level	Comment
Surf Beach	8.8 n	Yes - Surf train station parking lot	50 to 150 m normal break, sandy bottom, “hollow, fast, powerful”	Experienced, not for beginners	Use listed as “empty”. Recent Great White Shark attack
Boat House	0.5 e	No – VAFB pass only	50 to 150 m normal break, sandy bottom with rock, “ordinary break”	All levels	Use listed as “few surfers”, shark hazard
Del Morida	3.7 ese	No – VAFB pass only	<50 m normal break, sandy bottom with rock, “hollow, ordinary, fun break”	All levels	Use listed as “empty”; undertow, rock, shark hazard
Jalama	7.4 se	Yes - Jalama Beach County Park, public access	50 to 150 m normal break, sandy bottom with rock, “ordinary break”	Experienced surfers	Crowded on weekends, otherwise “empty”; shower, bathroom, grill, parking
Tarantulas	7.9 se	Yes – park at Jalama Beach and walk 30 minutes	50 to 150 m normal break, reef rock bottom, “hollow, fast, powerful break”	Experienced surfers	Crowded on weekends, otherwise “empty”; shower, bathroom, grill

[8] http://cosb.countyofsb.org/parks/parks02.aspx?id=13418

[9] http://longrange.sbcountyplanning.org/landuse_element2.php

Table 4.7-1. Surfing spots within 12 miles of the CalWave Shore Station, listed north to south

Name	Miles/ direction from Shore Station	Public access?	Break/Conditions	Experience level	Comment
Whitey's	11.6 se	No – surrounding land private	50 to 150 m normal break, flat rock bottom, "hollow, fast, powerful break"	Experienced surfers	Use listed as "empty"; rock, shark hazard

Source: wannaSurf world surf spot atlas: http://www.wannasurf.com/. Surfline: www.surfline.com

Jalama Beach County Park is also listed as a kite-surfing location.

4.7.1.3 Diving

Regionally, diving is particularly popular in the Channel Islands and along the Santa Barbara Channel. The nearest diving spot recommended by wannaDive, a global diving location atlas, are at Refugio Beach in the Santa Barbara Channel area, about 31.5 air miles east-southeast from the CalWave shore station and Wilson Rock, offshore of San Miguel Island, about 33.8 miles southeast of the shore station. There are also several spots along the coast near Morro Bay, more than 50 air miles north of the CalWave shore station. There do not appear to be popular dive locations near the CalWave shore station.

Dive boats are available for hire in Morro Bay and Santa Barbara, Ventura, and Oxnard. There are dive shops in Santa Barbara, Goleta, Ventura, Lompoc, Pismo Beach, and San Luis Obispo. The nearest of these to the project area is Lompoc, which is 10 air miles northeast of the shore station site.

4.7.1.4 Recreational Fishing and Boating

The ports within 60 nautical miles of the project site are Morro Bay, Port San Luis at Avila Beach, and Santa Barbara. The number of boat slips in each harbor is a follows:

- Morro Bay: 50 slips, 125 moorings (50 private)
- Port San Luis/Avila Beach: 175 private moorings
- Santa Barbara: 1139 slips

Recreational saltwater fishing use of the project area is somewhat difficult to evaluate because of the lack of hard data. However, some indication of fishing patterns can be developed by looking at sport fishing interest web sites and the availability of support facilities such as ports, harbors, and fishing equipment shops in the region. Table 4.7A-2 lists sport fishing services within 60 air miles of the shore station that are listed in Fishing Network, with details about services provided.

Table 4.7-2. Sport fishing services within 60 nautical miles of the CalWave test berth (north to south)

Name, Port	Services	Typical catch	Areas fished
Morro Bay – 51 nm north			
Virg's Landing	• Half-day to two-day trips • Private charters (rock cod, salmon, albacore) • Whale watching trips	• Rockfish • Albacore • Salmon	Not indicated
Morro Bay Landing	• Half-day to 12-hour trips • Private charters • Whale watching trips	• Rockfish • Ling cod • Greenling cod	12-hour to Cape San Martin (43 nm)

Table 4.7-2. Sport fishing services within 60 nautical miles of the CalWave test berth (north to south)

Name, Port	Services	Typical catch	Areas fished
Morro Bay Fishing Charters	• Private charters	• Rockfish • Ling cod • Crab	Morro Bay
JT's Full-on Fishing Charters	• Private charters	• Salmon • Rockfish • Halibut • Tuna	Offshore of Morro Bay
San Pedro Sport Fishing and Marine Tours	• Half-day, three-quarter day trips • Private charters • Whale watching trips	• Rockfish • Ling cod • Salmon • Halibut • White Sea Bass	Not indicated
Ocean Pacific Charters	• Whale watching • Fishing charters	Not indicated	Not indicated
Avila Beach – 38 nm north			
Patriot Sport Fishing (also operates from Morro Bay)	• 5-, 8-, and 10-hour trips • Private charters • Whale watching trips	• Rockfish • Ling cod • Crab • Sand dab • Albacore • Salmon	Pt. Buchon (12 nm) to Pt. Purisima (26 nm)
Santa Barbara – 45 nm south-southeast			
Stardust Sport Fishing	• Half-day, three-quarter day trips • Private charters • Whale watching trips	• Rockfish • Barracuda • White sea bass • Halibut • Calico bass • Sand bass • Ling cod	Channel Islands
Santa Barbara Sport Fishing Charters	• Half-day, three-quarter, full-day trips • Private charters	• Rockfish • Barracuda • Salmon • Halibut • Calico bass • Thresher shark	Inshore, Santa Barbara Channel

Source: Fishing Network, http://fishingnetwork.net/

The nearest ports to the test berth site that offer sport fishing charters are Avila Beach, at 43 (statute/air) miles, Santa Barbara, at 54 miles, and Morro Bay, at 57 miles. On-line information available for two of the charter services provided some information about distance of travel on a typical charter. Patriot Sport Fishing, operating out of Avila Beach, fishes for "rock cod" (presumably rockfish) between Point Buchon, which is about 12 nautical transit miles from Avila Beach, and Point Purisima, which is 26 nautical miles south of Avila Beach. Morro Bay Landing (operating out of Morro Bay) offers a 12-hour charter trip, its longest one-day trip, to Cape San Martin, which is 43 nautical miles north of Morro Bay (86 miles round trip), which is slightly more than the 38 nm distance from Avila Beach to the test berth site. Although the CalWave test berths appear to be within range of a long-distance, single-day fishing charter trip, it is likely

that the majority of sport fishing charters cover less distance and therefore, it seems unlikely that there would be much conflict with this type of recreational fishing (charter boats). Interviews with charter providers during the field studies phase of permitting are recommended to evaluate this topic more thoroughly.

4.7.1.5 Whale Watching

Sport fishing charters listed in Table 4.7A-2 generally also offer whale watching tours. Considerations of range (distance from port) would presumably be similar to those for sport fishing journeys.

4.7.2 (B) Recreational use of lands and waters compared to facility or resource capacity

Surfing interest organizations classify use of the nearest surfing beaches to CalWave as "empty" on weekdays. Jalama Beach and Tarantulas, served by the Jalama Beach County Park parking lot are listed as "crowded" on weekends. Surfing locations at VAFB are seldom used but are not open to the public.

The capacity of the ocean for recreational fishing would appear to be very high and not approaching saturation. Sport fishing, however, is governed by daily per-person catch limits on most species (see Table 4.7-3) and charter operations approach the limits on a regular basis and must curtail fishing.

Table 4.7-3. CDFW Marine Sport Fishing Limits for the Central California Coast, major species

Species or group	Daily Limit	Seasonal	Other
Rockfish (*Sebastes sp.*)	10 (w/in RCG complex)	• Boat – 4/1 to 12/31 • Shore/diver – all year	• Waters < 40 fathoms (240 feet) only • Sub-limits for certain species • Four rockfish species not permitted to be taken (bronzespotted, canary, cowcod, yelloweye) • Limit of 10 per Rockfish-Cabezon-Greenling (RCG) complex
Cabezon (*Scorpaenichthys marmoratus*)	3	"	• Waters < 40 fathoms (240 feet) only • Limit of 3 within RCG complex
Kelp and rock greenling (*Hexagrammos* spp.)	10 (w/in RCG complex)	"	• Waters < 40 fathoms (240 feet) only • Limit of 3 within RCG complex
Ling cod (*Ophiodon elongatus*)	3	"	• Waters < 40 fathoms (240 feet) only • Limit of 3 within RCG complex
California sheephead (*Semicossyphus pulcher*)	5	"	• Waters < 40 fathoms (240 feet) only
Ocean whitefish (*Caulolatilus princeps*)	10	"	• Waters < 40 fathoms (240 feet) only
Leopard shark (*Triakis semifasciata*)	3 fish, 36 inch total length	"	• Waters < 40 fathoms (240 feet) only • Exceptions apply in Elkhorn Slough
Soupfin shark (*Galeorhinus zyopterus*) and spiny dogfish (*Squalus acanthias*)	1 soupfin, 10 spiny dogfish	"	• Waters < 40 fathoms (240 feet) only
Federally managed groundfish (90 species)	Various	"	• Waters < 40 fathoms (240 feet) only
Sharks	1 or 2 (dep on species)	Year around	-
California halibut (*Paralichthys californicus*)	5 (south of Pt. Sur)	"	Limit is 1 fish south of Pt. Conception between March 15 and June 15 only
White sea bass (*Atractoscion nobilis*)	3	"	-

Table 4.7-3. CDFW Marine Sport Fishing Limits for the Central California Coast, major species

Species or group	Daily Limit	Seasonal	Other
Surfperch (family Embiotocidae)	20	"	• Limit is 20 except no more than 10 per single species. • Separate limit of 20 for shiner perch
White sturgeon *(Acipenser transmontanus*)	1 daily 3 annual	"	• Must be 40 to 60 inches only • Single hook and line methods only
Tunas	Albacore-25 Bluefin-2 Skipjack-none Others-10	"	• Albacore and bluefin limits are in addition to overall daily 20 fish limit
Dungeness crab *(Metacarcinus magister*)	10	November 5 to June 30	-
Rock crab species (*Cancer* spp.)	35	Year around	-
Mussels (*Mytilus* spp.)	10 pounds	"	• Poundage limit applies to California sea and bay mussel in combination • May to October quarantine on sport-harvested mussels taken for human consumption
California scorpionfish (*Scorpaena guttata*)	Closed	NA	May reopen April 1, 2017
Pacific halibut (*Hippoglossus stenolepis*)	Closed	NA	May reopen May 1, 201
Ocean salmon	Closed	NA	Closure to be reviewed in April 2017
Red abalone (*Haliotis rufescens*)	Closed	NA	-

Source: CDFW 2016: https://www.wildlife.ca.gov/Fishing/Ocean/Regulations/Fishing-Map/Central

CDFW sport fishing limits help to ensure the sustainability of the fishery. The most popular sport fish listed in daily catch reports by Central Coast charter services (rockfish, ling cod, cabezon, greenling) are assigned seasonal restrictions (from boats but not from shore) and daily limits. In addition, these species are not allowed to be taken in water deeper than 40 fathoms (260 feet) in the territorial sea. Although some other sport fishing species do not have this restriction (albacore, salmon, etc.), this provides some information on the likely range of charter sport fishing activities. The CalWave test berths are targeted for water that is 50 to 60 fathoms in depth so would be unlikely to conflict often with recreational fishing from charter boats operating in state waters. As stated above, permitting phase surveys of charter service representatives will help to clarify the potential for conflict with recreational fishing uses of the ocean.

4.7.3 (C) Existing shoreline buffer zones

This category applies to the relicensing of hydroelectric facilities with reservoir shorelines and so does not apply to CalWave.

4.7.4 (D) Current and future recreation needs from existing state or regional plans

This category applies to the relicensing of hydroelectric facilities with reservoir shorelines and so does not apply to CalWave.

4.7.5 (E) Existing shoreline management policies

This category applies to the relicensing of hydroelectric facilities with reservoir shorelines and so does not apply to CalWave.

4.7.6 (F) Existing shoreline management policies

This category applies to the relicensing of hydroelectric facilities with reservoir shorelines and so does not apply to CalWave. CalWave facilities will not directly involve a river.

4.7.7 (G) Project lands under study for inclusion in the National Trails System or as a Wilderness Area

There are no project lands under study for inclusion in the National Trails System or as a Wilderness Area. The project is sited on VAFB.

4.7.8 (H) Regionally or nationally important recreation areas

The nearest regionally and nationally important recreation area to the CalWave test berth sites is Channel Islands National Park. This park consists of five mostly uninhabited and undeveloped islands in the Santa Barbara Channel (or rather, that define the southern boundary of the Channel). These islands are, from west to east, San Miguel, Santa Rosa, Santa Cruz, Anacapa, and Santa Barbara. There are no services offered on the islands and so it offers opportunities only for wilderness recreation activities such as kayaking, snorkeling, skin diving, fishing, surfing, swimming, hiking, and wilderness camping. Visitation in 2012 (most recent year reported) was 265,746[10]. A significant portion of the park's lands, and 100 percent of two of the islands (Middle, and West Anacapa) are proposed as wilderness areas.

There would be no conflict between recreational uses of Channel Islands National Park and CalWave. The nearest CalWave test berth would be 27 nautical miles (31 statute miles) from San Miguel, the westernmost of the Channel Islands. Visitors to San Miguel Island would not be able to see WEC devices at CalWave at this distance and CalWave operations and maintenance would not interfere with access to or recreation activities at the Park.

There are no other regional or nationally important recreation areas near the project site.

4.7.9 (I) Non-recreational land use and management within the project boundary

Areas within the project boundary on shore are under management of VAFB for military and commercial space launch operations.

Areas along the cable runs in the territorial sea are under the management of the California State Lands Commission and sister agencies such as the CDFW.

Areas on the OCS are under management of the Bureau of Ocean Energy Management and are not currently leased for oil and gas production or other uses.

4.7.10 (J) Recreational and non-recreational land use adjacent to the project boundary

Areas adjacent to the project boundary on shore are also under management of VAFB for military and commercial space launch operations on the approximately 100,000-acre VAFB.

[10] https://www.nps.gov/chis/learn/management/statistics.htm

Areas adjacent along the cable runs in the territorial sea are also under the management of the California State Lands Commission and sister agencies such as the CDFW.

Areas on the OCS are also under management of the Bureau of Ocean Energy Management. Uses include leasing for offshore oil production at oil platforms, shipping transit, and commercial and recreational fishing.

4.8 Aesthetic Resources

§ 5.6 (d)(3)(ix) – Aesthetic Resources

Description of the visual characteristics of facilities, affected lands, and affected waters

4.8.1 Visible Project Features

The CalWave test berths will be located in the ocean 3.2 to 4.0 nautical miles off of Vandenberg Air Force Base on the segment of the Santa Barbara County coast that extends from Point Arguello on the north to Jalama Beach on the south. Undersea cables will transport the electricity generated by the test WECS from the test berths to the proposed on-shore facilities that will be located near the Vandenberg dock, which is located on the coast approximately 3 miles south of Point Arguello. The onshore facilities that will be located on the elevated coastal shelf area above the dock will include two buildings housing offices and meeting rooms for test facility and WEC test customer staff. In addition, nearby, there will be a facility with switchgear, a diesel generator, and a 70 kV substation. A 70 kV transmission line will extend northward from the substation for five miles to carry power generated by the WECs to the existing Vandenberg Air Force Base Sub-Station N. The transmission line will be carried on structures that will be 70-feet high, except at the two points where they cross roads, where they will be 110-feet in height.

4.8.2 Viewshed Analysis

Figure 4.8-1 is a map that indicates the locations of the CalWave test berths and their relationship to the shoreline. The map also indicates the location of the onshore buildings and substation and of the 5-mile 70kV transmission line. In addition, the map identifies the areas from which the WECs and the proposed transmission line will have the potential to be visible.[11] The onshore areas with a tan overlay are areas where both the WECs and the transmission line structures have the potential to be visible. The areas with the blue overlay are places where the transmission line structures have the potential to be visible, but not the WECs, while the areas with the green overlay are places where the WECs but not the transmission structures have the potential to be seen. The areas with the purple overlay are places where neither the WECs nor the transmission structures will be visible. Although their visibility is not called out separately, the project office buildings and substation will be visible in the nearby portions of the surrounding area within which the transmission line will be visible.

The study area for the purposes of the aesthetics analysis consists of the areas indicated on Figure 4.8-1 between Bear Creek Road on the north and Point Conception Lighthouse on the south from which any of the project features will have the potential to be visible. The area proposed for aesthetic analysis does not extend as far north as Surf, which is located on the coast approximately two miles north of Bear Creek Road. Surf is of potential interest, because with its AMTRAK station and County beach, is the only point on the coast between Jalama Beach, 18 miles to the south and Point Sal 15 mile to the north where there is public access to the coastline. Surf was not included in the study area because it is located over 11 miles

[11] The visibility data displayed on this figure was developed by using GIS tools and data to run a viewshed analysis. This analysis assumed arrays of 10 WECs at each of the berths, and assumed that all 40 WECs would be point absorbers, 15 meters in height. Because the point absorbers are the tallest of the WEC designs being considered for testing as a part of this project, running the viewshed analysis using the assumed point absorber heights identified the maximum extent of the area from which the WECs that might be arrayed at the four berths would have the potential to be visible. The viewshed analysis run for the transmission line was based on the visibility of the transmission line structures, which were assumed to be 110 feet high at road crossings, and 70 feet high along the rest of the line's route.

from the closest berths and because of the intervening land forms, few if any of the proposed WECs would have any potential to be visible. The aesthetic analysis area extends 20 miles along the coastline from Bear Creek Road in the vicinity of Vandenberg Air Force Base Space Launch Complex 4 on the north to Point Conception on the south. The physical environment along this segment of coastline is striking and has a high level of visual quality. The landscape in this area is characterized by a complex, rocky shoreline, behind which there are high steep cliffs that rise to a bench area that gently slopes up to the base of the high, steep ridges of the Santa Ynez Mountains that frame this area's narrow coastal corridor. In places, the bench is cut by the steep-sided channels of large and small seasonal streams. Although stands of native and non-native trees can be found in the canyons these streams flow through, overall, the landscape has an open, pastoral character. For the most part, the landscape is covered with grass and areas of coastal sage scrub vegetation. In a few places, most notably in the vicinity of the former Coast Guard Station near the Vandenberg Dock, there are rows of Monterey cypress trees that had originally been planted as windbreaks.

The 20-mile coastal strip where the features may have the potential to be visible has a generally low level of development. Perhaps the most important developed feature in this landscape is the Union Pacific Railroad's rail line that that travels through the entire area on an alignment that parallels the coastline, and which in some places is located close the edge of the coastal bluff. The rail line has a single track located on a raised berm covered with a light colored ballast that contrasts with the surrounding landscape. The rail line is paralleled by utility lines carried on a set of wooden poles with wide crossbars. The area is served by a network of paved and unpaved roads. Because the roads are mostly narrow and few in number, they are not visually dominant elements in the landscape. At the northern end of this landscape area, there are four rocket launch complexes sited on mesas approximately a mile to the east of the shoreline. At Point Arguello, which is near the southernmost of the rocket launch complexes, there is a navigational light mounted on the top of a tall steel pole. Further south, where the Project's shore station will be located, is the Vandenberg Dock.

Figure 4.8-2 is a map on an air photo base that focuses on the dock and the landscape features and existing and proposed facilities in its vicinity. The dock consists of a landing and five circular mooring dolphins located in a small cove protected by a breakwater constructed of large granite boulders. On the shoreline of the cove, there is a wide, sloping, asphalt paved apron that serves as a loading dock. On the top of the bluff that overlooks the cove is a two and a half story, white-shingled, gable-roofed, Colonial Revival structure that was built in 1935 as the headquarters and barracks building for the Coast Guard rescue station that once operated at this location. This building, which is now known as the Vandenberg Boathouse, and the nearby garage structure associated with it constitutes an important landmark in this area's landscape. In addition, this complex is considered to be an historic resource and has been documented in the Historic American Building Survey. At present, the boathouse is used as the location for occasional receptions and other special events.

The 7.5-mile stretch of the coastal strip that extends from the Vandenberg Boathouse southward to Jalama Beach appears to be essentially rural and empty. The only structures in this area are at Sudden Ranch, located 4.6 miles south of the Vandenberg Boathouse, where there are several small ranch buildings and a small complex of bunkers that are no longer in use. Jalama Beach is located on the coast at the mouth of Jalama Creek and just south of the southern boundary of the Air Force base. This beach is a Santa Barbara County Park. Development at the beach includes an access road, parking lot, a camp ground with 107 camp sites, and small buildings that house a store, grill, and park offices. Between Jalama Beach and Point Conception, the landscape in the coastal strip is also open and nearly empty. One of the few structures in this area is the picturesque lighthouse on Point Conception that was built in 1855 and is on the National Register of Historic Places. The lighthouse is 9.6 nautical miles from the CalWave shore station and is in an area that is closed to the public.

LEGEND

- Point Absorber (49.2 feet tall)
- Test Berth
- Shore Station
- VAFB Dock
- Cable Route
- Transmission Line
- Vandenberg Air Force Base
- Buoys
- Platform

WEC and Transmission Line Visibility

- Both Visible
- Transmission Line Visible
- WEC Visible
- Neither Visible

Service Layer Credits: Content may not reflect National Geographic's current map policy. Sources: National Geographic, Esri, DeLorme, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.

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Figure 4.8-1
WEC and Transmission Line Visibilty
California Wave Energy Test Center (CalWave^{sm})

ch2m:

Figure 4.8-2
Boathouse and Shore Station Area
California Wave Energy Test Center
(CalWave^{sm})

BAOTSP01 C:\PROJ\CALIFORNIAPOLYTECH\675035CALWAVE2\GIS\MAPS\WORKING\2017\VISUAL\FIG4.8-2_BOATHOUSE_AND_SHORE_STATION_AREA.MXD CARCHER 2/8/2017 12:07:23 PM

Views toward the ocean are a key contributor to the high visual quality of the project study area. From most locations in the study area, there are wide, sweeping panorama views toward the sea. From the beaches and from the locations atop the coastal bluffs, many of the views are framed by dramatic rock formations. Ocean views from this area are not entirely unaltered in that at locations approximately two miles further out to sea than the proposed locations of the project's berths, there are four oil platforms (Irene, Hidalgo, Harvest and Hermosa) that are owned by Freeport-McMoRan Oil and Gas. The locations of these platforms are indicated on Figure 4.8-1. These platforms are large in scale, and on clear days, can be seen from onshore locations, in spite of the viewing distance.

The fact that much of the project's visual analysis area lies within the boundaries of Vandenberg Air Force Base limits the numbers of viewers. Because Vandenberg is a closed military facility, except for the occasional authorized visitor, viewers are restricted to military personnel. Most military viewers are likely to be concentrated in the area north of Point Arguello where the launch pads and other military facilities are located. South of Point Arguello, viewers will consist primarily of military personnel who are in the area for recreation, which consists primarily of use of the beaches for swimming, surfing, and fishing. Most of this recreational activity is likely to be concentrated in the areas in the vicinity of the Vandenberg Boathouse and to the north of it. The potential for recreational use of areas south of the Boathouse is constrained by distance from the base's residential areas and by the area's limited road system. From time to time, when group events take place at the Vandenberg Boathouse, there are concentrations of viewers there. Jalama Beach County Park, which is located approximately 6 nautical miles down the coast from the site of the proposed shore station, provides the only public access to the coastal area in the segment of the coast from Point Conception to Surf. The park, with its beach, reputation as a destination for experienced surfers, campground, and support services draws a substantial number of visitors, particularly on summer weekends. Although the stretch of coastline between Jalama Beach and Point Conception lies outside of the boundaries of the Air Force base, it is not accessible to the general public because it is part of a large private ranch property that is fenced and gated to prevent public access.

A viewer group to be considered in the entire project landscape analysis area consists of the passengers on the Amtrak Surfliner and Coast Starlight trains that use the Union Pacific tracks that travel through this entire segment of coastline. Both the trains are famous for the scenery they travel through and the scenic appeal of their routes is emphasized in their marketing. One of the particular appeals of these trains is that they provide the only way that most members of the public can see the segment of the coastline in Vandenberg Air Force Base. These views are particularly scenic and dramatic because the train tracks follow so closely along the edge of the bluff overlooking the ocean and because the landscape is so open and undeveloped.

4.8.3 Licensing Issues and Studies

- Visibility of the future WECs from the shoreline, particularly from the passenger trains, the recreational use areas at and in the vicinity of the Boathouse, and from Jalama Beach.

  Although this issue needs to be addressed, simulations that will need to be prepared as a part of the visual impact assessment may indicate that because of the low heights of most of the WEC machines and their distance from shoreline viewpoints, the level of potential impact will not be high. Because they will be seen in the context of the existing oil platforms, the landscape that they will be seen in is not currently pristine. Another variable to factor in will be the limited number of viewers.

- Visibility of the transmission line from the train.

  The transmission line segment between the substation and the railroad tracks (about 0.6 miles from the substation to the track crossing) is located between the train and the ocean, with the

potential to adversely affect the ocean views seen by train passengers as they travel past this area. A factor to evaluate is the elevation difference between much of the transmission line and the railroad tracks (much of the line will be lower than the viewing height on the train and thus may be below the line of sight of passengers). Another consideration is the amount of time train passengers are likely to be exposed to this view (likely to be very short).

Another area of concern is the fact that the line will cross over to the east side of the train tracks and follow the railroad right-of-way very closely, which could mean that passengers on the east side of the train will be looking out their windows directly into the transmission line structures and conductors. Detailed studies will need to be undertaken to determine how much of a problem this is likely to be and if it is an issue, perhaps suggest some changes to the transmission line alignment to attenuate the adverse effects.

- Visibility of the onshore facilities, particularly the substation, from the train.

  These facilities will be located in the area between the train and the ocean. The substation will create a contrast in visual character and substation and the buildings will interfere with and clutter up the view toward the iconic, landmark Boathouse. In terms of mitigation, there might be a need to look into a screening wall for the substation and perhaps to plant a row of Monterey cypress between the substation and the train tracks.

- Visibility of the onshore facilities, particularly the substation, from the former Coast Guard Station Administration Building, often referred to as The Boathouse

  The two shore station buildings are not likely to cause so much of a contrast with the former Coast Guard Administration Building because they will be designed in an architectural style similar to that of the Coast Guard Station. The substation and transmission line, however, have the potential to contrast with and detract from the area's current rural appearance. Based on simulations and detailed line of sight studies, it might turn out that the best approach for mitigating any adverse visual related to these facilities would be to do some strategic plantings of Monterey cypress (the same species that is already used for windbreaks around the boathouse). Trees placed on the west side of Boat House Road, just west of the former Coast Guard Station could be effective in providing screening of views from the former Coast Guard Station toward the onshore facilities.

- Lighting effects

  There will be a need to evaluate the visual effects of the navigation safety lights that will be required on the WECs. In addition, there will be need to identify any lighting that will be required at the two buildings, the substation, and parking lot, and to prescribe measures to ensure that its effects will be attenuated as needed.

4.9 Cultural Resources

§ 5.6 (d)(3)(x) - Cultural Resources

(A) Identification of any historic or archaeological site in the proposed project vicinity especially those listed in or recommended for the National Register of Historic Places

(B) Description of existing discovery measures for locating, identifying, and assessing the significance of resources

(C) Identification of Indian tribes that may attach religious and cultural significance to historic properties, and available information on Indian traditional cultural and religious properties.

4.9.1 (A) Identification of Historic or Archaeological Sites

The permitting project team has met with the US Air Force, Space Command, 30th Civil Engineering Squadron (AFSC/30th CES) at VAFB to discuss biological and cultural resources management aspects of CalWave. These discussions have led to identification of a National Register site, the Vandenberg Coast Guard Station, in the project's area of potential effects. Prehistoric archaeological sites are also located along the VAFB marine terrace. Once a location for the 70 kV upgrade line and shore station are final, CalWave will conduct a formal search of the VAFB cultural resources inventory records and also a pedestrian archaeological survey (see next section). If it is feasible to adjust the 70 kV transmission line route to avoid known archaeological sites, then CalWave may do so.

The Vandenberg Coast Guard Station was constructed as the U.S. Coast Guard Rescue Station and Lookout Tower at Point Arguello in 1936 and operated until 1941. The associated boathouse was removed in 1982 to allow for the expansion of the Vandenberg Dock facilities and the installation of a tow road for the Space Shuttle rocket motor fuel tanks. The administration and barracks building and a garage remain. The facility was designed in the residential Colonial Revival style, as were most Coast Guard facilities during this time. The facility was found eligible for the National Register as part of the National Environmental Policy Act (NEPA) analysis for the Space Shuttle Program (United States Air Force 1978, 1982). As a mitigation measure for the removal of the boathouse and effects to the historic setting of the administration building, the Air Force submitted archival drawings and photos to the Historic American Building Survey and created an interpretive program that includes interpretive signs near the harbor.

CalWave will not affect the administration building directly, but there is a potential effect on the historic setting of the property from the shore station and its switching yard, which are located nearby. This is a regulatory issue that will be addressed during licensing. Visual resources studies of the administration building will be conducted to address this issue and it is possible that vegetative screening and other measures can be used to mitigate this effect, if analyses find that it would be significant.

4.9.2 (B) Description of Discovery Measures

Discovery measures for locating, identifying, and assessing the significance of the land-based resources will be coordinated closely with the US Air Force, Space Command, 30th Civil Engineering Squadron (AFSC/30th CES) Environmental Office (personal communication, Chris Ryan, VAFB 30th CES, 2017). VAFB holds the records of historic properties for the base and is a depository for reports of previous inventories and excavations.

Considerable previous identification and testing has taken place in the vicinity of Vandenberg Dock and along the 70 kV upgrade line due to the construction of the Vandenberg Dock and tow road and upgrades to the 12 kV distribution line that serves the dock area. The first step in identifying historic properties will be to work with VAFB cultural resources management staff to review and asses previously recorded resources in the vicinity of the project facilities. This provides an understanding of the types of historic properties that might be found in the project area and also may provide information including historical information and site records that indicate the boundaries of previously discovered historic and prehistoric archaeological sites and artifacts found there.

Discovery measures for CalWave will include pedestrian archaeological survey conducted by archaeologists meeting the Secretary of the Interior's Standards and Guidelines for Archaeology and Historic Preservation of areas not previously surveyed within the past 10 years. Surveys will be conducted by walking linear transects spaced no more than 10 meters apart, looking for evidence of historic or prehistoric archaeological deposits. Previously recorded historic and prehistoric archaeological sites will be revisited and surveys and their site forms will be updated.

The survey will cover the shore station area including a 10-meter buffer. It will also cover the approximately 6-mile-long 70 kV transmission line upgrade route, including access roads to the right-of-way and a buffer 20 meters either side of the centerline or other survey area/protocol acceptable to VAFB cultural resources staff.

The CalWave cultural resources management team will also closely inspect the side-scan sonar images for shipwrecks not previously recorded in the CSLC's shipwreck database.

If historic or prehistoric archaeological resources are identified within the project's area of potential effects, the next step would be to implement test measures to determine the significance of the resources in question. Significance is defined as meeting the criteria for listing in the National Register of Historic Places as found in 36 CFR 60.4, as follows:

> **National Register criteria for evaluation.** The quality of significance in American history, architecture, archeology, engineering, and culture is present in districts, sites, buildings, structures, and objects that possess integrity of location, design, setting, materials, workmanship, feeling, and association and
>
> (a) that are associated with events that have made a significant contribution to the broad patterns of our history; or
>
> (b) that are associated with the lives of persons significant in our past; or
>
> (c) that embody the distinctive characteristics of a type, period, or method of construction, or that represent the work of a master, or that possess high artistic values, or that represent a significant and distinguishable entity whose components may lack individual distinction; or
>
> (d) that have yielded, or may be likely to yield, information important in prehistory or history.

Properties of the historic era might be evaluated in relation to criteria (a), (b), or (c) by conducting historic research, interviewing persons with knowledge of local history, examining archival sources, etc. Properties of the prehistoric era and historic archaeological sites are generally significant in relation to criterion (d) or because they have the potential to produce artifacts and other materials that archaeological scientists can use to define data that have value for the study of prehistory or history. The research potential of an archaeological site, however, is seldom evident from surface observations alone. For this reason, studies to

determine the significance of a site usually involve test excavations to determine the depth of an archaeological deposit and types and density of artifacts and other materials found there.

4.9.3 (C) Identification of Indian Tribes

CalWave Stakeholder Engagement and Public Involvement program staff identified the following tribes that may attach religious and cultural significance to historic properties, as part of project activities under Task 13 (Table 4.9-1). Please see the Task 13 Summary report for further information.

Table 4.9-1. Tribe Names and Designated Representatives of Interested Tribes

Tribe name	Designated Representative
Northern Band of Chumash Indians	Fred Collins
Chumash Maritime Association	Roberta Cordero
Barbareño Chumash Council	Deborah Sanchez
Santa Ynez Band of Chumash Indians	Freddie Romero
Coastal Chumash	Michael Cordero
Yak Tityu Tityu	Mona Olivas Tucker

Members of the Yak Tityu Tityu attended the Advisory Group meeting and offered comments, and the project team has held discussions with Mr. Fred Collins of the Norther Band of Chumash Indians regarding a proposed marine sanctuary in the project region. To date, tribal representatives have not provided information regarding traditional cultural properties that could be affected by project activities. As regards the federally recognized Santa Ynez Band of Chumash, future consultation with this tribe is required to take place on a government-to-government basis, with VAFB as the lead for the federal government.

4.9.4 (D) References Cited

United States Air Force. 1978. Environmental Impact Analysis Process. Final Environmental Impact Statement, Space Shuttle Program, Vandenberg Air Force Base, California. January.

United States Air Force. 1983. Environmental Impact Analysis Process. Supplement to Final Environmental Impact Statement, Space Shuttle Program, Vandenberg Air Force Base, California. July.

4.10 Socio-economic Resources

§ 5.6 (d)(3)(xi) - Socio-economic resources

Description of socio-economic conditions in the project vicinity including patterns of land use and population and sources of employment

4.10.1 Patterns of Land Use and Population

The shore station is located on property belonging to the U.S. Air Force, within VAFB. VAFB is the third largest Air Force Base in the United States, and contains about 100,000 acres of land that extends from Pacific Ocean beaches and bluffs to adjacent dune and table lands and ridge crests of the Tranquillon Mountains, which are part of the southern California Traverse Ranges.

The base is divided into two pieces, with one-mile-wide corridor of privately owned land in between them. The CalWave shore station is located in the southern portion of the base. In between the north and south base flows the Santa Ynez River, and State Route 246 runs also in this corridor between the town of Lompoc and the Surf Railway station and Ocean Beach. A railroad right-of-way that is wholly owned by the Union Pacific Railroad runs through the base, for the most part, along or very near the shoreline, but turning inland in the north part of the base.

Since the base's transfer to the Air Force in 1957, VAFB has served as a space and missile test facility operated on behalf of the Air Force, Department of Defense, and National Aeronautics and Space Administration. By 2010, more than 1,900 orbital and ballistic missiles had been launched from VAFB. The base's location is uniquely situated in the United States for safe launches into polar orbit over water.

The base's headquarters and supporting facilities are located 9.2 miles north of the town of Lompoc. A large airfield and several space launch complexes are also situated on the north portion of the base. The south portion of the base also contains several space launch complexes, including a complex used by SpaceX, a private company that is developing space launch vehicles.

In the south portion of the base, Vandenberg property rises from ocean bluffs and beaches for more than 3,000 feet to adjacent rigdetops. The north base consists of dunelands and low plateaus. VAFB has 42 miles of coastline, 9,000 acres of sand dunes, and 5,000 acres of wetlands (U.S. Force 2017).

Further inland, the Santa Ynez River valley broadens to width of approximately two miles that is under intensive agricultural production up to the point, approximately seven miles inland, where the City of Lompoc is located. Lompoc is a residential center for employees of VAFB and a agricultural center for the production of flower seeds.

Beyond Lompoc in rural Santa Barbara County, land consists of heavily dissected hills and low mountains, with a few narrow alluvial valleys between them. The city of Santa Maria lies approximately 18 miles north of Lompoc and 10 miles north of the VAFB main gate and also serves as a residential center for VAFB employees. Agricultural activities in the valley surrounding Santa Maria include wine grapes, strawberries, lettuce, celery, peas, squash, cauliflower, broccoli, and beans, in addition to cattle ranching on the adjacent hills.

The population of Santa Barbara County was 435,248 in 2014 (ProximityOne 2017). Of this, the City of Santa Maria comprised 103,410 (23.8 percent), the City of Santa Barbara comprised 91,196 (21.0 percent), and Lompoc comprised 44,013 (10.1 percent). The population on VAFB is 58,950.

4.10.2 Sources of Employment

The most important industries in Santa Barbara County in terms of employment, providing 40 percent of the county's jobs are listed in Table 4.10-1 (Santa Barbara County 2017).

Table 4.10-1. Key Employment Clusters in Santa Barbara County

Industry/ Cluster	Employees	Pct of Work Force	Comment
Agriculture, tourism, wine	36,088	15	Food production a wineries, accommodation, amusement and recreation industries.
Business Support	18,354	8	Graphic design, accounting, advertising and employment services.
Healthcare	18,259	7	Ambulatory health care services, hospitals, and nursing and residential care facilities.
Building and Design	16,623	7	Design, interior design and building of residential and non-residential buildings.
Technology and Innovation	10,756	4	Industries focused on development and production of new technologies and products.
Energy and Environment	566	0.2	Industries that produce and sell energy, improve environmental sustainability and meet environmental regulations.

4.10.3 Commercial Fishing

Commercial fishing is an important component of the economy in the project area. In addition, there is the possibility conflict between MHK energy development and commercial fishing regarding the use of marine space. The following is a summary of important fishing species by port, followed by a summary of commercial fishing data from the four 10-minute CDFW fishing blocks in that incorporate and surround the CalWave test berth area. It is useful to compare the data from port landings with the information about commercial fishing take from the project site specifically.

4.10.3.1 Ports

There are three ports relatively near the CalWave test berth sites from which there are commercial fishing operations, from north to south, Morro Bay, Port San Luis/Avila Beach, and Santa Barbara (Table 4.10-2).

Table 4.10-2. Commercial Fishing Ports nearest to the CalWave Test Berths

Port	Distance /direction from CalWave	2015 Ex-Vessel Value[a]	2015 Landings, pounds[a]	Commercial Fishing Vessels in port[b]
Morro Bay	52 nm, north	$7,811,634	3,455,138	25
Port San Luis/Avila	38 nm, north	$2,279,877	523,268	Not available
Santa Barbara	47 nm, east	$13,969,559	6,185,378	73

[a]Source: CDFW Final California Commercial Landings, https://www.wildlife.ca.gov/Fishing/Commercial/Landings

[b]Boat Database, https://boatdb.net/port/morro-bay-ca.htm

Tables 4.10-3, 4.10-4, and 4.10-5 show the most economic (top dollar) species on average over the past three years, for commercial fishing landings at Morro Bay, Port San Luis/Avila, and Santa Barbara, respectively.

Table 4.10-3. Morro Bay Port Ex-Vessel Commercial Fishing Value per Year, 2013-2015

Year	2013	2014	2015	3-yr average
Sablefish	$1,768,731	$2,063,347	$1,351,950	$1,728,009
Dungeness crab	$1,148,995	$2,667,789	$3,651,883	$2,489,556
Market squid	$1,356,477	$1,385,231	$377,539	$1,039,749
Thornyheads	$634,035	$490,785	$457,905	$527,575
Hagfishes	$450,160	$386,748	$413,913	$416,940
Rockfish, all	$318,056	$366,259	$414,714	$366,343
Chinook salmon	$337,708	$83,611	$185,547	$202,289
Spot prawn	$278,817	$212,567	$330,398	$273,927
Dover/petrale sole	$226,551	$125,654	$78,003	$143,403
Cabezon	$65,149	$93,307	$121,325	$93,260
Swordfish	$54,846	$47,796	$75,889	$59,510
California halibut	$66,161	$34,327	$18,067	$39,518
Total, key species	$6,705,686	$7,957,421	$7,477,133	$7,380,080
Total value - all species	$6,961,372	$8,297,265	$7,811,634	$7,690,090

Source: California Department of Fish and Wildlife: http://www.dfg.ca.gov/marine/fishing.asp, accessed June 10, 2015 and January 3, 2017

Sablefish, Dungeness crab, and market squid made up more than 70 percent of the commercial fishing landings at Morro Bay during these three years.

Table 4.10-4. Port San Luis/Avila Port Ex-Vessel Commercial Fishing Value per Year, 2013-2015

Species/Year	2013	2014	2015	3-yr average
Dungeness crab	$758,409	$1,081,191	$793,990	$877,863
Rockfish	$761,664	$693,077	$762,444	$739,062
Cabezon	$107,080	$103,206	$115,620	$108,635
Salmon	$145,310	$55,068	$92,534	$97,637
Rock crabs	$80,690	$49,347	$121,045	$83,694
Ling cod	$55,860	$62,579	$77,746	$65,395
California halibut	$10,114	$12,965	$72,493	$31,857
Greenling	$17,577	$16,631	$19,593	$17,934
Serfperch	$14,547	$8,597	$12,719	$11,954
Sand sole	$9,143	$6,567	$14,715	$10,142
Market squid	$0	$237	$0	$79
Total, key species	$1,960,394	$2,089,465	$2,082,899	$2,044,253
Total value, all species	$1,997,934	$2,138,340	$2,279,877	$2,138,717

Source: California Department of Fish and Wildlife: http://www.dfg.ca.gov/marine/fishing.asp, accessed June 10, 2015 and January 3, 2017

*Not a top commercial species at this port but included for comparison.

Dungeness crab, rockfish, and cabezon made up more than 84 percent of the commercial fishing landings at Port San Luis during these three years.

Table 4.10-5. Santa Barba Port Ex-Vessel Commercial Fishing Value per Year, 2013-2015

Species/Year	2013	2014	2015	3-yr average
Spiny lobster	$3,189,983	$4,885,180	$4,803,243	$4,292,802
Red sea urchin	$3,191,496	$3,033,928	$3,104,285	$3,109,903
Rock crabs	$1,901,771	$2,452,076	$2,391,859	$2,248,569
Sablefish	$764,241	$794,019	$1,129,634	$895,965
Thornyhead, shortspine	$310,680	$424,138	$708,804	$481,207
Sea cucumber	$370,998	$280,582	$328,683	$326,754
White seabass	$309,812	$183,956	$236,700	$243,489
Rockfish	$125,818	$195,675	$241,500	$187,664
California halibut	$130,140	$110,480	$200,402	$147,007
Cabezon	$73,130	$60,984	$36,658	$56,924
Market squid	$75	$55	$564	$231
Total, key species	$10,370,157	$12,423,087	$13,184,347	$11,992,530
Total, all catch	$10,713,272	$12,981,970	$13,969,559	$12,554,934

Source: California Department of Fish and Wildlife: http://www.dfg.ca.gov/marine/fishing.asp, accessed June 10, 2015 and January 3, 2017

*Not a top commercial species at this port but included for comparison.

Spiny lobster, red sea urchin, and rock crabs made up more than 80 percent of the commercial fishing landings at Santa Barbara during these three years.

4.10.3.2 Species Rankings

The tables show the top 11 species landings at each port over the past three years. Note that these species make up over 90 percent of the landing value for these ports for each year. Although a large number of species are landed in addition to these, they have low economic value. Also note that the line titled “Rock crabs” includes the yellow, red and brown rock crabs (*Cancer* spp.) as well as a category in the CDFW records called “Rock crabs, unspecified”. The larger and more abundant Dungeness crabs (*Metacarcinus magister*) are differentiated. In addition, all of the many species of rockfish (*Sebasates spp*) are combined in the tables for simplicity (there are 56 species in Southern California). Although they may have somewhat different habitat requirements, these are all groundfish.

The species value ranking over these three years is fairly consistent, as is the species value landed at a given port. In a few cases, however, value and ranking can fluctuate significantly from year to year. Over a longer period of time, species can change significantly in their ranking. Long-term fluctuations in the importance of various species is described more clearly in the economic analysis reports that have been prepared for the Morro Bay and Santa Barbara commercial fishing communities (Morro Bay Commercial Fisherman’s Organization 2015, Commercial Fishermen of Santa Barbara, 2015). Overall value of the fishery has also fluctuated, reaching peaks in the 1990s, a low in the 2006-2007 time frame, and recovering in recent years.

It is not possible to tell from port landing ex-vessel data where in the ocean space the fish were caught. To determine this, fishing block catch data was requested from CDFW. Commercial fishers are required to record where their catch takes place, in terms of rectangular blocks of ocean that are 10 seconds of a degree (10 nautical miles, or 11.5 statute miles) on a side. Four CDFW fishing blocks contain and surround the CalWave test berth sites, per Table 4.10-7 and Figure 4.10-1.

Platform Irene

644

Shore Station

VAFB Dock

643

WIS Station 83086

Platform Hidalgo

Platform Harvest

CDIP Station 063

CDIP Station 071

Platform Hermosa

659

658

WIS Station 83087

LEGEND

- CDFW Commercial Fisheries Data Blocks
- VAFB Dock
- Shore Station
- Test Berth
- Transmission Line
- Cable Route
- Vandenberg Air Force Base

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Miles

Figure 4.10-1
CDFW Commercial Fisheries Data Blocks
California Wave Energy Test Center (CalWave^{sm})

Table 4.10-6. CDFW Fishing Blocks in and near the CalWave Test Berths

Block number	NW Corner location	Water Depth Range (fathoms)	Comment
643	34° 40′ 00″ N/120° 40′ 00″ W	0-52 fathoms	Mostly coastline shelf around Point Arguello, 70 percent land
644	34° 40′ 00″ N/120° 50′ 00″ W	16-278 fathoms	One-third offshore shelf, two-thirds slope
658	34° 30′ 00″ N/120° 50′ 00″ W	0-285 fathoms	One-third coastline shelf, two-thirds slope
659	34° 30′ 00″ N/120° 40′ 00″ W	52-425 fathoms	Slope to deeper water

The CalWave test berths are located in roughly the center of the 20 x 20 nm square (400 square nm) that the four fishing blocks comprise. The South group of test berths is located in the southeast corner of Block 644 and the South by Southeast group of berths is in the northwest corner of Block 658. The eastern boundary of Block 658 is only about 200 meters from the shore at its nearest (northeast) corner, making blocks 644, 658, and 659 entirely in the sea. Block 643, however, is about 70 percent on land and 30 percent in the water although the portion in the water consists of shallow continental shelf that is productive fishing grounds.

Table 4.10-7. Commercial Fishing Catch from 400 square nm CalWave area*, 2013-2015, Key Species

Species	Scientific name	2013	2014	2015	Annual Average
Market squid	*Loligo opalescens*	$1,615,957	$1,555,908	$255,201	$1,142,355
Rock crab (three species)	*Cancer spp.*	$180,054	$19,232	$94,603	$97,963
Dungeness crab	*Metacarcinus magister*	$49,453	$43,618	$129,852	$74,308
Spot prawn	*Pandalus platyceros*	$0	$63,866	$410	$21,425
Sablefish	*Anoplopoma fimbria*	$6,373	$0	$25,280	$10,551
Thorneyhead, shortspine	*Sebastolobus alascanus*	$7,871	$0	$23,903	$10,591
California spiny lobster	*Panulirus interruptus*	$0	$6,781	$23,273	$10,018
Chinook salmon	*Oncorhynchus tshawytscha*	$0	$0	$21,719	$7,240
Rockfish (several species)	*Sebastes, spp.*	$10,168	$0	$3,559	$4,576
Giant red sea cucumber	*Parastichopus californicus*	$2,506	$0	$160	$889
Red sea urchin	*Mesocentrotus franciscanus*	$723	$1,140	$1,135	$999
Key species value		$1,873,105	$1,690,546	$579,096	$1,380,916
Total Catch Value		$1,910,050	$1,693,681	$584,756	$1,396,162

Source: California Department of Fish and Wildlife: http://www.dfg.ca.gov/marine/fishing.asp

*Consolidated data from CDFW Fishing Blocks 643, 644, 658, and 659

Given that the four blocks comprise a relatively small area, it is not surprising that there are large fluctuations from year to year in the catch value of different species. For example, spot prawn value is high in 2014 and practically non-existent in the other two years. Market squid drops to a fraction of its previous value in 2015. This could simply reflect small shifts in fishing location from year to year

It is clear from the CDFW block data that market squid is overwhelmingly the most important economic species in the four fishing blocks near CalWave. By itself, on the three-year average basis, it comprises about 82 percent of the total value. In 2014, it is about 92 percent of the total value from the four blocks combined. Rock and Dungeness crab and spot prawn were also significant fisheries in these blocks during these years.

This raises two important questions: (1) where is the catch from the fishing blocks containing CalWave being landed and (2) to what extent is fishing for economic species taking place in habitats occupied by the CalWave test berths?

Comparing the average market squid catch in the CalWave blocks with landings at the three nearest ports, it is clear that the landings of market squid at Port San Luis and Santa Barbara, the nearest commercial fishing ports, are negligible and that the landings at Morro Bay averaged in value only 91 percent of the average value from the CalWave blocks, yet Morro Bay is the furthest of these ports from CalWave and has available to it at much closer distance hundreds of square miles of available space from which to harvest market squid. This means that, because of the high value of this fishery (the highest value fishery in California in 2014) fishers are coming from distance to fish the CalWave area for market squid, but only from certain ports. While it is not possible to say whether the out-of-area market squid fishers are coming from Ventura, Port Hueneme, Monterey, or elsewhere, it is clear that some ports, such as Santa Barbara and Port San Luis, simply do not host market squid fishers (Table 4.10-8). Port San Luis is a small port, but Santa Barbara's total landings are almost twice those of Morro Bay (see Table 4.10-2), yet Santa Barbara does not appear to host a significant market squid fishery.

The CalWave fishing blocks produced approximately 2.1 percent of the state's market squid in 2014.

Table 4.10-8. Market squid landings, selected California ports, listed north to south, 2014*

Port	Pounds	Value	Pct Total CA value
San Francisco	5,591,775	$1,792,723	2.5%
Moss Landing	35,094,620	$11,430,209	15.8%
Monterey	55,260,853	$17,982,815	24.8%
Morro Bay	4,265,770	$1,385,281	1.9%
Port San Luis	692	$237	0.0%
Santa Barbara	62	$55	0.0%
Ventura	36,320,344	$10,878,505	15.0%
Oxnard	15	$0	0.0%
Port Hueneme	34,305,508	$10,769,368	14.9%
San Pedro	15,070,931	$4,682,293	6.5%
Terminal Island	19,316,876	$6,136,267	8.5%
Total for listed ports	205,227,446	$65,057,753	89.9%
Total California, all ports	227,799,383	$72,382,617	

Source: California Department of Fish and Wildlife: http://www.dfg.ca.gov/marine/fishing.asp
*2014 is used because 2015 was an anomalously low yield year for market squid

As the CalWave blocks comprise a wide variety of fishing habitats, from nearshore to relatively deep water (425 fathoms) and the CalWave test berths occupy a relatively narrow band of depths within this range, it is useful to examine the habitat requirements and characteristics and the fishing techniques used for the species that are economically important in the CalWave blocks (Table 4.10-9).

Table 4.10-9. Habitat requirements, key species from CalWave fishing blocks*, in order of economic value

Species	Seasonality	Fishing Methods	Depths where common/fished	Potential CalWave Area Use Conflict
1-Market squid	June-Nov	Night lights, seine during spawning	10-40 fathoms when spawning[a]	No – CalWave > 48 fathoms
2-Rock crab (three species)	Dec-July	Baited pots	Intertidal to 50 fathoms	Some, though most fishery in shallower water
3-Dungeness crab	Nov-June	Baited pots	Not abundant > 50 fathoms[b]	Some, though most fishery in shallower water
4-Spot prawn	Aug-April	Baited traps in strings	65 to 165 fathoms	No – CalWave < 62 fathoms
5-Sablefish	12 months	Trawl, longline, trap	80 to 320 fathoms	No – CalWave < 62 fathoms
6-Thorneyhead, shortspine	12 months	Deep trawl	80 to 250 fathoms	No – CalWave < 62 fathoms
7-California spiny lobster	Oct-Mar	Traps, nets, trawl	Rocky bottom to 40 fathoms	No – CalWave > 48 fathoms
8-Chinook salmon	May-Aug	Trolled hook and line	Nearshore to 100 fathoms	Yes
9-Rockfish (several species)	12 months	Trawl	To 1650 fathoms	Yes – but CalWave on soft bottom
10-Giant red sea cucumber	12 months	Dive and trawl	Intertidal to 50 fathoms	Some, but mostly in shallower water
11-Red sea urchin	12 months	SCUBA or hose-supplied air dive	Intertidal to 50 fathoms	No, most dive harvest from kelp beds < 10 fathoms

[a]National Oceanic and Atmospheric Agency, Southwest Fisheries Science Center. 2017. https://swfsc.noaa.gov/textblock.aspx?Division=FRD&id=1117
[b]Pacific States Marine Fisheries Council Dungeness Crab Report. 2012.

Based on the fishing habitat analysis of the key species from the CalWave CDFW fishing blocks and the 48 to 62 fathom depth zone of the CalWave test berths, there is potential for CalWave to displace a rock crab, Dungeness crab, rockfish, and giant sea cucumber fisheries. For the three top species economically (in the CalWave blocks), however (market squid, rock crab, and Dungeness crab) most of the fishing is closer to shore, in shallower water. For example, in 2015, all of the market squid catch is from the nearshore blocks (643, 658); there is none from the offshore blocks. For spot prawn, sablefish, and shortspine thornyhead, the fishing is in deeper water. A larger risk of use conflict might be retrieval of lost gear if, for example, crab pots drift from shallower waters out to the test berths area and become tangled in mooring cables.

4.10.4 References

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4.11 Tribal Resources

§ 5.6 (d)(3)(xii) - Tribal Resources

(A) Identification of how existing project construction and operations, and their affects (on water resources, fish and aquatic resources, wildlife and botanical resources, wetland, rare species, recreation and land use, aesthetic resources, cultural resources and socio-economic resources) may impact tribal cultural or economic interests.

(B) Identify other impacts of existing projects on Indian tribes.

Project construction and operation are expected to impact tribal cultural and economic interests in a positive way. Project construction and operation will benefit the local economy and provide opportunities for construction and operation employment in the project region and this will benefit tribal members. Project effects on environmental resources will be small or negligible. Although many tribal members and organizations in the region have expressed strong interest in environmental protection, the region's tribes do not have reservation lands/trust resources, or treaty-specific resources, as is the case in other regions.

Project effects on tribal cultural and religious resources is address above in Section 4.9.

4.12 Description of River Basin and Sub-basin

§ 5.6 (d)(3)(xiii) - Description of river basin and sub-basin including information on:

(A) Area of river basin and sub-basin and length of stream reaches

(B) Major land and water use in project area

(C) All dams and diversion structures

(D) Potentially affected tributary rivers and streams

This section is not applicable because, as a marine hydrokinetic project, the project site is located in the Pacific Ocean rather than on a river system or in a river basin. Operation of the project will not have a significant effect on the ocean system.

4.13 Preliminary Issues and Studies

§ 5.6 (d)(4) - Preliminary issues and studies list for each resource area

(i) Issues pertaining to the identified resources

(ii) Potential studies and information gathering requirements

(iii) Relevant Federal, state or tribal waterway plans

(iv) Relevant resource management plans

4.13.1 (i) Issues Pertaining to the Identified Resources and

4.13.2 (ii) Potential Studies and Information Gathering Requirements

Information gathered from literature search, biological resources data analysis, and meetings and other discussions with the regulatory agencies have identified environmental permitting regulatory issues that deserve further exploration and in some cases, special studies to collect relevant data to address the issues. In discussions with the regulatory agencies, CalWave divided the discussions into three separate zones, corresponding with the major project facility zones:

- Shore facilities - shore station, switching yard, 70 kV transmission line
- Cable Run - subsea cables to the test berth locations
- Test berths – WEC testing locations

The potentially affected environments for these three zones are significantly different, as are the possible permitting issues. Table 4.13-1, 4.13-2, and 4.13-3 summarize the regulatory agency discussions regarding the issue areas, specific issues, existing available data, possible mitigation or avoidance measures, and studies proposed that may address the issues for the shore facilities, cable run area, and test berths, respectively.

4.13.3 (iii) Relevant Waterway Plans

There are no relevant Waterway Plans that would pertain to the CalWave project or that would help to guide issues identification and study definition.

4.13.4 (iv) Relevant Resource Management Plans

The VAFB Integrated Cultural Resources Management Plan is a relevant resource management plan.

Table 4.13-1. Potential regulatory/permitting issues and studies proposed to evaluate the issue, shore station and 70 kV transmission line upgrade

Issue Area	Potential Issue/Impact	Existing Studies	Possible avoidance/mitigation	Studies
Pinniped/Harbor Seal Haul-out	Temporary disruption during construction	VAFB surveys	- Monitor beach during construction - Avoid known pupping sites during pupping season	- Observe use of beach adjacent to shore station - Determine pinniped pupping seasons and locations
Endangered/Sensitive Species Habitats	-- Temporary or permanent habitat disruption, degradation or removal	VAFB surveys	- Avoid sensitive habitats in routing transmission line - Fencing, flagging during construction	Pre-permitting habitat survey of 70 kV route for wildlife and rare plants
Archaeological Resources	Damage to archaeological deposits	VAFB surveys	Plan 70 kV route to avoid sites	- Pre-permitting survey of 70kV route - Coordinate with Tribes/SHPO
VAFB Coast Guard Station Viewshed	Visual impact to human/recreational users of CG station	Space Shuttle program HABS/HAER recording	- Screen view of Shore Station with vegetation - Design Shore Station Buildings to Colonial Revival to match CG Admin Building	- Design study for shore station buildings - Visual simulations from CG station
Wetlands and drainages	- Disruption of wetland habitat, - Change in drainage patterns - Water quality impacts	- VAFB surveys - National Wetlands Inventory	- Plan 70 kV route to avoid/span wetlands and waters - LID features for parking lots and other structures	Pre-permitting survey of 70 kV route to delineate affected wetlands and waters
Noise/Lighting	- Behavioral change for wildlife (birds, pinnipeds) - Habitat loss	- Dark Skies - Wildlife Studies	- Muffling, shielding of lights/no constant exterior lighting	- Literature review on species' light sensitivities
Release of drilling mud during directional drilling (frac-out)	Temporary habitat degradation	Case studies from other projects	Remote sensing of drill head location and on-ground monitoring to detect frac-out	Habitat surveys on shore above cable route to determine which habitats would be affected

Table 4.13-2. Potential regulatory/permitting issues and studies proposed to evaluate the issue, subsea cable runs.

Issue Area	Potential Issue/Impact	Existing Studies	Possible avoidance/mitigation	Studies
Near-Shore Sensitive Habitats	Temporary or permanent habitat disruption or degradation disruption of habitat	- Existing VAFB studies, dive surveys - University LiMPETS	Pre-construction survey to avoid using HDD	Habitat mapping in near-shore area
Marine Habitat (esp. invertebrates)	Temporary disruption	Bathymetry and USGS habitat mapping	Obtain USGS information	USGS habitat maps, video if available
Cultural Resources (shipwrecks, etc.)	Damage to cultural resources (if not avoided)	Side-scan sonar of cable route	Review sonar results, avoid wrecks if present	Side-scan sonar
Electric and magnetic fields (EMF) from subsea cables	BOEM studies	EMF alters behavior of marine biota	None needed	Several studies show no significant effect of EMF on marine biota at these levels
Acoustics/Noise/Light During Construction	Behavioral, possible injury	Varies by species	Marine mammal mitigation/shutdown zones if injurious sound sources are identified	Noise levels from WECs
Collisions/entanglement with protected species during cable installations	Injury, entanglement, and possible mortality	Risk varies by species	Monitor during construction vessel speed restrictions	- Schedule of construction - Monitoring and avoidance plan

Table 4.13-3 Potential regulatory/permitting issues and studies proposed to evaluate the issue, test berths

Issue Area	Potential Issue/Impact	Existing Studies	Possible avoidance/mitigation	Studies
Noise/Acoustics (CWT)	Behavioral, injury Temporary or permanent habitat degradation	Varies by species	Plan to monitor construction and operation	- Noise levels of WECs permitted - Study of behavioral response in situ
Entanglement of marine biota with cables or derelict gear attached to cables	Injury/death of cetaceans, birds, turtles, pinnipeds	- Long-term data for fishing net entanglement - Several long-term studies of whale migration/density	- Periodic check of buoy cables for derelict gear - Use of remote sensing to determine when mooring is compromised	- Risk assessment of buoy cable entanglement Species dependent - Assessment of gray whale, leatherback turtle migration in project area
Changes in Habitat/Reefing from mooring and WECs	Decreases/Increases habitat for some species	For some habitats	- Consult NMFS - Monitor for non-native/invasive species associations	- Analysis of species affected Including commercially important and highly important prey species - Review of invasive species literature and associations with novel structures
Collision Risk	Vessels collide with cetaceans, causing Injury and death	- Cetacean/pinniped/ seabird studies (east and west coast)	Monitor construction vessels Plan to monitor construction vessels	Frequency of occurrence, expected vessel speed of support vessels
Fishing Effects	Loss of fishing access	CDFW catch statistics	Consult fishing community and CDFW	Additional information on catch, fishing areas
Wave resource effects	- Attenuation of surfing waves, - Change of sediment transport - Potential impacts to kelp beds depending	Previous modeling studies in other areas	None	Modeling study of the effects of energy removal from waves on nearshore wave height and sediment transport
Fish Attraction	May increase predation on protected species, may bring protected species (cetaceans, pinnipeds) into greater contact with WEC if attracted by prey	Studies of fish attraction to offshore oil platforms	Consult NMFS and CDFW regarding sensitive species	Which species susceptible, analysis of species affected, species dependent
Visual Impacts to Jalama Beach	Changes for recreational viewers	None	None	Visual simulation of views to test berths from Jalama Beach and analysis of viewshed

Table 4.13-3 Potential regulatory/permitting issues and studies proposed to evaluate the issue, test berths

Issue Area	Potential Issue/Impact	Existing Studies	Possible avoidance/mitigation	Studies
Electric and magnetic fields (EMF) from subsea cables	BOEM studies	EMF alters behavior of marine biota	None needed	Several studies show no significant effect of EMF on marine biota at these levels
Cultural Resources (shipwrecks, etc.)	Damage to cultural resources (if not avoided)	Side-scan sonar of cable route	Review sonar results, avoid wrecks if present	Side-scan sonar
Acoustics/Noise/Light During Construction and operation	Behavioral, possible injury Birds may collide with WECs, attracted by light	Varies by species	- Marine mammal mitigation/shutdown zones if injurious sound sources are identified - Use blinking lights to reduce bird collisions	- Noise levels from WECs - Literature review of lighting effects on bird behavior
Water Quality	Anti-fouling paints/coatings and corrosion inhibitors compounds used on equipment including WECs could affect water quality	Industry studies from harbors, etc.	BMPs, monitoring	Literature review regarding prevention of water quality degradation
Pinniped attraction/haulout	Behavioral, damage to WEC	- Pinniped deterrence workshops	Design to prevent pinniped haulout, monitor/remote sensing during operation	Pinniped deterrence and monitoring plan
Collisions with moving parts (NMFS)	Injury/death of cetaceans, sea turtles, fish, birds, pinnipeds	Varies by species, studies from Europe and other experience around the world	Shielding or other protection of biota from moving parts	Study of potential detection and avoidance behavior in situ

SECTION 5

Summary of Contacts

§ 5.6 (d)(5) - Summary of contacts used to prepare the PAD including:

- Federal, state and interstate resource agencies
- Indian tribes
- Non-governmental organizations and members of the public

Please refer to the report of SOPO Task 13 (Stakeholder Participation) for this information. For the final PAD submitted to FERC, this information will be summarized in this section.

SECTION 6

PURPA Benefits

§ 5.6 (e) PURPA Benefit – List if the PURPA benefits are sought

The PURPA benefits are not being sought.

ATTACHMENT 12-2

SOPO TASK 12 PERMITTING ELEMENT FINAL REPORT

Task 12.2 Biological Resources Data Evaluation

For the

California Wave Energy Test Center (CalWave)

DOE Award Number: DE-EE0006517.0005

Prepared for:

Cal Poly Corporation
Institute of Advanced Technology and Public Policy
California Polytechnic State University
San Luis Obispo, California

Prepared by:

CH2M Hill Engineers, Inc.
2485 Natomas Park Drive, Suite 600
Sacramento, CA 95833

February 2017

Department of Energy Award Number: DE-EE0006517.0005

Principal Investigator:

Sam N. Blakeslee, Institute of Advanced Technology and Public Policy, California Polytechnic State University (Cal Poly), San Luis Obispo

Project Manager:

William I. Toman, Institute of Advanced Technology and Public Policy, Cal Poly, San Luis Obispo

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Acronyms and Abbreviations

Cal Poly	California Polytechnic State University, San Luis Obispo
CalCOFI	California Cooperative Oceanic Fisheries Investigations
CalWave	California Wave Energy Test Center
CCE	California Current Ecosystem
CCE-LETR	California Current Ecosystem Long Term Ecological Research
CDIP	Coastal Data Information Program
CeNCOOS	Central and Northern California Ocean Observing System
CSMP	California Seafloor Mapping Program
DOE	Department Energy
EERE	Energy Efficiency and Renewable Energy
FERC	Federal Energy Regulatory Commission
GOOS	Global Ocean Observing System
GPS	Global Positioning System
HFR	high frequency radar
IOOS	Integrated Ocean Observing System
LETR	Long Term Ecological Research
LIDAR	light detection and ranging
MBON	Marine Biodiversity Observation Network
MHK	marine hydrokinetic
NDBC	National Data Buoy Center
nm	nautical mile
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NOAA-NMFS	National Oceanic and Atmospheric Administration-National Marine Fisheries Service
PISCO	Partnership for Interdisciplinary Studies of Coastal Oceans
SCB	Southern California Bight
SCCOOS	Southern California Coastal Ocean Observing System
SOPO	Statement of Project Objectives
SWFSC	Southwest Fisheries Science Center
USACE	United States Army Corps of Engineers
USGS	United States Geological Survey
WIS	Wave Information Studies

SECTION 1

Introduction

This document is part of the Final Report for the California Wave Energy Test Center (CalWave) project, Phase II; an attachment to the report for the Permitting Element (Task 12) of the CalWave Statement of Program Objectives (SOPO). CalWave is funded by the U.S. Department of Energy (DOE) Office of Energy Efficiency and Renewable Energy (EERE) and cost-share partners and is part of an effort to advance the development of marine hydrokinetic energy (MHK) technology. This phase of work, called CalWave Phase II, involves developing conceptual designs, a stakeholder engagement program, and regulatory roadmap for the project. It is funded as a continuation of the DOE Feasibility Study grant (DE-EE0006517.0005).

SOPO Task 12 involves permitting CalWave. Subtasks are to evaluate environmental baseline information, participate in stakeholder engagement activities, and prepare the regulatory roadmap for permitting the project. This report is intended to satisfy SOPO subtask 12.2, Evaluation of Biological Resources Data. As is stated in the SOPO for Task 12.2:

12.2 Evaluation of Biological Resources Data

SOPO Subtask 12.2, Evaluation of Biological Resources Data is as follows:

> *Analysis of the potential effects on marine biological resources for licensing may require baseline studies, based on experience with previous MHK and off-shore wind project permitting. During the Feasibility Study phase, CalWave identified a large number of marine biological studies relevant to species that may inhabit the project area and also identified a number of repositories for data that has been periodically collected in the ocean and in the project area for a number of years. Because these data were collected for different purposes and over a long period of time, it will be necessary to evaluate them for applicability to CalWave environmental permitting.*
>
> *Existing data, if it can be interpreted in terms of its relevance to CalWave, could possibly provide a long-term perspective on the project area and potential project effects on marine fish and wildlife that could not be feasibly duplicated by data gathering efforts carried out specifically for the project. In addition, if the data can be found to be useful for CalWave permitting, this could save considerable time and effort in carrying out new studies specifically for CalWave. Evaluation of this data will also help in designing longer-term monitoring that will fit with previously recorded data, if long-term environmental monitoring is required during project operation.*

Permitting team staff collected information about long-term biological resources data sets from the project region that may be available and relevant to permitting and licensing CalWave and evaluated these data sets for relevance to the CalWave permitting process.

This report is not intended to be a comprehensive review of all marine research studies or programs conducted in along the southern and central coasts of California. It focuses instead on long-term institutional programs that have collected and are collecting data on marine biota and physical oceanography in the vicinity of the CalWave project site that is useful for permitting-related studies of the effects of marine renewable energy.

Individual study programs that may be useful as background data for permitting were assessed during Phase I and that information is included here and updated in Section 3.0 as an Annotated Bibliography. Some of the studies cited in Section 3.0 are the result of long-term studies involving specific topics by researchers (for example, 15-year tagging study of blue whale abundance and distribution conducted by Irvine and others [2014]). Section 2.0 focuses instead on more broad-based institutional programs that

have developed long-term physical oceanographic or biological resources data sets of relevance to marine renewable energy permitting analyses.

There are a number of institutions that conduct or sponsor general research in the region that has relevance in terms of specific species or topics that will be reviewed and evaluated during preparation of the permit application documents for CalWave. For example, the Cal Poly Center for Coastal Marine Sciences conducts a variety of research programs on regional fisheries, water quality, climate change, coastal habitats, among other topics and operates a marine science laboratory on the Cal Poly Pier at Port San Luis (California Polytechnic University, San Luis Obispo, 2017). The University of California at Santa Barbara Marine Science Institute, similarly conducts research within a range of research areas including biotechnology, climate change, evolution and genetics, marine geology and geophysics, marine conservation policy, oceanography, and others (University of California at Santa Barbara, 2017).

Long-term Data Collection Programs

The availability of existing marine biological resources data is particularly important for permitting marine infrastructure projects. Marine biota are highly mobile and, in general, not well known or understood. Gathering baseline data simply to characterize the project area is much more time consuming and expensive than for terrestrial-only projects. In addition, the time frame allotted to gather baseline data for project area characterization is relatively short, given the potential variability of a particular location over time. In this context, the availability of existing long-term scientific data collection programs is of critical importance in reducing uncertainty regarding biological resource conditions and uncertainty surrounding environmental regulatory permitting issues. Long-term data collection programs are generally state, federal, university or other research organization sponsored and, though they are designed for purposes other than the permitting of marine renewable energy and research areas may or may not be co-incident with or very near a project site, such programs can provide data that is simply unattainable in any other way. In addition, the long tenure of some such programs provides higher confidence in the results.

This section briefly describes and evaluate some of the long-term marine biological data collection programs that could have relevance for the CalWave project. The purpose here is simply to identify the programs and summarize them and not to comprehensively describe all of the information that they collect or the many individual studies that have resulted from the data collection. If found relevant to project regulatory issues and, through further discussions with regulatory agencies, acceptable to provide background data and as a basis for impact assessment, the relevant information will be reviewed and presented in detail in the project's final Federal Energy Regulatory Commission (FERC) license Application.

2.1 California Cooperative Oceanic Fisheries Investigations

The California Cooperative Oceanic Fisheries Investigations (CalCOFI) Program started in 1949 as a partnership between the California Department of Fish and Wildlife (then Fish and Game), National Oceanic and Atmospheric Administration National Marine Fisheries Service (NOAA/NMFS), and Scripps Institution of Oceanography, now part of the University of California at San Diego (CalCOFI, 2017). Over its 67-year-long term of operation, the scope of investigations has expanded greatly, starting with an ecological study of the collapse of the sardine population to a very broad-based ecological study program that collects hydrographic and biological data at regular intervals along standard transects in central and southern California and at standard collection points between 0 and 500 m of water depth. The result is a very comprehensive set of basic data from which volumes of in-depth studies of ocean ecology have been published. For example, the following is a list of basic data collected at the transect locations:

Table 1. CalCOFI Data Collected

Physical parameters	Biological
Temperature	Chlorophyll
Salinity	Transmissometer
Oxygen	Photosynthetically active radiation (PAR)
Phosphate	C^{14} primary productivity
Silicate	Phytoplankton biodiversity
Nitrate	Zooplankton biomass
Nitrite	Zooplankton biodiversity

Physical parameters	Biological
Fluorescence	
pH	
Conductivity	

The sampling area in the Southern California Bight (SCB) has followed a pattern of 66 stations in southwest-northeast transects spaced 40 nm apart, from San Diego to Point Conception, since 1984. In 2004, CalCOFI added 9 additional stations. Thirty-eight additional stations may be scheduled seasonally. The stations are approximately 20 nm apart.

In addition to the basic physical parameters and biological data listed above, the data collected on the CalCOFI cruises includes bio-optics, air-sea interface, and atmospheric measurements, continuous underway sea surface measurements (temperature, salinity, fluorescence); acoustic Doppler current profiler data; trace metals; sediments; MOCNESS net sampling; and the Continuous Underway Fish Egg Sampler. Additional survey data collected includes the following:

Net Sampling—Net sampling is conducted using the following net devices:

- CalBOBL—Standard sampler consisting of two circular nets on a swivel harness. Equipped with a laser optical plankton counter and towed obliquely through the water column to a depth of 210 m
- MANTA Neuston net—Samples organisms on the ocean surface
- Planktonic Rate Processes in Oligotrophic Ocean Systems net—Vertical plankton sampler from 0 to 210 meters at certain stations
- Pairovet vertical plankton tow—Plankton sampler for inshore sampling to 70 m

Sea Surface Data—Sea surface, meteorological, and other data (GPS, thermosalinographic, fluorometric, wind speed, ship speed) are collected continuously during a sampling cruise.

Primary Productivity—Samples for primary productivity are taken daily, based on 14C uptake and estimates of light penetration.

Ancillary LTER—Additional data collected as part of the Long-Term Ecological Research Network program (LTER) includes dissolved organic carbon and total nitrogen, nano-microplankton abundance and biomass, particulate organic carbon and nitrogen, picophytoplankton and procaryotes, chlorophyll size fractionation, and taxon-specific phyto-pigments.

Fisheries Acoustics—CalCOFI cruises use multi-frequency acoustics (ground truthed with mid-water trawl samples) to help estimate the biomass and distribution of macrozooplankton, sardines, and anchovies. This system uses a hull-mounted SIMRAD EK-60 acoustical system with 5 frequencies: 18 kHz, 38 kHz, 70 kHz, 120 kHz, 200 kHz.

Dissolved Organic Carbon—CalCOFI regularly collects seawater samples at specific locations that are analyzed to determine inorganic carbon and total alkalinity levels. These measurements allow the calculation of pH and pCO2.

Seabirds—CalCOFI describes the seabird data collection program as follows (http://calcofi.org/field-work/underway-observations/380-bird-observations.html):

> Since 1987, seabirds and marine mammals have been surveyed along the CalCOFI transect during daylight hours while the ship is underway. Data counts on seabirds and marine mammals are entered into a handheld computer in real time and are available to filter or download on the Datazoo webpage. Bird observers participating on CalCOFI

> cruises are provided by support from the Farallon Institute for Advanced Ecosystem Research (Jul 2007 to present) and Point Reyes Bird Observatory (1987-2006).
>
> Sea birds are counted within a 300-meter wide strip off to one side of the ship. Counts were made while underway between stations during periods of daylight. These counts were summed over 20 nautical mile (nm) intervals, or the distance between consecutive stations, whichever was less. Included at the end of each data report are individual maps of the most numerous bird species (individuals/NM).

Cetaceans—CalCOFI describes the cetacean data collection program, conducted since 2004, as follows (http://calcofi.org/field-work/underway-observations/379-marine-mammal-observations.html):

> Visual monitoring is conducted during quarterly cruises by experienced marine mammal observers using handheld 7x binoculars. Supplementary Bigeyes (25x magnification) or image stabilizer hand-held binoculars (18x magnification) are used for species identification when necessary. Visual monitoring provides excellent data for highly visible species in calm to moderate weather.
>
> Concurrently, an acoustic technician surveys with a towed hydrophone array during the transit between CalCOFI stations and with sonobuoys while on station, allowing collection of distribution data on vocal animals that may have been missed visually due to darkness, rough weather, distance from transect line, being underwater, or other reasons.
>
> These data provide information on the annual and seasonal presence of cetaceans, and may be used to evaluate daily patterns of vocalization behavior. By integrating CalCOFI environmental and cetacean data, we plan to develop ecological models for cetacean habitat in the region offshore of southern California and to improve our understanding of their role in the California Current ecosystem.
>
> Concurrently, acoustic technicians survey with a towed hydrophone array during the transit between CalCOFI stations and with sonobuoys while on station, allowing collection of distribution data on vocal animals that may have been missed visually due to darkness, rough weather, distance from transect line, being underwater, or other reasons. Additionally, long-term acoustic monitoring is conducted at seven CalCOFI stations using bottom-mounted, High-frequency Acoustic Recording Packages. These data will provide information on the annual and seasonal presence of cetaceans, and may be used to evaluate daily patterns of vocalization behavior. By integrating CalCOFI environmental and cetacean data, we plan to develop ecological models for cetacean habitat in the region offshore of southern California and to improve our understanding of their role in the California Current ecosystem.

General Summary—Understanding the physical and organic parameters in the Southern California Bight and their variations over time and space, consistent with the overall goals of the CalCOFI program, is of great importance in developing a general baseline understanding of the marine biology in the CalWave project region. As a long-term program using consistent sampling and analysis methods and collecting data along the same transects and from the same sampling stations, the CalCOFI information and analytical results can achieve a high level of credibility and reproducibility. There are likely very few areas in the world where such robust data is available and this is a big help in reducing permitting uncertainty that surrounds projects sited in the marine environment.

More specifically, because CalCOFI focuses on physical parameters and plankton productivity, much of this data is of only peripheral or background use for environmental baseline analyses leading to analyses of the effects of marine renewable energy development. For example, the multi-frequency acoustics and

mid-water trawl macro-zooplankton and sardine/anchovy data is not likely to be very useful for specific impact analyses of marine renewables because these species are not listed as sensitive and significant impacts are not likely.

On the other hand, the seabird and cetacean count data is likely to be invaluable for establishing baseline information about the abundance and seasonal variations in the abundance of seabirds and cetaceans. It would simply not be feasible to provide comparable information for a specific project due to the constraints of time and funding that are available to a viable renewable energy project. Although the transect legs are 40 nm apart, the sampling stations are 20 nm apart, the data is collected continuously while cruising between stations and aggregated by 20 nm leg. Therefore, marine renewable energy sites located within the CalCOFI sampling grid will not be more than 20 nm from a sampling aggregation point. Distances between CalWave test berth sites and the CalCOFI sampling stations are shown in Table 2.

Table 2. Distance between CalWave Test Berths and Selected CalCOFI Stations

CalWave Test Berth	CalCOFI Station #	Distance (nm)	Station Water Depth (fathoms)
East	80.0 50.5 (nearshore)	6.1	15
East	80.0 51.0	4.7	40
Southeast	80.0 51.0	5.7	40
Southeast	80.0 55.0	12.5	427
North	76.7 51.0	31.2	131
North	76.7 55.0	32.7	307
West	76.7 60.0	43.6	509

The nearest point on a CalCOFI sampling transect about 3.8 nm from the southeast test berth. Although CalWave is significantly closer to CalCOFI transect 80 than 76 (about 31 nm at the nearest transect point), these six nearest stations on Lines 76.7 and 80 bracket the conditions to the north and south, east and west of the test berths and reflect a range of water depth conditions as well.

There are a number of publications based on CalCOFI data that are of particular relevance to CalWave permitting. They are too numerous to describe in this overview of programs and some of them are profiled in Section 3. One example, however, is the analysis of cetacean observation data along the CalCOFI transects conducted by Douglas and others (2014) that analyzed 693 observations of 20 species of cetaceans in terms of seasonal abundance for the 11 most common species. This data included CalCOFI lines 76.7 and 80 which lie north and south, respectively, of the CalWave site.

2.2 California Current Ecosystem-Long Term Ecological Research

The California Current Ecosystem Long Term Ecological Research (CCE-LTER) ecological studies network is a wide network of ecological scientists seeking a better understanding of the California Current pelagic ecosystem. The California Current Ecosystem is defined as an area offshore of southern California extending up to 500 miles offshore between San Diego and San Luis Obispo. It is the goal of the LTER network to take advantage of the long-term data set created under the CalCOFI program but to focus particularly on long-term ecosystem changes in food webs, alongshore advection, cross-shore transport and predation pressure.

The California Current Ecosystem program is part of a broader long-term ecological research studies program that is supported partly by the National Science Foundation. CCE is based at the Scripps Institution of Oceanography/University of California, San Diego. Partners are located at Duke University, Georgia Institute of Technology, Point Reyes Bird Observatory Conservation Science, and the Southwest Fisheries Science Center of the NOAA/NMFS.

LTER uses the CalCOFI data and sampling grid and collects for analysis additional seawater and vertical net samples. This program conducts additional cruises in the CalCOFI grid. It also operates autonomous gliders along CalCOFI sampling Line 80, which is the sampling line off Point Conception that is nearest to the CalWave test berths. The gliders are operated by Scripps Institution of Oceanography and deployed from nearshore vessels and can operate for several months per deployment. The gliders collect conductivity, temperature, depth, fluorimeter, acoustic Doppler profile and backscatter, nitrate, and other data. These devices operate up to 1,500 meters in depth (Scripps Institution of Oceanography, 2017).

As with CalCOFI, CCE-LTER focuses on physical parameters with a main goal of understanding long-term process and change across broad ecosystems. Much of this information is of only peripheral or background use for environmental baseline analyses leading to analyses of the effects of marine renewable energy development. Nevertheless, having the type of in-depth understanding of ecosystem processes that results from a long-term program like CCE-LTER decreases uncertainty about marine ecosystems and may help resolve general permitting-related issues or problems in the future.

2.3 California Seafloor Mapping Project

The California Seafloor Mapping Project (CSMP) is an initiative to comprehensively map the seafloor of the California territorial sea (shore to 3 nm). It is a component of the California Coastal Mapping Program, which also includes initiatives to complete LIDAR mapping of shore areas (California Shoreline Mapping Project), and the Collaborative Geospatial Data Management Project, which supports geospatial data sharing between California state agencies. CSMP is being implemented by the United States Geological Survey (USGS) with the support of the California Ocean Protection Council and participation a large number of participating federal, state, and private entities.

The CSMP uses multi-beam sonar and other techniques to develop bathymetric and sub-bottom profile data to create benthic habitat and geological base maps for California State Waters. The bathymetric and backscatter data has been collected for the entire territorial sea and the CSMP program is creating the map products in blocks of six USGS 7.5-minute topographic quadrangles (USGS, 2017). The map products for each quadrangle include the following:

- Colored Shaded-Relief Bathymetry
- Shaded-Relief Bathymetry
- Acoustic Backscatter (sub-bottom profile)
- Data Integration and Visualization
- Seafloor Character
- Ground-Truth Studies (using still and video photography)
- Potential Marine Benthic Habitats
- Seismic-Reflection Profiles
- Local and Regional Shallow-Subsurface Geology and Structure
- Offshore and Onshore Geology and Geomorphology

The availability of these mapping products will be invaluable for marine renewable permitting. Although many marine renewable projects more likely to be sited on the OCS than in the territorial sea, most

projects will require a subsea cable to carry power ashore and CSMP bathymetry can help in routing the cable. CSMP bathymetry shows the location of rocky bottom, which is both an engineering and permitting obstacle for subsea cable laying. Final cable routing will require the higher precision of side-scan sonar for the relatively narrow swath of seafloor where the cable will be sited, but the CSMP multi-beam sonar bathymetry can clearly show large areas of rocky bottom. Project engineers can use this information to avoid having to engineer protection for cables in rocky areas and also to avoid Habitat Areas of Particular Concern that consist of rocky bottom.

In addition, the CSMP habitat maps provide very interesting and useful environmental baseline information for the territorial sea. Ground-truthing videos show actual photograph of the seafloor and document the benthic organisms that live there.

2.4 Coastal Data Information Program

The Coastal Data Information Program (CDIP) operates a network of more than 100 nearshore buoys that record water temperature, wave height, and wave energy data (University of California, San Diego, 2017). The program is co-sponsored by the Scripps Institution of Oceanography at University of California, San Diego, the U.S. Army Corps of Engineers (USACE), and California State Parks Division of Boating and Waterways. CDIP buoys are deployed off the Atlantic, Gulf, and Pacific coasts of the United States, and off Puerto Rico, Hawaii, the Marshall Islands, Saipan, and Guam. Directional buoys that measure sea surface temperature and wave direction in addition to wave energy, are CDIP's primary instrument. Using the Iridium phone system, CDIP data are transmitted in real-time and posted on the internet. CDIP has a data archive from the 1990s using directional buoys and going back to 1947 using other equipment. The program also offers nowcast and forecast models of wave height and direction for the California Coast.

In conjunction with the USACE Wave Information Studies (WIS) buoy network, the CDIP buoys provide robust regional wave energy height and energy data for most locations off of the California Coast. This data is particularly useful for the CalWave site because there are two CDIP buoys, a WIS buoy, and a NOAA buoy very near (within 5 nautical miles) of the CalWave test berths. These and other buoys are listed under the National Data Buoy Center (NDBC).

Table 3. Wave information buoys near CalWave

Buoy	Nearest CalWave Test Berth	Distance (nm)	NDBC #
CDIP 216 - Harvest SE	South	5.1	46257
CDIP 71 - Harvest	Northwest	5.0	46218
NOAA HRVC1 – Harvest Platform	South	2.0	9411406
WIS 83086	West	2.3	-

Buoys to the northwest of CalWave at approximately 50 nm (CDIP 222/NBDC 46259) and 30 nm (NBDC 46011) from the CalWave test berths also provide wave energy data in the direction of the prevailing wave (upwave) from CalWave. In addition, buoys further north along the California Coast will receive southeasterly swells (prevailing wave) coming out of the North Pacific Ocean sooner than CalWave will, and this provides better wave resource predictability than other locations. There are also four buoys to the southeast within 15 nm of CalWave that are less useful in forecasting wave energy at the CalWave test berths because they are downwave in terms of the prevailing swell.

2.5 Central and Northern California Coastal Ocean Observing System

The Central and Northern California Coastal Ocean Observing System (CeNCOOS) is a regional affiliate of the national Integrated Ocean Observing System (IOOS) that is affiliated with the Global Ocean Observing System (GOOS). IOOS is managed by NOAA and is the funding source for the regional affiliates such as CeNCOOS that support NOAA's climate and weather forecast missions. The CeNCOOS focal region extends from the Oregon-California border south to Point Conception. The neighboring regional IOOS affiliate is the Southern California Coastal Ocean Observing System (SCCOOS) for California south of Point Conception.

Most of CeNCOOS resources go to ocean observations and modeling and associated data management programs (CeNCOOS, 2017). Products and activities include coastal weather forecasting, funding part of the IOOS network of High Frequency Radar (HFR) stations that provide ocean surface circulation data used in circulation models, shore station water sampling and measurements, and the operation of autonomous gliders on a CalCOFI transect off Monterey Bay and another off Humboldt County. (Note: SCCOOS operates the glider that operates on CalCOFI line 80 near Point Conception and CalWave.) CeNCOOS also partners with research organizations to conduct studies and develop models such as, for example, a forecast model for harmful algal blooms.

For marine renewable energy permitting, CeNCOOS information is most useful for weather and wave forecasting and provides another useful source of long-term information about oceanic and coastal physical and ecological systems.

Activities of IOOS coordinated through the various regions include animal telemetry programs, Marine Biodiversity Observation Networks (MBON), HFR radar systems for ocean current forecasting, and promotion of underwater autonomous glider use for data collection. The nearest MBON project to CalWave is operated out of the University of California at Santa Barbara and focuses mostly on the Santa Barbara Channel and Channel Islands.

2.6 Partnership for Interdisciplinary Studies of Coastal Oceans

The Partnership for Interdisciplinary Studies of Coastal Oceans (PISCO) is a consortium of marine scientists from:

- Oregon State University
- Stanford University Hopkins Marine Statin
- University of California Santa Cruz
- University of California, Santa Barbara

PISCO also includes collaborators from other institutions. The program is foundation-funded and its purpose is long-term ecosystem research and monitoring of the Pacific Coast with an emphasis on interdisciplinary studies. The program focuses particularly on hard bottom habitats, rocky shores kelp forests, and coastal currents. Long-term monitoring focuses mainly on rocky intertidal and nearshore habitats less than 25 m in depth (PISCO, 2017).

While marine renewable projects will generally seek to use horizontal directional drilling to avoid impacts to sensitive intertidal and nearshore habitats, the work of groups like PISCO is valuable in mapping the boundaries of these habitats so that it is easier to avoid them.

2.7 Cetacean Health and Life History Program

The NOAA Fisheries Southwest Fisheries Science Center (SWFSC) conducts many kinds of research activities off the Pacific Coast. Of particular interest for marine renewable permitting is a shore- and vessel-based survey of southbound migrating gray whales (*Eschrichtius robustus*) that has taken place at the Granite Canyon Marine Laboratory in Monterey County (about 120 nm from CalWave) since 1975 resulting in count data for 25 years. The whale count data have been the basis for long-term population estimates that have documented the growth and recovery of the gray whale population during the time of study (Punt and Wade, 2010; Shelden and Rugh, 2007).

In addition, SWFSC has conducted counts of northbound gray whale migrations since 1994 from an observation station near Piedras Blancas, near San Simeon in San Luis Obispo County (about 75 nm from CalWave) that focuses particularly on mothers and calves, their behavior and predation by killer whales (Perryman et. al 2002; Perryman, Reilly, and Rowlett, 2011).

Because the gray whale migrations continue along the entire Pacific Coast between Alaska and Baja California, the population estimates and behavioral observations from Piedras Blancas and Granite Canyon are applicable at the CalWave site. Although the distribution of gray whales between nearshore and deeper waters during migration may differ between areas, the general principles that govern whale migration are the same. In addition this research program has been instrumental in developing a variety of shore-based, vessel-based, and aerial observation techniques that have increased the accuracy of the population counts using high-resolution photographic imagery taken from airplanes and hexacopter drones.

2.8 References

California Current Ecosystem Long Term Ecological Research. 2017. http://cce.lternet.edu/ Accessed February 2017.

California Cooperative Ocean Fisheries Investigations. 2017. http://calcofi.org/. Accessed February 2017.

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Perryman, W.L., Reilly, S.B. and Rowlett, R.A. 2011. Results of surveys of northbound gray whale calves 2001-2010 and examination of the full sixteen-year series of estimates from the Piedras Blancas Light Station. Paper SC/62/BRG1 presented to the IWC Scientific Committee.

Perryman, W., Donahue, M., Perkins, P., and S. Reilly. 2002. Gray whale calf production 1994-2000: Are observed fluctuations related to changes in seasonal ice cover? Marine Mammal Science, 18(1):121-144.

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Shelden, K. and D. Rugh. 2007. Forty Years of Winter: Cetaceans Observed During the Southbound Migration of Gray Whales, *Eschrichtius robustus*, Near Granite Canyon, Central California. *Marine Fisheries Review* 72(4):1-19.

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Selected Annotated Bibliography

3.1 General

Kaplan, B., CJ Beegle-Krause, D. French McCay, A. Copping, S. Geerlofs, eds. 2010. Updated Summary of Knowledge: Selected Areas of the Pacific Coast. U.S. Dept. of the Interior, Bureau of Ocean Energy Management, Regulation, and Enforcement, Pacific OCS Region, Camarillo, CA. OCS Study BOEMRE 2010-014.

Large compilation of research papers covering everything from the benthos, infauna, plankton, fish, turtles, birds (pelagic, seabirds, and shorebirds), marine mammals, and so forth. Also includes physical oceanography. This would be a good document to use as a reference for individual species. Info isn't very spatially resolved, just discusses southern area. Good species accounts for ESA listed species.

3.2 Specific Issues

Haikonen, K., J Sundberg, and M. Leijon. 2013. Characteristics of the operational noise from full scale wave energy converters in the Lysekil Project. Estimation of potential environmental impacts. *Energies* 6: 2562-2582.

Hydrophone data deployed near a full-scale WECs in Sweden showed that noise from WECS would likely be audible to marine live at a distance of 20m. Noises from this particular WEC consisted mostly of short duration and high amplitude pulses that occurred when the WEC translator would hit the end stop.

Harnois, V. H.C.M Smith, S. Benjamins, L. Johanning. 2015. Assessment of entanglement risk to marine megafauna due to offshore renewable mooring systems. *International Journal of Marine Energy* 11:27-49.

The risk of large cetaceans becoming entangled with marine renewable energy device mooring cables is rated as low. This paper examines the risk of different mooring configurations relative to one another, based on physical parameters of the moorings.

Kropp, R.K. 2013. Biological and existing data analysis to inform risk of collision and entanglement hypotheses. Environmental Effects of Marine and Hydrokinetic Energy. Pacific Northwest National Laboratory publication PNNL-22804. United States Department of Energy, Contract DE-AC05-76RL01830.

Evaluates the risk of whale species encountering a wave energy facility offshore of Oregon. Concludes that due to the mostly nearshore pattern of the gray whale migration and relative rarity of other baleen whales in nearshore waters, "entanglement in wave park cables should not be a significant issue for baleen whales."

Parvin, S.J., R. Workman, and A. Brooker. 2007. Assessment of underwater noise impact from the Wave Dragon device construction and operation. Prepared by Subacoustech, Ltd, Bishops Waltham, UK. Prepared for PMSS Ltd, Bath, UK. Subacoustech Report No. 674R0205.

Evaluates sound associated with the Wave Dragon device, including a review of marine biota sound sensitivities. Noise levels from the device's turbine are capable of causing behavioral responses in marine mammals to a distance of a few meters.

Thomsen, F. et. al. 2015. MaRVEN – Environmental impacts of noise, vibrations, and electromagnetic emissions from Marine Renewable Energy. Final Study Report. Prepared for the European Commission, Directorate General for Research and Innovation. RTD-KI-NA-27-738-EN-N.

> Studies the effects of noise, vibration, and EMF on marine biota. Focuses mainly on identifying data gaps and research priorities.

Wilson, B., R.S. Batty, F. Daunt, and C. Carter. 2007. Collision risks between marine renewable energy devices and mammals, fish, and diving birds. Report to the Scottish Executive. Scottish Association for Marine Science. Oban, Scotland. PA37. 1QA.

> Comprehensive review of potential collision risks for various forms of marine biota with WECs. Concludes that much more research is needed to understand how marine biota perceive and navigate around objects in the water.

3.3 Invertebrates

Butler, J. et al. 2009. Status Review Report for Black Abalone. NMFS Southwest Region.

> Species ranges from Pt. Arena to Bahia Tortugas in Mexico. Susceptible to withering foot syndrome, and all known populations south of Monterey County have experienced major decreases in population size. All harvest is illegal in California from 1993 on. In many locations the density of the species has decreased to the point where successful fertilization may not be possible. Species may become effectively extinct in 30 years. Populations in the Channel Islands and Pt. Conception/Vandenberg area have known occurrences of withering foot syndrome. This species resides in the shallowest waters of the abalone species, and primarily occurs from high intertidal to ~6m depth. Great reference document. Species not likely to be affected by CalWave unless rocky intertidal will be impacted.

Goddard, J.H.R., and M.S. Love. 2010. Megabenthic Invertebrates on Shell Mounds Associated with Oil and Gas Platforms off California. *Bulletin of Marine Science.* Vol. 86 (3), pp. 533-544.

> Looked at 15 platforms including Irene and Hidalgo (surveyed 1997-2001, and 2004-2005). Found large numbers of sea stars, anemones, sea slugs, rock crabs, spot prawns, and a few sea urchins. Large masses of a non-native bryozoan were present at one platform. Echinoderms (sea stars and brittle stars) were the most abundant taxa. Except for filter feeders the dominant species were carnivorous or omnivorous and depended on mussels and other fouling organisms.

Hobday, A.J., and M.J. Tegner. 2000. Status review of white abalone (*Haliotis sorenseni*) throughout its range in California and Mexico. NOAA Technical Memorandum NMFS. US Department of Commerce, NOAA-TM-NMFS-SWR-035. 20 90 pp.

> Populations have declined by several orders of magnitude since 1970. Estimate of total abundance is around 1600 animals which is less than 0.1% of the estimated pre-exploitation population size. Authors suggest that without protection and intervention that the species could go extinct in California within 10 years. This is a deeper living species than most other west coast abalone with depths ranging from 20-60 meters. Paper provides a great species account and population estimates, but these may be slightly dated.

Page, H.M. et al. 1999. Effects of an offshore oil platform on the distribution and abundance of commercially important crab species*. Marine Ecology Progress Series*. Vol. 185 pp. 47-57.

> Found higher densities of large, highly mobile crab species on and under platforms when compared to nearby soft bottom areas. Conducted off of Platform Holly, results are likely applicable to other platforms in the area.

National Marine Fisheries Service. 2008. White Abalone Recovery Plan (*Haliotis sorenseni*). National Marine Fisheries Service, Long Beach, CA.

> Species listed as endangered from Pt. Conception to Punta Abreojos in Baja California in 2001, this came after the comprehensive status review from Hobday and Tegner (2000). Describes population ending at Pt. Conception, but is also out at Channel Islands. Population estimates are higher than reported in Hobday and Tegner (2000), with approximately 12,820 individuals estimated at Tanner Bank, and 7,360 at Cortes Bank.

3.4 Fish

Bence, J.R., D. Roberts, W.H. Lenarz. 1992. An Evaluation of the Spatial Distribution of Fishes and Invertebrates off Central California in Relation to EPA Study Areas with Emphasis on Midwater Ichthyofauna. Unpublished Report to the National Marine Fisheries Service, Tiburon, CA.

> Study on spatial distribution of fish and invertebrates collected during NMFS research surveys and CalCOFI ichthyoplankton surveys. Overall abundance of adult fish of potential commercial and recreational value was highest at the shallower bottom depths of the study. Provides good species descriptions and expected depth ranges for species.

Love, M.S., and A. York. 2005. A Comparison of the fish assemblages associated with an oil/gas pipeline and adjacent seafloor in the Santa Barbara Channel, Southern California Bight. *Bulletin of Marine Science.* Vol 77 (1), pp. 101-117.

> Surveyed waters that were 95-235m deep along a 20mm pipeline between Platforms Gail and Grace, and between Grace and the mainland. Identified four different areas, shallow and deep pipeline, and shallow and deep seafloor. Fish densities were about 7 times higher on the shallow pipeline versus shallow seafloor. Rockfish composed 84% of fish. Densities of cowcod in deeper parts of the pipeline were higher than has been observed at over 80 natural outcrops and 10 platforms. Provides good list of species found in the area, these species are commonly associated with areas of low relief.

Love, M.S., D.M. Shroeder, and W.H. Lenarz. 2005. Distribution of Bocaccio (Sebastes Paucispinis) and cowcod (Sebastes levis) around oil platforms and natural outcrops off California with implications for larval production. *Bulletin of Marine Science*. Volume 77 (3) pp. 397-408.

> Long discussion of distribution of Bocaccio and cowcod at offshore oil platforms. Densities of mature bocaccio were generally very low at both natural reefs and platforms, but had a higher overall mean at platforms than reefs. This equates to a higher potential larval production than other areas. Estimated that removing Platform Gail would be equivalent to removing 12.57 ha of average producing habitat for cowcod and 29.94 ha for Bocaccio.

Love, M.S., D.M. Shroeder, and M.M. Nishimoto. 2003. The Ecological Role of Oil and Gas Production Platforms and Natural Outcrops on Fishes in Southern and Central California: A Synthesis of Information. Marine Science Institute, University of California, Santa Barbara, CA.

> Paper discusses oil platforms including “shell mounds” around them, and decommissioning. Shell mounds are created when mussels and other invertebrates are dislodged during cleaning and storms. A rock outcrop (North Reef) by Platform Hidalgo sampled annually. Most of surveys on nine structures (Platforms Irene, Hidalgo, Harvest, and others further south). Surveys included the shallower areas (1995-2000) and deeper areas (1995-2001). Platform midwaters were generally “nursery” areas for rockfish, and other demersal fish (generally young of the year). Shell mounds around platforms support a rich and diverse species assemblage largely for small fish and young-of-

the-year (YOY) fish. Compared densities at Hidalgo to North Reef which is ~1000 meters from the platform. Assemblages were similar, but densities were generally higher at the platform. YOY generally 100 times denser at platform than north reef. Includes good metrics on species diversity and abundance, including different age classes.

Love, M.S. J. Caselle, and L. Snook. Fish Assemblages on Mussel Mounds Surrounding Seven Oil Platforms in the Santa Barbara Channel and Santa Maria Basin. *Bulletin of Marine Science.* Vol. 65 (2) pp. 497-513.

Discusses how mussel shell mounds surround all offshore oil and gas platforms in California. They surveyed fish assemblages at 7 platforms including Irene and Hidalgo. They observed at least 35 fish species, and 18 of these were rockfish (Sebastes sp.). Researchers determined that species richness, density, and mean lengths were less than on the platform bottoms, but these values are more similar to the platform bottom than other mounds and these mounds should be considered an integral part of the oil platform system, and not distinct communities. Paper includes species lists.

Love, M. S. and M. M. Nishimoto. 2012. Completion of Fish Assemblage Surveys around Manmade Structures and Natural Reefs off California. BOEM OCS Study 2012-020 Marine Science Institute, University of California, Santa Barbara, California. BOEM Cooperative Agreement No.: M10AC2001.

Author discusses how the oil platforms may play a role in the recovery of important groundfish populations in southern California. Bocaccio and cowcod are both species of concern. Bocaccio were once considered for listing as threatened under ESA. Four federally declared overfished species have been observed at platforms. Rockfish are dominant species at platforms (~84% of all fish). Midwaters are “nursery” area for YOY fish, platform bottoms primarily composed of subadult and adult rockfish, shell mounds included more dwarf species. Primarily discusses platforms further to the southeast (off Santa Barbara).

Love, M.S., M. Nishimoto, S. Clark, and D.M. Schroeder. 2012. Recruitment of Young-of-the-Year Fishes to Natural and Artificial Offshore Structure Within Central and Southern California Waters, 2008-2010. *Bulletin of Marine Science*. Volume 88 (4), pp. 863-882.

Survey looked at comparisons of recruitment at oil platforms, reefs, and shipwrecks. Goal to analyze whether there were differences in recruitment for structures that didn’t crest the surface of the water. Found that there is likely little effect for rockfish, but that blacksmith recruitment will likely decrease. Relevant in that the CalWave facility may provide recruitment habitat for YOY fish.

Page, H.M., et al. 2007. Trophic links and condition of a temperate reef fish: comparisons among offshore oil platform and natural reef habitats. *Marine Ecology Progress Series*. Vol. 344, pp. 245-256.

Compared fish health between artificial structures and natural reefs and correlated this with small invertebrate prey base. Researchers found that the artificial structures (oil platforms) had higher densities of invasive exotic species (caprellids). But the native fish fed heavily on the exotic species and this had a positive effect on fish condition.

Schroeder, D.M., and M.S. Love. 2002. Recreational Fishing and Marine Life Populations in California. *CalCoFI Report*. Vol. 43, pp 182-190.

Compared rockfish assemblages among three differently fished areas (one open to all fishing, another open to only recreational fishing, and a de facto marine protected area [Platform Gail]). Area open to all fishing had the highest density of fish (7,212 fish/ha), but size structure and species composition were dominated by small fish. Area open to only recreational fishing had 423 fish/ha, and similar species composition and size as the area open to all fishing. Protected area had high density (5,623 fish/ha) and a size structure and species composition shifted towards larger fish. Two federally listed as overfished species (bocaccio and cowcod) had 32-fold and 408-fold higher

densities in protected area versus recreational-only area and 8-fold and 18-fold higher densities than the area open to all fishing. Demonstrates damaging effects of catch and release fisheries.

3.5 Turtles

Benson, S.R., K.A. Forney, J.T. Harvey, J.V. Carretta, P.H. Dutton. 2007. Abundance, distribution, and habitat of leatherback turtles (*Dermochelys coriacea*) off California, 1990-2003. *Fish. Bull.* 105: pp. 337-347

Surveys conducted by airplane over waters less than 92 meters deep. Leatherback turtles are regularly observed off of the U.S. West Coast, where they forage on jellyfish in the summer and fall. Greatest densities were off central California. Nearshore waters off California represent an important foraging region. Species is critically endangered, partly due to by-catch in drift gillnet fisheries. Most commonly encountered between August and November, but overall rare in South Central California. Nearest detection to CalWave was off Point Arguello.

Plotkin, P.T. (Editor). 1995. National Marine Fisheries Service and U. S. Fish and Wildlife Service Status Reviews for Sea Turtles Listed under the Endangered Species Act of 1973. National Marine Fisheries Service, Silver Spring, Maryland

Goes over status reviews for loggerhead, leatherback, hawksbill, Kemp's ridley, and olive ridley sea turtles. Does not discuss green sea turtle. Document includes good species descriptions including general ranges and population estimates. Brief discussion of incidental catch and entanglement of species, primarily from longlines and drift/gillnets. Good references regarding entanglement, but they all deal with shrimp trawlers, or drift/gill nets.

3.6 Birds

Adams, J., J.Y.Takekawa, H.R. Carter. 2004. Foraging Distance and Home Range of Cassin's Auklets nesting at two colonies in the California Channel Islands. *Condor*. Volume 106 (3), pp. 618-637

Measured home range size of 99 radio-marked Cassin's auklets nesting in two colonies (Prince Island and Scorpion Rock). They generally foraged within 30 km from each colony, Prince Island foraging was northeast of the colony over the insular shelf near the shelf break (somewhat near Hidalgo, Harvest, and Irene). Foraging areas ranged from 654 km2 (Prince Island) to 204 km2 (Scorpion Rock).

Ainley, D.G., S.G. Allen, L.B. Spear. Offshore Occurrence Patterns of Marbled Murrelets in Central California.

Researchers assessed occurrence patterns offshore of Waddell Creek, in Central California primarily in June 1986-1994. Majority of the sightings were within 10km of Point Ano Nuevo, directly offshore of breeding habitat. Three sightings occurred 12-24km offshore.

Ainley, D.G. et al. 1995. Variations in Marine Bird Communities of the California Current, 1986-1994. *CalCoFI Rep*. Vol. 36, pp. 72-77

Did sampling off of central and southern California and found fluctuations in several of California's most numerous seabirds. Found that when sea surface temperatures were high that cold-water species were scarce and warm water species were abundant, and vice versa. Point Conception/Vandenberg area is included in the southern survey area. Includes estimates on population densities by square kilometer.

Burkett, E.E., N.A. Rojek, A.E. Henry, M.J. Fluharty, L. Comrack, P.R. Kelly, A.C. Mahaney, and K.M. Fien. 2003. Report to the California Fish and Game Commission: Status Review of Xantus's Murrelet

(*Synthliboramphus hypoleucus*) in California. Calif. Dept. of Fish and Game, Habitat Conservation Planning Branch Status Report 2003-03. 96 pp. + appendices.

Includes good life history and distribution of the species (at the time of this paper it was considered a single species with two subspecies, now it is two distinct species). Also includes good info on threats to the species, in particular oil spills and artificial light pollution. Species is also known to get entangled in drift gill nets off the coast of British Columbia. These mesh sizes ranged from 2.75" to 9". As of this report there was no documented bycatch in California.

Carter, H.R., D.L. Whitsworth, J.Y., T.W. Keeney, and P.R. Kelly. 2000. At-sea threats to Xantus' Murrelets (*Synthliboramphus hypoleucus*) in the Southern California Blight. Proceedings of the Fifth Channel Islands Symposium, pp. 435-447.

10,000-20,000 breeding individuals of Xantus' murrelet breed and forage in the Southern California Blight (SCB), this is the northern limit of the breeding range. Between April to June in 1995 to 1997 the radio-marked murrelets from Santa Barbara Island were distributed widely in the northwestern SCB. Authors determined that the species primary threat was oil production, especially spills. Figure 2 is a good map showing locations of birds, appear to be further offshore from Platform Irene. Additional threats are incidental by-catch in gill-net fisheries, attraction to bright lights from vessels and platforms at sea. Alcids were reportedly killed only once in gill-net fisheries between 83 and 94 based on observer data, but Canadian data shows by catch. It is deemed unlikely that large numbers are killed this way. Also attracted to strong lights, sometimes striking them and causing injury.

Carter, H.R., et al. 1992. Breeding Populations of Seabirds in California, 1989-1991. Pacific Outer Continental Shelf Region of the Mineral Management Service.

Lots of info on specific seabird species. Use as a reference. Includes population estimates for various regions.

Henry, R.W., W.B. Tyler, and M.Z. Peery. 2012. Abundance and Productivity of Marbled Murrelets off Central California during the 2010 and 2011 Breeding Seasons. The Luckenbach and Command Oil Spill Trustees, 2012. Unpublished Report, UC Santa Cruz, Santa Cruz, CA, and University of Wisconsin-Madison, Madison, WI.

At-sea surveys between Half Moon Bay and Santa Cruz in Conservation Zone 6. Estimated population at 336 in 2010 and 320 in 2011. Did not conduct surveys south of Santa Cruz.

Mason, J.W. et al. 2007. At-sea distribution and abundance of seabirds off Southern California: A 20-year comparison. Cooper Ornithological Society. *Studies in Avian Biology*, Number 33.

Provides good species overviews of birds that may be in the area. Surveys conducted in ocean waters off southern California, and focused on the Southern California Blight. Study area extended between Cambria and Mexican border. Platform Irene is in Sub-area 1, this extends from Pt. Piedras Blancas to Point Conception. Central mainland coast (CMC) is a focused area within sub-area 1 and this includes areas between Point Arguello to Point Dume, North mainland coast (NMC) is between Cambria and Point Arguello. Densities of birds were generally the highest in January. Provides estimates of density for individual species in January, May, and September for CMC area. Also has maps showing the density for the species over the different months. Good as reference.

McGrath, T., and J. Feenstra. 2007. Checklist to the Pelagic Birds of Southern California.

Paper just includes figures that show seasonal abundances of pelagic birds. Great visual of when species are in the area.

McIver, W.R., A.L. Harvey, H.R. Carter. 2014. Monitoring and Restoration of Ashy Storm-Petrels and Santa Cruz Island, California, in 2012. Unpublished Report for Montrose Settlements Trustee Council.

Colony size at Orizaba Rock in the Channel Islands increased in 2012 to 34 egg-laying pairs. Documents numbers of individuals and nest success.

Robinette, D.P, R. Ball, J. Miller, and J. Howard. 2013. Monitoring and Management of the Endangered California Least Tern and the Threatened Western Snowy Plover at Vandenberg Air Force Base, 2013. Unpublished Report, Point Blue Conservation Science, Petaluma, CA.

VAFB contains approximately 13.8 linear miles of coastal breeding habitat for California least tern and Western snowy plover. Least tern colony is at Purisma Point, and is one of only three colonies between Monterey Bay and Point Conception. In 2013 there was an estimated 15 breeding pairs at this colony. Species appears to forage in the vicinity Platform Irene (and CalWave site). Historic colonies have been closer to the site than the existing colony, there was one historic colony at the mouth of the Santa Ynez River. Western snowy plover breeds throughout the 13.8 miles of coastal beach habitat. Mean number of adults on Vandenberg was 240 individuals.

Rodriguez, D.A., A. Chapman, R. Cartwright. 2011. Shorebird Abundance and Distribution on Beaches of Ventura County, California 2007-2010. Unpublished Report submitted to BOEM.

Surveyed area between La Conchita (Rincon) and Leo Carillo. Provides good info on numbers and species accounts, but likely not particularly relevant to bird populations in the vicinity of the project area.

Takekawa, J.Y., et al. 2004. At-Sea Distribution and Abundance of Seabirds and Marine Mammals in the Southern California Bight: 1999-2003. Unpublished summary report, U.S. Geological Survey, Western Research Center, Vallejo, CA; and Humboldt State University, Department of Wildlife, Arcata, CA 309 pp.

Excellent reference for species counts and locations of observations of seabirds and marine mammals. Includes estimated densities per square kilometer near project area in January, May, and September for birds and marine mammals. Also includes radio-telemetry data for Cassin's auklet and Xantus's Murrelet.

Takekawa, J.Y., and J. Adams. At-sea distribution of radio-marked ashy storm-petrels, *Oceanodroma homochroa*, captured on the California Channel Islands. *Marine Ornithology* Vol. 36: pp. 9–17.

Study re-located 57 of 70 radio-marked ashy storm petrels that were captured at three colonies in the Channel Islands: Scorpion Rocks, Santa Barbara Island, Prince Island. Study conducted in the summertime and the storm-petrels were aggregated over the continental slope from Pt. Conception to Pt. Buchon, and the Santa Cruz basin between Santa Cruz, San Nicolas, and Santa Barbara Islands. Individuals ranged more than 600 km. and located as far north as the Farallones. Map on page 13 shows distribution near CalWave project area.

Whitworth, D.L. et al. 2006. Initial Recovery of Xantus's Murrelets following rat eradication on Anacapa Island, CA. *Marine Ornithology*. Vol. 33, pp. 131-137

Species nests in sea caves, and after eradication of rats they moved back into areas that they historically nested in, but were excluded due to nest predation by rats. As eradication proceeds the species range could expand.

Whitworth, D.L., H.R. Carter, A.L. Harvey and F. Gress. 2009. Nest monitoring of Xantus's Murrelets at Anacapa Island, California: 2009 annual report. Unpublished report, California Institute of Environmental Studies, Davis, California (prepared for the American Trader Trustee Council and Channel Islands National Park). 37 p.

Study conducted to assess recovery of species after the eradication of black rats. In 2009 there was a higher nest occupancy and hatching success than in any year since 2000. Twelve new nest sites established at Anacapa. Population may increase in coming years.

3.7 Marine Mammals

Fissipeds

Riedman, L.M., and L.A. Estes. 1990. The Sea Otter (*Enhydra lutris*): Behavior, Ecology, and Natural History. *Biological Report*. Volume 90 (14) pp. 1-136

Somewhat outdated text in terms of population size and locations, but provides good info on ecology, feeding behavior, and description of the species. Largest cause of death in CA seem to be incidental drowning in commercial fishing nets. The nets that were causing the highest mortality were gill and trammel nets. Both small nets and "entanglement nets" (> 3inch mesh) were causing mortality. Law closed gill and trammel net fishery (net mesh >= 3.5") within the 15-fathom isobaths.

U.S. Fish and Wildlife Service (USFWS). 2003. Final Revised Recovery Plan for the Southern Sea Otter (Enhydra lutris). Portland, Oregon. 64 pp. plus appendix.

As of 2003, the population estimated to be about 2,150 animals. The translocated colony at San Nicholas Island contains about 27 individuals. Provides good species account, and description of the status and risks to the population. Appendices and recovery plan document that coastal set-nets (gillnets and similar) and fish/crab traps (referred to as "pots" in this document) are a risk for the species.

U.S. Fish and Wildlife Service (USFWS). 2014. Stock Assessment Report for Southern sea otter. *Federal Register* Vol. 79, No. 14, pp. 3612-3614

Population is estimated to be 2,924 individuals as of late 2013: mainland population of 2,882, and 59 at San Nicolas Island. Losses in gillnet fisheries are estimated to be at or near zero individuals. This is likely due to depth restrictions and regulations that prohibit setting nets in closure areas. In areas from Point Reyes to Point Arguello, the fishery is restricted to depths greater than 60 fathoms. Set gillnet sizes are > 3.5" for halibut and white seabass. Drift gillnets are > 3.5" to < 14" for California yellowtail, barracuda, and white seabass, and >14" drift gillnet fisheries for California thresher shark/swordfish. Five-inch funnels are required on live-fish traps to exclude otters. Other mortality is largely disease and shark-bite related.

Pinnipeds:

Lowry, M.S., J.V. Carretta, K.A. Forney. 2008. Pacific Harbor Seal Census in California during May-July 2002 and 2004. *California Fish and Game*. Vol. 94 (4) pp. 180-193.

Aerial surveys conducted from May to July (molt period) in 2002 and 2004 to document hauled out seals. In 2012, 3,878 harbor seals counted onshore at the Channel Islands, 21,433 total statewide. In 2014, 4,344 in Channel Islands, and 26,333 statewide. Correction factor for total seals is presumed to be 1.65, so multiply numbers by that correction factor to get estimate of total population. In Southern California 70% of the seals were found at Santa Cruz, Santa Rosa, and San Miguel Islands.

MMCG and SAIC. 2011. Annual report, monthly marine mammal surveys, Vandenberg Air Force Base, California. 1 February 2010 through 31 January 2011.

Includes discussions of population size and haulouts. A series of landslides at Weaner Cove, a harbor seal haulout site, buried the cove. Harbor seal has largely abandoned this cove now. There have also been increased occurrences of coyotes in the vicinity of the haulouts the may be causing localized decreases in population. Coyote are known to prey on harbor seals, particularly pups.

Takekawa, J.Y., et al. 2004. At-Sea Distribution and Abundance of Seabirds and Marine Mammals in the Southern California Bight: 1999-2003. Unpublished summary report, U.S. Geological Survey, Western Research Center, Vallejo, CA; and Humboldt State University, Department of Wildlife, Arcata, CA 309 pp.

Excellent reference for species counts and locations of observations of seabirds and marine mammals. Includes estimated densities per square kilometer near project area in January, May, and September for birds and marine mammals. Also includes radio-telemetry data for Cassin's auklet and Xantus's Murrelet.

DeLong, R.L., and S.R. Melin. 2000. Thirty Years of Pinniped Research at San Miguel Island. Pp. 401-406 in: D.R. Browne, K.L. Mitchell, and H.W. Chaney (eds.), Proceedings of the Fifth California Islands Symposium, 29 March to 1 April 1999, Santa Barbara Museum of Natural History, Santa Barbara, CA. Sponsored by the U.S. Minerals Management Service, Pacific OCS Region, 770 Paseo Camarillo, Camarillo, CA 93010. OCS Study No. 99-0038.

Study began in 1968 on San Miguel Island after a small colony of breeding northern fur seals was discovered in 1968. As of 1999, the populations of Northern fur seal, California sea lion, harbor seal, and northern elephant seal have increased up to three-fold, while Steller sea lions no longer breed on the island. Researchers found that El Nino events cause changes in pinniped population dynamics at the island. Paper provides good graphs of population size of species on the island.

Cetaceans:

Irvine LM, Mate BR, Winsor MH, Palacios DM, Bograd SJ, et al. (2014) Spatial and Temporal Occurrence of Blue Whales off the U.S. West Coast, with Implications for Management. *PLoS ONE* 9(7): e102959. doi:10.1371/journal.pone.0102959.

Fifteen-year satellite tracking study of 170 tagged blue whales documents a "home range" area around the western Channel Islands and extending north past and a "Core Area" that is a smaller area closer to the Channel Islands. Discusses management concerns having to do with mortality from vessel strikes.

Sund, P.N., and J.L. O'Connor. 1973. Aerial Observations of Gray Whales during 1973. *Marine Fisheries Review*, Vol. 36, Paper 1057, pp. 51-52

Aircraft observations between Monterey Bay and Point Sur in January 1973. Study to test effectiveness of shore based observers versus aircraft observers. All aerial observations were within 7 miles of the shoreline even though survey area extended 25 miles offshore. 94% of observations were within 1 mile of the shoreline suggesting their migration in this area is very close to the coastline in this area.

ATTACHMENT 12-3

SOPO TASK 12 PERMITTING FINAL REPORT

Task 12.4 Regulatory Roadmap

For the

California Wave Energy Test Center (CalWave)

DOE Award Number: DE-EE0006517.0005

Prepared for:

Cal Poly Corporation
Institute of Advanced Technology and Public Policy
California Polytechnic State University
San Luis Obispo, California

Prepared by:

CH2M Hill Engineers, Inc.
2485 Natomas Park Drive, Suite 600
Sacramento, CA 95833

February 2017

Department of Energy Award Number: DE-EE0006517.0005

Principal Investigator:

Sam N. Blakeslee, Institute of Advanced Technology and Public Policy, California Polytechnic State University (Cal Poly), San Luis Obispo

Project Manager:

William I. Toman, Institute of Advanced Technology and Public Policy, Cal Poly, San Luis Obispo

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Acronyms and Abbreviations

AFB	Air Force Base
BA	Biological Assessment
BLM	United States Bureau of Land Management
BO	Biological Opinion
BOEM	Bureau of Ocean Energy Management
CA	California
Cal Poly	California Polytechnic State University, San Luis Obispo
CalWave	California Wave Energy Test Center
CCC	California Coastal Commission
CCRWQCB	Central Coast Regional Water Quality Control Board
CDFW	California Department of Fish and Wildlife
CDP	Coastal Development Permit
CEQA	California Environmental Quality Act
CESA	California Endangered Species Act
CFR	Code of Federal Regulations
CSLC	California State Lands Commission
CWA	Clean Water Act
CZMA	Coastal Zone Management Act
DOE	Department Energy
EFH	Essential Fish Habitat
EA	Environmental Assessment
EERE	Energy Efficiency and Renewable Energy
EIR	Environmental Impact Report
EIS	Environmental Impact Statement
ESA	Endangered Species Act
FERC	Federal Energy Regulatory Commission
FONSI	Finding of No Significant Impact
HAPC	Habitat Area of Particular Concern
HDD	horizontal directional drill
MBTA	Migratory Bird Treaty Act
MHK	marine hydrokinetic
MM	marine mammal
MMPA	Marine Mammal Protection Act
MOU	Memorandum of Understanding
nm	nautical mile
NEPA	National Environmental Policy Act
NHPA	National Historic Preservation Act
NMFS	National Marine Fisheries Service
NNMREC	Northwest National Marine Renewable Energy Center
NOAA	National Oceanic and Atmospheric Administration

NOAA-NMFS	National Oceanic and Atmospheric Administration-National Marine Fisheries Service
NOI	Notice of Intent
NOI/PAD	Notice of Intent/Pre-Application Document
NREL	National Renewable Energy Laboratory
OCS	Outer Continental Shelf
OEERE	Office of Energy Efficiency and Renewable Energy
PAD	Pre-Application Document
PG&E	Pacific Gas and Electric Company
PNNL	Pacific Northwest National Laboratory
RFI	Request for Interest
ROD	Record of Decision
ROM	Rough Order-of-Magnitude
ROV	Remotely Operated Vehicle
RWQCB	Regional Water Quality Control Board
SOPO	Statement of Project Objectives
SWRCB	State Water Resources Control Board
USACE	United States Army Corps of Engineers
USC	United States Code
USGC	United States Coast Guard
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
VAFB	Vandenberg Air Force Base
WEC	wave energy converter
WQC	Water Quality Certification

SECTION 1

Permits and Authorizations

This document is part of the Final Report for the California Wave Energy Test Center (CalWave) project, Phase II; an attachment to the report for the Permitting Element (Task 12) of the CalWave Statement of Program Objectives (SOPO). CalWave is funded by the U.S. Department of Energy (DOE) Office of Energy Efficiency and Renewable Energy (EERE) and cost-share partners and is part of an effort to advance the development of marine hydrokinetic energy (MHK) technology. This phase of work, called CalWave Phase II, involves developing conceptual designs, a stakeholder engagement program, and regulatory roadmap for the project. It is funded as a continuation of the DOE Feasibility Study grant (DE-EE0006517.0005).

SOPO Task 12 involves permitting CalWave. Subtasks are to evaluate environmental baseline information, participate in stakeholder engagement activities, and prepare the regulatory roadmap for permitting the project. This report is intended to satisfy SOPO subtask 12.4, Regulatory Roadmap. As is stated in the SOPO for Task 12.4

> *CalWave will identify the regulatory agencies with permitting authority and the permits and authorizations that will be needed before construction of the test center can begin. After consultation with regulatory agencies that has taken place during the Feasibility Study and that will continue through FY2015 funded work, CalWave will prepare a detailed permitting roadmap and schedule that identifies timing and key linkages between authorizations of different agencies and that considers subsequent pre-construction permitting phases.*

There are two major types of authorizations needed for CalWave to begin construction: land/seafloor use leases or agreements, and environmental/regulatory permits. Leases include the agreement with the U.S. Air Force for the use of facilities at Vandenberg Air Force Base, Bureau of Ocean Energy Management (BOEM) marine energy research lease of the project test site, the California State Lands Commission (CSLC) submerged lands lease for the portion of the subsea cable run that is located in state waters. Table 1-1 lists the major permits and authorizations, responsible agencies, and legal authorities.

1.1 Lease Agreements

1.1.1 Vandenberg Air Force Base Agreement

The project will require an agreement to lease the on-shore facilities site from Vandenberg AFB and to interconnect with the Vandenberg electrical grid. Onshore facilities include the subsurface cable run from the test berths onshore to the shore facilities, horizontal directional drill (HDD) bore site, shore station, and Vandenberg Dock. CalWave will at some point upgrade the existing 12 kV distribution cables from Vandenberg Dock to Substation 'N', and add 70 kV cables capability on the existing poles for approximately six miles between the shore site and Substation 'N'.

1.1.2 CSLC Submerged Lands Lease (Cal. Pub. Res. Code § 6501 et seq.)

Submerged lands below the mean high tide line within the California territorial sea (to 3 nm from shore) are sovereign lands of the State of California and managed by the CSLC. Use of these lands for submerged cable installation will require a Submerged Lands Lease, issued by the CSLC. As the trustee of California's sovereign lands, CSLC reviews lease and permit applications for consistency with its responsibilities under the Public Trust Doctrine, and to ensure that proposed activities and projects are in the best interests of the state. Approval of applications may also be contingent upon other criteria and conditions including, but not limited to, environmental review documentation and compliance pursuant to the California Environmental Quality Act (CEQA) and authorizations and permits from other local, state, and federal agencies. CSLC may

act as the lead, responsible, or trustee agency for the CEQA process, depending on the type of activity or project. The State CEQA Guidelines direct state lead agencies to coordinate environmental review with federal lead agency counterparts conducting review pursuant to the National Environmental Policy Act (NEPA) for projects that encompass both state and federal jurisdictions, when feasible (Cal Code Regs. tit. 14, § 15222). Preparation of a joint CEQA/NEPA document would require the federal lead agency's cooperation, and the document would need to provide information sufficient to comply with both CEQA and NEPA requirements.

1.1.3 BOEM Research Lease (30 CFR 585.238)

BOEM is the federal agency with responsibility for issuing leases to entities wishing to develop energy projects on the Outer Continental Shelf (OCS). For oil and gas leases or commercial offshore energy (wind, MHK) leases, BOEM may define lease blocks (seafloor lease areas) and hold auctions allowing multiple parties to bid on the areas for energy resources development. Under the provisions of 30 Code of Federal Regulations (CFR) §585.238, BOEM may also issue leases to certain public entities for research purposes.

> The Director may issue OCS leases, ROW grants, and RUE grants to a Federal agency or a State for renewable energy research activities that support the future production, transportation, or transmission of renewable energy (30 CFR 585.238[a]).

Before issuing a Research Lease, BOEM must make a Determination of No Competitive Interest by advertising the proposed research lease. If there is no competitive interest in the lease area, BOEM may issue the Research Lease. For the CalWave project, it is likely that the Research Lease holding entity will be the State of California, either through Cal Poly or the California Resources Agency. If there were competitive interest in the lease area, BOEM would hold an auction to determine the best value to the government of issuing the lease.

If, for some reason, the lease holding entity were a private entity, then CalWave would obtain a commercial lease. In this case, the same requirements for BOEM to make a determination of competitive interest would apply.

BOEM and FERC signed a Memorandum of Understanding (MOU) on April 9, 2009 to establish their respective jurisdictions and roles in authorizing renewable energy development on the OCS. This document established the exclusive jurisdiction of BOEM to issue renewable energy leases on the OCS and FERC to issue licenses for renewable energy projects using MHK technologies (BOEM maintains jurisdiction to license offshore wind projects). In July of 2012, FERC and BOEM released a document titled "BOEM / FERC Guidelines on Regulation of Marine and Hydrokinetic Energy Projects on the OCS" outlining procedures for licensing MHK projects on the OCS. Most importantly, this document simplifies permitting for MHK projects by combining what would otherwise be the separate processes of BOEM and FERC into a single process.

In the standard BOEM renewable energy permitting process for offshore wind development, an applicant would prepare a series of activities plans (Site Assessment Plan [or Research Activities Plan], General Activities Plan, and Construction and Operation Plan) and BOEM's environmental review process would be based on environmental information gathered in conjunction with preparing these plans/project description documents. In the standard FERC licensing process, by contrast, an applicant prepares a Pre-Application Document (PAD) that serves as a draft project description and also contains initial baseline environmental information about the project area. The applicant then consults with regulatory agencies to prepare environmental study plans and, once these are accepted, prepares a final application and environmental effects analyses. FERC then issues an Environmental Assessment or Environmental Impact Statement. Under the new BOEM/FERC agreement, licensing will follow the FERC process. BOEM will be a consulting/cooperating agency, but once the Determination of No Competitive Interest has been made, the

FERC will be the lead agency for environmental review and permitting that will take place mainly under FERC licensing procedures.

1.2 Licenses, Permits, and Authorizations

To authorize the start of construction, CalWave will require a number of separate permits from various agencies (Table 1-1). These are discussed briefly below.

Table 1-1. Permits and authorizations needed to begin construction

Agency	Permit/Authorization	Project Purpose	Regulatory Authority
Federal Agencies			
United States Air Force (USAF), Vandenberg Air Force Base (VAFB)	Onshore lease agreement, utility sale agreement	Project host, interconnection with VAFB grid	Federal land manager/property owner
Bureau of Ocean Energy Management	Offshore Research Lease	Sole authority to lease areas in the Outer Continental Shelf (OCS) for energy development	Federal Power Act (16 USC 791-828c as amended), 30 Code of Federal Regulations (CFR) 585.238
Federal Energy Regulatory Commission	Hydrokinetic Project License and federal lead agency for National Environmental Policy Act (NEPA) review	Responsible for siting and operation of grid-connected hydrokinetic power facilities. Lead NEPA agency.	-Federal Power Act (16 USC 791-828c as amended) -National Environmental Policy Act (42 USC 4321)
U.S. Fish and Wildlife Service (USFWS)	Incidental Take Authorization (terrestrial species)	Protection and recovery of threatened and endangered species Protection of migratory birds	-Federal Endangered Species Act (16 USC 35) -Migratory Bird Treaty Act (16 USC 703-712)
National Oceanographic and Atmospheric Administration National Marine Fisheries Service (NOAA-NMFS)	- Incidental Take Authorization (marine species) - Marine Mammal Incidental Harassment or Take Authorization -Essential Fish Habitat Analysis	Protection and recovery of threatened and endangered species and marine mammals and Essential Fish Habitat	- Federal Endangered Species Act - Marine Mammal Protection Act (16 USC 31) - Magnuson-Stevens Fishery Conservation and Management Act (16 USC 38)
U.S. Army Corps of Engineers (USACE)	- Section 10 RHA Permit - Section 404 CWA permit	- Responsible for use of navigable waterways - Protect water quality and wetlands	- Rivers and Harbors Act - Clean Water Act (33 USC 1251-1387)
U.S. Coast Guard (USCG)	Private Aids to Navigation	Responsible for siting of navigation aids in coastal waters	33 CFR 66
U.S. Bureau of Land Management (BLM)	Consulting Agency under NEPA	Construction near offshore rocks that are part of the California Coastal National Monument	National Environmental Policy Act

Agency	Permit/Authorization	Project Purpose	Regulatory Authority
State Agencies			
California Coastal Commission	- Coastal Zone Consistency Determination - Coastal Development Permit (submerged lands)	Responsible for development in the Coastal Zone; ensures public access to the Coastal Zone	- Coastal Zone Management Act (16 USC 33) - California Coastal Act (CA PRC 3413)
California State Lands Commission	- Submerged Lands Lease - Geologic or Geophysical Survey Permit - California Environmental Quality Act Compliance	- Leasing of state-owned submerged lands - Permission to conduct geologic and geophysical studies - CEQA review for Public Trust-consistent development on state submerged lands	- CA PRC 6301 et seq, 6501 et seq- - CA PRC 6212.3 - California Environmental Quality Act (CA PRC 21000)
California Department of Fish and Wildlife	- Incidental Take Authorization - Streambed Alteration Agreement (if stream crossing)	Protection and recovery of threatened and endangered species	- California Endangered Species Act incidental take permit (CA Fish am Game Code 2081(b)) - California Fish and Game Code, Section 1602
Central Coast Regional Water Quality Control Board	- Section 401 Water Quality Certification Waste discharge requirements (if waters of the state) - General National Pollution Discharge Elimination System Permits for construction and operation	Protect and manage water quality	- Federal Clean Water Act - Porter-Cologne Water Quality Control Act (CA PRC 4629)
California Office of Historic Preservation	-Section 106 compliance review -State Historic Preservation Officer consultation	Protect and manage historic properties and other cultural resources	-National Historic Preservation Act -CA PRC 5024, 5024.5

1.2.1 Federal Authorizations

Federal authorizations include the FERC License and ancillary authorizations such as permits or authorizations that would be issued under NEPA, the Endangered Species Act, Marine Mammal Protection Act, Rivers and Harbors Act, Clean Water Act, and other laws and regulations.

1.2.1.1 FERC License (18 CFR 5)

The FERC license serves as a kind of master environmental permit for CalWave. It is through the FERC licensing process and through the FERC acting in the capacity as lead Federal agency for compliance with the NEPA that other agencies will have their most important opportunity to comment on the project and its potential effects on the environment. It is also through the FERC licensing authority that consultations with key sister agencies will take place, leading to authorizations under the Endangered Species Act, Marine Mammal Protection Act, Magnuson-Stevens Act, and National Historic Preservation Act that are separate from, but closely linked with, the FERC license.

FERC has three variations on its licensing processes (Integrated, Traditional, and Alternative) that vary in terms of the timing and means of working with agencies and stakeholder groups and it is premature to decide which path is best for CalWave. Nevertheless, a characteristic of all three processes is early consultation with regulatory agencies and development of study plans before implementing the plans and entering the environmental analysis phase.

Using the Alternative process as an example, the applicant would form a stakeholder working group to discuss key permitting issues and provide input to study plan development. The applicant then submits a Pre-Application Document and draft study plans. After agreement on the Study Plans, the applicant carries out the studies. The applicant can then file the formal application document along with a draft NEPA Environmental Assessment. The Traditional and Integrated processes differ in the organization and timing of stakeholder involvement and study plan submittal. One advantage of the Alternative Process is that it allows the Applicant to prepare the draft NEPA EA. If the project requires an EIS, the Applicant can participate in selecting a third-party contractor to prepare the document. Under these circumstances, the Applicant may have better control of the permitting schedule during this phase of work.

1.2.1.2 Consultations with Federal Agencies

As lead permitting agency and lead NEPA agency, FERC is required to consult with sister agencies to confirm that CalWave would comply with laws and regulations for which those agencies are responsible (such as the Endangered Species Act, Marine Mammal Protection Act, National Historic Preservation Act). These agencies have promulgated regulations for coordinating with other federal agencies to carry out this responsibility.

Endangered Species Act (16 USC § 1531 et seq.)

FERC, as the federal action agency, is required under Section 7 of the ESA to consult with the US Fish and Wildlife Service (USFWS) for terrestrial species and marine birds and NOAA-NMFS for marine species if a project may affect species listed under the Federal Endangered Species Act or their critical habitat. This may take the form of an informal consultation or technical assistance, if the USFWS or NOAA-NMFS determines that adverse effects are not likely, or more consultation, if the USFWS or NOAA-NMFS determines the project is likely to adversely affect a listed species. After completion of formal consultation, the USFWS or NOAA-NMFS issues a Biological Opinion (BO) regarding the effects of the project on listed species, and whether the project would jeopardize the continued existence of the species. If the species would not be jeopardized, the USFWS or NOAA-NMFS includes an Incidental Take Statement at the end of the BO that specifies the amount or level of take that will be allowed that is incidental to the activity permitted, and any reasonable and prudent measures that would be required to minimize the take of the species. The BO is partly based on the applicant's/FERC's analysis of project effects and proposed measures to avoid and minimize them provided in a Biological Assessment (BA) document.

Marine Mammal Protection Act (16 USC § 31)

Marine mammals are protected from harm and harassment under the Marine Mammal Protection Act. Because of the potential for the project to affect marine mammals, the FERC will consult with NOAA-NMFS regarding the potential effects of the project on marine mammals and type of authorization needed. If the effects would be limited to short-term harassment (injury or disturbance), NOAA-NMFS can issue an Incidental Harassment Authorization (IHA); however, if the effects would include serious injury or mortality, or cause harassment over multiple years, NOAA-NMFS can issue a Letter of Authorization (LOA). For NOAA-NMFS to issue an LOA for incidental take of marine mammals, the take must be of small numbers, and have no more than a negligible impact on species or stocks. These authorizations are similar to an Incidental Take Permit under the US Endangered Species Act and allow a clearly defined level or amount of harassment or take per annum to marine mammals.

Magnuson-Stevens Fishery Conservation and Management Act (16 USC §§ 1801-1884)

The FERC is also required to consult with NOAA-NMFS regarding a project's possible effects on the viability of commercial fisheries. NOAA-NMFS has designated certain areas as essential fish habitat (EFH) and carefully reviews proposed actions that would affect EFH in a way that could damage the productivity of commercial fisheries. In the project area, the defined EFH mostly has to do with eelgrass, kelp forests, and rocky seafloor bottom and CalWave proposes to route the cable to avoid these habitats.

National Historic Preservation Act (16 USC § 470 et seq. and 36 CFR 800)

Under Section 106 of the National Historic Preservation Act, federal agencies must consider the effects of their actions on historic properties (those meeting the criteria for listing in the National Register of Historic Places). FERC would issue this request to the California Office of Historic Preservation, along with a copy of CalWave's report of surveys of archaeological and historic properties that could be affected by the project. Historic properties could include shipwrecks along the submarine cable lay or in mooring areas.

Consultations under NEPA

Migratory Bird Treaty Act (16 USC § 703 et seq.)—As part of its responsibilities as lead agency under NEPA, FERC would consult with the USFWS under the Migratory Bird Treaty Act (MBTA). The USFWS would provide comments to FERC regarding the project's potential effects to migratory birds, particularly those nesting in or near the project area.

California Coastal National Monument–Also as lead NEPA agency, FERC will consult the BLM regarding their management responsibility for offshore rocks that are part of the California Coastal National Monument. All offshore rocks not otherwise owned or managed by other entities are part of this National Monument. The BLM would provide comments on the project's potential effects on natural resources of the offshore rocks, such as seabirds and marine mammals.

1.2.1.3 Other Federal Permits and Authorizations

U.S. Army Corps of Engineers Section 10 and 404 Permits—Under Section 10 the Rivers and Harbors Act (330 USC §§ 407) the USACE has the authority to permit development in navigable Waters of the United States and under Section 404 Clean Water Act (30 USC §§ 1251-1387), the USACE has the authority to regulate dredge and fill (construction activities) in Waters of the United States. The agencies would require a detailed project description and analyses of the potential impacts on navigation and on water quality. These permits are at times issued in tandem. USACE would rely on FERC to be the lead NEPA agency for the overall analysis of environmental impacts associated with the project.

1.2.1.4 U.S. Coast Guard Aids to Navigation, 33 CFR 66

CalWave has begun coordinating procedures for the U.S. Coast Guard's review and comment on private aids to navigation, in this case, WEC lighting and marking, per Coast Guard regulations at 33 CFR 66.

1.2.1.5 Federal Authorizations Delegated to State Agency for Administration

California Water Resources Control Board Section 401 Water Quality Certification—Under the Federal Clean Water Act, the USACE's issuance of a Section 404 permit automatically requires a Water Quality Certification (WQC) under Section 401 of this law. Responsibility for implementing Section 401 has been delegated by the federal government in California to the State Water Resources Control Board and Regional Water Quality Control Boards, in this case, the Central California Regional Water Quality Control Board, located in San Luis Obispo. The WQC will dictate conditions for the preservation/control of water quality associated with construction and operation of the project.

California Coastal Commission CZMA Consistency Determination—The FERC requires a determination that the project is consistent with the federal Coastal Zone Management Act (16 USC §§ 1451–1464). In

California, this determination is made by the California Coastal Commission (CCC), which also issues Coastal Development Permits (CDP) (see discussion, below, under State Authorizations.

1.2.2 State of California Authorizations

State of California authorizations include review and project approval under the California Environmental Quality Act (CEQA) required as part of the CSLC's discretionary review of CalWave's Submerged Lands Lease Application and Coastal Development Permit under the California Coastal Act.

1.2.2.1 California Environmental Quality Act Review

The California Environmental Quality Act (CEQA) requires that state and local agencies in California disclose and analyze the environmental effects of a project subject to their discretionary decision-making. While there are a number of parallels between the NEPA and CEQA requirements and processes, while NEPA is ultimately a disclosure document, CEQA includes a mandate that prohibits lead agencies from approving projects that result in significant effects on the environment unless those effects are minimized and mitigated to the extent feasible and the lead agency finds that certain economic, legal, technological, social, or other benefits outweigh the adverse environmental consequences. If the lead agency determines the project could not result in a significant effect on the environment, it may prepare and adopt a Negative Declaration, or Mitigated Negative Declaration if project changes or measures are incorporated to ensure significant impacts are avoided. If the project may result in significant impacts, the lead agency will prepare an Environmental Impact Report, which contains an explanation and analysis of the potentially significant impacts of the proposed project, introduces and discusses a range of alternatives to the project, examines cumulative impacts, and imposes mitigation measures that would reduce the significance of the impact to the extent feasible.

The lead agency for CEQA would most likely be the CSLC, because it is the state trustee land manager of tide and submerged lands which will be leased for project infrastructure such as seafloor cables. As the lead agency, CSLC would organize and lead the environmental review process, including public engagement, as well as coordinate with Federal agencies on a possible joint EIR/EIS document. Other state agencies, such as the California Coastal Commission (CCC) and the California Water Resources Control Board, will participate as responsible agencies, based on their regulatory authorities managing coastal resources and ensuring environmental quality standards.

As CEQA and NEPA processes examine many of the same topics within a similar analytical framework and with similar requirements for stakeholder engagement and public information, it is possible to combine the processes, as long as the state and federal lead agencies agree do to so. Guidelines for this joint coordination and review processes are available through the California Governor's Office of Planning and Research.

1.2.2.2 Coastal Development Permit

The CCC has authority under the California Coastal Act to issue discretionary CDPs for developments within the coastal zone. The width of the coastal zone varies from place to place, but is generally no less than 1,000 feet from the mean high tide line on land. To comply with the Coastal Act, local planning agencies prepare a Local Coastal Plan (LCP). The CCC reviews the LCP and, once approved, the local (City or County) planning agency has jurisdiction to review and approve CDPs, consistent with the LCP, within the area the LCP covers. In areas with no LCP, the CCC retains jurisdiction. CalWave would not require a CDP for the shore station because it is on federal land where the CCC does not apply.

The CCC also retains jurisdiction within submerged lands of the territorial sea, including submerged lands adjacent to federal property at VAFB. To obtain the CDP, CalWave^{sm} will submit a Coastal Resources Assessment and CDP application to the CCC. The CCC will assess the potential effects of the project on

coastal resources and consider issuance of a CDP. Topics of particular interest to the CCC in CDP review include public access to the coastal zone, recreation, biological resources, and effects on geomorphology and potential geological hazards. In considering and issuing proposed CDPs, the CCC complies with CEQA pursuant to its Certified Regulatory Program (Pub. Resources Code § 21080.5; Cal Code Regs. § 15251(c)).

1.2.2.3 California Department of Fish and Wildlife CESA Consultation, Section 2081 Permit

Consultation with the CDFW regarding the project's potential effects on species listed under the California Endangered Species Act (CESA) will take place through the CEQA process with CSLC as lead agency. In some cases, a combined state/federal listed species process, coordinated through the FERC license, is possible. If the project could result in the incidental take of a species listed under the CESA, CalWave[sm] would need to apply for an incidental take permit from the CDFW pursuant to Fish and Game Code section 2081(b). The CDFW issues incidental take permits when the applicant can demonstrate that the impacts of the taking are minimized and fully mitigated, that funding to ensure the success of any mitigation measures has been provided, and that the project would not jeopardize the continued existence of the species.

1.2.2.4 CDFW Lake and Streambed Alteration Agreement, Section 1602 Permit

CalWave may also need a Lake and Streambed Alteration Agreement (Section 1602 of the California Fish and Game Code) if it will involve construction within the bed and bank of a stream or lake. It is possible, but unlikely, that this would be required for the generator tie-line pole upgrade between the shore site and substation. Final routing and pole placement will determine whether this is needed.

1.2.2.5 CSLC Geological or Geophysical Permit

The CSLC issues permits for geologic and geophysical surveys conducted within state waters, and administers a specific program for offshore low energy geophysical permits pursuant to California Public Resources Code section 6212.3. These permits are designed to ensure the acoustic effects of geophysical survey devices do not cause disturbance or harm to trust wildlife, fishers, or recreational users of the ocean. CalWave[sm] is likely to need to conduct, or contract with a permitted operator to conduct, geological and low energy geophysical surveys as part of preliminary site evaluation to determine the seafloor substructure and other factors important to engineering and site design considerations.

1.2.3 Local Government Authorizations

All of the components of the CalWave project are on federally owned and managed land or in submerged lands. For this reason, the project will not require authorization from Santa Barbara County (for example, a CDP).

SECTION 2

Permitting Schedule and Process

The time that it will take to secure permits and authorizations needed for CalWave to begin construction will depend on a number of factors, including whether there are changes to the project design or siting during permitting, the level of controversy over the project among the public and agencies, and the kinds of studies that agencies require in order to resolve environmental permitting issues. Figure 2-1 is a hypothetical scheduling scenario that assumes that there is a relatively mature project description to begin permitting at the initial stages depicted on the bar chart.

2.1 BOEM Lease Application

Submitting an application to BOEM for a marine renewable energy lease on the OCS is a precursor to other major permitting activities. CalWave will submit an unsolicited application for an outer continental shelf marine renewable energy research (or commercial) lease under 36 CFR 585.230 for BOEM's data adequacy review. The application will identify the applicant and the marine renewable energy aliquots (locations) CalWave is seeking to lease. Aliquots are square grid units that are 1200 meters on a side that are organized in block units that are 4800 meters on a side. CalWave will request a number of aliquots situated both north and east of the existing oil and gas lease P00451. These aliquots will most likely be located in the following aliquot block units: 6474, 6575 (north of P00451), and 6526 (east of P00451). Portions of oil and gas lease P00451 could also be requested from BOEM and use could be granted with consultation from the existing oil and gas lease holder. Oil Platforms Hidalgo, Harvest, and Hermosa are located in adjacent oil and gas blocks to P00451.

Once BOEM determines that the application contains sufficient information, BOEM will issue a public notice of an unsolicited request for a marine renewable energy lease, request for interest (RFI), and request for public comment. If other parties indicate competitive interest in the lease area, BOEM procedures require a competitive auction to determine which party will lease the aliquots in question. If competing parties do not come forward indicating competitive interest within a set period of time (30 days), then BOEM will issue a Determination of No Competitive Interest, and negotiate the lease with CalWave. This process, including review of the draft application, can take several months.

2.2 FERC NOI/PAD

Execution of the BOEM lease is a prerequisite to filing application documents with FERC to start the licensing process. To start this process, CalWave will submit a Notice of Intent (NOI) to file an application and a Pre-Application Document (PAD) to FERC. The NOI/PAD will contain a detailed description of the project site location, a description of the project design, and general information about the environmental baseline that will allow agencies, stakeholders, and interested parties to understand the scope of the project. The PAD will include sufficient baseline information that is publically available without field studies to identify key issues for permitting and to develop study plans to address the issues.

FERC will then hold scoping meetings and prepare scoping documents that identify key regulatory and public interest issues. In consultation with FERC, CSLC as CEQA lead agency, and the regulatory agencies and the collaborative working group established through the stakeholder involvement program, CalWave will prepare draft study plans for review. These study plans will identify data that will need to be collected to address the key regulatory issues. Preparation of study plans is CalWave's opportunity to focus the study effort on substantive issues having a clear nexus to the project. It is the opportunity of the regulatory agencies to request data they feel is necessary to address key issues.

CalWave will implement the study plans and begin collecting the data that will be necessary to permit the project. After this phase of initial encounter with FERC, the public, and regulatory agencies, issues may arise that lead to minor changes to the project design.

2.3 FERC License Application and Environmental Analysis

CalWave can begin preparing the FERC license application based on the initial project design and the results of scoping studies and discussions with regulatory agencies, and the public. The actual time it will take to complete this phase of the schedule is undetermined at this early stage because it is not clear whether the study plans will require data from more than one season or even more than one year. If long-term studies will not be needed to resolve environmental resources issues (for example, potential effects on listed species or marine mammals), then less time may be needed for field studies and the schedule might possibly be shortened. Stand-alone study reports would likely include, among others:

- Biological Assessment (Endangered Species act)
- Biological Assessment (Marine Mammal Protection Act)
- Biological Assessment (California Endangered Species Act)
- Cultural Resources Inventory and Evaluation (National Historic Protection Act)

Topics required to be included in the environmental analysis and application are as follows:

- Geology, Topography, and Soils
- Water Resources
- Fish and Aquatic Resources
- Wildlife and Botanical Resources
- Floodplains, Wetlands, Riparian, and Littoral Habitat
- Rare, Threatened and Endangered Species
- Recreation and Land Use
- Aesthetic Resources
- Cultural Resources
- Socio-economic Resources
- Tribal Resources

CalWave will prepare the final license application and file the document with FERC. The license application will contain a detailed project description suitable for the FERC License, CSCL Submerged Lands Lease and other permitting processes, environmental baseline analyses of the key environmental resources disciplines of interest to FERC, and analysis of CalWave's potential effects on environmental resources. Under the Alternative Licensing Process, CalWave could also submit a preliminary draft NEPA EA document at or shortly after this time which, after acceptance by FERC, would serve as FERC's NEPA compliance document if an Environmental Impact Statement (EIS) is not necessary. In the latter case, the EIS or joint NEPA/CEQA EIS/EIR would be prepared by a third-party, paid for by CalWave, instead of by FERC/CSLC staff.

2.4 Ancillary Permit Applications

During this phase also, CalWave will prepare the following application documents and submit them to the applicable regulatory agencies:

- Clean Water Act Section 404/Rivers and Harbors Act Section 10 Permit – USACE
- Submerged Lands Lease – CSLC
- Coastal Development Permit and CZMA Consistency Determination – CCC
- Clean Water Act Section 401 Water Quality Certification – SWRCB/CCRWQCB

After acceptance of the application and CalWave's Biological Assessment as complete, FERC will initiate the required consultations with sister agencies (NOAA-NMFS, USFWS, California Office of Historic Preservation), work with the applicant or third-party consultant to finalize the NEPA document and then issue the document to the public and agencies for comment. After receiving comments, FERC, with CalWave's help and that of the third-party consultant, will respond to the public and agency comments and issue the final NEPA document. After consultations with sister-agencies are completed, FERC will issue the final NEPA document and its own findings.

2.5 Permit and Lease Issuance

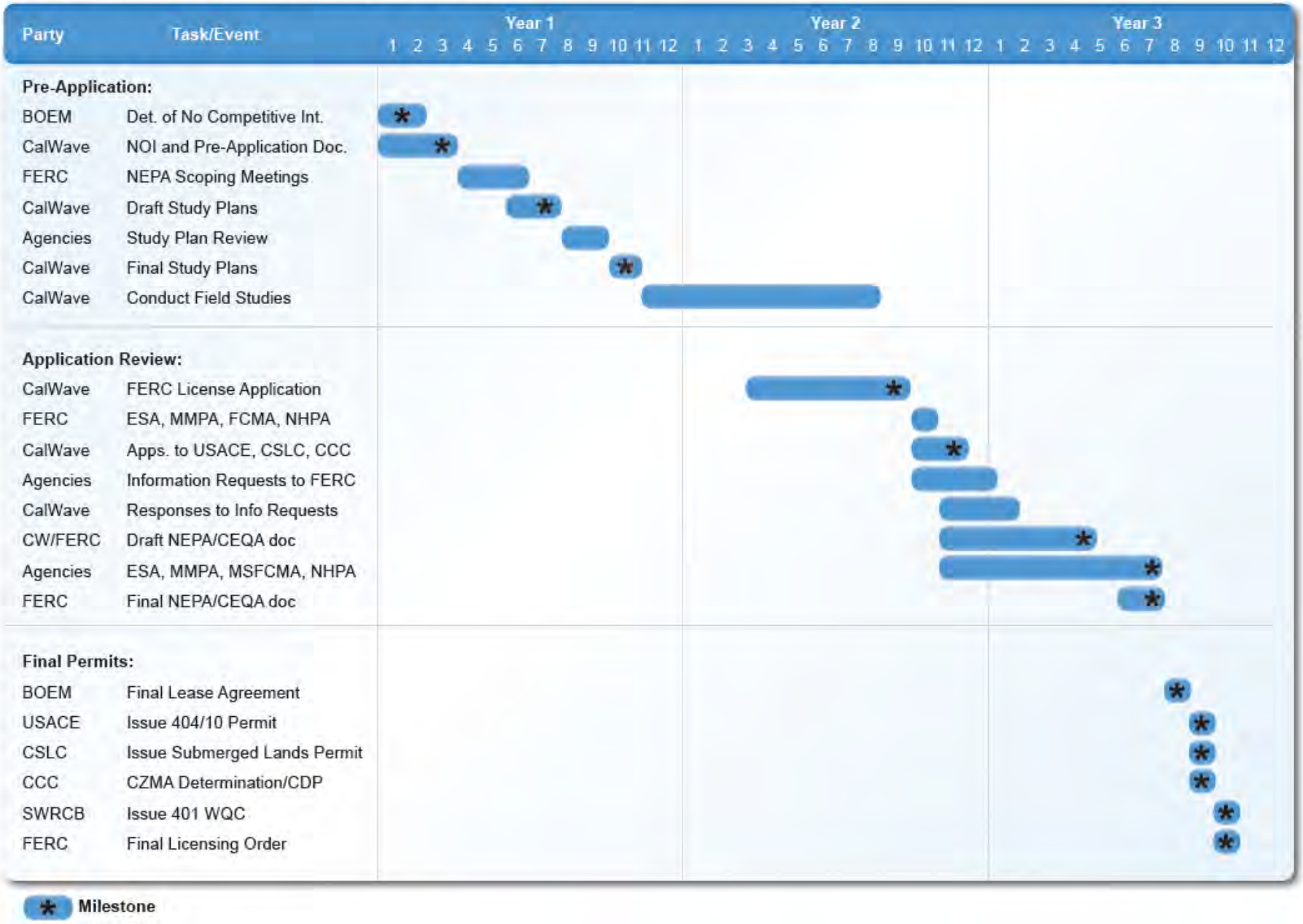
Once the final NEPA/CEQA document is certified BOEM can issue the Research Lease, contingent on obtaining all authorizations needed from other agencies. Once the federal and state agencies have issued the ancillary permits and their comments to FERC with proposed licensing conditions for resources under their responsibility, FERC can issue the final licensing order and CalWave can enter the construction phase.

2.6 Key Linkages and Sequencing Summary

The following are some of the key linkages/permitting sequences that will determine the critical path schedule:

- **BOEM Lease Application process before Filing the FERC PAD** – FERC will not accept the NOI/PAD without certainty from BOEM that the OCS lease is in place or very likely to occur.
- **Completion of field studies before filing FERC Application and Environmental Analysis**—Field studies and their results must be fully reflected in the Application and Environmental Analysis and study reports must be appended to the Application.
- **FERC application filed before starting formal consultations under the Endangered Species Act, Marine Mammal Protection Act, or National Historic Preservation Act**—To begin formal consultation, FERC must have a completed application and Biological Assessment (Endangered Species Act) and Historic Properties Survey Report (National Historic Preservation Act).
- **Consulting agency findings/permits before NEPA EA Finding of no Significant Impact (FONSI) or EIS Record of Decision (ROD)**—FERC prefers to have the findings of or necessary authorizations from consulting agencies before issuing a formal Record of Decision under NEPA. For example, the Biological Opinion or a Memorandum of Agreement to resolve adverse effect under the National Historic Preservation Act should be in place before FERC issues the NEPA EA FONSI or EIS ROD.
- **NEPA FONSI (or ROD) before the FERC License**—FERC cannot issue a final licensing order before NEPA is concluded.
- **CEQA EA Negative Declaration or EIR Notice of Determination before CSLC lease and CDP**—Similarly, CSLC cannot issue its lease and CCC cannot issue a CDP before CEQA is concluded.
- **Ancillary Permits before FERC License**— FERC does not issue a final licensing order before ancillary permits are granted, such as Water Quality Certification and the Section 10 Rivers and Harbors Permit and the Coastal Zone Consistency Determination is made through the CCC's CDP process.

Figure 2-1. CalWave℠ Hypothetical Permitting Process Schedule



SECTION 3

Cost Estimate[1]

The cost of licensing and permitting CalWave has the following essential components:

- Gather baseline data/literature search
- Gather site-specific field data
- Prepare and file application documents
- Respond to information requests and comments on the license and permit applications
- Prepare construction monitoring and compliance plans
- Monitor construction
- Monitor post construction

Costs in each of these phases will also include costs of coordination with the CalWave project development team and of participating in the public involvement and stakeholder engagement program (meetings with regulatory agencies, etc.).

At this stage of development (before filing the PAD), costs of two components in particular are especially difficult to predict. These are the site-specific data gathering and the post-construction monitoring components. Costs of site-specific data gathering will depend to a large extent on the outcomes of the outcome of negotiations with regulatory agencies regarding which issues will require site-specific data gathering and the extent of data needed to address regulatory issues. Costs of post-construction monitoring will depend largely on the level of uncertainty that remains regarding potential project effects after construction as determined through the permitting process.

3.1 PNNL Permitting Cost Studies

The DOE Pacific Northwest National Laboratory (PNNL) has conducted several studies to estimate the potential contribution of licensing and permitting to the development of MHK power projects. These studies established several reference models (tidal, ocean current, point absorber, oscillating water column, nearshore flap, etc.) and prepared generic estimates of potential licensing costs for each reference model. Copping and Geerlofs, 2011; Copping, Geerlofs, and Hanna, 2013, 2014).

The PNNL studies assumed that the following biological field data collection efforts would be needed to license an MHK wave farm (point absorber, oscillating water column), among other studies needed:

- **Marine Mammals—**Large vessel for gray whale surveys in spring and winter; small vessel surveys for resident gray and humpback whales in summer and fall; acoustic monitoring with autonomous recorders for other species
- **Fish and Invertebrates**—Grab sampling to assess benthic invertebrates, trawling to assess demersal fish and benthic invertebrates
- **Birds**—Small boat surveys and line transects, some of which can be done in conjunction with marine mammal surveys
- **Sea turtles**—Surveys done in conjunction with marine mammal and seabird boat surveys or by aircraft.

These studies are recommended to continue for a year (marine mammals, sea turtles) or more (fish and invertebrates) for sites where baseline data is not available, and for CalWave would commence later in Year 1 (see schedule, above) after study plans are approved.

[1] The cost estimates found here are minor updates of those found in the Phase I Feasibility Study for CalWave. Cost estimating is not in the Task 12 Scope of Service, but is provided here for convenience.

The PNNL studies developed low and high cost range estimates for three scenarios: (1) pilot project, <5 M for 5 years, (2) small-scale commercial (10 to 50 devices), and (3) large-scale commercial (> 50 devices). The scenario that best fits CalWave is the small-scale commercial model. Differences are that CalWave may host fewer than 50 devices. It will operate for more than 5 years, but possibly less than the 30-year presumed lifetime of a large commercial wave farm (assume 25 to 30 years). Table 3-1 reproduces the PNNL cost estimates (adjusted for inflation), for Reference Model #3, point absorber buoy with a reaction plate, anchored to the seafloor, assuming northern California location, and Reference Model #6, Oscillating Water Column devices sited in 50 m of water in Northern California. Copping and Geerlofs note that these costs estimates do not include possible costs of mitigation, which would be specific to a particular project and which, for some projects, could be substantial.

Table 3-1. PNNL Permitting Cost Estimates, Point Absorber and, Oscillating Water Column Reference Models

Reference Model	RM#3, Point Absorber		RM#6, Oscillating Water Column	
Project Phase	Low Estimate*	High Estimate*	Low Estimate	High Estimate
Siting & Scoping	$341,794	$538,585	$330,000	$530,000
Pre-Installation Studies	$2,055,944	$3,847,774	$1,753,000	$3,452,000
NEPA & Process	$937,345	$1,786,652	$1,100,000	$2,300,000
Subtotal	$3,335,083	$6,173,010	$3,183,000	$6,282,000
Post-Installation Monitoring	$7,493,579	$18,068,484	$9,355,000	$19,800,000
Grand Total	$10,828,662	$24,241,495	$12,538,000	$26,082,000

Source: Copping and Geerlofs, 2011; Copping, Geerlofs, and Hanna, 2014
* These costs have been adjusted upward from those provided by Copping and Geerlofs by 3.5 percent to account for price inflation between 2011 and 2013.

The PNNL reference models indicate that, not surprisingly, the largest costs will be for pre-installation data gathering and post-installation monitoring. PNNL estimates costs to permit an oscillating water column as higher than point absorber, partly due to the size and deck area required for an oscillating water column. This leads to more potential conflicts with marine mammals and sea birds.

These costs are relatively high compared with energy facilities on land, but this is partly due to the high cost of collecting data in the ocean and also the scale of the facilities. Costs for large-scale solar farms requiring large amounts of land have reached, and exceeded, these levels routinely for initial permitting.

The post-construction monitoring cost estimates seem particularly high, although less so when placed in the context of a 30-year project life. The standard approach for environmental permitting is that applicants and regulatory agencies, working together, should be able to predict or foresee what impacts to public resources will be significant and adverse, and prepare plans or mitigation measures to avoid or compensate for adverse impacts before construction takes place. In reality, however, some impacts of MHK projects implemented in the marine environment are still uncertain and agencies are likely to require post-construction monitoring to determine whether or not unforeseen impacts are taking place. Copping and Geerlofs put it this way:

> Until sufficient data exist to anticipate interactions of MHK devices with marine animals and habitats, extensive monitoring is likely to be required during the initial years of deployment at the commercial scale, resulting in front-loading of costs in the first five years (2011:3.13)

Once the MHK industry is well established, it is expected that post-construction monitoring will be required only for a few particularly intractable issues for which additional information needs to be gathered to resolve issues.

3.2 CalWave Permitting Cost Estimate

The PNNL reference model cost estimates are very helpful in estimating MHK project permitting costs and were intended as reference models for developing site-specific cost estimates for proposed facilities. Each location will have special data-collection needs that will drive permitting costs at that location.

The cost estimate included here in Table 3-2 for CalWave is based on the PNNL cost models and also assumes the following:

- It will take approximately three years to permit the project
- One year of field studies (or less) will be sufficient to gather baseline data needed to permit the project
- These permitting costs do not include bathymetry and wave resource assessment, turbulence, and other oceanographic site characterization tasks, which are done to support engineering design
- CalWave will host up to 40 WECs and will operate for 25 to 30 years
- Post-construction monitoring can be significantly reduced after 5 years
- These permitting costs do not include the costs of stakeholder participation and public involvement (those are estimated separately – see Section 5.0)
- This cost estimate is preliminary and Rough Order-of-Magnitude (ROM) estimate only and is based on current information (feasibility study).

Table 3-2. CalWave Permitting Preliminary Cost Estimate*

Task	Low	High	Notes
Gather Baseline Data	$40,000	$80,000	Additional lit search for environ. disciplines
Field Studies:			
Marine Mammals	$300,000	$800,000	Vessel, airplane, or sonar-buoy
Fish and Invertebrates	$200,000	$750,000	Trapping, netting, trawling
Seabirds	$50,000	$100,000	Combine with MM survey
Habitat mapping (from bathymetry)	$20,000	$30,000	Assumes bathymetry available
Terrestrial Biology	$40,000	$80,000	Survey shore site, gen-tie line
Cultural Resources	$35,000	$60,000	Survey shore site, gen-tie line, assume historic shipwrecks avoided
Commercial Fishing Assessment	$35,000	$120,000	LOE depends on fisher concern
Visual Resources, Recreation, etc.	$25,000	$50,000	Prepare visual simulations
Water Quality modeling	$100,000	$200,000	Deploy conductivity, temperature, depth instrument, combine with other surveys
Noise modeling	$20,000	$50,000	Estimates of project noise levels
Air emissions modeling	$30,000	$50,000	Model construction and operation emissions for NEPA/CEQA analysis
Sediment transport modeling	$30,000	$50,000	Model effects of wave energy removal on sediment, recreational surfing
Ship navigation transponder	$5,000	$10,000	Deploy AIS transponder to record ship tracks (if not available from VAFB)

Task	Low	High	Notes
Subtotal field studies	**$890,000**	**$2,350,000**	
Applications (FERC, USACE, CSLC, CCC)	$250,000	$300,000	Applicant-prepared documents
NEPA/CEQA document	$100,000	$650,000	If EIS/EIR, consultant-prepared (high)
Information Request Responses	$150,000	$250,000	Applicant and 3rd party consultant
Subtotal Application process	**$500,000**	**$1,200,000**	
Total Permitting Costs	**$1,430,000**	**$3,630,000**	**Cost to authorize construction**
Post-Licensing Compliance Plans	$60,000	$80,000	Plans required by permit for construction compliance
Construction Monitoring	$150,000	$350,000	Whale monitors, etc. for construction
Post-Construction Monitoring	$3,463,333	$8,710,000	Most in first five years, 20-year project
Total Post-permitting costs	**$3,673,333**	**$9,140,000**	
Grand Total, permitting and operation	**$5,103,333**	**$12,770,000**	

*Estimates based roughly on PNNL reference models for a site with no previous pilot project to establish baseline data.

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Statement of Project Objectives Task 12 Permitting Element Summary Report

For the

California Wave Energy Test Center (CalWave)

DOE Award Number: DE-EE0006517.0005

Prepared for:

Cal Poly Corporation
Institute of Advanced Technology and Public Policy
California Polytechnic State University
San Luis Obispo, California

Prepared by:

CH2M Hill Engineers, Inc.
2485 Natomas Park Drive, Suite 600
Sacramento, CA 95833

February 2017

Department of Energy Award Number: DE-EE0006517.0005

Principal Investigator:

Sam N. Blakeslee, Institute of Advanced Technology and Public Policy, California Polytechnic State University (Cal Poly), San Luis Obispo

Project Manager:

William I. Toman, Institute of Advanced Technology and Public Policy, Cal Poly, San Luis Obispo

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12-1 Draft FERC Pre-Application Document
12-2 Biological Resources Data Evaluation
12-3 Regulatory Roadmap

Acronyms and Abbreviations

BOEM	Bureau of Ocean Energy Management
Cal Poly	California Polytechnic State University, San Luis Obispo
CalWave	California Wave Energy Test Center
CFR	Code of Federal Regulations
DOE	Department Energy
EERE	Energy Efficiency and Renewable Energy
FERC	Federal Energy Regulatory Commission
FY	fiscal year
MHK	marine hydrokinetic
NGO	non-governmental organization
NOI	Notice of Intent
NOI/PAD	Notice of Intent/Pre-Application Document
NREL	National Renewable Energy Laboratory
OEERE	Office of Energy Efficiency and Renewable Energy
PAD	Pre-Application Document
SOPO	Statement of Project Objectives
VAFB	Vandenberg Air Force Base

SECTION 1

Introduction

This document is part of the Final Report for the California Wave Energy Test Center (CalWave) project, Phase II Permitting Element (Task 12) of the CalWave Statement of Program Objectives (SOPO). CalWave is funded by the U.S. Department of Energy (DOE) Office of Energy Efficiency and Renewable Energy (EERE) and cost-share partners and is part of an effort to advance the development of marine hydrokinetic energy (MHK) technology. This phase of work involves developing conceptual designs, a stakeholder engagement program, and regulatory roadmap for the project. It is funded as a continuation of the DOE Feasibility Study grant (DE-EE0006517.0005).

SOPO Task 12 is intended to advance the permitting of CalWave. Subtasks are to evaluate environmental baseline information, review the applicability of existing marine life data, participate in stakeholder engagement activities, and prepare the regulatory roadmap for permitting the project. This document is the general report summarizing Task 12 activities for the grant. The SOPO text for the individual subtasks is presented in Section 2. Deliverables defined in the SOPO are included as separate reports that are attached to this summary report. They are:

- Attachment 12-1: Draft Federal Energy Regulatory Commission (FERC) Pre-Application Document (Subtasks 12.1 and 12.5)
- Attachment 12-2: Biological Resources Data Evaluation (Subtask 12.2)
- Attachment 12-3: Regulatory Roadmap (Subtask 12.4)

The following is the introduction SOPO Task 12, Permitting Element Description, verbatim, from the SOPO.

> *During Feasibility Study phase (FY2013-funded), the CalWave Project Team consulted with regulatory agencies, elected officials, and other stakeholders, held public meetings to accept general public input, and conducted literature reviews of available baseline data. This phase also involved the initial screening of candidate sites for ocean use conflicts and regulatory permitting issues.*
>
> *For the FY2015-funded phase, CalWave proposes to carry the Feasibility Study work forward to the development of environmental baseline summaries and a permitting roadmap suitable to populate the outline of a Draft Notice of Intent to File an Application for New License and Pre-Application Document (NOI/PAD) to the Federal Energy Regulatory Commission (FERC)*
>
> *Underpinning the work on the PAD will be continued stakeholder involvement and public participation focused on specific candidate project sites (rather than a general siting area) that will lead to the development of permitting study plans and identification of key permitting issues.*
>
> *CalWave proposes the following subtasks during the FY2015-funded phase:*
>
> - *Literature review for key environmental disciplines and preparation of environmental baseline sections that will be included in a future PAD*
> - *Detailed evaluation of biological resources data sources identified during the Feasibility Study in terms of relevance for long-term licensing studies and monitoring plans*
> - *Additional consultation with regulatory agencies and their subject matter experts, Non- governmental Organizations (NGOs) and other stakeholders (*this is accomplished under SOPO Task 13*)*

- *Identification of the permits and authorizations and regulatory agencies with permitting authority and a detailed permitting roadmap and schedule with analysis of the interactions between the various permits and authorizations*

Section 2 of this report summarizes project activities for the Task 12 SOPO subtasks in turn. These are:

- 12.1 Literature Review
- 12.2 Evaluation of Biological Resources Data
- 12.3 Consultation with Regulatory Agencies and Others
- 12.4 Regulatory Roadmap
- 12.5 Preparation of Environmental Baseline Summaries
- 12.6 Project Coordination

SECTION 2

SOPO Subtask Summaries

The following subsections provide summaries of the CalWave SOPO Task 12 activities during the Period of Performance.

12.1 Literature Search

SOPO Subtask 12.1, Literature Search is as follows:

> *During the Feasibility Study phase, CalWave conducted detailed literature searches for (1) general environmental permitting documents in the project area such as EAs and EISs, and (2) marine biological resources in the project area. During FY2015-funded phase of work, we propose to conduct environmental baseline literature searches suitable for preparing preliminary draft environmental description sections of the PAD, for the key environmental disciplines that are required to be addressed in FERC application documents:*
>
> - *Geology and Soils*
> - *Water resources*
> - *Fish and Aquatic Resources*
> - *Wildlife and Botanical Resources*
> - *Wetlands, Riparian, and Littoral Habitats*
> - *Rare, Threatened, and Endangered Species*
> - *Recreation and Land Use*
> - *Aesthetic Resources*
> - *Cultural Resources*
> - *Socioeconomic Resources*
> - *Tribal Resources*

The activities of SOPO Subtask 12.1 were designed to gather available environmental baseline information suitable to prepare a draft FERC PAD. The purpose of the PAD, per 18 CFR 5.6, are to collect environmental baseline information suitable for the identification of key environmental regulatory permitting issues and the understanding of field and other studies that will be needed to address the issues identified during FERC licensing and through ancillary permitting processes. The PAD is then a basis for further discussions with FERC and other regulatory agencies regarding the preparation of Study Plans. Once the Study Plans are designed and approved by FERC and other agencies, they are implemented. After the studies are completed, the Applicant prepares environmental impact analyses, and designs mitigation measures, if studies identify impacts that might be significant and adverse. Thus the PAD does not include or focus on analysis of environmental effects.

SOPO Task 12.1 contemplates collecting environmental baseline data applicable to a PAD and preparing this information in the format of a draft PAD so that, during the design and permitting future phase of the project, this information could be quickly and easily modified to a PAD that could be submitted to the FERC to formally start the permitting process (after the Bureau of Ocean Energy Management [BOEM] lease application has been accepted). The SOPO mentions the FERC NOI because that document normally accompanies a PAD. The NOI is a notice of intention to start the FERC licensing process, however, and so it is premature to prepare the NOI in this early stage and it will be prepared during a future stage of the project. Preparation of the NOI is not a listed deliverable of Task 12.

The literature search conducted for Task 12.1 is summarized in the Draft PAD prepared in response to SOPO Task 12.1 and also SOPO Task 12.5 (Preparation of Environmental Summaries, see below). Task 12.1

involves the collection of the data and Task 12.5 involves the preparation of the draft PAD. The draft PAD is incorporated in this final report as Attachment 12-1.

12.2 Evaluation of Biological Resources Data

SOPO Subtask 12.1, Evaluation of Biological Resources Data is as follows:

> *Analysis of the potential effects on marine biological resources for licensing may require baseline studies, based on experience with previous MHK and off-shore wind project permitting. During the Feasibility Study phase, CalWave identified a large number of marine biological studies relevant to species that may inhabit the project area and also identified a number of repositories for data that has been periodically collected in the ocean and in the project area for a number of years. Because these data were collected for different purposes and over a long period of time, it will be necessary to evaluate them for applicability to CalWave environmental permitting.*
>
> *Existing data, if it can be interpreted in terms of its relevance to CalWave, could possibly provide a long-term perspective on the project area and potential project effects on marine fish and wildlife that could not be feasibly duplicated by data gathering efforts carried out specifically for the project. In addition, if the data can be found to be useful for CalWave permitting, this could save considerable time and effort in carrying out new studies specifically for CalWave. Evaluation of this data will also help in designing longer-term monitoring that will fit with previously recorded data, if long-term environmental monitoring is required during project operation.*

Permitting team staff collected information about long-term biological resources data sets from the project region that may be available and relevant to permitting and licensing CalWave and evaluated these data sets for relevance to the CalWave permitting process. The results of this analysis are presented in a separate deliverable, the Biological Resources Data Evaluation, included here as Attachment 12-2.

12.3 Consultation with Regulatory Agencies and Others

SOPO Subtask 12.3, Consultation with Regulatory Agencies and Others is as follows:

> *The mechanics of regulatory agency, NGO, and public stakeholder consultation are discussed below (12.4). CalWave will use the information gathered during the consultations to identify key regulatory and permitting issues and consider preliminary study plan concepts. Preparing and implementing the study plans in a subsequent phase of work will result in collection of relevant data to address the regulatory and other issues identified during literature searches and consultations.*

Consultation with regulatory agencies took place in conjunction with the stakeholder engagement and public involvement program coordinated by vendor Kearns & West under SOPO Task 13. These activities are described in much greater detail in the Task 13 report. See also the discussion under Subtask 12.6 Project Coordination as well.

Regulatory consultation activities included attendance and making presentations about the project and the proposed permitting plan at the following meetings:

- Agency Coordination Meeting – July 11, 2016 – Camarillo, CA
- Agency Coordination Meeting – October 20, 2016, Camarillo, CA
- Advisory Group Meeting – October 20, 2016, San Luis Obispo, CA
- Agency Coordination Meeting – December 8, 2016, Camarillo, CA

The permitting team also participated in specially scheduled coordination calls or meetings with the following regulatory agencies:

- BOEM Marine Renewable Energy Lease Group, Jean Thurston and Susan Zaleski, discussed // Marine Renewable Energy Lease process.
- FERC Licensing Project Manager James Hastreiter, discussed FERC Licensing process
- California State Lands Commission, Jennifer Maddox, Science Policy Advisor and members of the CSLC Staff – discussed CSLC regulatory process
- U.S. Bureau of Land Management, David Ledig, California Coastal National Monument, discussed regulatory requirements of the BLM for the California Coastal National Monument

Permitting Team Staff also participated in a site visit to Vandenberg Air Force Base (VAFB) on June 14, 2016 to meet with VAFB Environmental Affairs Staff to discuss permitting issues at the base and request copies of environmental review and analysis documents.

12.4 Regulatory Roadmap

SOPO Subtask 12.4, Regulatory Roadmap is as follows:

> *CalWave will identify the regulatory agencies with permitting authority and the permits and authorizations that will be needed before construction of the test center can begin. After consultation with regulatory agencies that has taken place during the Feasibility Study and that will continue through FY2015-funded work, CalWave will prepare a detailed permitting roadmap and schedule that identifies timing and key linkages between authorizations of different agencies and that considers subsequent pre-construction permitting phases.*

The CalWave permitting and stakeholder engagement staff worked with regulatory agencies and engaged regulatory agency staff at all-agency coordination meetings and in special meetings or conference calls with agency personnel (see discussion of Subtask 12.6, below). Information collected during these coordination activities included information about data requirements for permit applications, permit process and schedule, and linkages between allied permitting processes. The results of these efforts and other regulatory process research are consolidated and presented in the Regulatory Roadmap, Attachment 12-3 to this document.

12.5 Preparation of Environmental Baseline Summaries

SOPO Subtask 12.5, Preparation of Environmental Baseline Summaries is as follows:

> *The literature search, data evaluation, regulatory roadmap, stakeholder involvement program, and engineering design work will culminate in draft environmental baseline summaries, suitable for future inclusion in a PAD. By definition and per FERC and 18 CFR 5.6, the PAD contains "existing, relevant, and reasonably available information". Its purpose is to inform FERC and the public regarding key issues and related information needs for licensing the proposed facility. The PAD will be finalized and filed with FERC during a future phase of the project that begins the formal permitting process.*

Collection of environmental baseline data took place as part of Subtask 12.1 Literature Search. Under Subtask 12.5, the permitting team summarized the baseline data in a draft PAD document. This document is included in this report as Attachment 12-1. The Draft PAD includes identification of key environmental regulatory permitting issues.

12.6 Project Coordination

SOPO Subtask 12.6, Project Coordination is as follows:

> *This task includes coordination with the project team, weekly project team conference calls and administrative expenses (review and approval of invoices, etc.), quarterly reports, and input to draft final report and final report. It also includes coordination with other wave energy test centers, including a site visit to previously established test centers, in particular the UK Wave Hub.*

Project Permitting Team staff participated in the stakeholder engagement and public involvement program coordinated by vendor Kearns & West under SOPO Task 13 and these activities are described in much greater detail in the Task 13 report.

Permitting Team Staff also participated in a site visit to VAFB on June 14, 2016 to meet with VAFB Environmental Affairs Staff to discuss permitting issues at the base and request copies of environmental review and analysis documents. The VAFB site visit also included meeting with the cable route desktop study and cable installation lessons learned subcontractors, a horizontal directional drill specialist, and the project team's Chief Engineering and lead Electrical Engineer.

The permitting team leader attended weekly conference calls for the duration of the project.

The permitting team leader also attended the following conferences focused on marine renewable energy:

- California Offshore Renewable Energy Conference, University of California, Davis, October 3, 2017
- Marine Renewable Energy Workshop for the California Energy Commission Integrated Energy Policy Report, May 25, 2016. Permitting lead Douglas Davy made a presentation on renewable energy permitting.

A site visit to the UK Wave Hub test center was not included in the final scope and budget for the program. However, CalWave sponsored officials from the UK Wave Hub on a site visit to the CalWave site and members of the permitting team interviewed Wave Hub Commercial Director Stuart Herbert, regarding the permitting and environmental regulatory issues surrounding Wave Hub.

Attachment 12-1
Draft FERC Pre-Application Document

Attachment 12-2
Biological Resources Data Evaluation

Attachment 12-3
Regulatory Roadmap

CalWave^{SM} Wave Energy Test Center
Permitting Agency Meeting Summary
Monday July 11th, 2016, 10am-3pm
Hampton Inn and Suites, Camarillo, CA

Participants:

Organization	Name
Bureau of Energy Management (BOEM)	Doug Boren
Bureau of Energy Management (BOEM)	Jean Thurston
Bureau of Energy Management (BOEM)	Susan Zaleski
California Coastal Commission	Tom Luster (phone)
California Ocean Protection Council	Chris Potter (phone)
California State Lands Commission	Maren Farnum
California State Lands Commission	Cheryl Hudson (phone)
California State Lands Commission	Pat Mulcahy
California State Water Resources Control Board	Joanne Jensen (phone)
California State Water Resources Control Board	Catherine Woody (phone)
Federal Energy Regulatory Commission (FERC)	Jim Hastreiter (phone)
NOAA Office of National Marine Sanctuaries	Lisa Wooninck
NOAA Fisheries	Bill Foster
PG&E	Brendan Dooher
Point Mugu Naval Air Warfare Center	John Burke
United States Army Corps of Engineers (USACE)	Crystal Huerta (phone)
United States Coast Guard (USCG)	Darryl Harvey
United States Coast Guard (USCG)	James Morgia
United States Fish and Wildlife Service (USFWS)	Lilian Carswell (phone)
United States Fish and Wildlife Service (USFWS)	Dou Yang
United States Navy	Walter Schobel (phone)
Vandenberg Air Force Base	Ken Domako
Vandenberg Air Force Base	Brad King
CalWave Team	
Cal Poly	Sam Blakeslee
Cal Poly	Nick Osterbur
Cal Poly	Bill Toman
CH2M	Doug Davy
CH2M	Chris Rein
Kearns & West	Anna West
Kearns & West	Janet Thomson
Leidos	Rick Williams

Introductions and Session Overview
Sam Blakeslee, Principal Investigator for the Cal Poly CalWave^{SM} Wave Energy Test Center (CalWave^{SM}), welcomed the group and shared remarks on the importance of this effort to achieve our renewable energy goals. Anna West, Kearns & West, opened the meeting and asked meeting participants on the phone and in the room to introduce themselves. Anna reviewed the agenda and meeting objectives.

CalWave^{SM} Overview
Bill Toman, Co-Principal Investigator and Project Manager, introduced the CalWave^{SM} Wave Energy Test Center. CalWave^{SM} is an open ocean test center for evaluation of Wave Energy Converters (WECs) at mature Technology Readiness Levels (TRLs) that is intended to be a permanent facility (25-30 year design life). Cal Poly is currently performing a two-year feasibility study for the U.S. Department of Energy (DOE), working to understand engineering, siting, permitting, and stakeholder issues. The study will be completed in mid-2017.

The conceptual design includes a modular, phased implementation of Test Center capacity, starting at 1-2 megawatts (MW), progressing to 4-6MW, reaching 25-30MW, with an upgrade path to potentially achieve as much as 50MW. The WEC test berths will be located in federal waters, and the cables will transit through territorial waters to come ashore on Vandenberg Air Force Base (VAFB). A moored oceanographic buoy is being considered as a feature to collect wave and weather data and as a mooring to test WECs prior to installing them in the test berths.

Wave energy can be particularly useful for California, as its generation profile is consistent and complementary to intermittent wind and solar resources. Furthermore, it could make use of more than 12,200MW of unused coastal substation capacity that will be available with the phase-out of Once-Through-Cooling power plants and the retirement of Diablo Canyon. The state of California, in a letter requesting that the Department of Interior establish a Federal-California Marine Renewable Energy Task Force, cited support for CalWaveSM. The State has provided a $125,000 cost share to support the Department of Energy CalWaveSM grant under FOA #DE-FOA-0000847.

The CalWave team and its partners include the Cal Poly Institute of Advanced Technology and Public Policy, CH2M, Coastal Data Information Program, Columbia Power Technologies, Electric Power Research Institute (EPRI), Pacific Gas and Electric Company, Humboldt State University, Glosten Associates, Kearns & West, Leidos, Lieutenant Governor Gavin Newsom, the California Natural Resources Agency, the National Renewable Energy Laboratory (NREL), Sandia National Laboratories, Schatz Energy Research Center at Humboldt State University, Scripps Institution of Oceanography at University of California (UC) San Diego, UC Davis, and Virginia Polytechnic Institute and State University.

The CalWave^{SM} timeline includes the current preliminary design phase running through 2017, and then, pending additional funding, permitting through the end of 2018, construction in 2019-2020, testing in 2021-2022, and operations in 2022 and beyond.

Participants had the following questions:
- Question (Q): Could the test center incorporate wind energy with wave energy?

    - Response (R): The CalWave team is looking into the feasibility of designing the system so it's flexible enough to accommodate both wave and wind systems. The current plan is focused on wave energy only.
- Question (Q): The timeline should reflect that the BOEM lease request process comes before a Notice of Intent (NOI)/Preliminary Application Document (PAD) is filed with FERC.
    - Response (R): The timeline should be adjusted to say "Draft PAD" or "Preliminary PAD." The project team will not file the PAD until after receiving further funding for the next phase of work in 2017, and will seek a lease from BOEM before doing so.

CalWave^{SM} System Design Concept

Rick Williams, CalWave^{SM} Chief Engineer, Leidos, noted that the CalWave^{SM} system is being designed so that it can accommodate a wide range of WECs through the facility design life to 2050; and, that CalWave^{SM} will be testing WECs that have yet to be conceived and invented. So, our design is modular and "requirements-driven, technology-neutral, and vendor agnostic."

The system is intended to host mature WECs that have already been tested by other methods (at small scale, non-grid connected, etc.) before being deployed in the open ocean in a fully-energetic location. The developers will provide their WECs, their own properly designed mooring and anchoring sub-system, umbilical cables with dry mate connectors, and power conditioning modules either as part of the WEC or ashore. The CalWave^{SM} system is being designed to integrate with a variety of WEC technologies, including linear attenuators, point absorbers, rotating mass systems, and floating oscillating water column systems. The mooring and anchoring options are expected to vary depending on the WEC design.

For the electrical interconnection, CalWave^{SM} will provide a 70 kilovolt (kV) transmission line and will otherwise leverage existing facilities at VAFB, including roads and other base infrastructure. CalWave^{SM} buildings will be designed to look consistent with the historic Coast Guard Boathouse Station at VAFB, and the team will use berms to visually screen structures.

Participants had the following comments and questions:

- Question (Q): Has the CalWave^{SM} team determined whether there will be feed-in tariffs or net metering with PG&E for the power that is delivered to the grid?
    - Response (R): This has not yet been determined, but these discussions should begin soon with PG&E and with the California Public Utilities Commission (CPUC). Because this is a test facility, it cannot be treated as a typical renewable energy commercial generator, so there should be discussions with the Departments of Defense and Energy about how to properly finance this.
- Comment (C): There are sensitive resources (the Gaviota tarplant) in the alignment of the existing 12kV distribution line. Can you avoid creating new structures there, and instead upgrade the existing line?
    - Response (R): Reconductoring the existing line would require re-poling and would cause a power outage (potential mission impact) to Vandenberg Dock, so it is not preferred for us to reconductor. For reliability reasons, we prefer both a 12kV and 70kV lines and we cannot place a second line immediately

adjacent to the existing line. Therefore, we would need to use the opposite side of the road

- Question (Q): Will the CalWave[SM] team be applying for a research lease or a commercial lease?
    - Response (R): A research lease.

Draft CalWave[SM] Project Description

In April 2015, the CalWave[SM] team presented a concept with five alternative offshore sites and four alternative cable landing and substation sites. The team conducted outreach with agencies, stakeholders, and the fishing community. The fishing community asked that the team work toward the south. We further optimized the sites to avoid:

- Encroachment on Department of Defense range issues and operations;
- Marine safety issues;
- Existing telecommunication cables;
- Vandenberg State Marine Reserve; and
- Proximity to Jalama Beach.

Therefore, the CalWave[SM] team is currently looking at the two southern site options. It is also possible that the team could reuse or repurpose the existing oil and gas Platform Irene, by having the WEC array cables connect there and using the platform's cables to shore. This use of existing infrastructure is an option that the team is studying.

The CalWave[SM] system design concept diagram includes individual WECs and arrays of WECs, riser cables, hubs, dynamic cables, and dry mate connectors, all of which comprise the WEC System.

The dry mate connectors will link to the CalWave[SM] System, which includes export cables that are run through horizontal directionally drilled (HDD) bores, to the CalWave[SM] shore station. The CalWave[SM] team has identified a Shore Station site location, with a preferred "Upland" HDD Launch Site at the Shore Station and an alternate "Dock" HDD Launch Site location.

Participants had the following questions:

- Question (Q): Can you describe the bookends around the extent of cable you're considering?
    - Response (R): Yes, we will put a design envelope around it.
- Question (Q): PG&E often conducts electric interconnection system simulations before allowing systems to join the grid. Will NREL be requiring that wave energy test facilities do the same?
    - Response (R): We will conduct a thermal (static) simulation study and a dynamic simulation study to satisfy PG&E requirements. We will have to see if NREL recommends any further simulations.
- Question (Q): For the alternate HDD dock location, do you anticipate building a shoreline protection device, such as a seawall, to handle accelerating erosion due to sea level rise?
    - Response (R): The protection is already there, as there is a 12-15-foot tall cliff at the shoreline.
- Question (Q): How advanced are these technologies globally?
    - Response (R): The current Wave Hub project off the coast of England is now fully subscribed, or will be very soon. Therefore, the industry is at the point of

needing additional test centers to get the technologies in the water in a responsible way. At the next meeting we can further discuss which WEC technologies are the furthest along in development.

The CalWave^{SM} team noted that it is using components that are standard technologies used by NOAA, the USCG, and marine industry (buoys, barges, mooring and anchoring, cables to shore, etc.) and standard design approaches for the CalWave^{SM} System – what is different is the "recipe" and using these standard technologies and approaches for a new, innovative purpose -- wave energy.

Existing Information; Anticipated Study Needs During Permitting
Susan Zaleski, BOEM, provided a presentation regarding BOEM's focus areas for analyzing offshore energy projects and BOEM's funded research studies. She included a packet with information on 30 studies relevant to renewable energy offshore California. Susan added that BOEM just listed the new national studies list, which identifies research priorities for the agency, pending funding. The list includes three studies in California, for seabird and marine mammal surveys, a partnership for mapping protected species, and a data analysis and mapping effort to better understand physical oceanography for renewable energy project avoidance and mitigation.

Participants had the following questions:

- Question (Q): Is BOEM planning any studies to look at whale entanglement with offshore renewable energy infrastructure, including mooring cables? California and NOAA National Marine Sanctuaries have been studying whale entanglement with fishing gear.
    - Response (R): We are interested in the topic but may not have plans for that at this point. BOEM would have to find a surrogate to examine entanglement, since mooring cables are a different thickness than fishing gear.
- Question (Q): Is BOEM the lead agency for NEPA?
    - Response (R): FERC is the lead agency for NEPA. BOEM would conduct a joint NEPA document with FERC.

Doug Davy, CH2M, delivered a presentation to describe the FERC application process, describe existing sources of data, and outline anticipated future data needs. Doug's presentation covered data sources and anticipated studies surrounding the shore station, the cable run between the shore and the test berths, and at/around the test berths. A substantial amount of data is available from various environmental documents prepared for VAFB facilities and related efforts, as well as from a number of long-term studies conducted offshore the central coast. Additionally, technology is now available to provide very detailed bathymetry and seismic profiling. Example graphics are included in the presentation attached to this summary.

CH2M is preparing a baseline study, which will be provided in the format of a Draft PAD. When the CalWave^{SM} team receives future funding in 2017, CH2M would work with agencies to develop detailed study plans, and the project team would solicit a lease from BOEM and then issue the NOI, complete the PAD, and file study plans with FERC. At this early stage, the CalWave^{SM} team is working to understand key issues and data requirements in order to be well prepared for future phases of permitting.

Participants had the following comments and questions:

- Comment (C): There has been a recent sharp increase in whale entanglements with fishing gear over the past two to three years. The State is putting together a working group with fishermen to look at this issue. There are more whales around now and food has become more available inshore causing the whales to go closer to shore, so those might be some reasons for the increase.
    - Response (R): It would be useful to learn more about this from the State at our next meeting.
- Comment (C): We should look at existing benthic habitat information to see if there are sections of the coast that are similar/comparable to this area. That could be a source of good information. Additionally, you should make sure your data are not too outdated.
- Comment (C): Given that the proposed 70kV transmission line is in an alignment with Gaviota tarplant, you should do surveys for the plant now that we are in an average rainfall year. The protocol for that species is that surveys must be done during average rainfall years.
- Question (Q): Will the cables be buried, to avoid interactions with fishing gear?
    - We do not expect to bury them, unless required by the regulatory agencies. Cable installers have told us that they do not bury cables in this region.
- Comment (C): You should present information about this project to the Pacific Fisheries Management Council (PFMC) so that fishermen coast-wide can provide information about what equipment they use in this area, and any potential interactions. You could also set up a meeting with the Joint Oil/Fisheries Liaison Office in Santa Barbara.
- Comment (C): The Navy will be interested in discussing the buoys to understand if there may be impacts to the Navy.
- Comment (C): The project team should consider that electromagnetic fields (EMF) may be an issue.
    - Response (R): A recent BOEM study has not found any significant difference between the use of AC and DC cables on fisheries. BOEM should have an additional study complete soon, which also demonstrates no impact.
- Comment (C): Some marine mammal researchers are concerned with the use of smaller (2-4 inch diameter) cable. We may want to look at that.
    - Response (R): If regulators prefer larger diameter cable we can provide that direction to the WEC developers for their mooring designs.
- Comment (C): At subsequent meetings we should discuss how to bookend the types of technologies and impacts that are anticipated to interconnect with the CalWave^{SM} system. The CalWave^{SM} team could categorize similar devices together, that are anticipated to have similar impacts, and study those impacts. Otherwise, the project team would need a NEPA amendment to take in any new technologies that are beyond the bookend. (This is what the Pacific Marine Energy Center has done for its permitting process.)
- Comment (C): We will also need to try to understand array effects.
- Comment (C): If offshore wind becomes part of this proposal, VAFB will need to discuss potential interaction with mission systems for both VAFB and the Point Mugu Sea Range.

Next Steps

Anna noted that future regulatory agency meetings will be held in the fall and winter, and solicited ideas on topics for future meetings. Participants suggested:

- Broadly categorizing the impacts of WECs, including how they operate, how they are moored;
- Discussing different types of anchors that could be used for each type of device;
- More detail on existing information; and
- Data from European marine renewable energy facilities on entanglement or other topics.

Actions

1. CalWave^{SM} Team to circulate recent EMF studies and data from European marine renewable energy facilities to the agencies.
2. CalWave^{SM} Team to coordinate with USCG regarding navigational safety review, marking of offshore renewable energy facilities per NAVIC 02-07, Private Aids to Navigation (PATON) per 33 CFR Part 66, and Areas to Be Avoided (ATBAs) per 33 CFR Part 150.

CalWave℠ Update

CalWave Regulatory Agency Meeting

July 11, 2016
Camarillo, California

CalWave℠

Cal Poly
San Luis Obispo

U.S. Department of Energy

Agenda

- Introductions/Session Overview
- CalWave^{SM} Overview and Update
- CalWave^{SM} System Design Concept
- Draft CalWave^{SM} Project Description
- *Lunch*
- Existing Information; Anticipated Study Needs During Permitting
- Next Steps and Anticipated Timeframes
- *Adjourn*

2

Meeting Objectives

- Provide update on CalWave[SM]
- Describe latest site and conceptual design information
- Review existing and expected data/information
- Seek feedback on conceptual level design and anticipated data needs during permitting

CalWave^{SM} Overview & Update

4

Intro to CalWave℠

- CalWave℠ is envisioned as a permanent (25-30 year design life), open ocean, National Wave Energy Test Center designed for evaluation of Wave Energy Converters (WECs) at mature Technology Readiness Levels.

- WEC developers will be able to evaluate Technology Performance Levels by having this at-sea test site.

- Cal Poly is currently performing a 2-year feasibility study for the U.S. Dept of Energy (DOE) which will complete mid-2017.

5

Intro to CalWave^{SM}

- Conceptual design is a modular, phased implementation starting with 1-2 MW, then 4-6 MW, progressing to 25-30 MW, with an upgrade path to 50 MW.
- CalWave^{SM} test berths will be in federal waters; CalWave^{SM} cables will transit through state territorial waters.
- A moored oceanographic buoy, in either state or federal waters, is being considered as a feature to measure wave and weather and to test (check out) WECs prior to installing them in test berths.
- CalWave^{SM} has an agreement with Vandenberg AFB (VAFB) for onshore operations and for negotiating a power sales agreement. Submarine power cables will land at the DoD facility.

6

CalWave^{SM} Area

Why Wave Energy?

- California features a high-energy wave climate and deep water close to shore and major population centers.
- Phase-out of Once-Through-Cooling (OTC) power plants and retirement of Diablo Canyon will provide greater than 12,200 MW of unused coastal substation capacity for ocean renewable energy projects.
- State RPS goals increased to 50% by 2030; wave energy could be part of attaining that goal.
- Wave energy generation profile is highly predictable and complementary to intermittency of terrestrial wind and solar energy.

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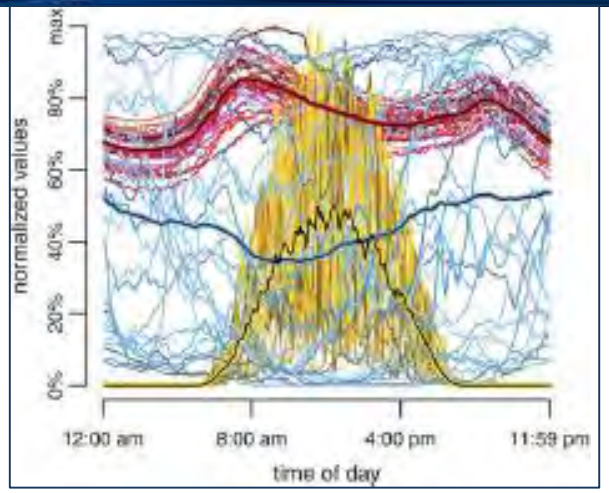
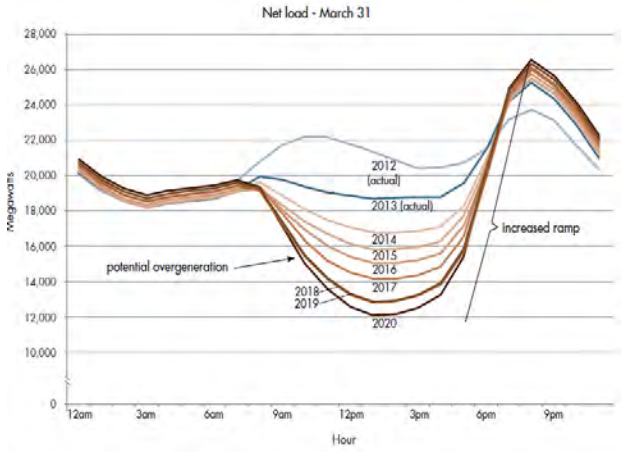
Challenge of Intermittent Renewables



Daily Profile, for 30 days: Electrical Demand (red), Wind Energy Supply (blue), Solar Insolation (yellow)

Source: Barnhardt, et al. 2013. "The energy implications of curtailing versus storing wind- and solar-generated electricity". Energy and Environmental Science.



The "Duck Curve" showing high ramp rates

- Traditional grid (central control):
  - Large central generating stations and long-distance transmission
  - Predictable "base load" power resources
  - Easily dispatched to balance load
  - Must be balanced every 4 sec
- Modern grid (sharing economy):
  - "Geographically-distributed" resources, including renewables and consumer rooftops
  - Dramatic increase of intermittent renewables – wind and solar – with high ramp rates.
  - Increasingly variable loads
  - Plus, major reductions in baseload power plants
  - And, still must be balanced every 4 sec
  - Marine renewables are more predictable and forecastable – approaching base load

State of California Role

- On May 12, 2016, California Governor Edmund G. Brown, Jr sent the U.S. Department of Interior a Request to Establish a Federal-California Marine Renewable Energy Task Force
  - Governor Brown's letter cited support for the California Wave Energy Testing Center (CalWave^{SM})
- Secretary John Laird of the California Natural Resources Agency has provided $125,000 of State cost share for the DOE CalWave^{SM} grant

CalWave℠ Partners

HUMBOLDT STATE UNIVERSITY

CAL POLY
Institute for Advanced Technology & Public Policy

VirginiaTech

UCDAVIS
CALIFORNIA WIND ENERGY COLLABORATIVE

SCHATZ ENERGY RESEARCH CENTER

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Sandia National Laboratories

EPRI ELECTRIC POWER RESEARCH INSTITUTE

COLUMBIA POWER TECHNOLOGIES
power from the next wave

ch2m

leidos

KEARNS & WEST

protean wave energy ltd

PG&E
Together, Building a Better California

GAVIN NEWSOM
LIEUTENANT GOVERNOR

CALWAVE℠

CAL POLY
SAN LUIS OBISPO

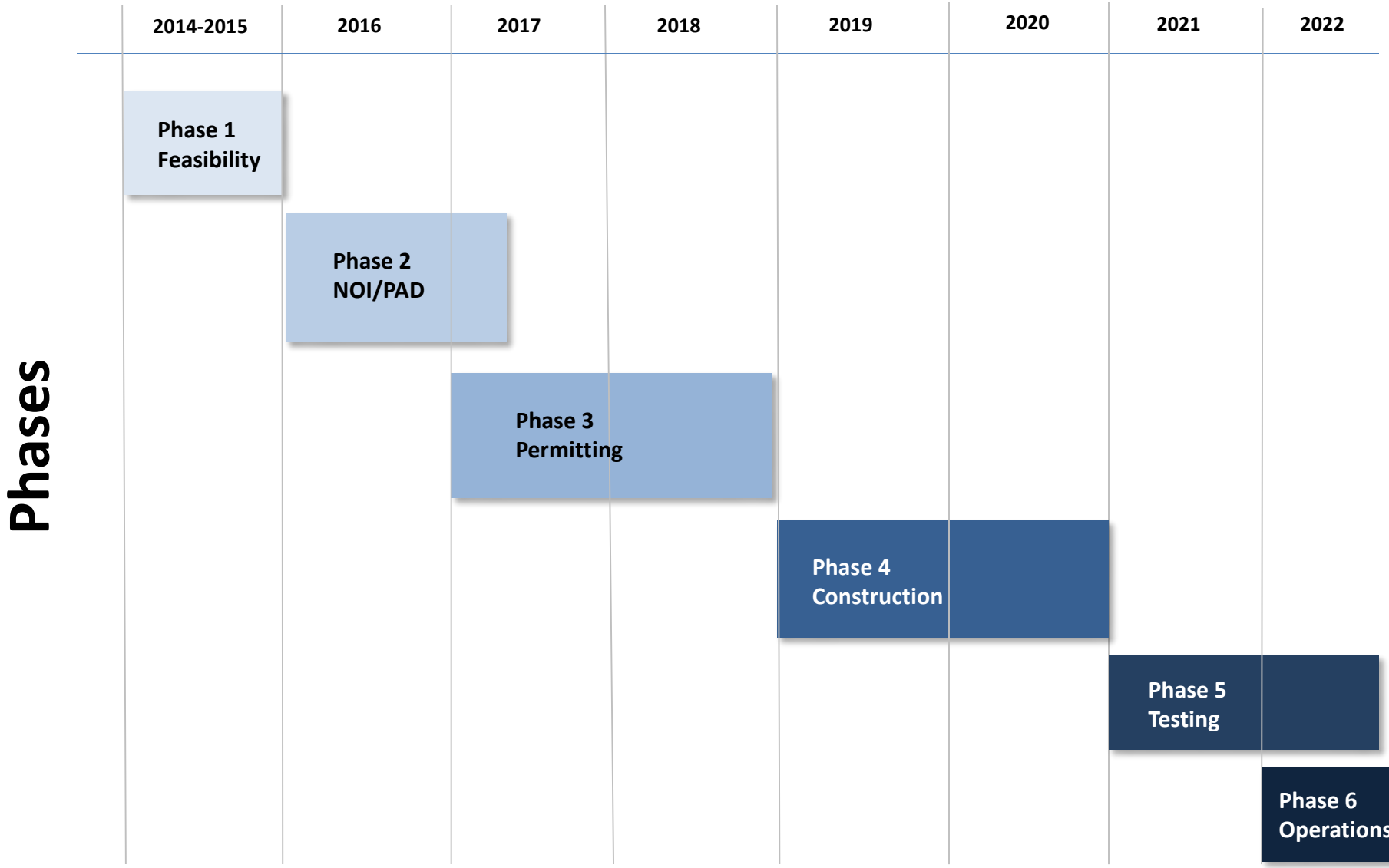
U.S. DEPARTMENT OF ENERGY

2015-2016 Stakeholder Engagement & Outreach Activities

- In 2015, Team held a public meeting in San Luis Obispo, CA & regulatory agency meeting in Camarillo, CA
- Team established a project website with map and comment form
- 2016 will include multiple regulatory agency meetings and establishment of a project Advisory Group

12

CalWave℠ Timeline



CalWave^{SM} System Design Concept

-Top-Level Requirements

-System Block Diagram

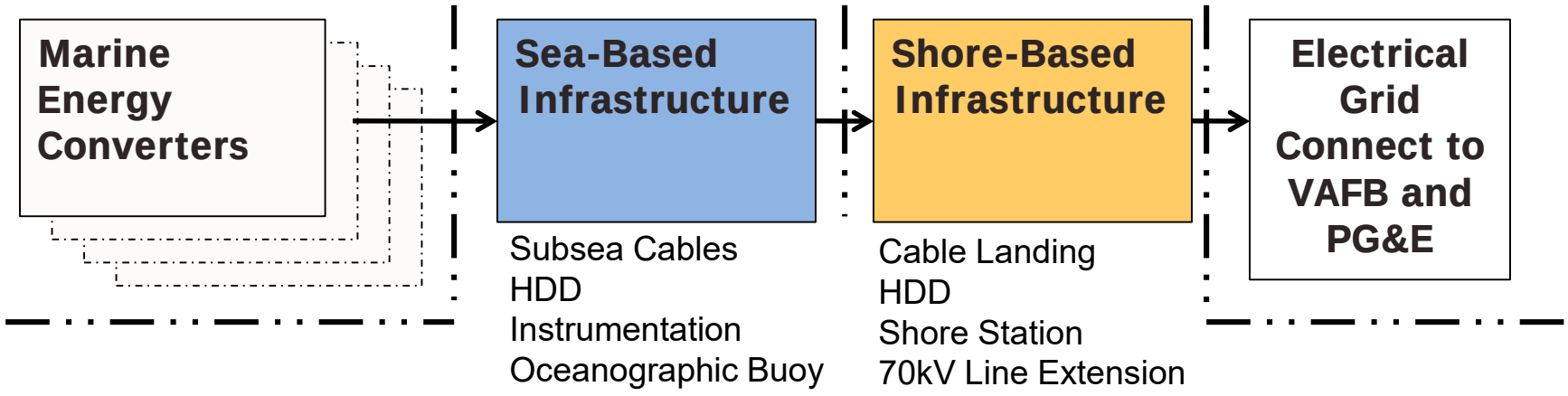
-Types of Wave Energy Converters

-Mooring and Anchoring

-Power Conditioning

-Grid Connection

-Base Facilities



CalWave^{SM} System Design

CalWave^{SM} will provide Test Center infrastructure that enables mature Marine Energy Converters (MECs), also known as Wave Energy Converters (WECs), to operate in open ocean fully-energetic conditions.

The CalWave^{SM} System design is:

"requirements-driven"

"technology-neutral"

"vendor agnostic"

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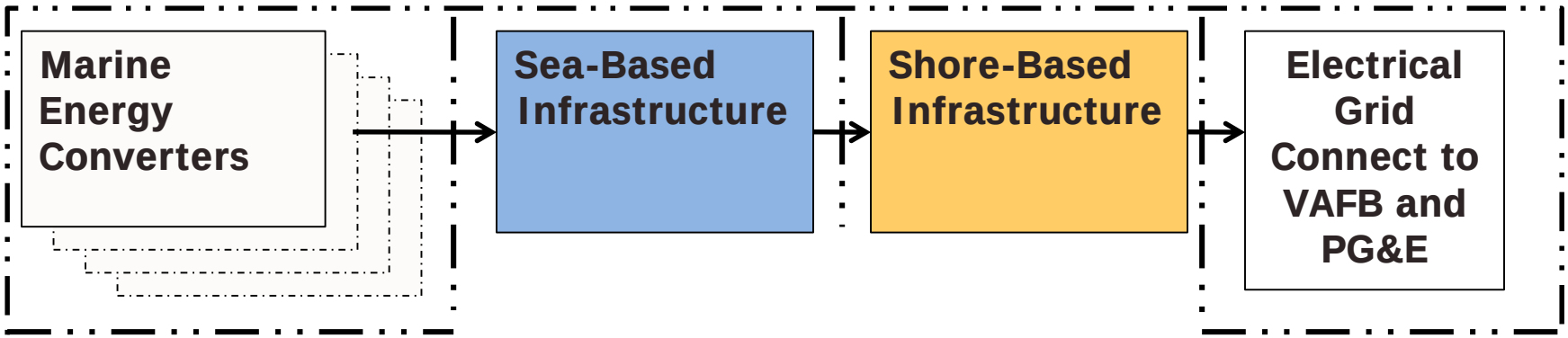
CalWave^{SM} System Block Diagram



CalWave^{SM} Functional Task Areas

Design & Planning	Resource adaptation, conceptual design, preliminary design, prototyping, detailed design, implementation planning
Regulatory & Permitting	Site evaluation and selection, environmental analysis, outreach, and agency interaction
Implementation, Operations and Maintenance	Procurement, fabrication, logistics, installation, commissioning, project operations, maintenance, monitoring, adaptive management, and decommissioning
Financial & Business Management	Business planning, finance, project management, cost accounting and control
Marine Energy Converters (MECs) interface	MEC technology development, installation planning, device operation and maintenance.

Wave Energy Converters (WECs)

CalWave^{SM} will host mature WECs.

WEC developers will provide the WEC devices, with properly designed mooring and anchoring, dynamic umbilical cables with dry-mate connectors, and power conditioning modules ashore.

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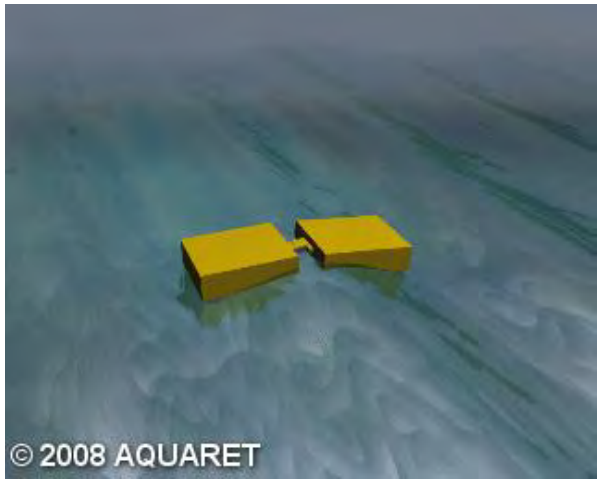
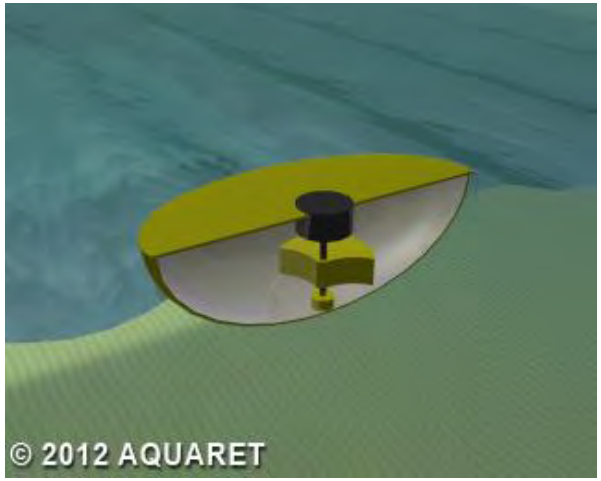
Overview of Wave Energy Converters

- Linear Attenuator

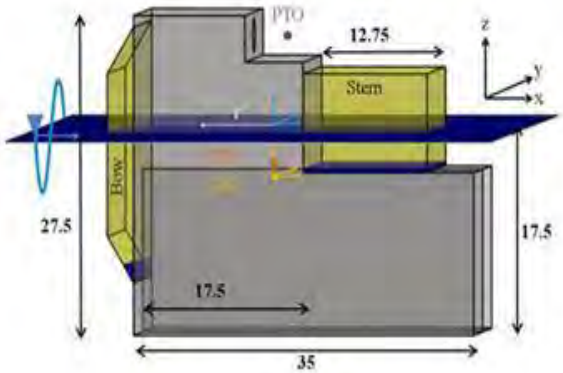


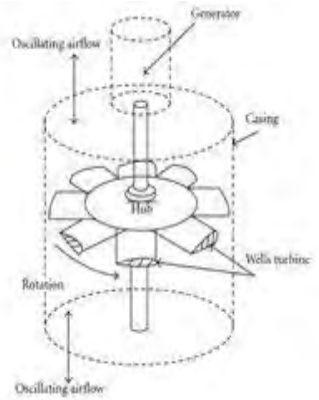
- Point Absorber

- Rotating Mass



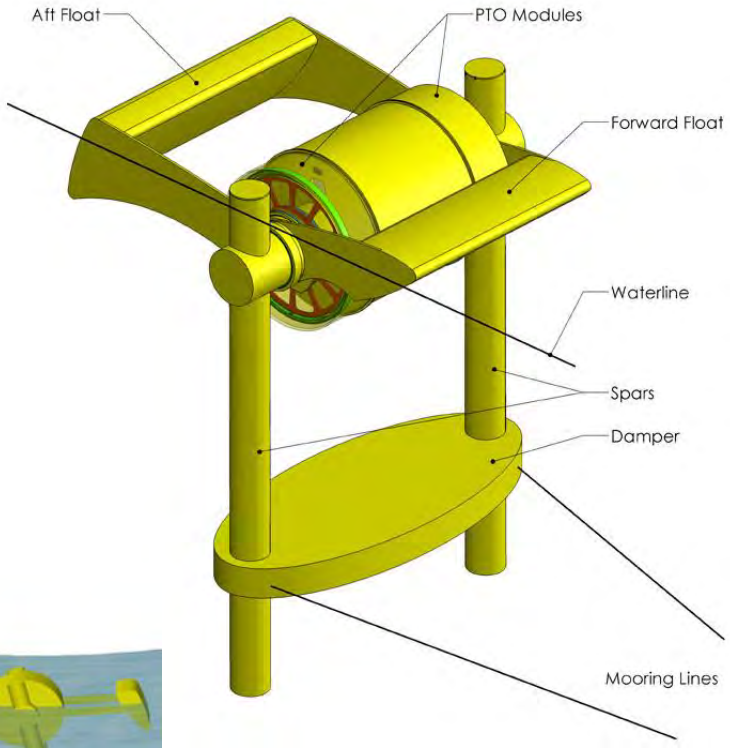
- Floating Oscillating Water Column

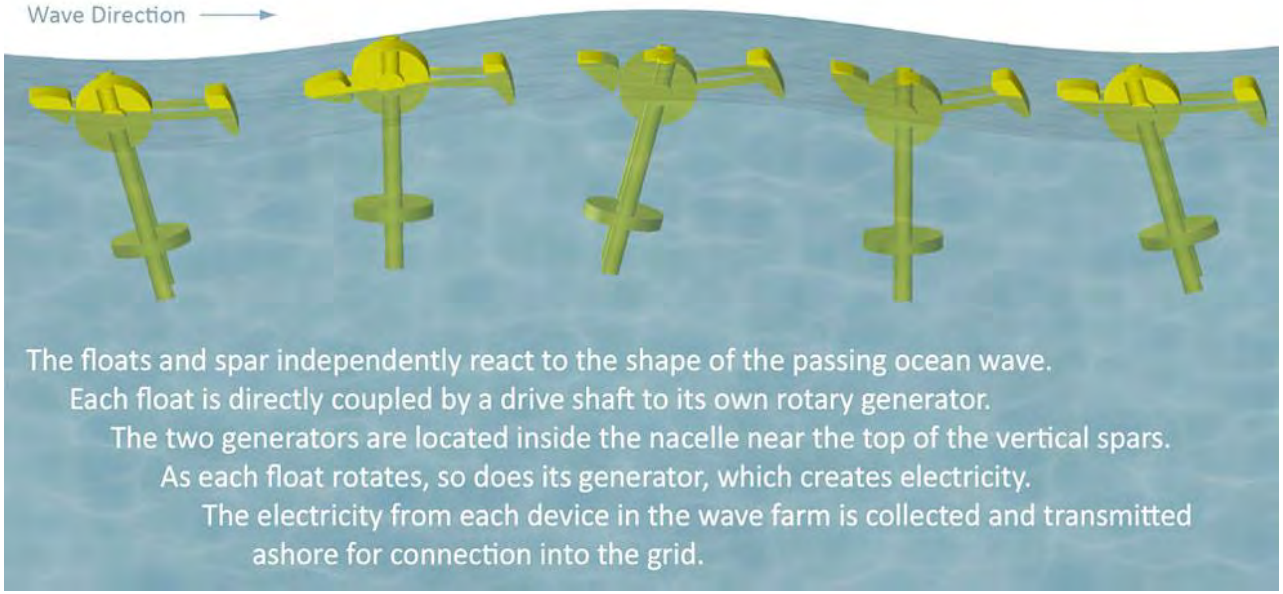




Examples of Wave Energy Converters

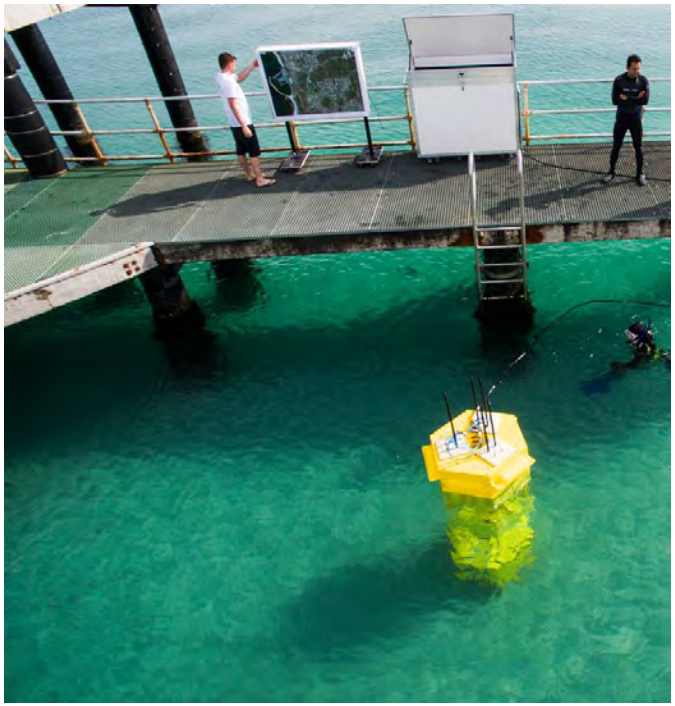
- Columbia Power StingRAY point absorber

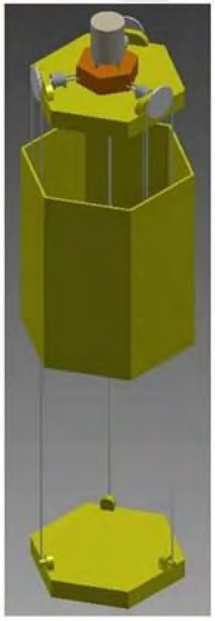


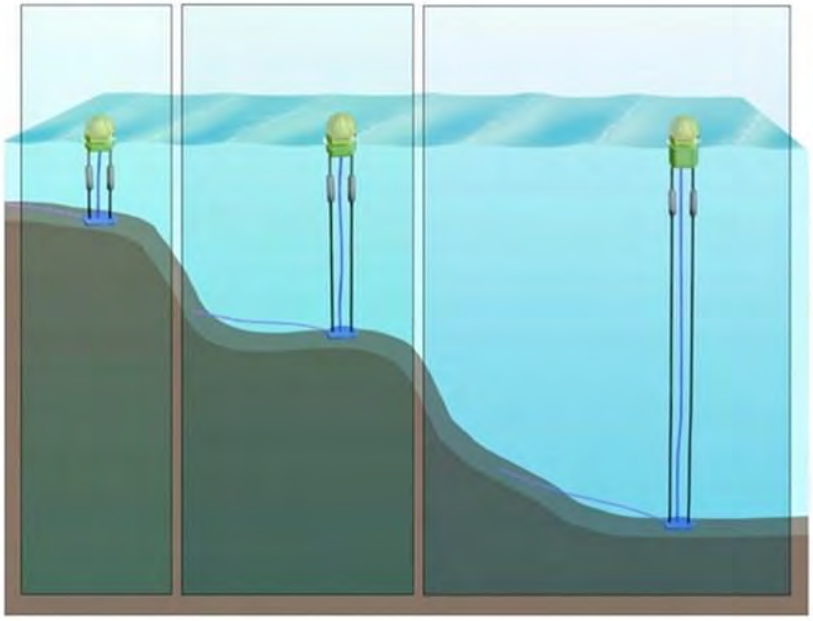


Examples of Wave Energy Converters

- Protean™ point absorber

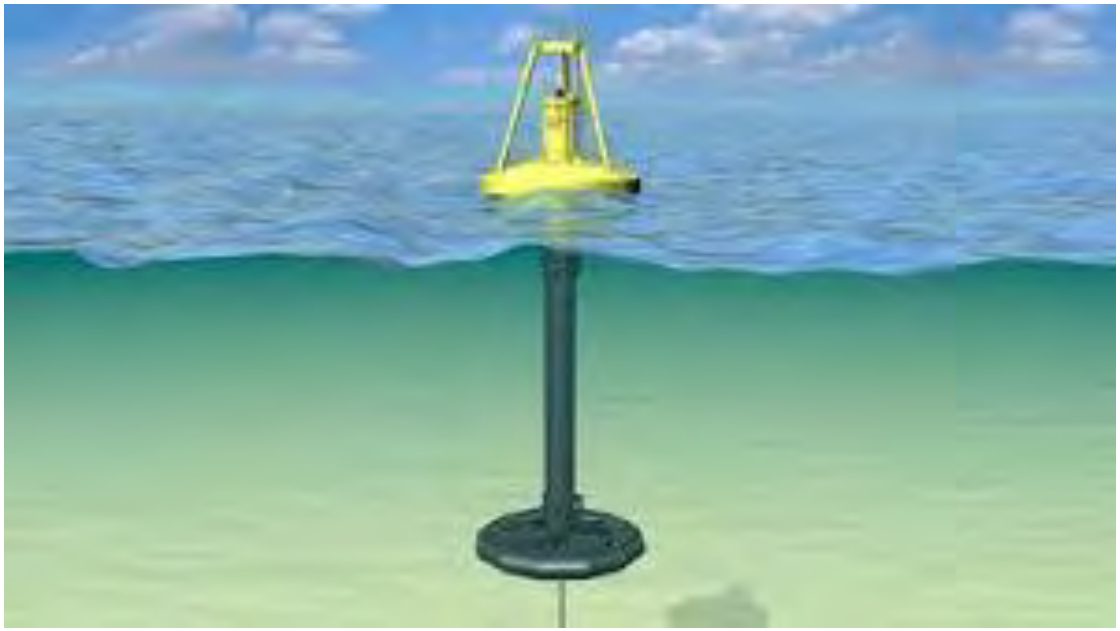






Examples of Wave Energy Converters

- Ocean Power Technology point absorber



Examples of Wave Energy Converters

- Fred Olsen BOLT Lifesaver point absorber

- Azura: multi-mode, point absorber

- Seatricity Oceanus 2 Pump Type point absorber

- Ocean Energy Floating Oscillating Water Column

Anchoring & Mooring Systems

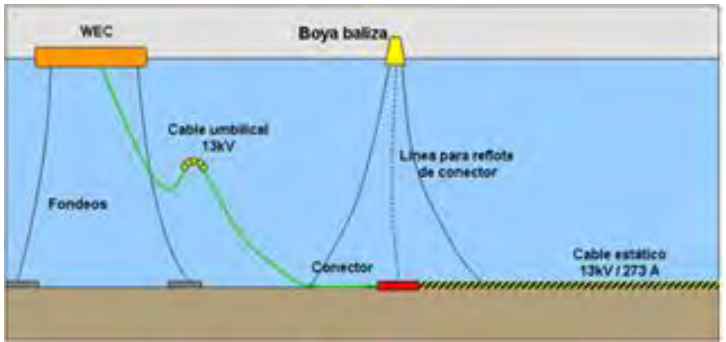
WEC Developers will provide their own properly engineered mooring, anchoring, dynamic cables and riser cables to ensure a holistic system design.

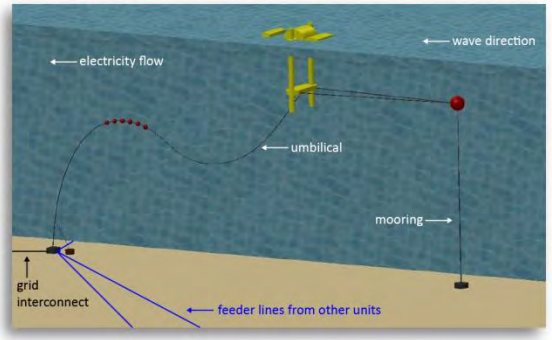
Moorings range from classic three point catenary (slack moors), with "scope" of 3 to 6 times depth, and conventional clump, drag or hybrid anchors.

Proven mooring alternatives: single point, semi-taut, or taut moor that require vertical reaction anchors and can reduce scope to 1 to 2 times water depth. Less space. More expensive.

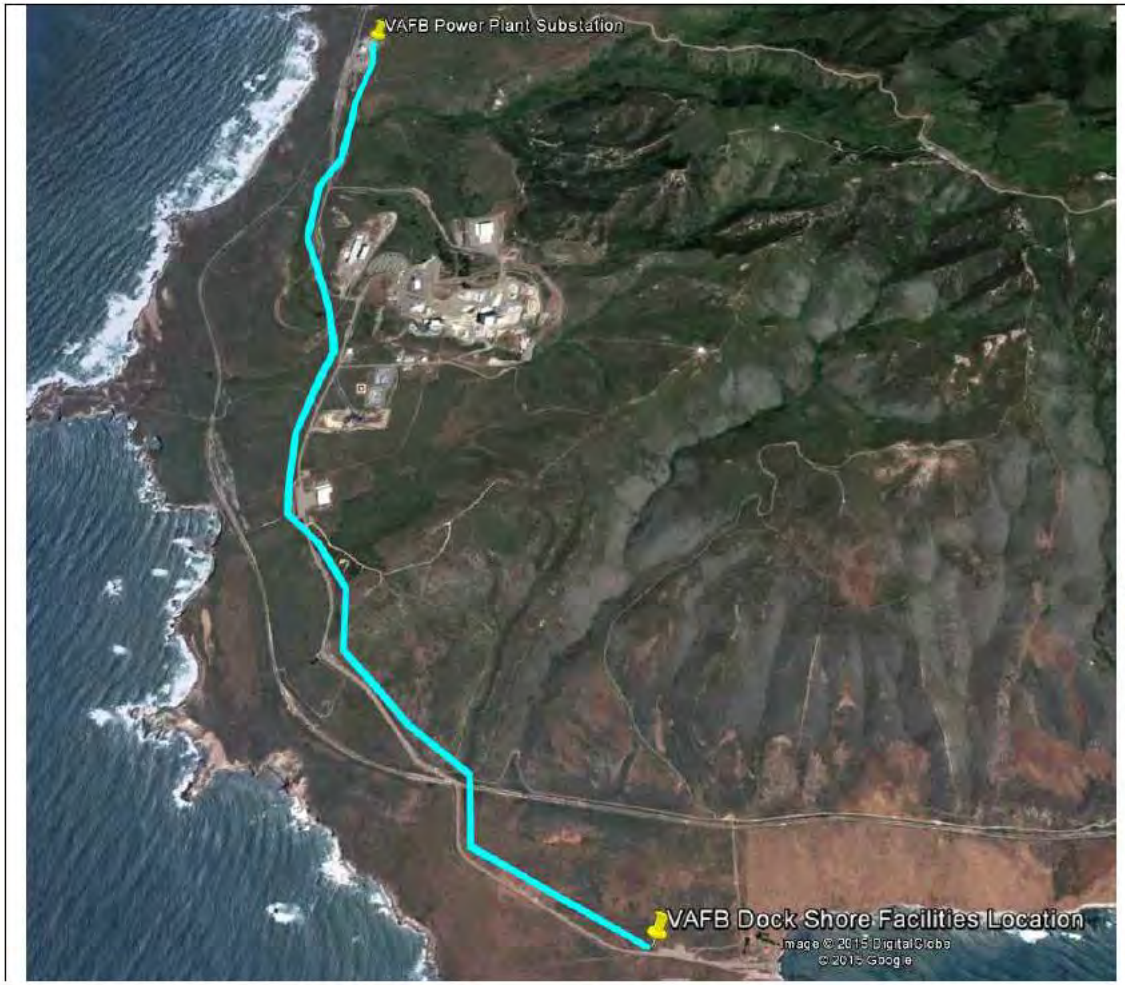
Proven anchoring alternatives: clump, drag, and hybrid anchors with slack moors. Vertical reaction or embedment anchors enable semi-taut or taut moor.

Mooring lines: vary in composition and size, depending on the application.
The range of materials includes synthetic line, wire rope, and chain.
The range of mooring line **diameters** is 2 inches to 6 inches. (Note about mooring line circumference)





CalWave^{SM}-VAFB Electrical Grid Interface



DESCRIPTION:
NOTIONAL 70kV EXTENSION LINE ROUTE TO VAFB SUB-STATION N

APPROX. LENGTH OF EXTENSION LINE = 4 MILES

N

CALWAVE CAL POLY

VANDENBERG AFB: CAL POLY CALWAVE PLANS

DRAWING TITLE: SITE MAP 2

REVISION DATES:

SHEET NO.: C-2

DRAWN BY: KYLIN VAIL

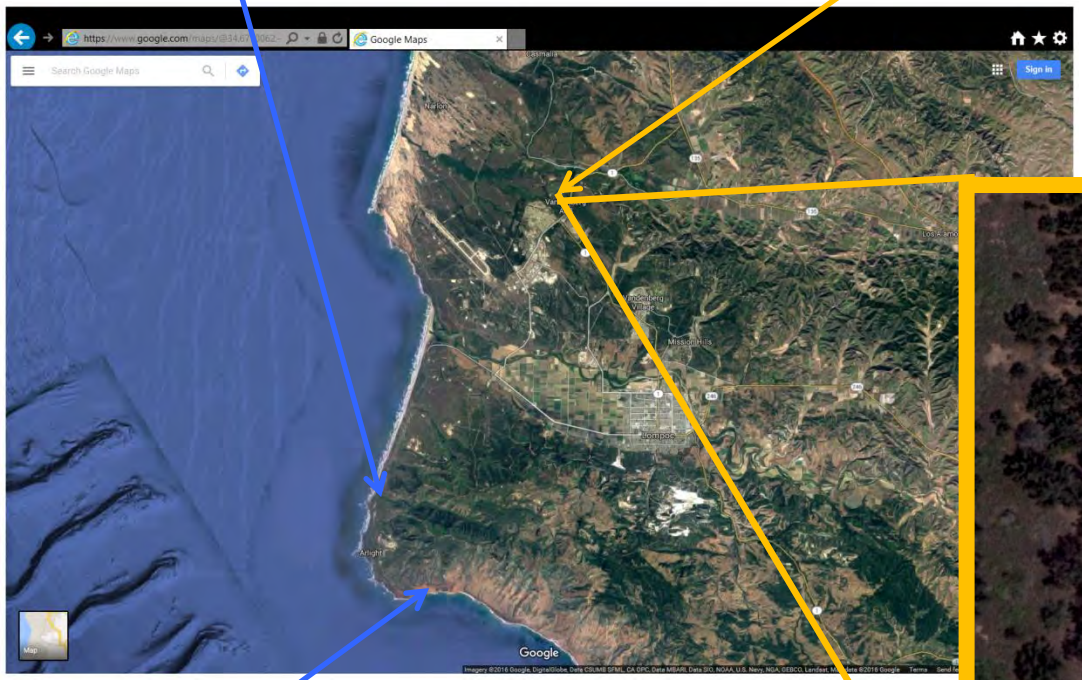
DATE: 5/28/15

SCALE: SEE MAP

VAFB-PG&E Electrical Grid Interface

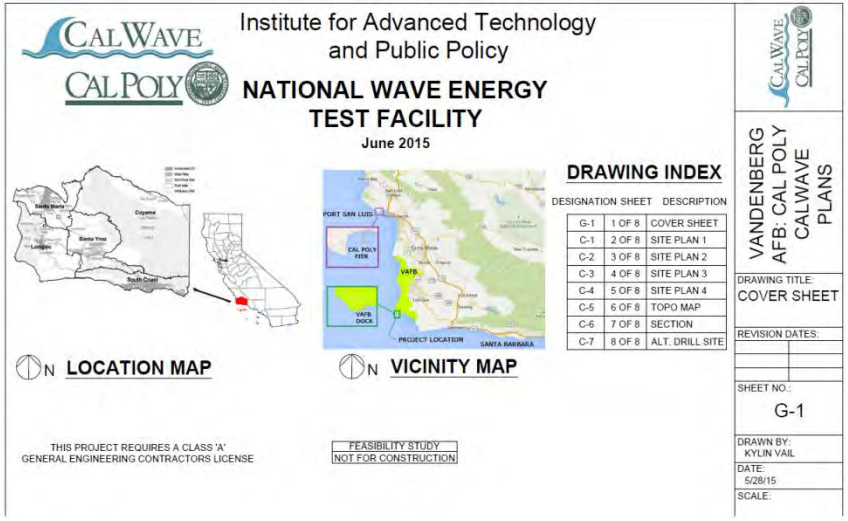
VAFB Substation N

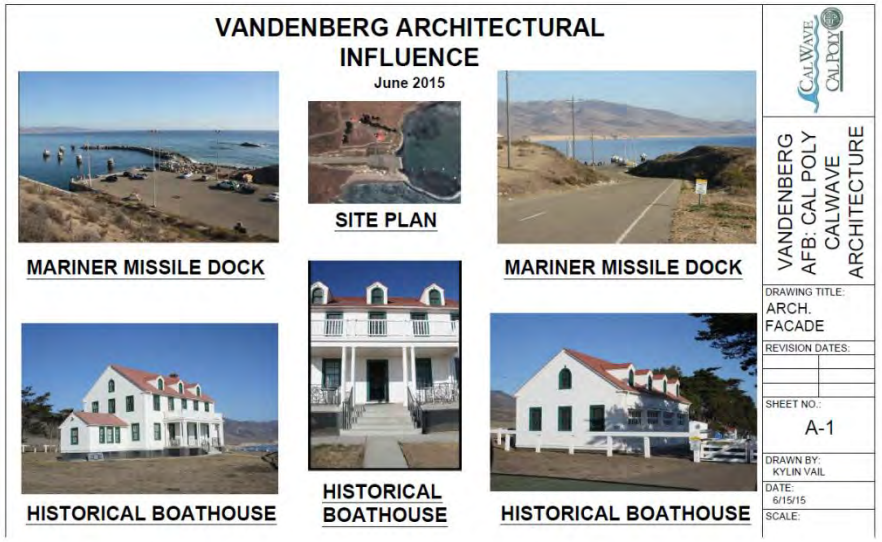
PG&E Substation serving VAFB

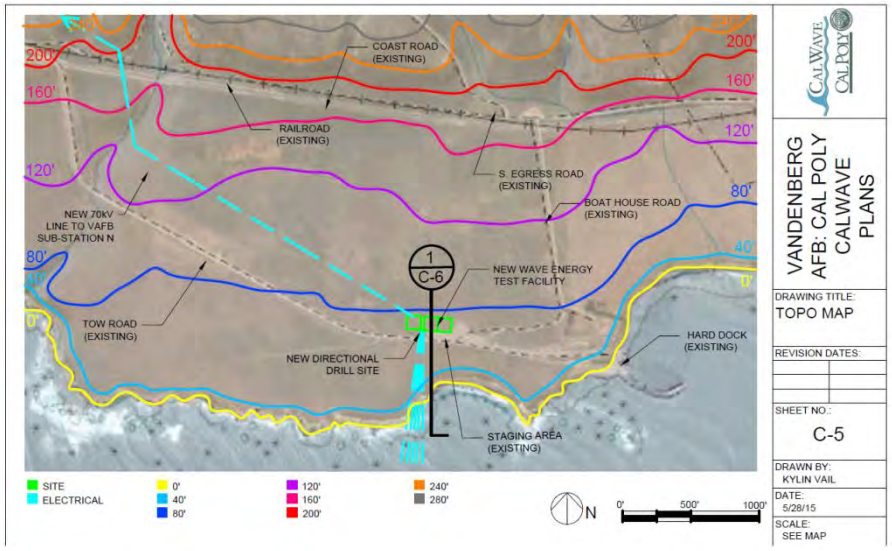


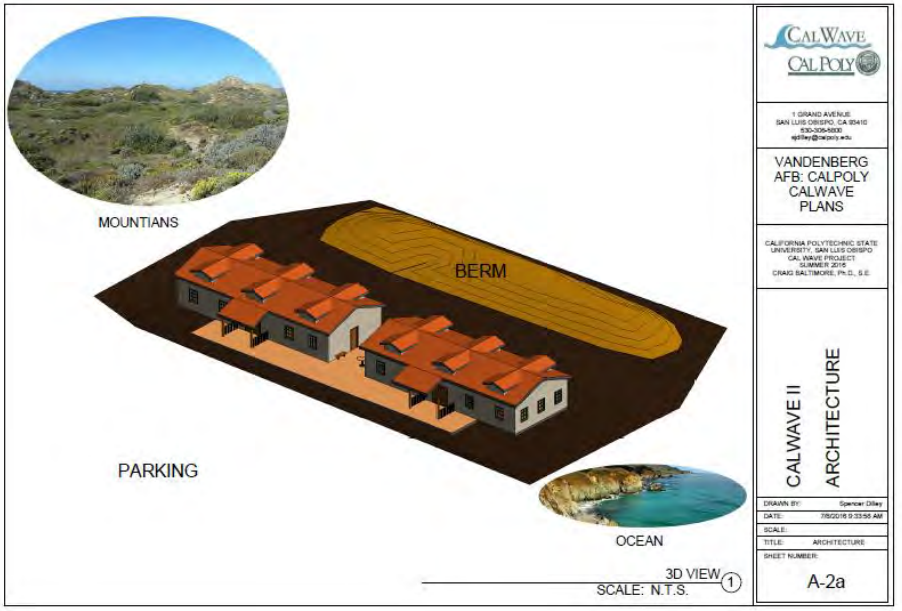
Vandenberg Dock

Vandenberg Base Facilities Interface



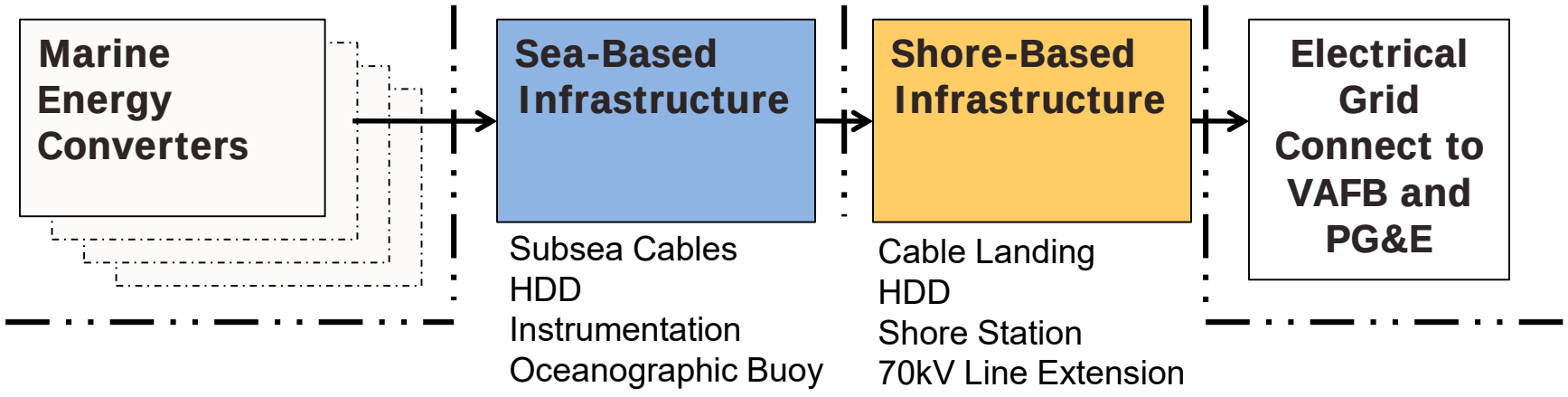




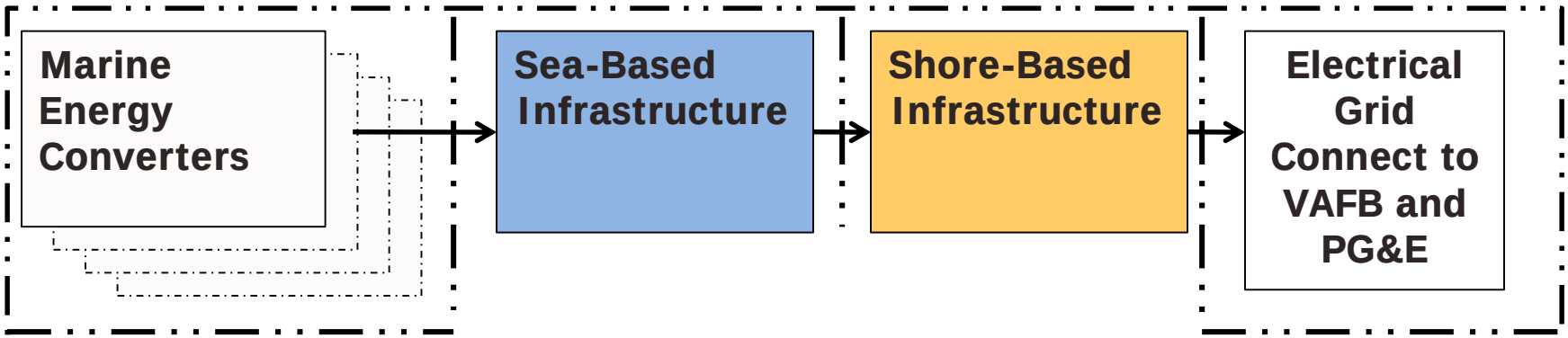


Draft CalWave^{SM} Project Description

- CalWave^{SM} Offshore Sites in BOEM Lease Blocks
- CalWave^{SM} System Design Concept
- CalWave^{SM} Subsea Cable Routes
- CalWave^{SM} Onshore Siting



CalWave^{SM} System Block Diagram



CalWave^{SM} Functional Task Areas

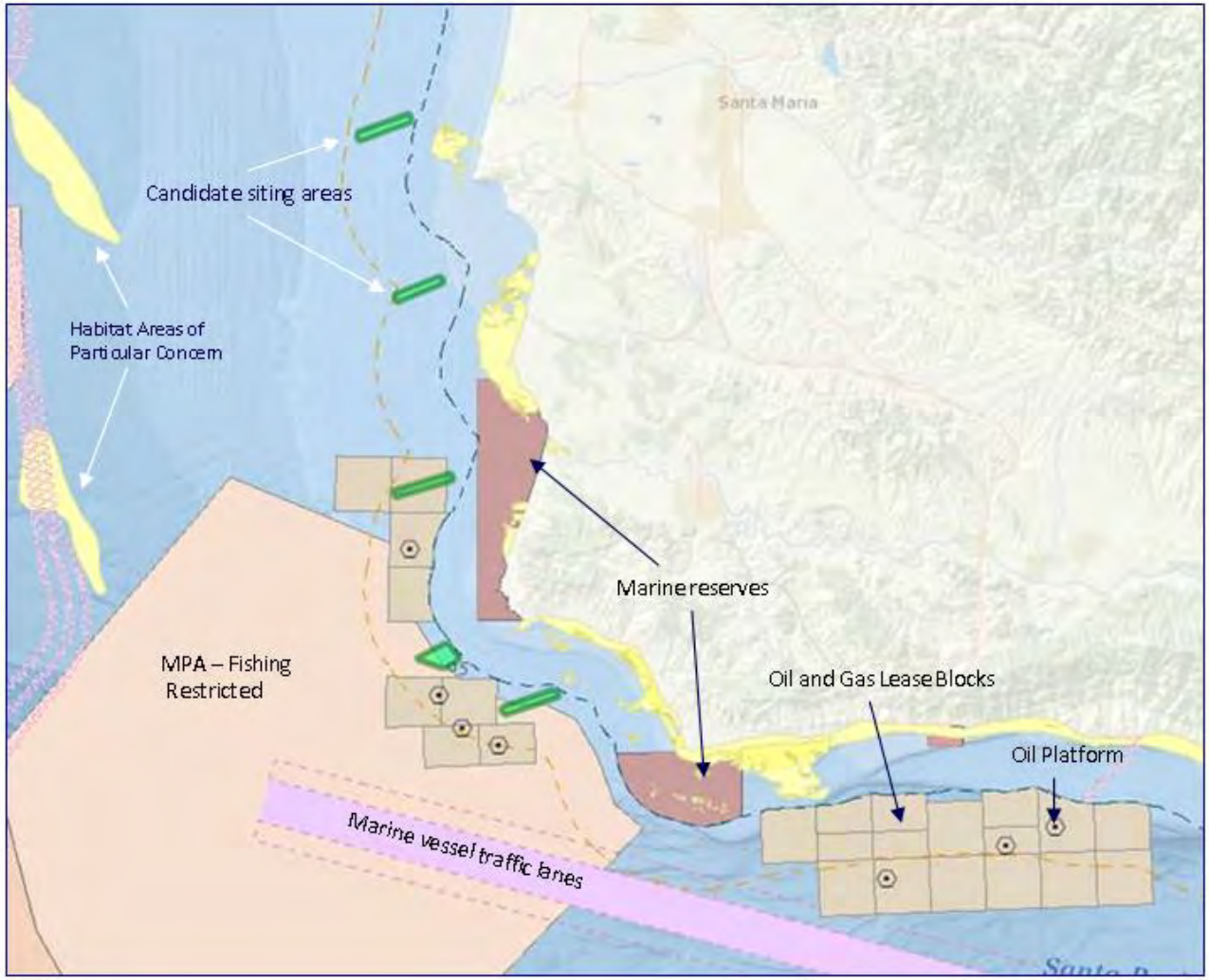
Design & Planning	Resource adaptation, conceptual design, preliminary design, prototyping, detailed design, implementation planning
Regulatory & Permitting	Site evaluation and selection, environmental analysis, outreach, and agency interaction
Implementation, Operations and Maintenance	Procurement, fabrication, logistics, installation, commissioning, project operations, maintenance, monitoring, adaptive management, and decommissioning
Financial & Business Management	Business planning, finance, project management, cost accounting and control
Marine Energy Converters (MECs) interface	MEC technology development, installation planning, device operation and maintenance.

Proposed CalWave^{SM} Sites

In April 2015, the CalWave^{SM} Team presented a concept with five alternative offshore sites & four alternative cable landing and substation sites.

Since then, the proposed project description uses BOEM lease blocks and the south-based cable landing and substation site.

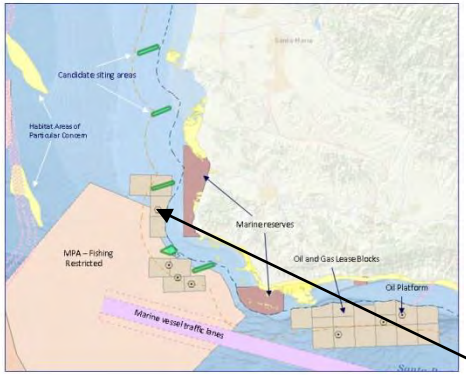
Resources and Siting Considerations



Source: Bureau of Ocean Energy Management, MarineCadastre.gov National Viewer, 2014

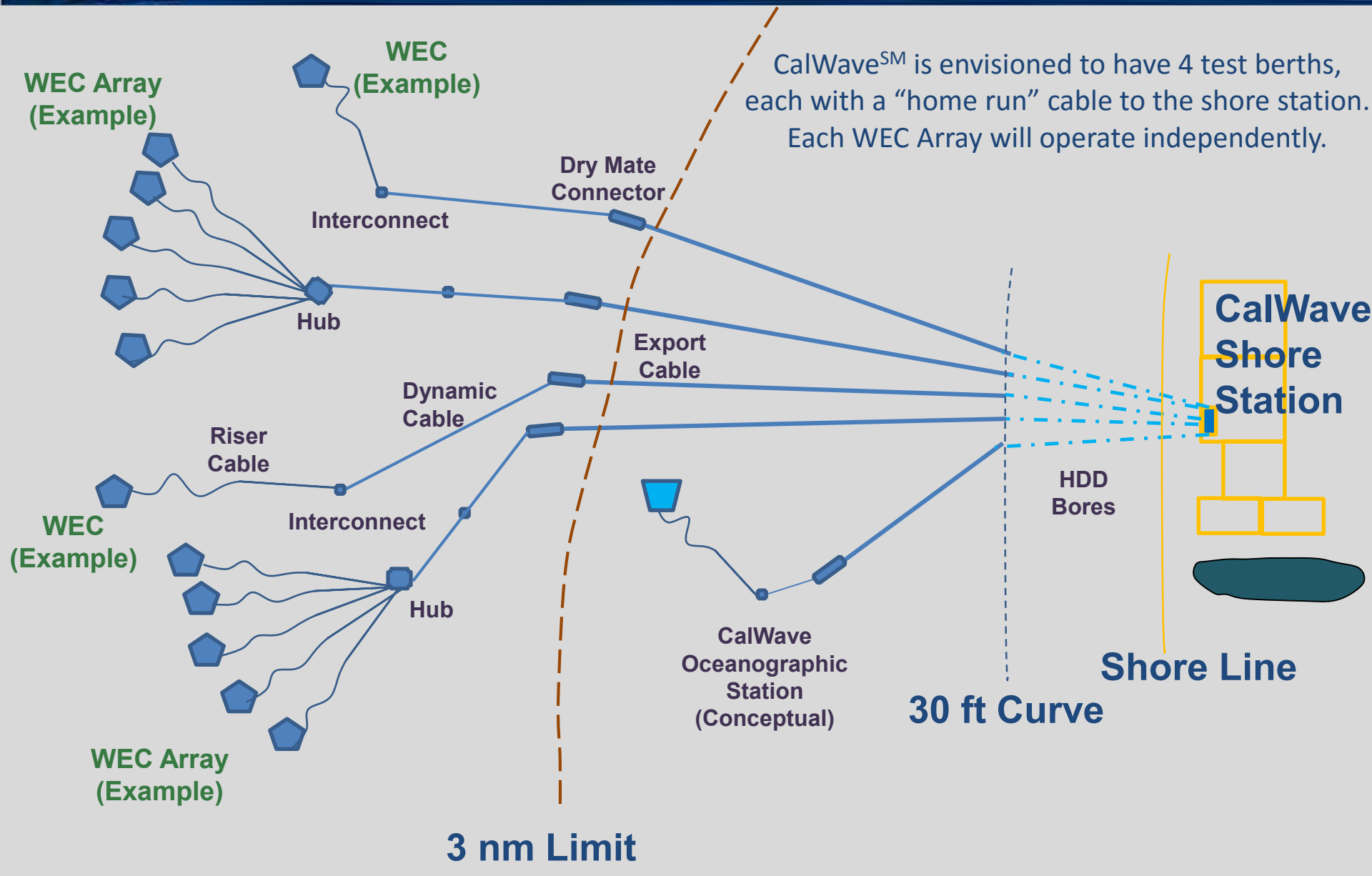
Potential Use of Offshore Infrastructure

Platform Irene has an existing 25MW subsea cable to Surf Substation



- In concept, the WEC array dynamic cables would connect to Platform Irene.
- Looking forward, the collaborative use -- or repurposing -- of offshore oil & gas platforms would provide offshore substations.
- Some of these platforms have existing cables to shore.

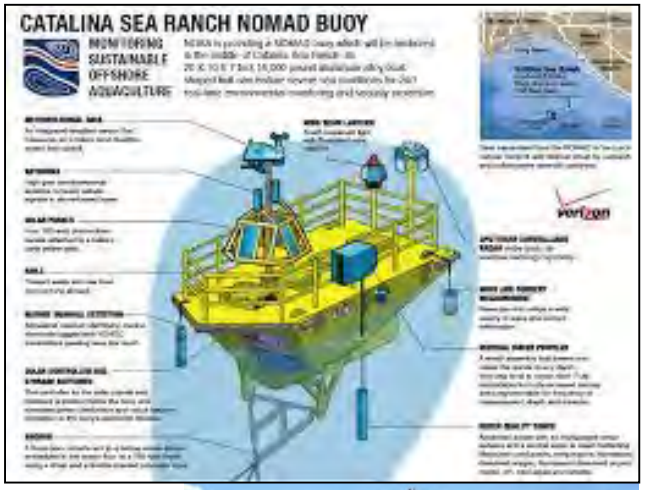
CalWave^{SM} System Concept



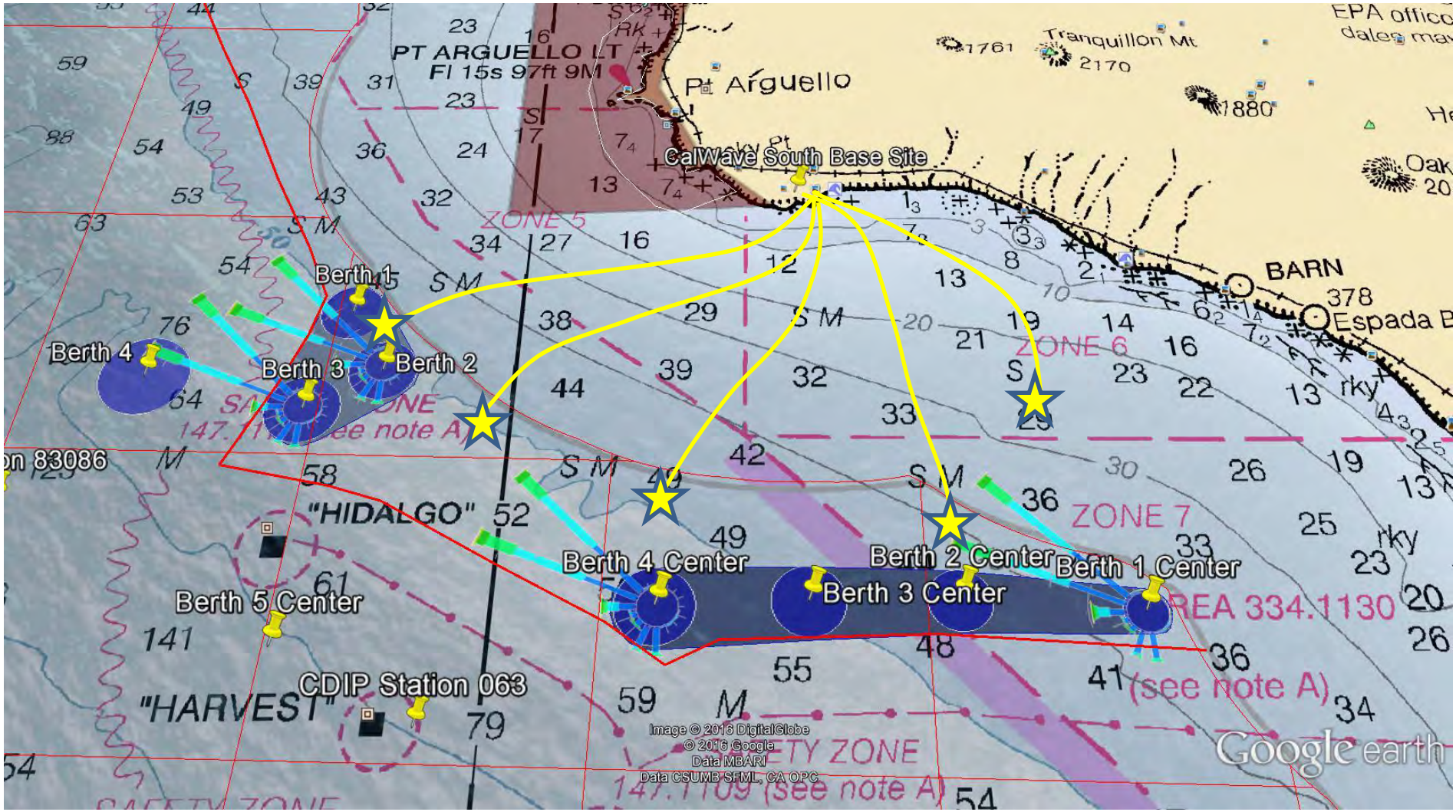
CalWave^{SM} Oceanographic Station Concept

The CalWave^{SM} Team is considering an oceanographic buoy south of VAFB dock, potentially in state territorial waters.

- The buoy would allow measurement of wave resource and meteorological instrumentation, telemetry relay, and serve as the terminus for the spare cable.
- Would allow WEC checkout enroute to the open ocean Test Berths.
- Options include surplus NOAA buoys, such as a 10m NOMAD, 12m discus, or 10m discus.
- Intention: Work with Scripps, NOAA, USC, IOOS, and WEC developers to explore requirements and alternatives.



Conceptual Cable Routes



West Cable

Southwest Cable

South Cable

Southeast Cable

CalWave Oceanographic Station Cable

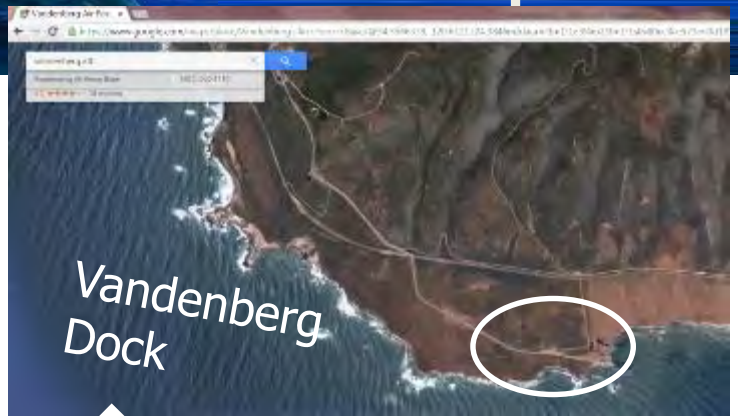
Onshore Cable Landings

The Feasibility Study identified South Base Site that leverages existing roadways, staging areas, 12kV line, and 70kV substation.

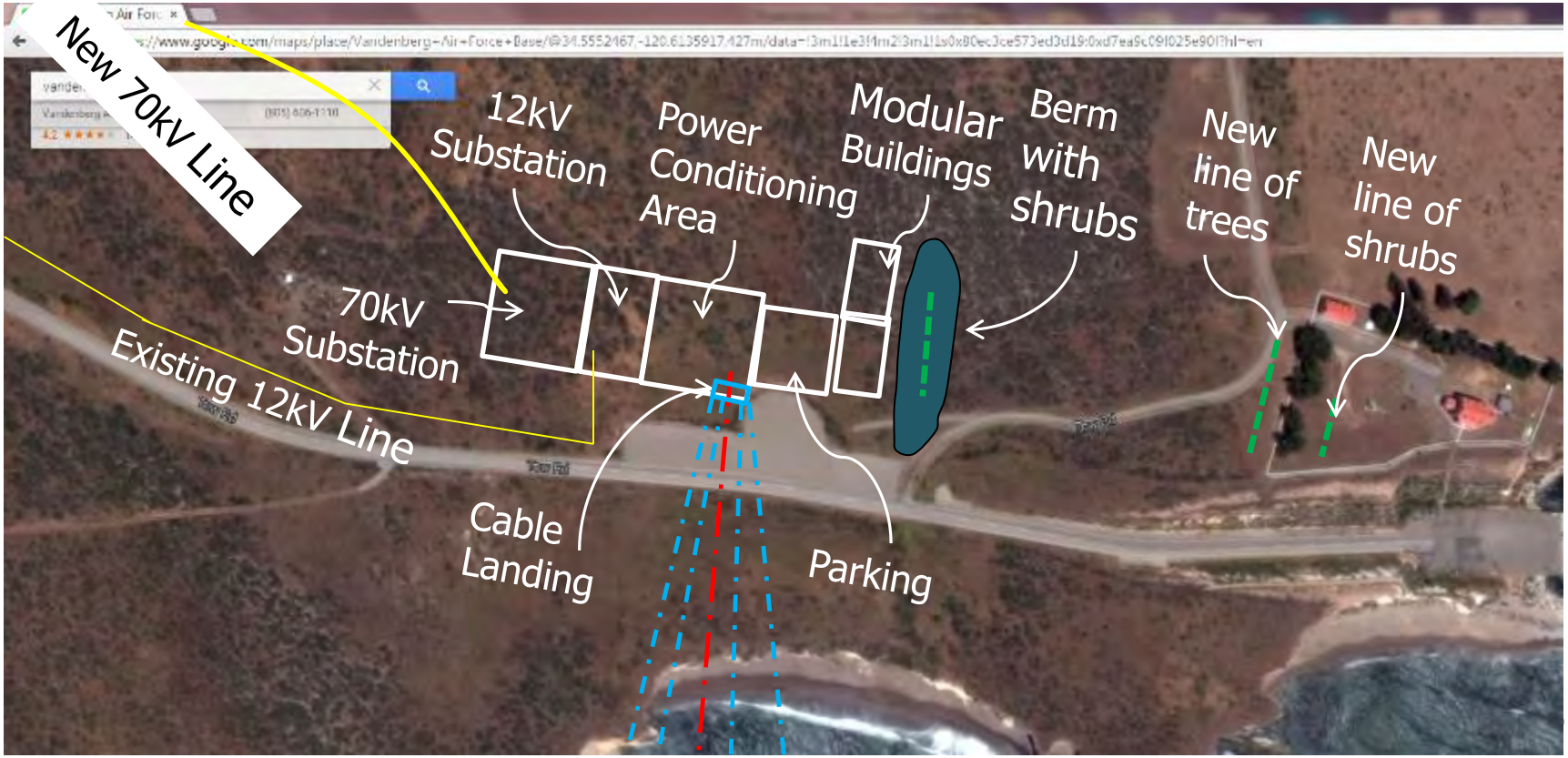
CalWave^{SM} Systems Approach:

- Establish shore station
- Horizontal Directional Drilling (HDD) from shore
- Deploy cable ship, pull export cables ashore from HDD "daylight" ~30fsw
- Then surface lay export cables (or bury if required) from ~30ft to ~4nm
- WEC Developer responsible for dynamic umbilical cable to test berth site
- WEC developer responsible for riser cables
- Connect subsea cable to WEC array
- Connect subsea cable to WEC developer's power conditioning equipment
- WEC developer responsible for power conditioning to meet grid integration requirements

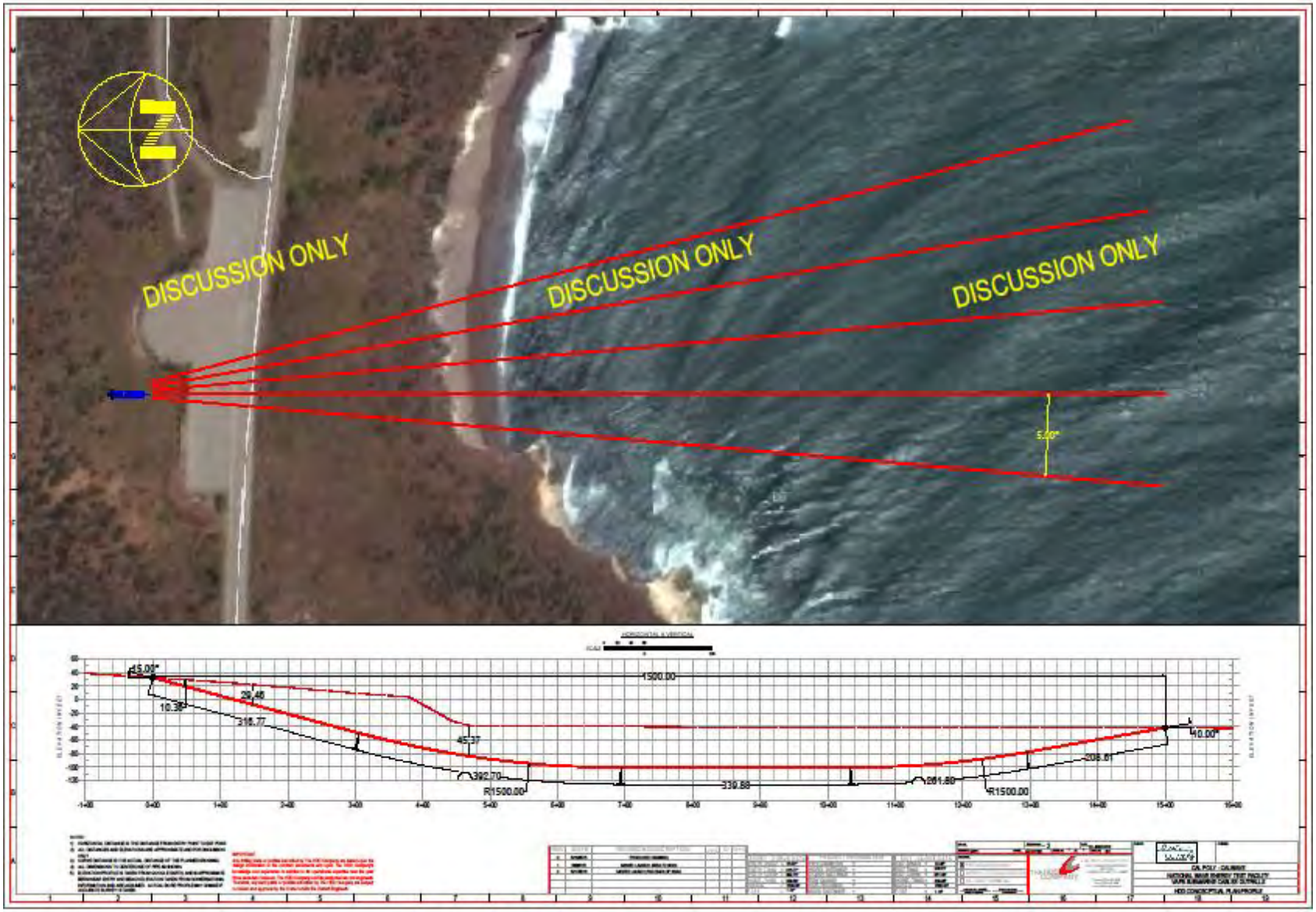
Conceptual Shore Station Site Plan



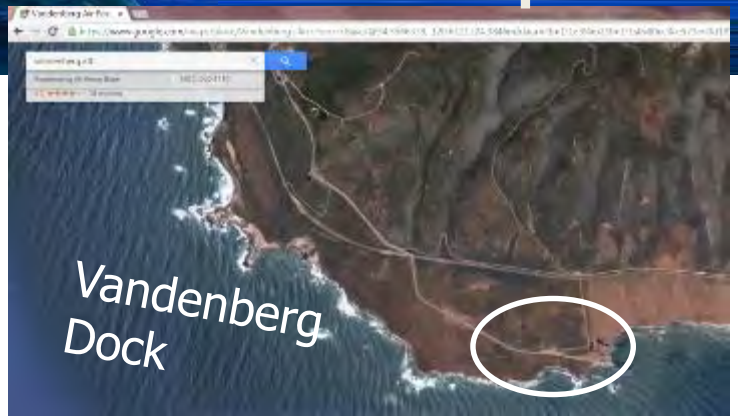
Primary HDD Upland Launch Location



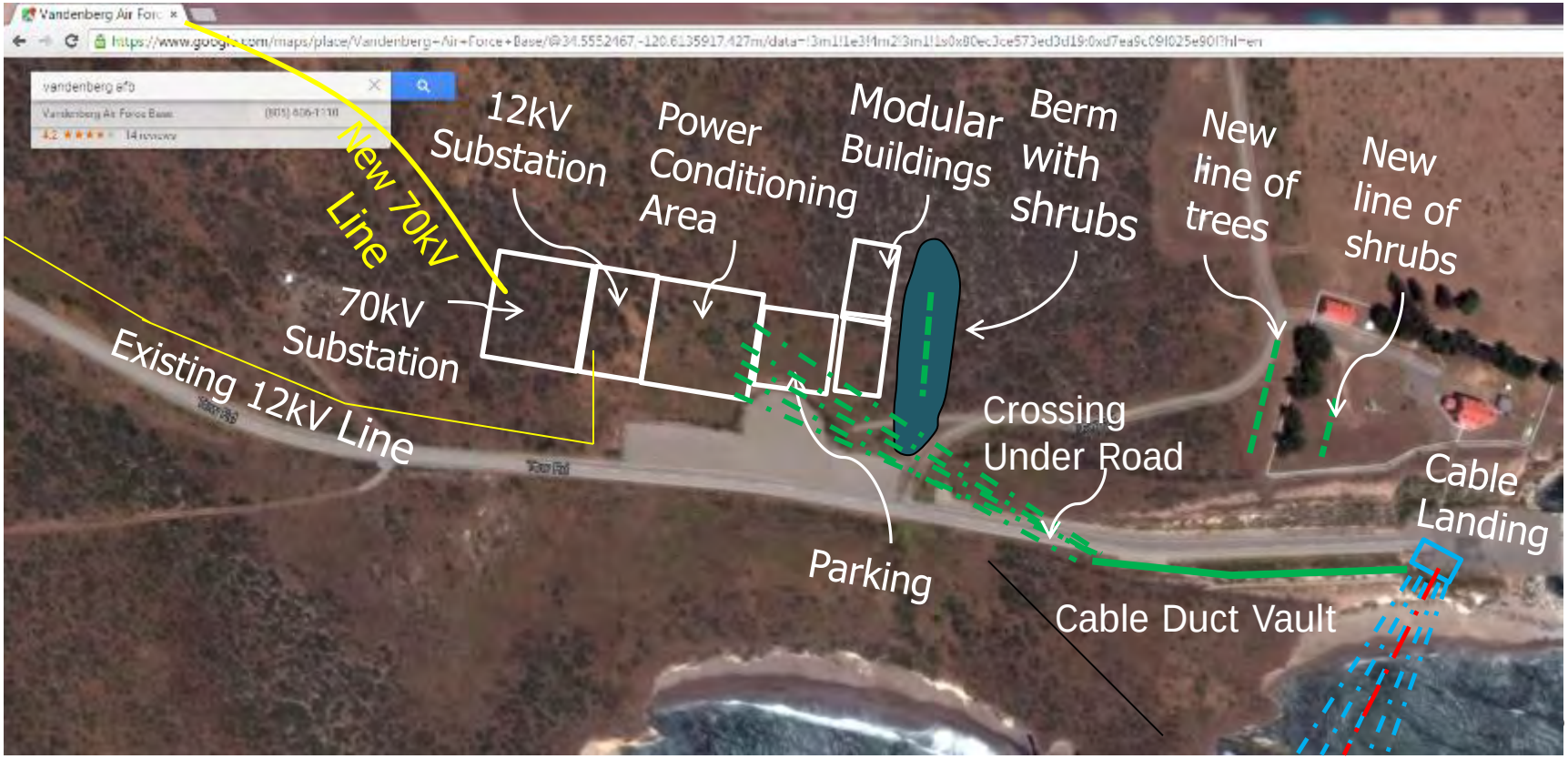
Onshore HDD Concepts - Upland



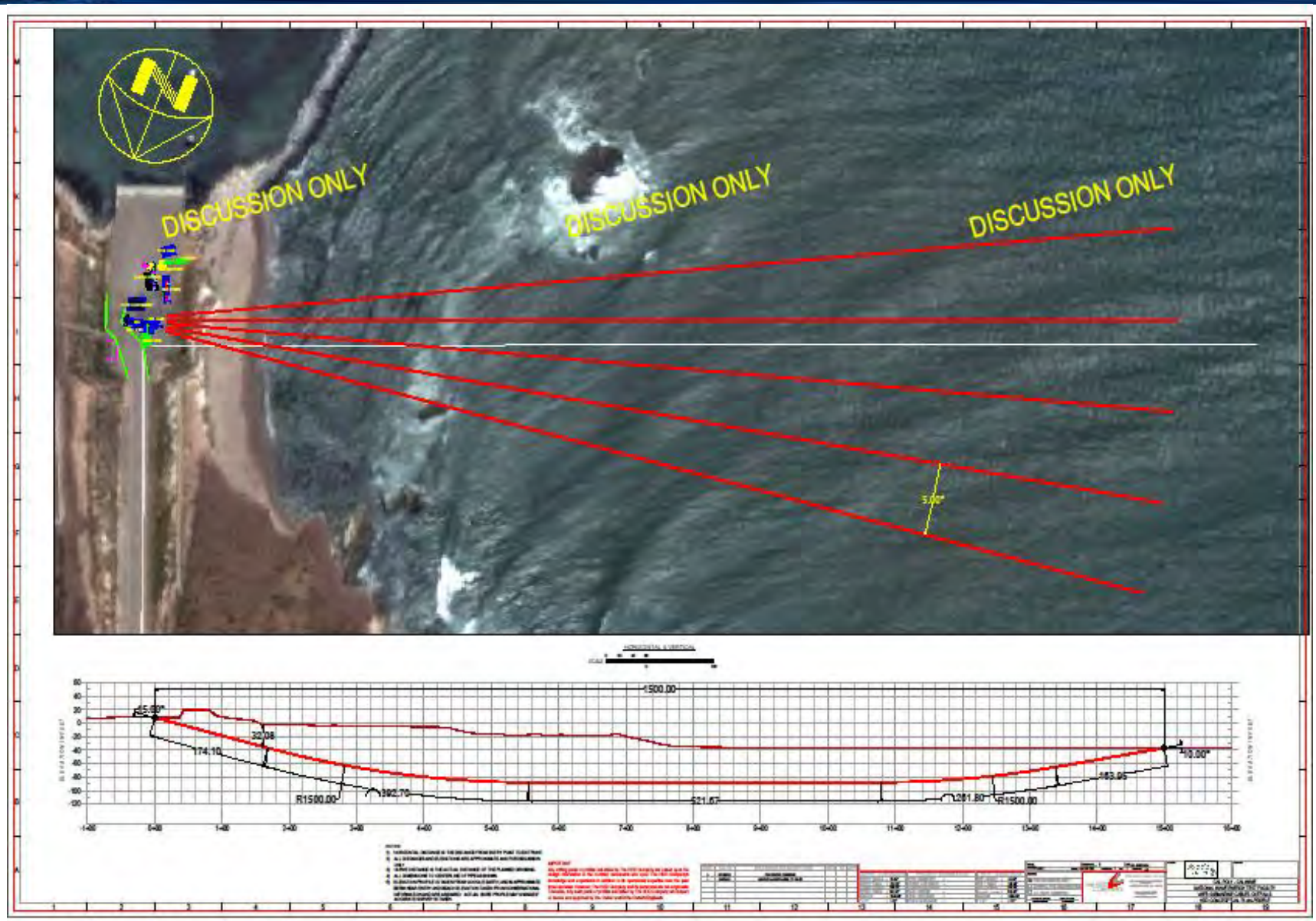
Conceptual Shore Station Site Plan



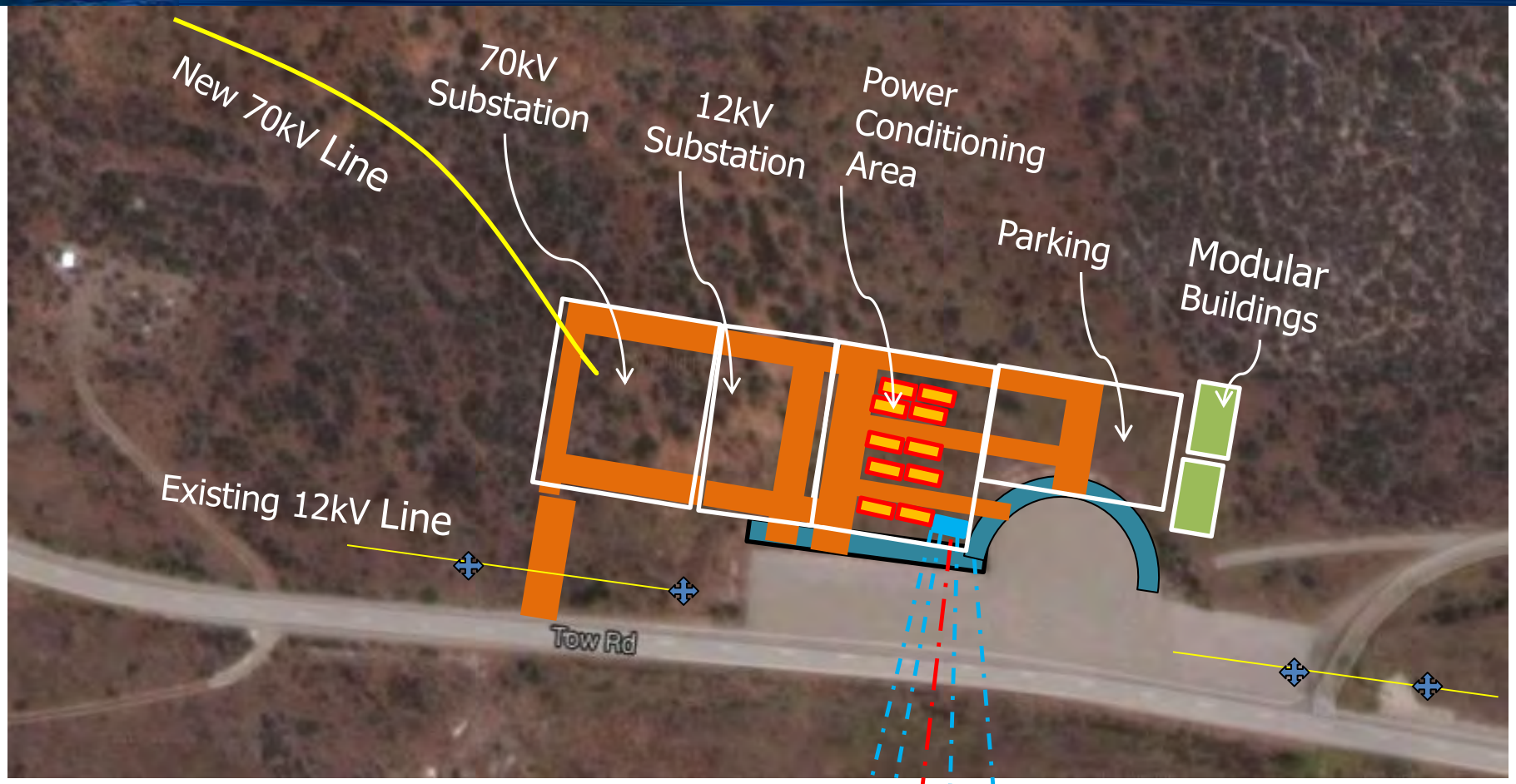
Alternate HDD Dock Launch Location



Onshore HDD Concepts - Dock



Conceptual Shore Station Site Plan



Two (2) 40 ft ISO Containers per circuit

Parking/Drainage Buffer

Suitable for trucks

Onshore HDD Concepts

Horizontal Directional Drill Equipment Setup

Shore Station Topography

General Notes:

Survey Basis: The Horizontal coordinate system is NAD83, Realization 2011 Epoch 2010.00 California State Plane Zone 5 (405). The orthometric heights are based on NAVD88. Units are U.S. Survey Feet.
This Survey is based on OPUS Static Positioning of Point 5. RTK Checks were made on PID DZ1221 and DZ0837. Control Information is shown below.

Control Points:

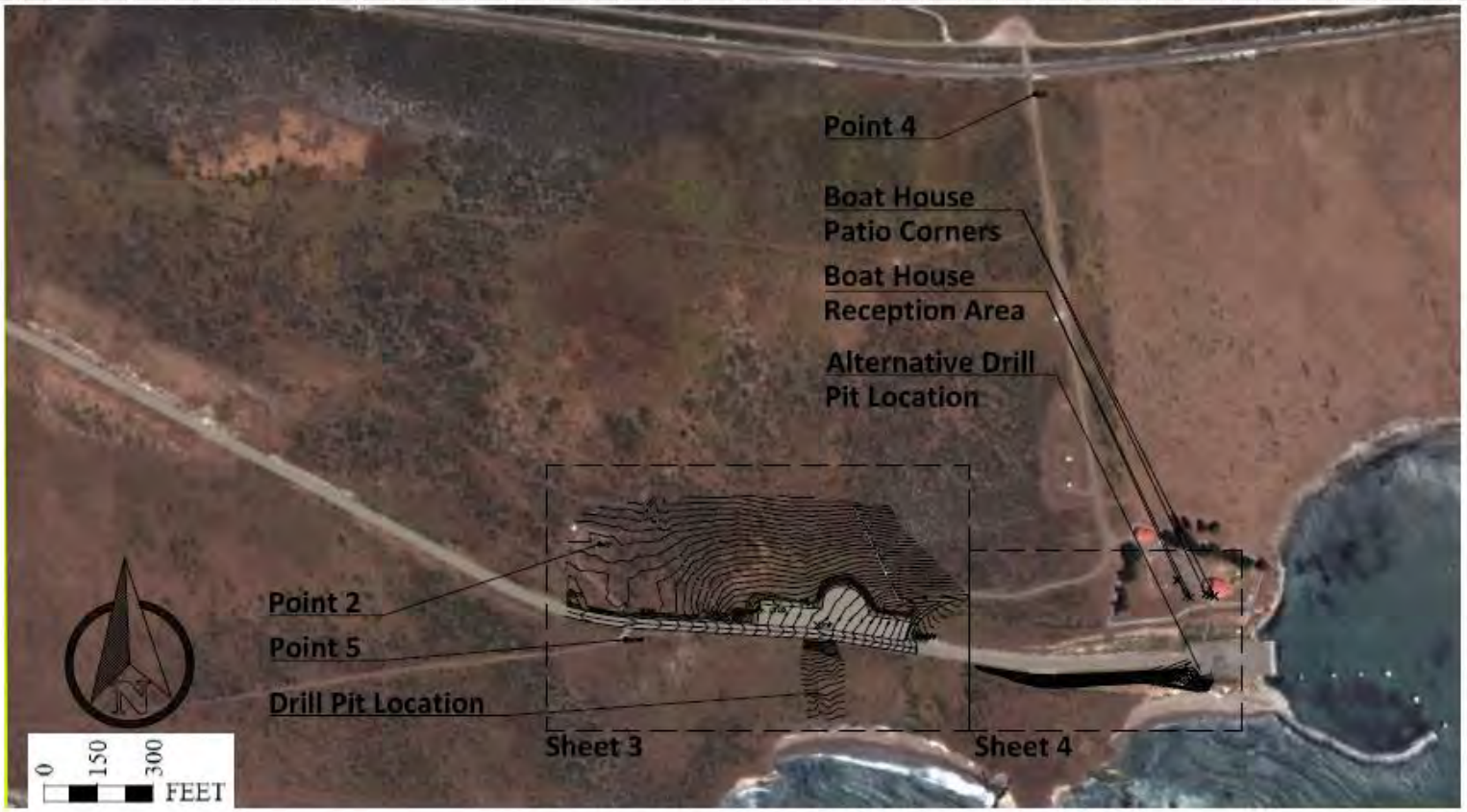
Point ID: 2
Description: PID DZ1221 Vandenberg VLBI STA 7223 3 1/2" Survey Disk stamped VLBI STA 7223 1983 DET 1 G SS

Measured (sFt):		Published (sFt)
North:	2,035,003.008	2,035,003.19
East:	5,773,985.00	5,773,984.99
Ortho Ht:	80.77	80.88

Point ID: 4
Description: PID DZ0837 N 1214 Bench Mark Disk Stamped N 1214 1970

Measured (sFt):		Published (sFt)	
North:	2,036,283.72	2,036,292	(hand held GPS)
East :	5,775,344.30	5,775,340	(hand held GPS)
Ortho Ht:	159.62	159.59	

Point ID: 5
Description: Set 5/8" Rebar capped "Survey Control"
Measured (sFt):
North : 2,034,715.209
East : 5,774,047.156
Ortho Ht: 79.1930

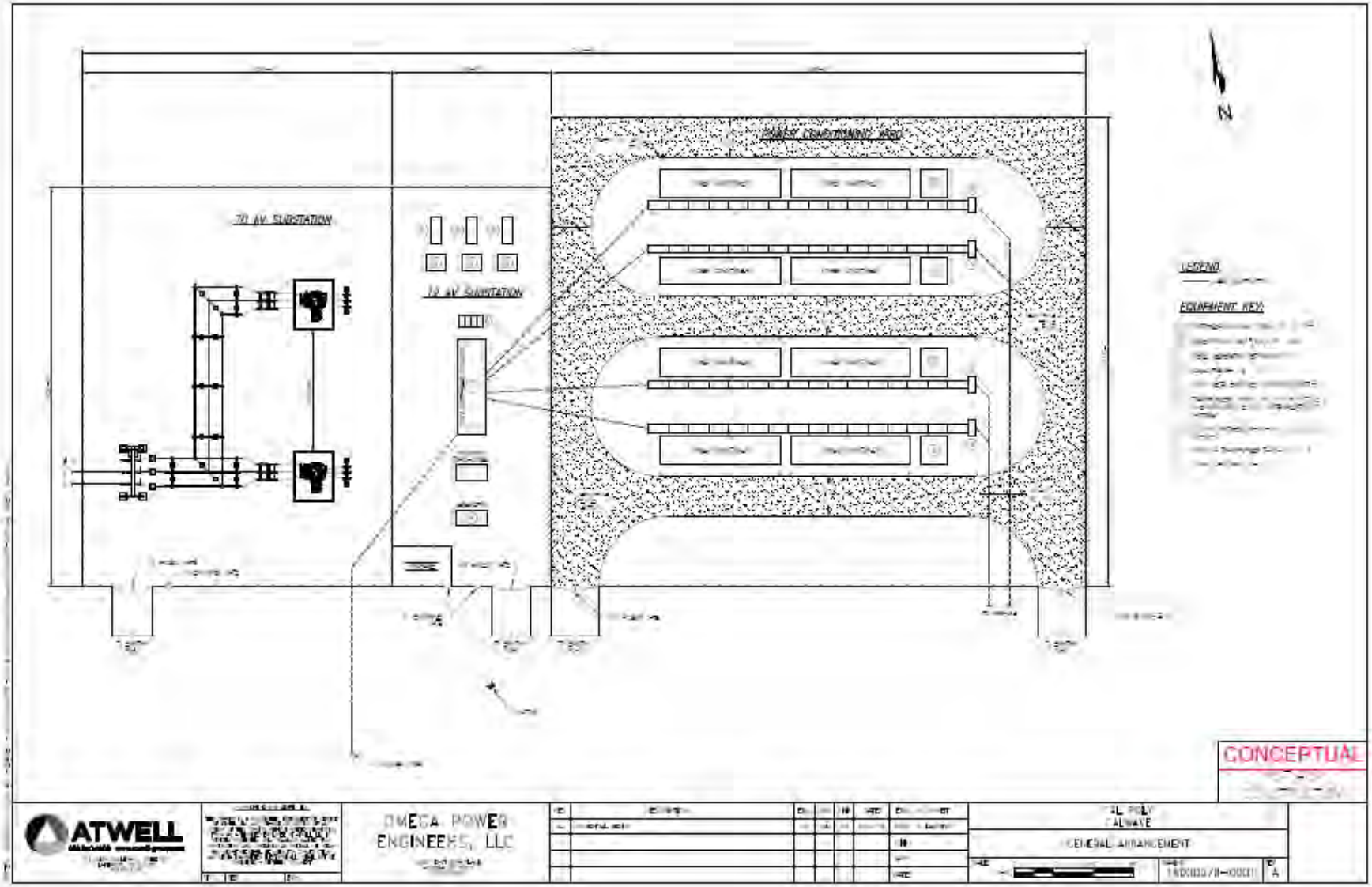


TOPOGRAPHIC MAP

GENERAL VICINITY

2 of 4

Conceptual Electrical Arrangement



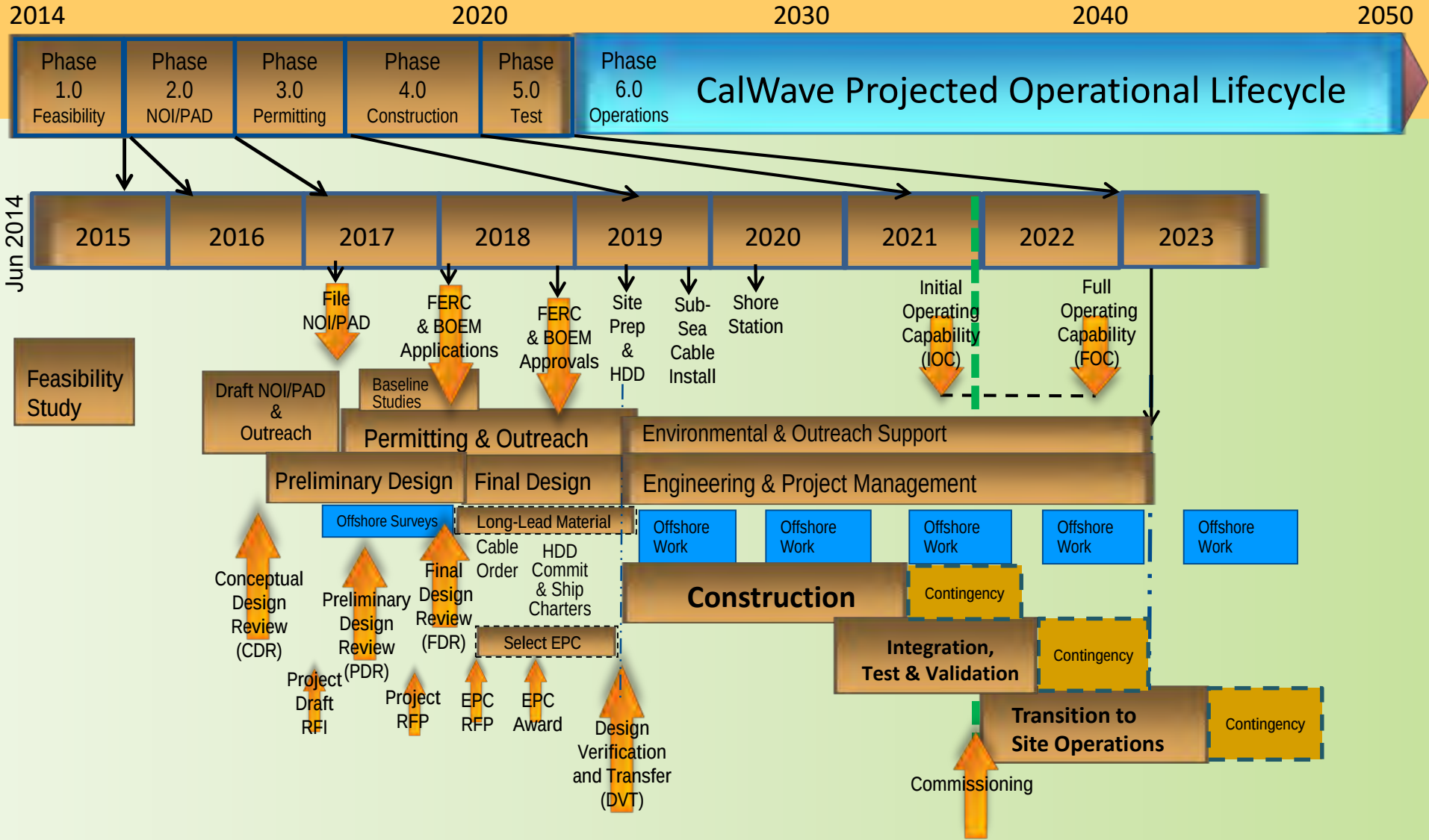
CalWave
Cal Poly

Institute for Advanced Technology and Public Policy

NATIONAL WAVE ENERGY TEST FACILITY

June 2015

Conceptual CalWave℠ Acqusition Timeline



Questions, Answers, & Discussion

Draft CalWave^{SM} Project Description

- CalWave^{SM} Offshore Sites in BOEM Lease Blocks
- CalWave^{SM} System Design Concept
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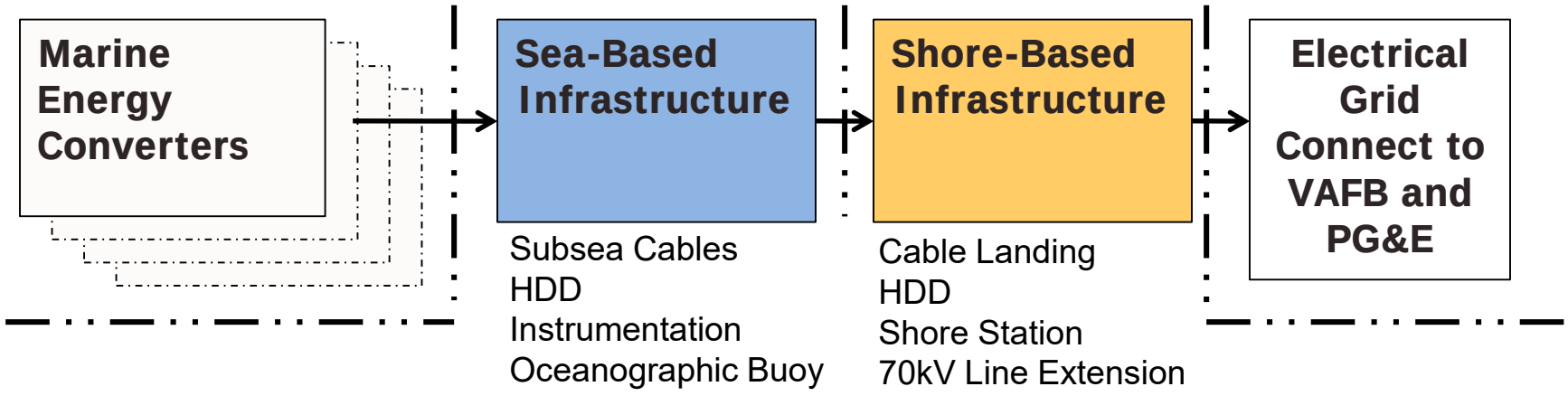
- CalWave^{SM} Onshore Siting



Contact CalWave℠

calwave@calpoly.edu

Dr. Sam Blakeslee, Principal Investigator

Bill Toman, Project Manager
(President, Protean Wave Energy, Inc)
707-731-9261 (m)

CalWave National Wave Energy Test Center
Stakeholder Advisory Group Meeting
Thursday, October 20th, 6pm-8:30pm
Sands Inn and Suites, San Luis Obispo, CA

Participants:

Stakeholder Advisory Group Organization	**Name**
Associated Pacific	Paul Gillen*
Coalition of Labor, Agriculture and Business	Mike Brown
Coalition of Labor, Agriculture and Business	Andy Caldwell*
Commercial Fishermen of Santa Barbara	Kim Selkoe*
Community Environmental Council	April Price
Congresswoman Lois Capps' Office	Greg Haas
CSU Channel Islands	Sean Anderson*
Maritime Logistics in Morro Bay	Frank Loving
Morro Bay Commercial Fishermen's Organization	Jeremiah O'Brien
Morro Bay Harbor District	Eric Endersby
Natural Resources Defense Council	Sandy Aylesworth*
The Nature Conservancy	Michael Bell
Port San Luis Commercial Fishermen's Organization	Dave Kirk
Port San Luis Harbor District	Andrea Lueker
San Luis Obispo Surfrider	Cynthia Replogle
San Luis Obispo Surfrider	Brad Snook
Santa Barbara County	Bob Nelson
Southern California Trawlers' Association	Mike McCorkle
Trac Tide	Jon BelChere*
Yak Tityu Tityu Northern Chumash	Haylee Bautista
CalWave Team	
Cal Poly	Sam Blakeslee
Cal Poly	Nick Osterbur
Cal Poly	Bill Toman
CH2M	Doug Davy
Kearns & West	Janet Thomson
Kearns & West	Anna West
Leidos	Rick Williams
PG&E	Brendan Dooher
Vandenberg Air Force Base	Ken Domako

Members of the Public	
Ambient Research	John Hedgepeth
California Department of Fish and Wildlife	Eric Wilkins
Citizen	Steve Rebuck
Maritime Logistics in Morro Bay	Bob White
National Marine Fisheries Service	Bill Foster
Port San Luis fisherman	Butch Powers
San Marino Venture Group	Eric Miller
San Marino Venture Group	Peter Kimbrell
Tenera Environmental	Joe Phelan
Tenera Environmental	John Steinbeck
TransElect	Bob Mitchell
Yak Tityu Tityu Northern Chumash	Lisa Dignan

Introductions:
Cal Poly Principal Investigator Sam Blakeslee welcomed participants and thanked them for attending. He described how important the CalWave National Wave Energy Test Center is in the context of California's need to meet its 50% renewable energy portfolio standard (RPS) in the coming years.

Bill Toman, CalWave Project Manager, explained that the project is in the second year of a $2 million, Department of Energy-funded study effort, working to determine what it would take to address stakeholder issues and develop and construct a CalWave national wave energy test facility.

Overview Presentations:
Bill Toman described that the CalWave concept was developed first by PG&E in 2008, under the name Central Coast WaveConnect, and then was continued by Cal Poly in 2013 to accelerate wave energy industry growth in the United States. Through the project's feasibility study phase, the team has determined that the area off Vandenberg Air Force Base (VAFB) is the most promising wave energy test center location nationwide. This analysis is supported by the review and analysis of UK WaveHub, now a project team partner and the developer of one of the most advanced wave energy test centers worldwide.

CalWave will be an opportunity to test multiple wave energy technologies. Bill described that the facility is intended to have a 25-30 year design life, largely funded by the U.S. Department of Energy. This will enable wave energy developers to test their technologies before rolling them out commercially. The facility will be constructed in a modular fashion, eventually providing up to 50 megawatts (MW) of capacity. CalWave will be connected to VAFB and all produced power will be sold to VAFB.

Wave energy is a useful choice for California, as the state has some of the best waves in the country. The state has a number of coastal power plants that use once-through-

cooling technologies that are being shut down over the next several years, leaving substations connected to the energy grid with no power to relay. This creates a low-cost, available set of interconnections for offshore wave energy infrastructure. Furthermore, wave energy is predictable and complementary to when wind and solar energies are most abundant.

Through stakeholder discussions over the past two years, in addition to engineering and design feasibility work, the project team has concluded that the southern-most two of the five original study sites are most appropriate. These sites are most adjacent to the VAFB dock, with an option to use Platform Irene and its existing power cable to bring energy to shore.

Bill introduced the CalWave team and its partners, including the Cal Poly Institute of Advanced Technology and Public Policy, CH2M, Coastal Data Information Program, Columbia Power Technologies, Electric Power Research Institute (EPRI), Humboldt State University's Schatz Energy Research Center, Glosten, Kearns & West, Leidos, Lieutenant Governor Gavin Newsom, the National Renewable Energy Laboratory (NREL), Pacific Gas & Electric Company, Protean Wave Energy, Sandia National Laboratories, Scripps Institution of Oceanography, UC Davis, and Virginia Tech University.

The project is still in the feasibility study phase. With more funding, which the team hopes to secure at the end of 2016, CalWave will enter the permitting phase in 2017 and will have construction in 2019-2020, start-up testing in 2021, and operations in 2022.

Rick Williams, CalWave chief engineer from Leidos, provided an overview of the engineering aspects of the project. Wave energy converter (WEC) devices have gone through early stages of testing and are ready for pre-production testing to prepare for commercial use. CalWave will be designed to be requirements-driven, technology neutral, and vendor agnostic. The system will have four test berths, at which single WECs or arrays of WECs can be "plugged in" to the system; each WEC device or array will operate independently.

CalWave will consist of the sea-based infrastructure with subsea cables that WECs connect to, cable landings that come through horizontal directional drilled (HDD) bores onto shore, into the shore station at VAFB, and interconnection to the transmission system. There will be a moored oceanographic buoy, in either state or federal waters, to measure wave and weather and to test (check out) WECs prior to installing them in the test berths.

Doug Davy, CalWave environmental lead from CH2M, provided an update on pre-permitting activities. The team has been gathering background information in order to prepare for the upcoming permitting activities in 2017. CalWave will require a Federal Energy Regulatory Commission (FERC) license for operations of a marine hydrokinetic project, and a Bureau of Ocean Energy Management (BOEM) subsea research lease. The CalWave team will be using a permitting process that is focused on engagement and consultation to prepare a well-vetted preliminary environmental document for FERC.

The team will work with the following federal agencies: VAFB as the host, BOEM for the research lease, FERC for the operations license, U.S. Fish and Wildlife Service for terrestrial and biological issues and listed species, National Marine Fisheries Service for effects to marine biota, U.S. Army Corps of Engineers for rivers and harbors permits, and the U.S. Coast Guard for safety and navigation. CalWave will work with the following state agencies: California Coastal Commission for any impacts in state waters, California State Lands Commission for a lease for state-owned submerged lands, California Department of Fish and Wildlife for state listed species, the Central Coast Regional Water Quality Control Board for management of water quality, and the California Office of Historic Preservation to ensure preservation of cultural resources.

Q & A:
Following the presentations, there was a dialogue between participants and the CalWave team:

- Question (Q): Are the cables buried or surface-laid?
    - Response (R): They are usually surface-laid.
- Q: Would a WEC developer test technology for the entire 25-30-year project life, or do you envision that multiple developers will test in each berth?
    - R: We expect multiple devices in each berth during the 25-30-year design life.
- Q: What will be the protocol if a fisherman gets caught on the cables if they're surface laid?
    - R: We will discuss that during the next (permitting) phase of the project. We expect to start by understanding the protocols for other types of cables and pipelines that are out there.
    - Comment (C): The Morro Bay and Southern California Cable Committees may be able to provide advice. With the Monterey research cable from Moss Landing there were problems with getting caught on the cable.
- C: The Center for Biological Diversity has advocated for a marine mammal corridor on another project. You may hear about this.
- C: Most of the cables into Morro Bay are buried, by requirement. The commercial fishing industry uses the sea bottom around there, and any interactions with cables can be deadly for us.

Engineering Parameters:
Rick Williams described the four types of WECs that are currently in production and might be tested in a deep water facility: point absorbers, linear attenuators, rotating masses, and floating oscillating water columns. Each of the WECs working at CalWave will bring its own anchoring and mooring system that is most appropriate for its own devices. Their WEC riser cables will connect to the CalWave system. Rick also showed a diagram with conceptual cable routes from shore to the berths, and wave roses that indicate both the direction and intensity of incoming waves.

Rick noted that if there is not active drilling at Platform Irene, it is possible to re-use the subsea transmission cable to connect to shore. At the shore station, the project team will create a berm to shield the historic boathouse. The team will use the substation and

power conditioning area to convert power from the WECs to the existing transmission grid.

Q & A:

- Q: How big will your entire footprint be? Will buoys and mooring systems fall outside of the footprint you'd previously described?
    - Response (R): The team is still working on this with BOEM and other regulators and stakeholders. Overall the project will not occupy more than 6 square nautical miles (nm) of sea floor. We will use the International Association of Lighthouse Authorities (IALA) standard to chart, mark, light, and notice the facilities.
    - C: We had expected that all the facilities, including the spaces in between parts of the facilities, would be within the 1x6 nm footprint. We prefer them to be closer together
- C: Please use fathoms rather than meters; all the fishermen use fathoms. Fishermen may have noise concerns with use of HDD during construction if it affects whether fish bite. You won't be able to have barges and cranes at the boathouse because there is only ten feet of water depth there and fishermen need to have access there.
    - R: HDD use will take months. We can work with you to understand when the best season/time for drilling might be.
- Q: How long will your kelp studies be?
    - R: We have not yet determined that.
- Q: Developments are typically required to be removed after their installation timeframe is completed. Often the debris is left on the bottom, which inhibits fishermen from doing their job. How will you manage that?
    - R: We will comply with the permit conditions for removal. Also, California just enacted a crab pot debris law which we will comply with and extend to our activities. We will also find out how our sister facility, WaveHub, handles this in the United Kingdom. Furthermore, we'll have a submerged lands lease for buried cable from the California State Lands Commission, which will have requirements for cable removal at the end of the project.
- Q: Have you thought about setting up a mitigation program for fishermen using the area?
    - R: We understand that entangled gear is likely to happen at some point and we will want to create a mechanism to address that, including economic mitigation.

Environmental Parameters:

Doug Davy provided an overview of the resource considerations for siting. The CalWave team worked to avoid essential fish habitat, marine reserves, vessel traffic lanes, existing oil and gas leasing areas, and incorporated stakeholder input from fishermen and others. This work resulted in the selection of the two preferred sites shown in the diagrams.

Within the shore zone there is a lot of existing information available from the space shuttle program, harbor dredging, and other activities. We will need environmental surveys to look for listed plant species at VAFB, and cultural resources inventories near the 70 kilovolt (kV) extension line. We will do fine-scale surveys to avoid sensitive habitats and visual simulations from Jalama Beach County Park.

The California Seafloor Mapping Program has information for the area around Point Arguello, which should be available in about a year. This will help us understand where to lay cable routes. Additionally, we will need to understand the bathymetry in the project area to engineer the cable routes. For this, we can use multi-beam sonar and side-scan sonar.

We will need to do our own bathymetric surveys in the area of the test berths. There is a lot of existing biological survey data available, such as information about blue and grey whales. Around the test berths we will have to explore additional topics regarding the use of marine space, such as commercial fishing activities, recreational boating, habitat analysis for commercial species, and others.

We will continue to work with the engineering team and continue to collect baseline data, understand the environmental issues, and start to design study plans and engage with stakeholders and agency staff.

In order to permit the test berths we'll be using what's called an "envelope analysis" which involves accurately and clearly describing the types of devices and moorings and predicting what their effects will be. WECs that fall within those ranges will be pre-permitted. Any WECs that want to join CalWave but fall outside the boundaries of the envelopes will need to go through extra permitting work.

Lastly, Doug presented several matrices that the CalWave team is developing to help everyone understand the potential effects of various aspects of the project and the likelihood that those effects will happen. The team is soliciting feedback on these matrices.

Q & A:

- Q: What would be the impact of designation of the Chumash Heritage National Marine Sanctuary?
    - R: The project team has had continuing conversations with the sanctuary applicant, as well as conversations with the National Marine Sanctuaries office in Monterey. We hope that the conclusion is that a marine renewable energy project and supporting infrastructure is compatible with the mission of a national marine sanctuary.
- C: It would be helpful to have the anchoring spots for cables charted so that crabbers and salmon trollers can avoid the facilities.
    - R: We will work to have the cables charted by NOAA.
    - R: NOAA charts show the project but not the anchor locations, which the fishing community would like to see.

- C: The proposed project area is very lucrative for drift gill netting, and the way this project is designed, it would end that type of fishing in that area.
- Q: Will the bathymetry data be made publicly available?
    - R: Yes, any data we develop will be in the public domain.
- C: For some State Lands Commission projects where exploration is being done, Surfrider is trying to get the Commission to post notices on the beaches so people know what the boats are doing and assess whether it is safe to go in the water. We would appreciate if there is a voluntary effort on your behalf to post on beaches when survey work is being done offshore from Jalama Beach.

Public Comment:

- C: The areas you have proposed are historic fishing grounds. We would like you to meet with the Port San Luis Fishermen's Association, we have about 60 members, so we can work through issues with you.
    - R: The CalWave Team looks forward to meeting with the Port San Luis Fishermen's Association.
- C: March and April are a good time for meeting with fishermen because there are fishery closures during those months, although the crabbers will be out on the water then. The Gateway Building at the Port San Luis Harbor would be a good place to meet.
- C: The National Marine Fisheries Service is eager to work with the fishermen to understand conditions and needs.
- C: The project team should present to the Pacific Fisheries Management Council, perhaps in March or April next year.
- C: The fishing community would like to help you designate the six square nautical mile project area so that we can find a spot that would be least costly for our industry.
    - R: The project team will continue to work on this issue with the fishing community.

CalWave[SM] Wave Energy Test Center
Permitting Agency Meeting Summary
October 21st, 2016, 10am-3pm
Courtyard Marriott, Camarillo, CA

Participants:

Organization	Name
Bureau of Energy Management (BOEM)	Doug Boren
Bureau of Land Management (BLM)	David Ledig*
California Department of Fish and Wildlife	Eric Wilkins
California Ocean Protection Council	Chris Potter*
California State Lands Commission	Maren Farnum*
California State Lands Commission	Cheryl Hudson*
California State Lands Commission	Mark LeClair*
California State Lands Commission	Jennifer Mattox*
California State Lands Commission	Pat Mulcahy*
California State Water Resources Control Board	Joanna Jensen*
California State Water Resources Control Board	Catherine Woody*
Federal Energy Regulatory Commission (FERC)	Jim Hastreiter*
NOAA Fisheries	Bill Foster
NOAA Fisheries	Penny Ruvelas*
NOAA Office of National Marine Sanctuaries	Lisa Wooninck*
NOAA Office of Protected Resources	John Fiorentino*
PG&E	Brendan Dooher
United States Army Corps of Engineers (USACE)	Ian Bordenave
United States Coast Guard (USCG)	Petty Officer Michael Hughes*
United States Coast Guard (USCG)	Commander James Williamson*
United States Navy	Robert Nowak*
United States Navy	Walter Schobel*
Vandenberg Air Force Base	Ken Domako
CalWave Team	
Cal Poly	Sam Blakeslee
Cal Poly	Nick Osterbur
Cal Poly	Bill Toman
CH2M	Doug Davy
Kearns & West	Anna West

Kearns & West	Janet Thomson
Leidos	Rick Williams

*Participated by phone

Introductions and Session Overview

Sam Blakeslee, Principal Investigator for the Cal Poly CalWave[SM] Wave Energy Test Center (CalWave[SM]), welcomed the group and shared remarks on the importance of this effort to achieve our renewable energy goals. Anna West, Kearns & West, opened the meeting and asked meeting participants on the phone and in the room to introduce themselves. Anna reviewed the agenda and meeting objectives.

CalWave[SM] Updates

Rick Williams, Leidos, reviewed the updated system concept diagram. The project will include four grid-connected test berths, a 30-year design life, with 12kV export capability rated at 12MW and 70kV export rated for 40MW, and a 5th (spare) cable. CalWave[SM] is also being designed to allow for the inclusion of an NREL Grid Emulator and an Oceanographic Station. Since Vandenberg Air Force Base (VAFB) has an electric demand of 25 megawatts (MW), and connection with the PG&E grid beyond the Base is possible, CalWave[SM] provides a realistic grid-connection scenario for utility-scale generation and utility-grade reliability. The wave energy converter (WEC) developers will be able to demonstrate their technologies in a grid-connected scenario and can prove their preferred array configuration with their designed mooring and anchoring approaches.

Doug Davy, CH2M, described that the CalWave[SM] team reviewed five proposed sites, all of which could have feasible connection to VAFB, and down-selected to two sites that avoid sensitive resources, aim to avoid major fishing areas, and are good areas for wave energy resources. There would be four test berths total using one or both of these two proposed sites.

The project will use 4.25-inch static cables. Typically, power cables and pipelines are surface-laid and telecommunications cables are buried one meter below the sea floor. The shore station will have five horizontal direction drill (HDD) bores out to about ten meter water depth; those bores will be steered to avoid rocky outcroppings and kelp. The fifth bore provides a redundant line in the system in case one cable fails. It will take four to six months to drill all five of the HDD bores. The bores will be lined with high density polyethylene (HDPE).

Rick Williams noted that the Cable Routing Desktop Study has found that the area includes Monterey Formation substrate, which is a tough rock, so the team is reviewing how to drill through that area and also avoid rocky bottom (essential fish habitat) and avoid kelp forest and kelp attachments on the bottom (sea otter habitat).

Rick provided images of existing marine infrastructure including buoys with mooring and anchoring mechanisms currently used by NOAA and the U.S. Coast Guard. Based on what the CalWave[SM] team has learned from other wave energy deployments, entanglement with whales is not likely to be an issue. Rick also reviewed pictures of

cable installations and WEC devices. Other wave energy testing stations such as the Hawaii National Marine Renewable Energy Center (HINMREC) Wave Energy Test Site (WETS) are taking acoustic and other measurements; those five to ten years of data will be available for review.

Understanding WECs & Anchoring/Mooring Mechanisms

Rick reviewed types of anchoring and mooring mechanisms that the WEC developers are likely to use, reminding the group that WEC developers will provide their own properly engineered mooring, anchoring, dynamic cables, and riser cables to ensure a holistic system design. The classic mooring mechanism is a three-point catenary with a scope of 6:1. Taut and semi-taut moorings take up less space, but are more expensive. Rick also showed a variety of anchors that could be used. During the next phase of the CalWave^{SM} project, the team will be doing more geophysical and geotechnical surveys, which will help to inform what types of anchors would be appropriate for the area. Short-term tests would probably employ drag or clump anchors because they can be removed quickly and less expensively. Testing for longer, such as 2-3 years, would likely involve use of an embedded plate anchor.

- Q: Are any of these anchors unable to be removed in the future?
    - R: For BOEM regulations, the default plan is to remove any anchors. If there are anchors that a developer wants to leave in place, those would have to be approved. Clump anchors are simplest to retrieve.
    - R: BOEM also has a concept of decommissioning infrastructure in place. What this means is that if equipment is one meter or more below the sea floor, it can be left at the end of the project.
- Q: What lights are used on the devices?
    - R: We will meet the requirements of the controlling circular from U.S. Coast Guard headquarters, which requires proper marking and lighting for offshore renewable energy devices. These requirements can include surface colors, lights on the outer devices in an array, and automatic identification system (AIS) transponders on the devices so vessels can locate them.

Introduce the "Envelope" Approach for Permitting

Doug Davy described the "envelope" approach for permitting, which is a method of permitting infrastructure by accurately and clearly describing the types of devices and anchoring and mooring mechanisms and predicting what their effects will be. The CalWave^{SM} project will have clearly defined and permitted shore-based infrastructure and cables; however, the WEC devices and their anchoring and mooring mechanisms will not be definitively known until those developers apply to join the test center. The envelope approach enables permitting within a certain set of bounds, such as types of devices, scale of devices, and anticipated potential impacts. WECs that fall within those ranges will be pre-permitted. Any WECs that want to join CalWave^{SM} but fall outside the boundaries of the envelopes will need to go through extra permitting work.

- Comment (C): FERC will require a description of the scope of the project, number of test berths, number of devices, maximum energy production, types of devices to be tested, types of mooring mechanisms and any static features, the

submarine cables, and the land-based infrastructure. If a totally different WEC device seeks to join CalWave℠ in the future, FERC will have to do an amended NEPA analysis at that point.

- C: Past experience shows that the wider you make the envelope, the harder it will be to permit the project.
- Q: Will there be a joint NEPA/CEQA document?
    - R: The permitting agencies have an intent to develop a joint NEPA/CEQA document.
    - R: The CalWave℠ team wants to work with agencies to understand their special needs under CEQA to ensure those requirements are built into the process.
- Q: What happens if a developer wants to produce more energy than what is permitted?
    - R: The FERC license caps the amount of power that can be produced by the facility, typically 50MW.

Recent Research on EMF

Ann Scarborough Bull, BOEM, presented information about the potential environmental effects and risks of electromagnetic fields (EMF) from subsea AC and DC power cables, culled from a number of studies. The full presentation is appended to this summary, which includes references to the source studies.

- Q: Does EMF increase linearly or exponentially with an increase in electric load carried by cables (megawatts)?
    - R: It's a linear increase.

Based on these studies, Ann concluded that there is no indication from scientific research that EMF from seafloor power cables is a significant risk to marine animals or their habitats, or that EMF from cables prevents movement within habitats. Ann recommended considering EMF as a low risk stressor, and suggested that regulating agencies focus effort on reviewing higher priority interactions.

- C: It might be productive for agencies to have a workshop on EMF across states so that the agencies can come to a similar understanding about potential effects of cables and devices.
- Q: Are non-agency stakeholders asking for specific kinds of information about EMF, or for certain studies?
    - R: Fishermen are requesting information about impacts to crabs, and about catchability of fished species in general.

Potential Environmental Effect Risk Profiles

Doug Davy introduced the potential environmental effect and risk matrices, which the CalWave℠ team hopes to use to understand available baseline information, identify potential issues, and determine anticipated levels of effects and risks, in order to form study plans for the project. The CalWave℠ team seeks agency review of the matrices so that the group's combined knowledge can inform development of study plans.

Update on State of CA Offshore Renewable Activities
Chris Potter, California Ocean Protection Council, provided an update on California's offshore renewable energy activities. He reported that the BOEM-California Interagency Renewable Energy Task Force was launched on October 13th in Sacramento, with about 50 representatives of federal, state, and tribal governments around the table. The meeting focused on BOEM's leasing process, the planning process that the state and BOEM will be undertaking for wind offshore the central coast of California, and a data gathering effort for that offshore wind planning process. Chris also provided a brief presentation at that meeting about the state's Marine Renewable Energy Working Group. The next Task Force meeting will likely be around the middle of 2017 after the state has conducted some of the offshore wind planning process. Additionally, the California Energy Commission, Governor's Office of Planning and Research, and California Ocean Protection Council have committed to holding a series of listening sessions on coast.

Next Steps
Anna noted that the next regulatory agency meeting will be held on December 8th. At that meeting the group will review the environmental effect and risk matrices and additional topics associated with the upcoming permitting phase.

The CalWave[SM] Team expects to learn in December about whether this project has been selected for future funding by the U.S. Department of Energy.

Actions
1. The CalWave[SM] Team to will distribute the environmental effects and risks matrices to agencies for their review prior to the December 8th agency meeting.

CalWave^{SM} Update

CalWave^{SM} Regulatory Agency Meeting

October 21, 2016
Camarillo, California

CalWave^{SM}

Cal Poly
San Luis Obispo

U.S. Department of Energy

Meeting Objectives

- Provide updates on CalWave[SM]
- Understanding groupings of WECs and their anchoring/mooring mechanisms
- Define the permitting "envelope" for the Test Center
- Review/discuss recent research on electromagnetic fields (EMF)
- Review/discuss potential environmental effect risk profiles

Agenda

- Introductions/Session Overview
- CalWave^{SM} Updates
- Understanding WECs & Anchoring/Mooring Mechanisms
- *Lunch*
- Introduce the "Envelope" Approach for Permitting
- Recent Research on EMF
- Potential Environmental Effect Risk Profiles
- Update on State of CA Offshore Renewable Activities
- Next Steps and Anticipated Timeframes
- *Adjourn*

3

CalWave^{SM} Updates

- Updates to project engineering and design
  - Cable routing desktop study
- Information about existing infrastructure

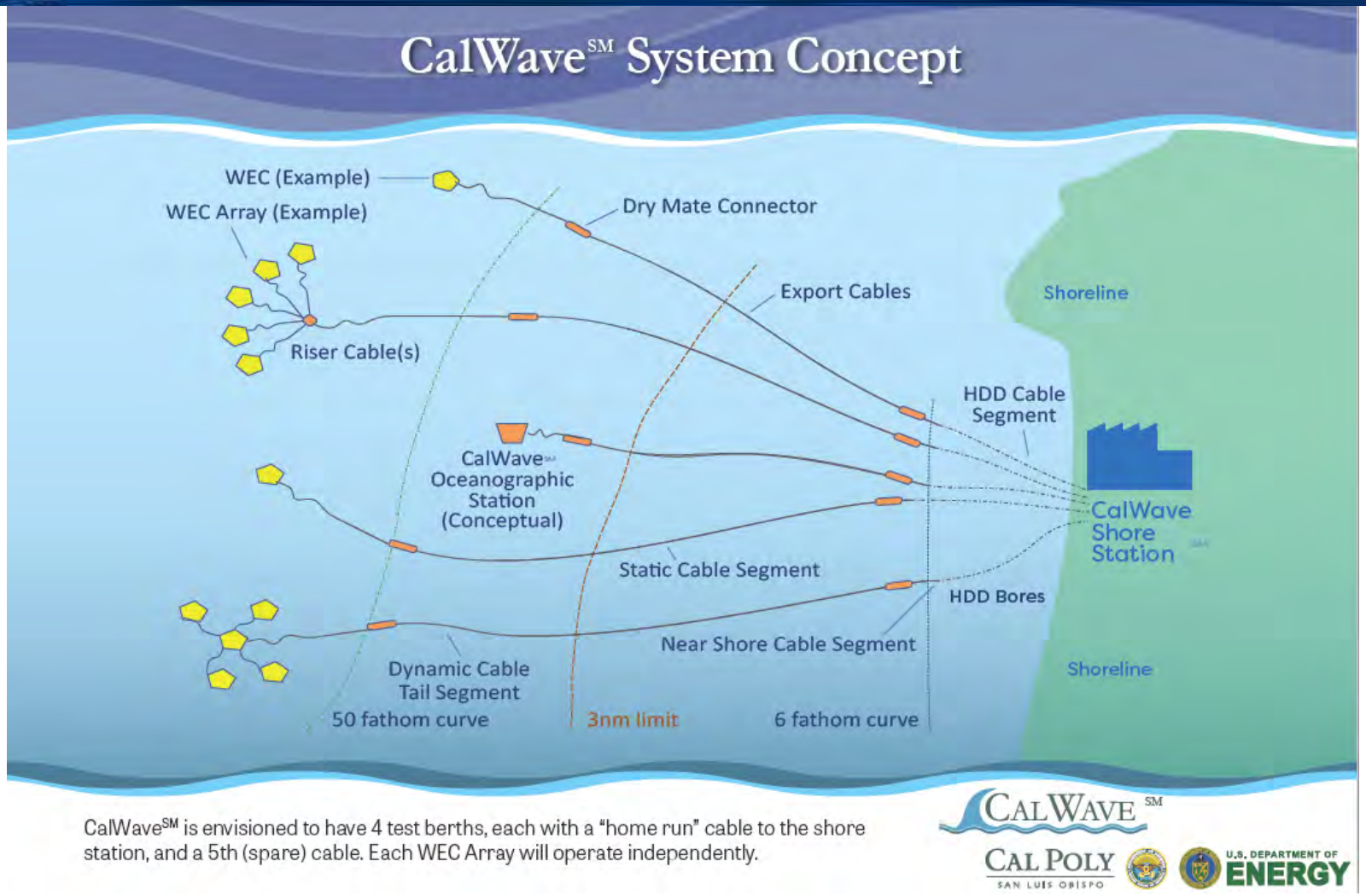
4

Draft Project Description

- CalWave: 4 grid-connected Test Berths, 30-year design life, with 12kV export capability rated at 12MW and 70kV export rated for 40MW, and a 5th (spare) cable.
- Design options: NREL Grid Emulator and Oceanographic Station.
- Designated area for Shore Station leverages extensive base infrastructure: Vandenberg Dock; hardened pavement areas; haul roads; 12 kV distribution grid; and, access to a 70 kV transmission grid at a nearby substation.
- The design maximizes flexibility and minimizes risk, cost, & time-to-market.
- VAFB's 25MW demand and PG&E interconnection provide a realistic grid-connection scenario for utility-scale generation and utility-grade reliability.
- WEC Developers can demonstrate and prove their production configuration without Test Center artificialities or constraints.

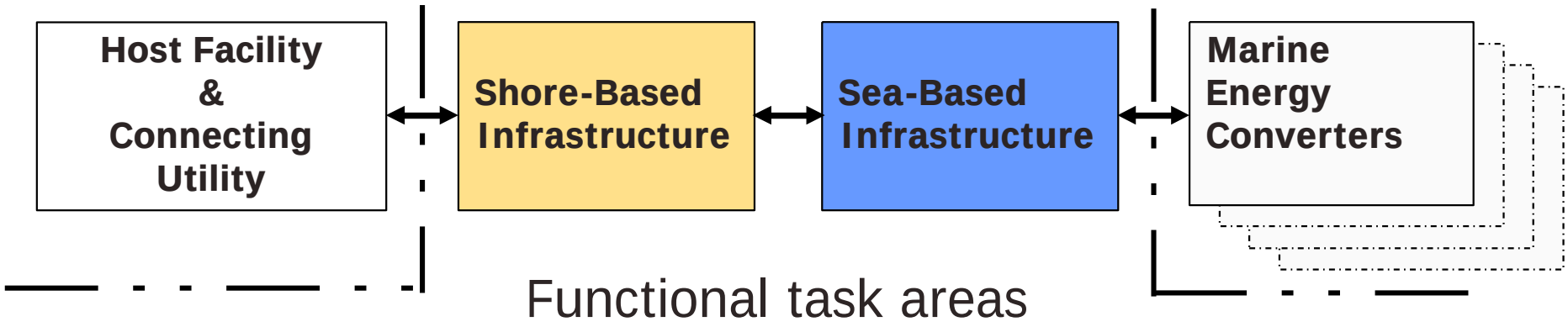
5

CalWave℠ System Concept



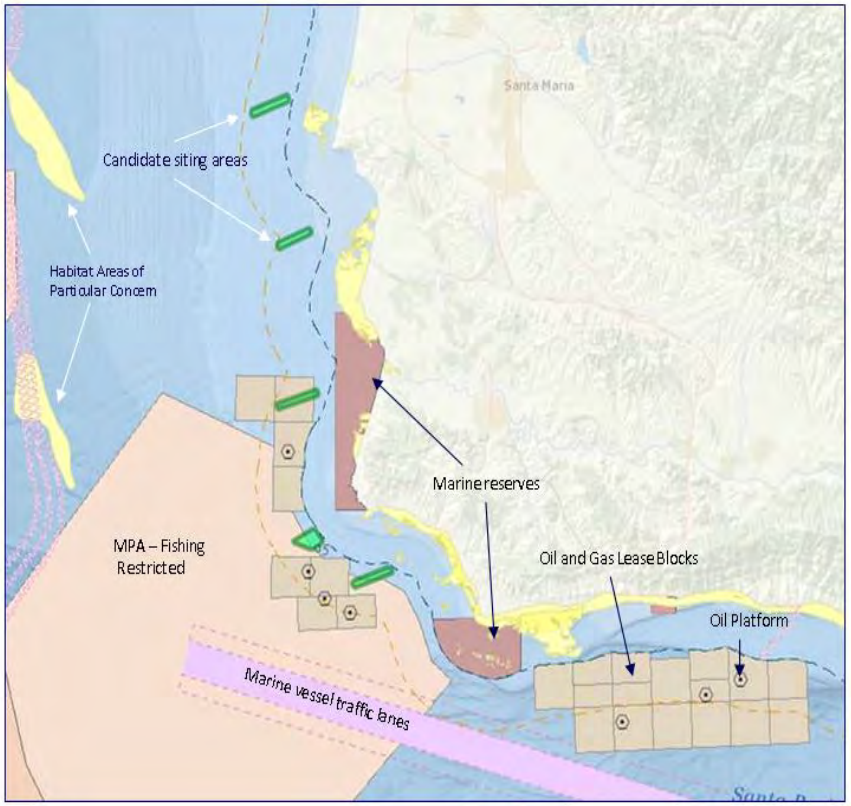
CalWave berths at ~ 3.25 nm (~6,000 meter/30 furlong/1.08 nautical league) will have a "home run cable" from ~ 50 fathom curve (90 meter)

CalWave℠ System Block Diagram



Host Facility	**Boundary System: Mature** Base infrastructure and procedures. Connecting utility infrastructure and procedures. O&M
Design & Planning	Resource adaptation, conceptual design/preliminary/detailed design, program planning
Regulatory & Permitting	Site evaluation and selection, environmental analysis, outreach, and agency interaction
Implementation, Operations & Maintenance	Procurement, fabrication, logistics, installation, commissioning, project operations, maintenance, monitoring, adaptive management, and decommissioning
Financial & Business Management	Financial & Business Models, Planning, Acquisition Program & Project Management, Program & Grant Administration, Contingency/Configuration/Change Control, Cost Controls
Marine Energy Converters (MECs)	**Boundary System: New Product Development** Technology invention, prototyping, progressive test, planning, and demonstration. O&M

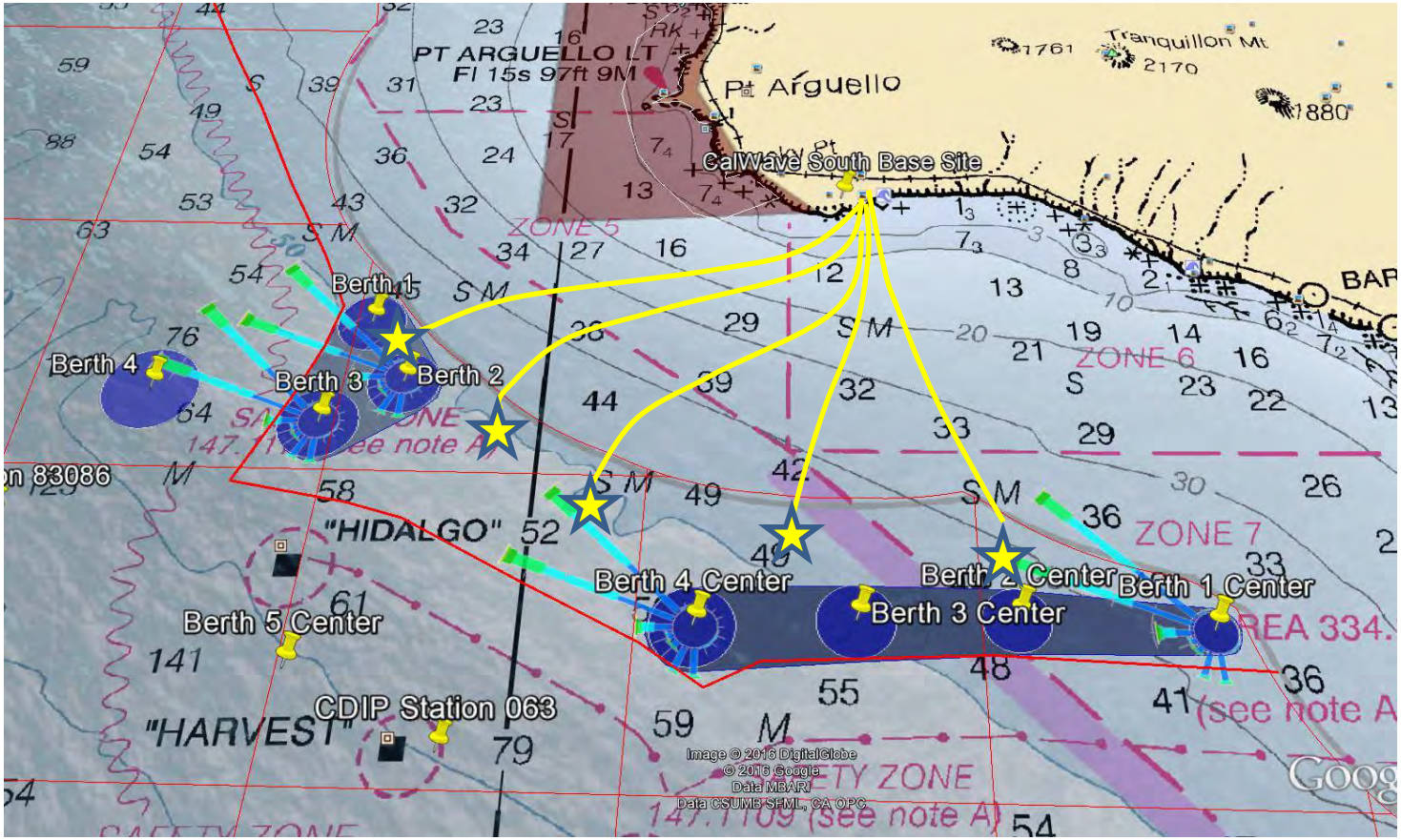
Proposed CalWave^{SM} Site



Source: Bureau of Ocean Energy Management, MarineCadastre.gov National Viewer, 2014

In April 2015, the CalWave^{SM} Team presented four alternative cable landing and substation sites & five alternative offshore sites. After engagement with stakeholders, down-selected to South Base Site & BOEM Lease Blocks.

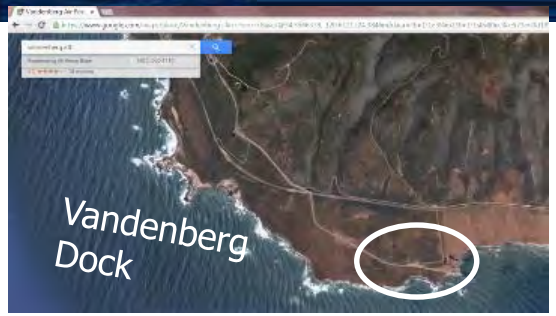
Proposed Cable Routing



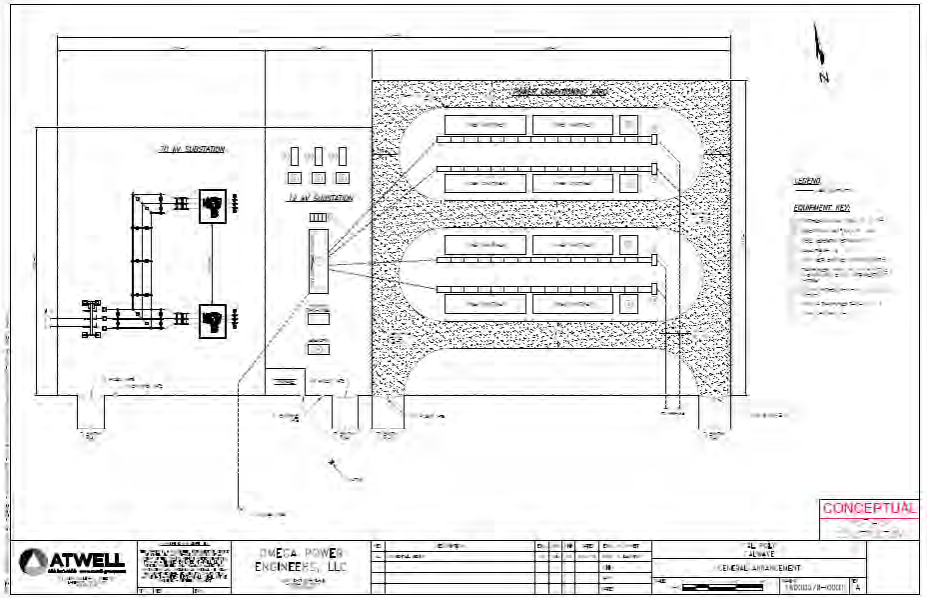
West Cable | Southwest Cable | CalWave Oceanographic Station (Spare) Cable | South Cable | Southeast Cable

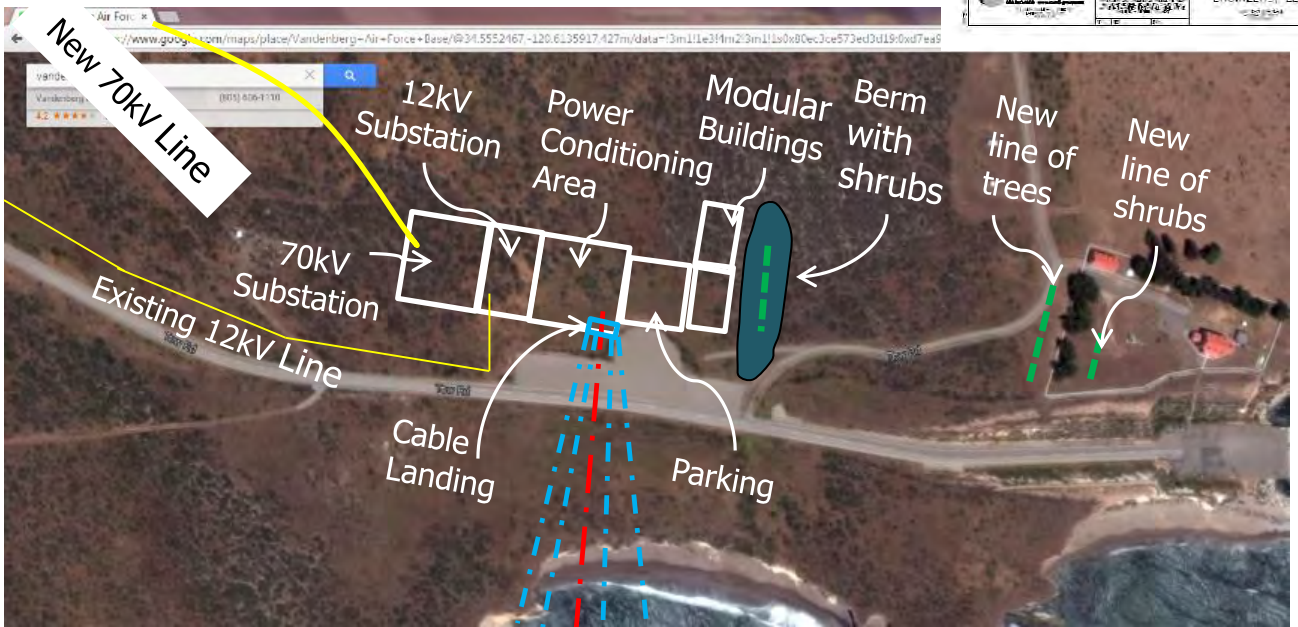
CalWave berths at ~ 3.25 nm (~6,000 meter/1.08 nautical league/30 furlong) will have a "home run cable" from ~ 50 fathom curve (90 meter)

Conceptual Shore Station

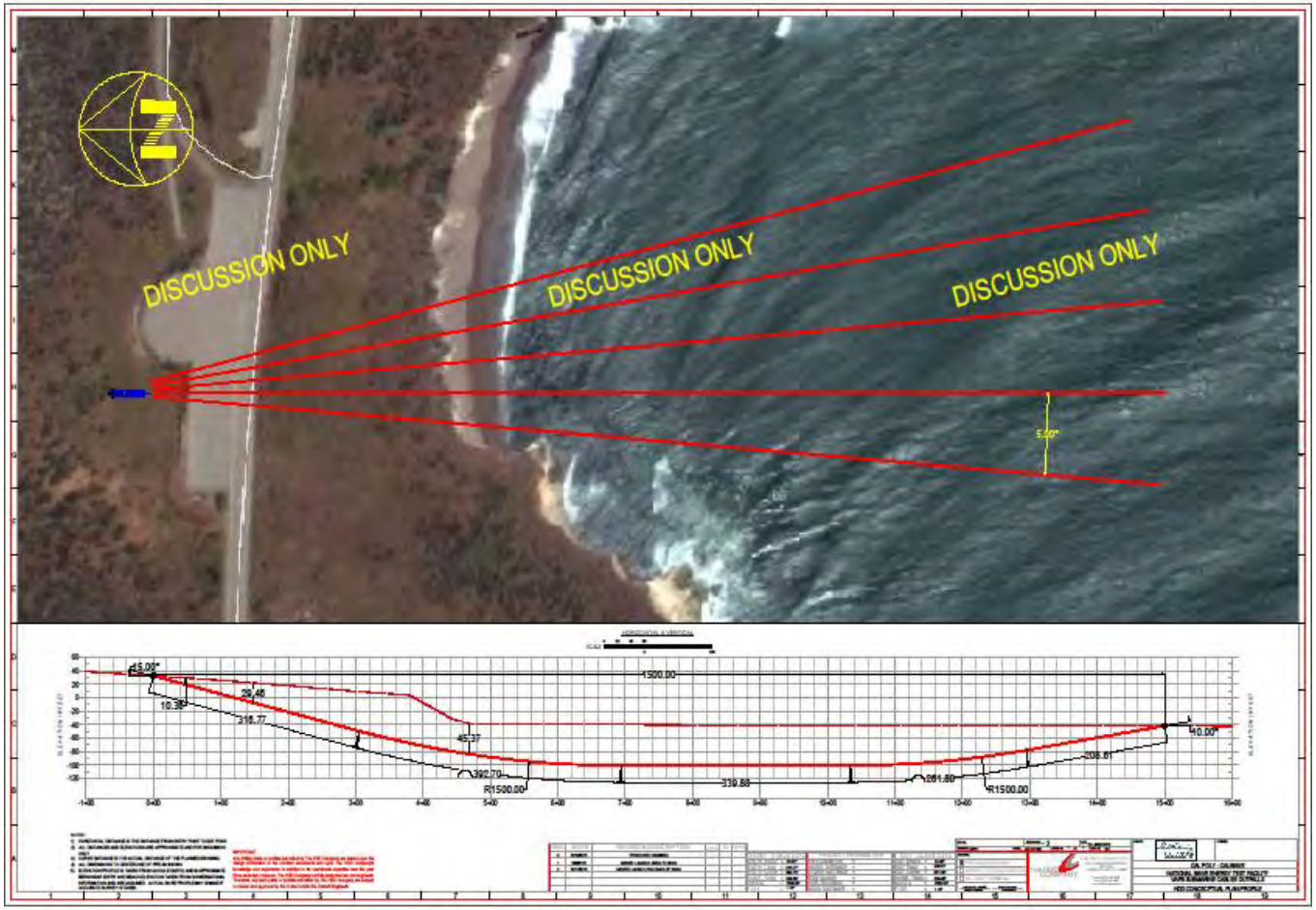


Primary HDD Upland Launch Location

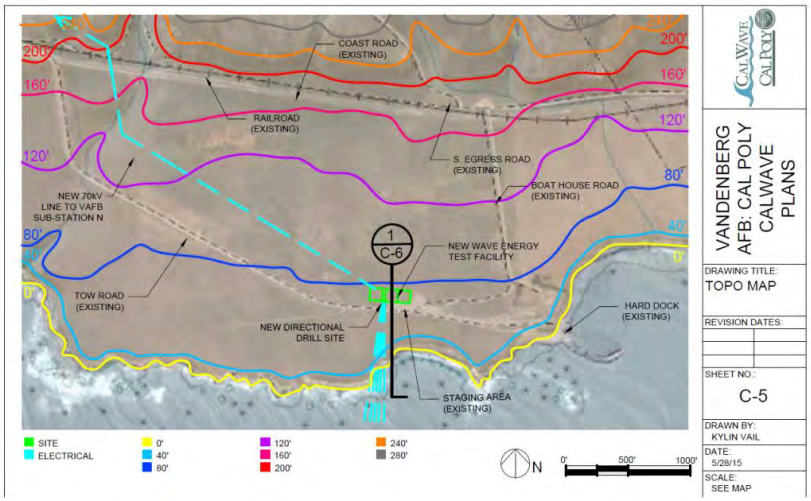


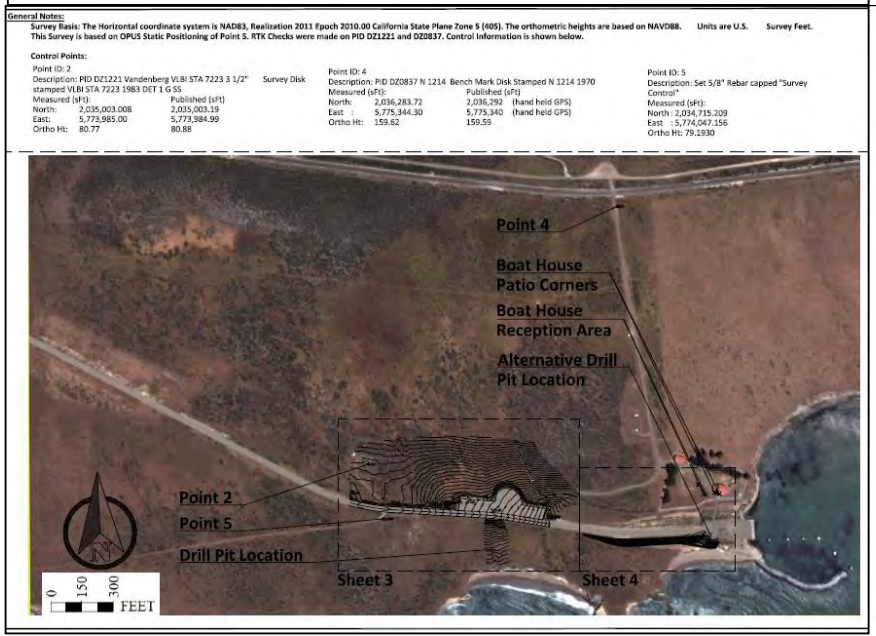


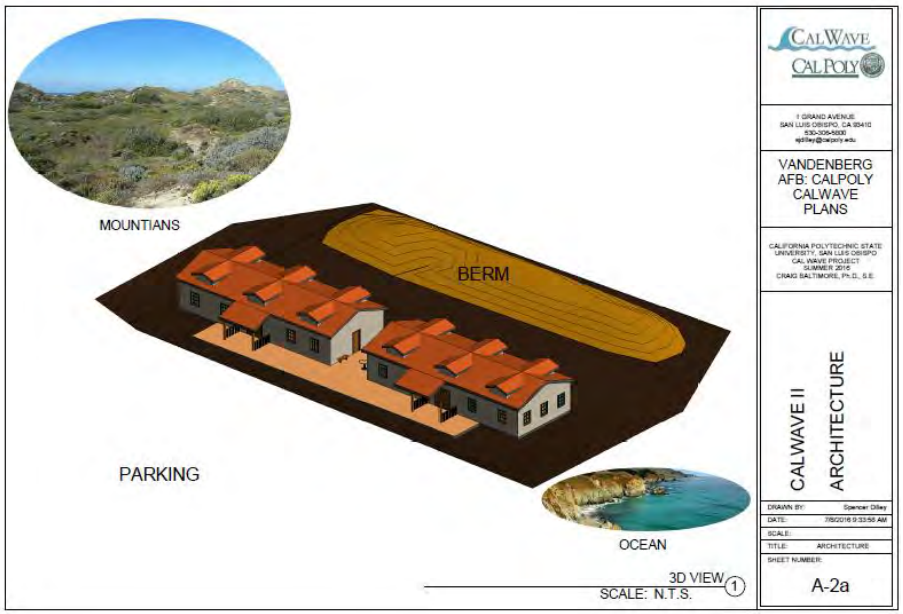
Conceptual HDD Drill Profile



Conceptual Base Interface







Cable Route Desktop Study

- The Cable Route Desktop Study by Fugro identified Monterey Formation substrate and probable rocky outcroppings.
- Core sampling, bathymetric surveys, and horizontal directional drilling (HDD) will be used to avoid rocky bottom (essential fish habitat) and avoid kelp forest and kelp attachments on the bottom (sea other habitat)

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Existing Marine Infrastructure

- How does the proposed CalWave test center compare to other types of existing infrastructure in the ocean?
- The following slides show:
  - Existing buoy types deployed off the West Coast by federal and state entities
  - Existing subsea cable types deployed off the West Coast

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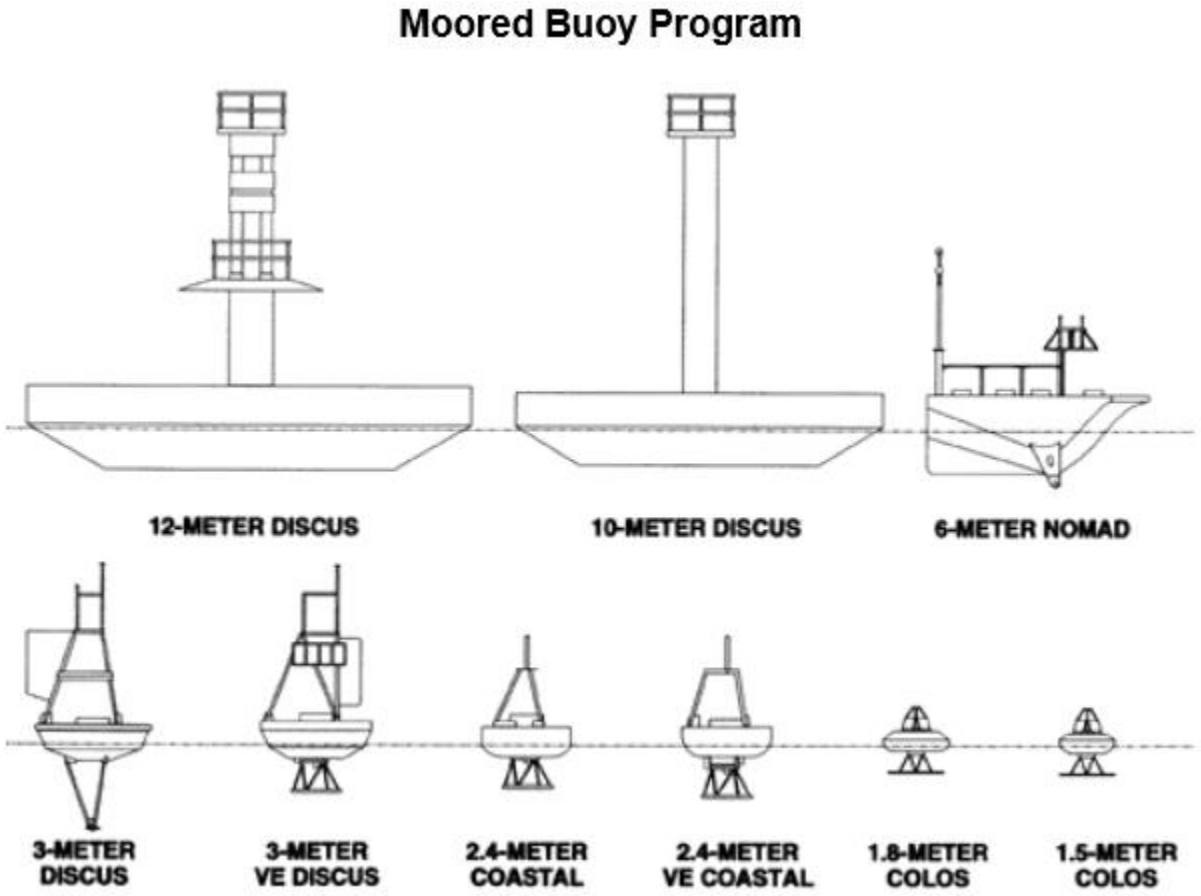
Representative Buoy Installations



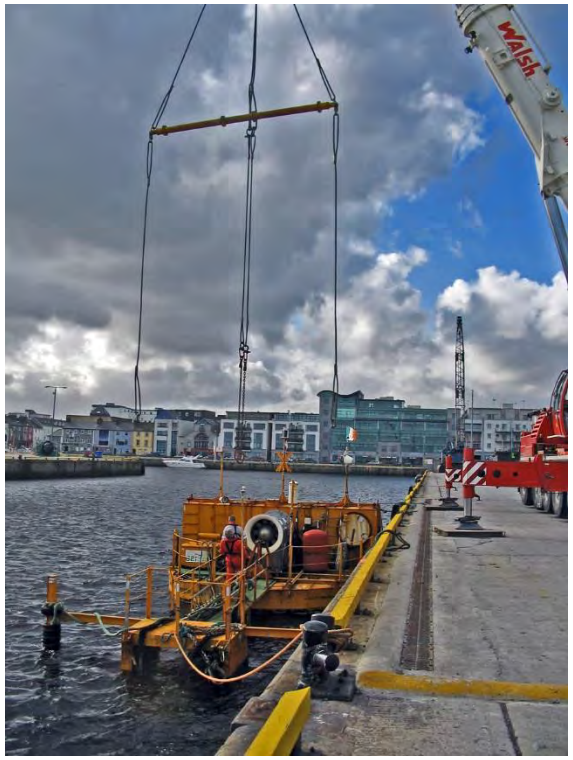
NOAA moored buoys deployed in coastal & offshore waters from western Atlantic to Pacific Ocean around HI, and Bering Sea to the South Pacific.

They measure & transmit barometric pressure; wind direction, speed, and gust; air and sea temperature; & wave energy spectra.

Existing WECs are typically the size of 10m to 12 m discus buoys. Obtaining data on future designs.

Representative Buoy Installations

USCG developed the Large Navigational Buoy (LNB) as a replacement for lightships in the early 1970s. These buoys are about 40 feet (~13m) high with a similar diameter.



The Ocean Energy (OE) Buoy tested in Ireland was of a similar size and is expected to scale up for Pacific wave resources. Obtaining data on estimated size.

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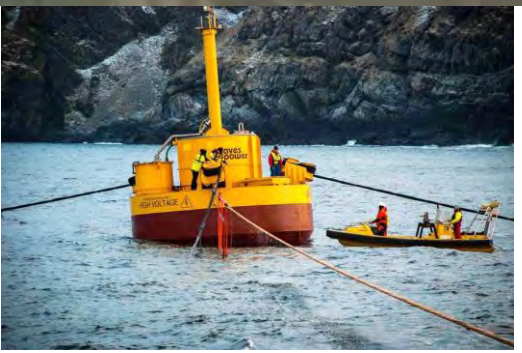
WEC Deployments – Near Term

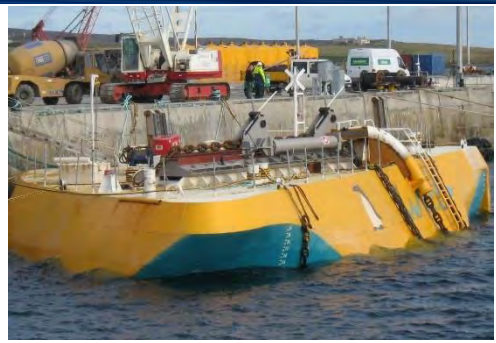
- Point Absorber WECs
  - Columbia Power (StingRay)
  - Ocean Power Technology – (PowerBuoy)
  - Fred Olson (Bolt Lifesaver)
  - Azura (Power Pod)
  - Seatricity - (Oceanus 2 Pump) Deployed Wave Hub UK
  - Carnegie Wave Energy – (CETO 6 device) To be deployed Garden Island Australia and Wave Hub UK
  - Protean Wave Energy - (Small device) Fremantle, Australia
  - Marine Power Systems – (WaveSub) Deploying FaBTEst Cornwall and Pembrokeshire, UK,
  - Wavetricity (Wave Rower) 6 million Euro, Eu grant) – Deploying FaBTEst Cornwall and Pembrokeshire, UK
  - Seabased – (Seabased WEC) Currently deploying array in Sweden (Sotanas)
  - Eco WavePower (EWP WEC). Has deployed device in Gibraltar. Needs to be mounted to a pier or similar
  - Waves 4 Power – (WaveEL) Currently deployed at Runde, Norway
  - CorPower,(CorPower WEC) Sweden. Scaled device to be tested at EMEC in 2017
- Rotating Mass WECs
  - Wello (Penguin) – Ongoing testing in the UK
  - Confidential (Large device, similar concept to rotating mass, due to be deployed in 2017, cannot disclose details at this stage)
- Floating Oscillating Water Column WECs
  - Ocean Energy Floating Oscillating Water Column
- Hybrid – Wave and Wind Technology
  - Floating Power Plant (P80) – Denmark. Have tested 2MW prototype. Combined wave and wind.

Point Absorbers

One wind turbine blade



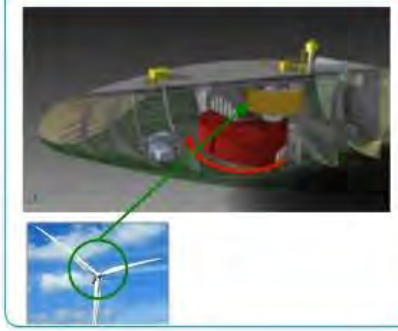
Rotating Mass



Our Innovation – the Penguin WEC

Wello
DIRECT CONVERSION

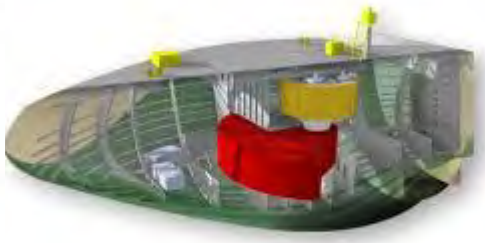
How it works



DIRECTLY FROM MOTION TO ELECTRICITY

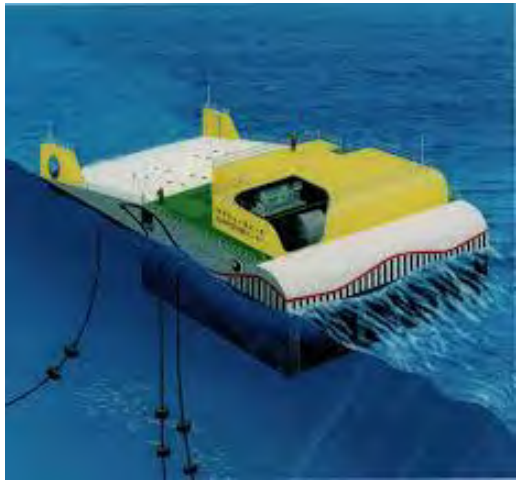
- **One floating element - everything inside**
- Motion energy is directly captured by generator
- Direct conversion, no hydraulics, no joints, no gears
- Proven industry components
- **Simple and patented**

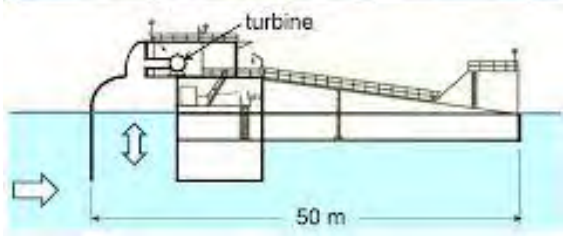
The device fully encapsulates a rotating eccentric mass that is actuated by waves, driving a generator typically used in wind turbines



April 2015 3

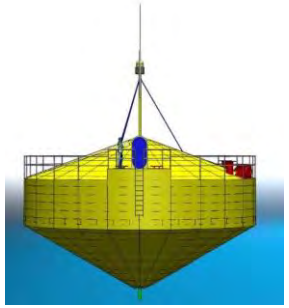
Floating Oscillating Water Columns

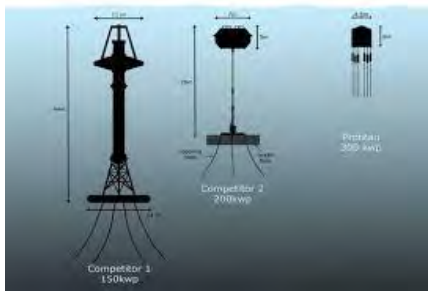


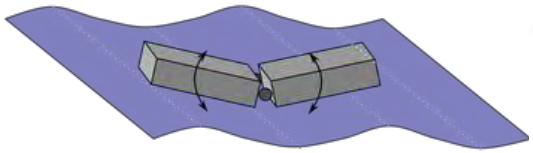


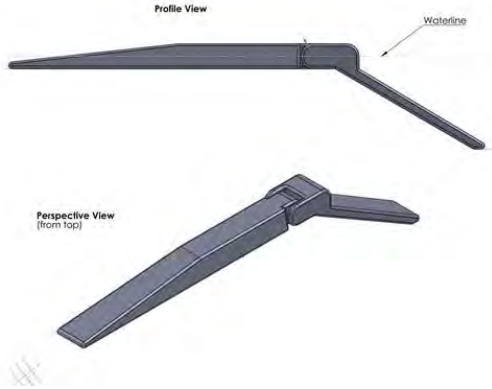
Future WEC Development – Wave Prize

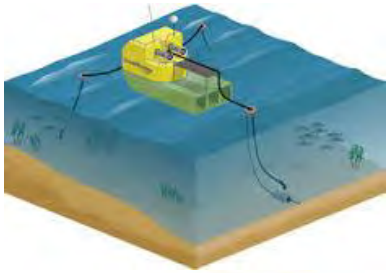
Future WEC Development – Wave Prize

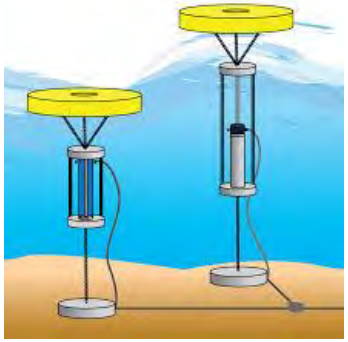




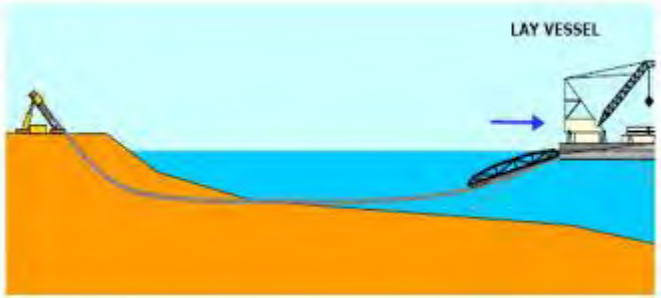


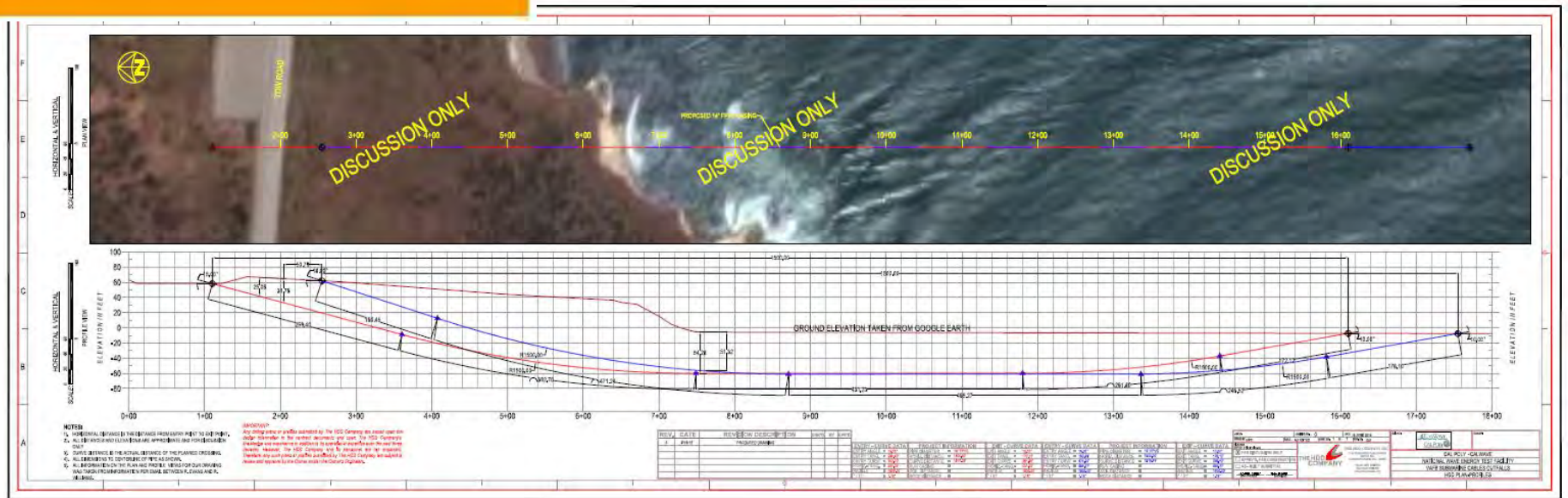






Representative Cable Installations





Representative Cable Installations

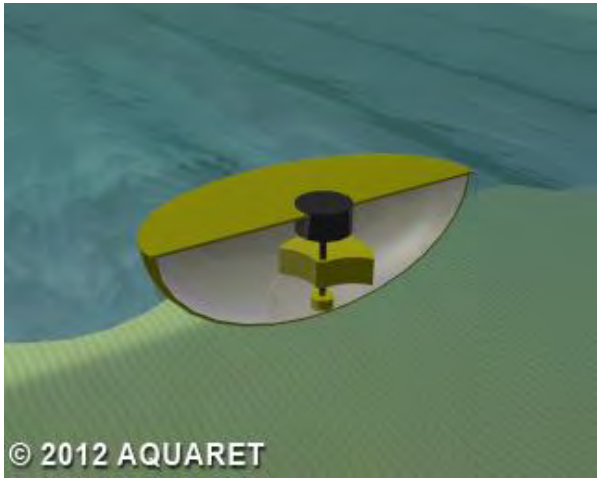
Introducing WEC Groupings & Anchoring and Mooring Mechanisms

25

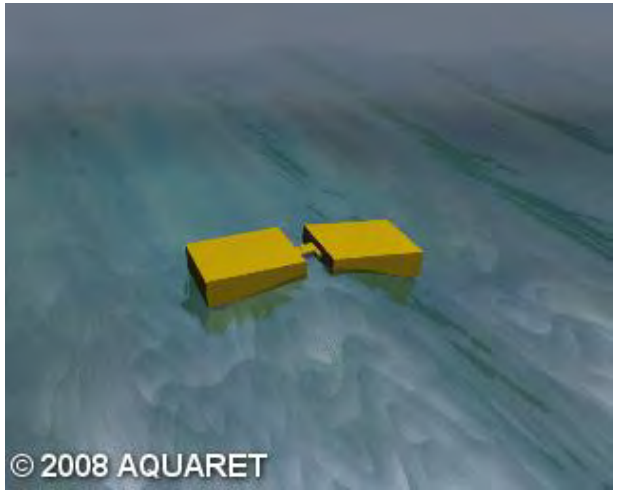
Overview of Wave Energy Converters

Point Absorber

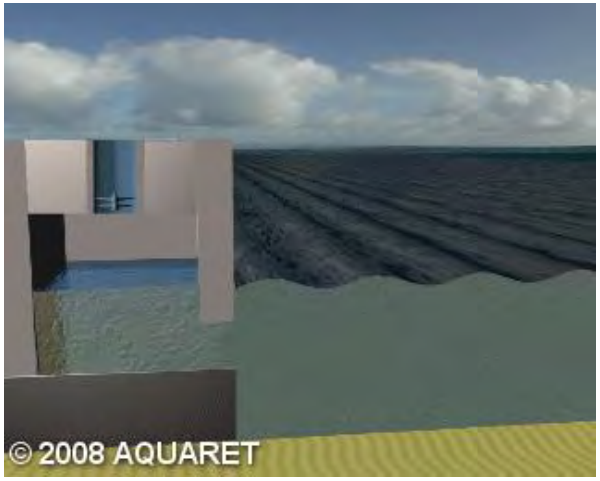
Rotating Mass



Linear Attenuator

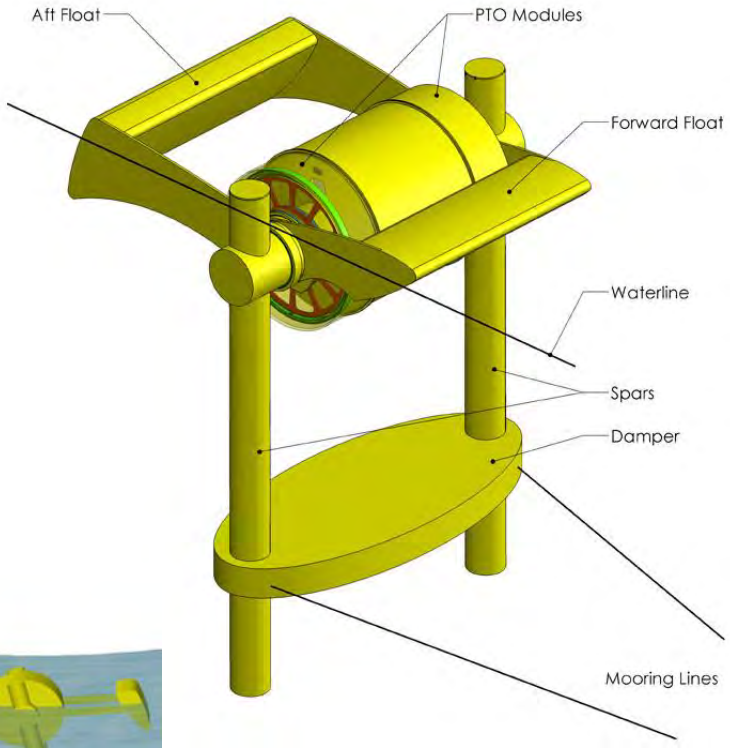


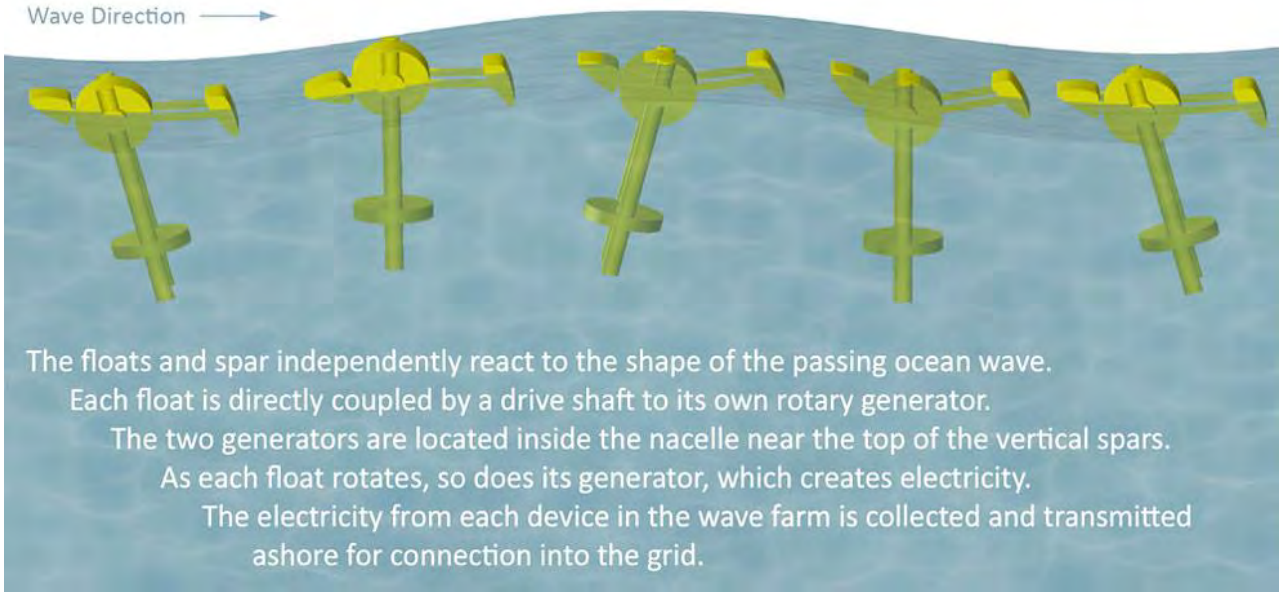
Floating Oscillating Water Column



Examples of Wave Energy Converters

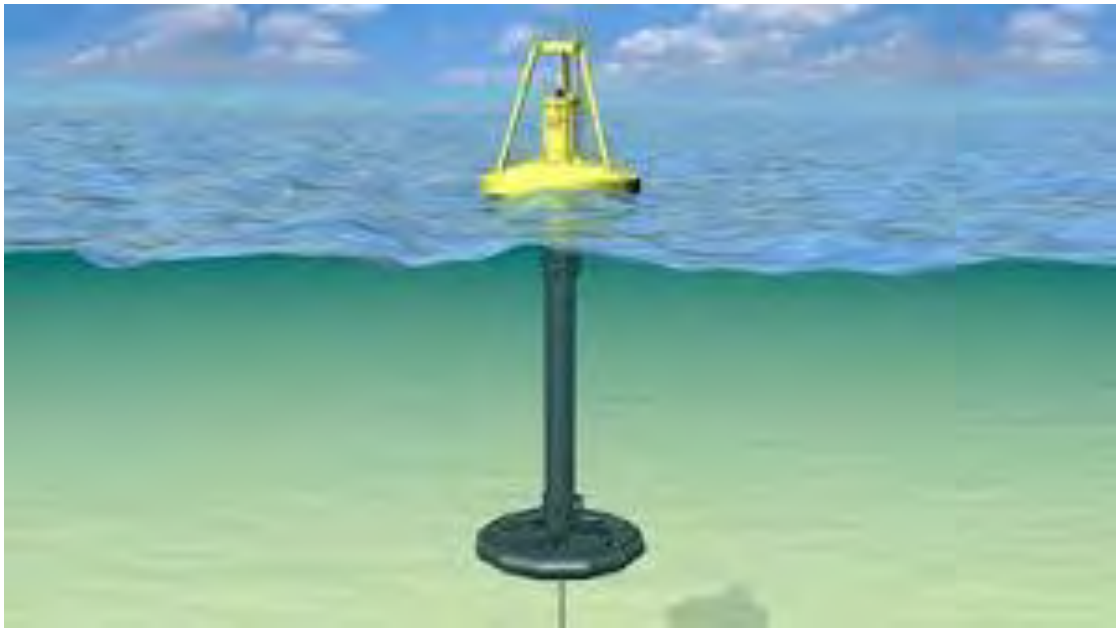
Columbia Power StingRAY point absorber





Examples of Wave Energy Converters

Ocean Power Technology point absorber



Examples of Wave Energy Converters

Fred Olsen BOLT Lifesaver point absorber

Azura: multi-mode, point absorber

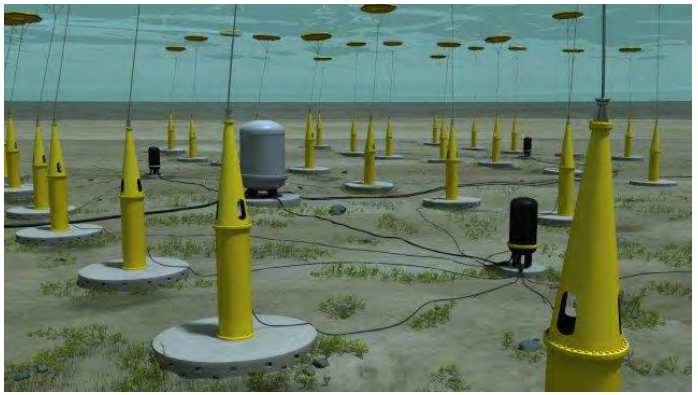
Seatricity Oceanus 2 Pump Type point absorber

Ocean Energy Floating Oscillating Water Column

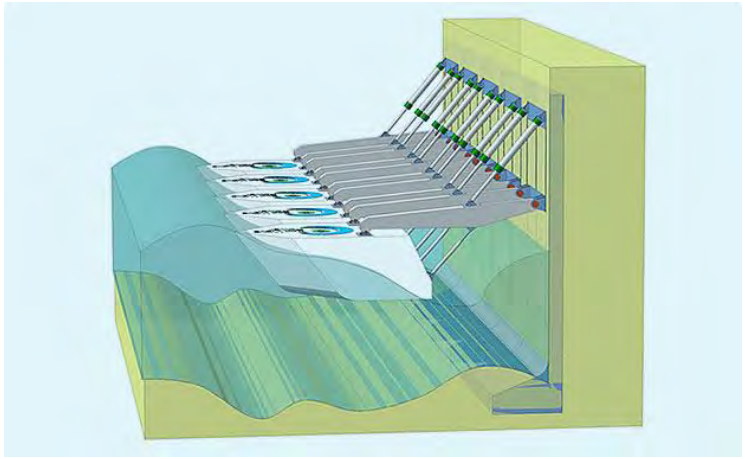
Examples of Wave Energy Converters

Carnegie CETO 6 point absorber

Seabased point absorber



Eco Wave Power Point absorber- Wave Clapper



Waves 4 Power point absorber

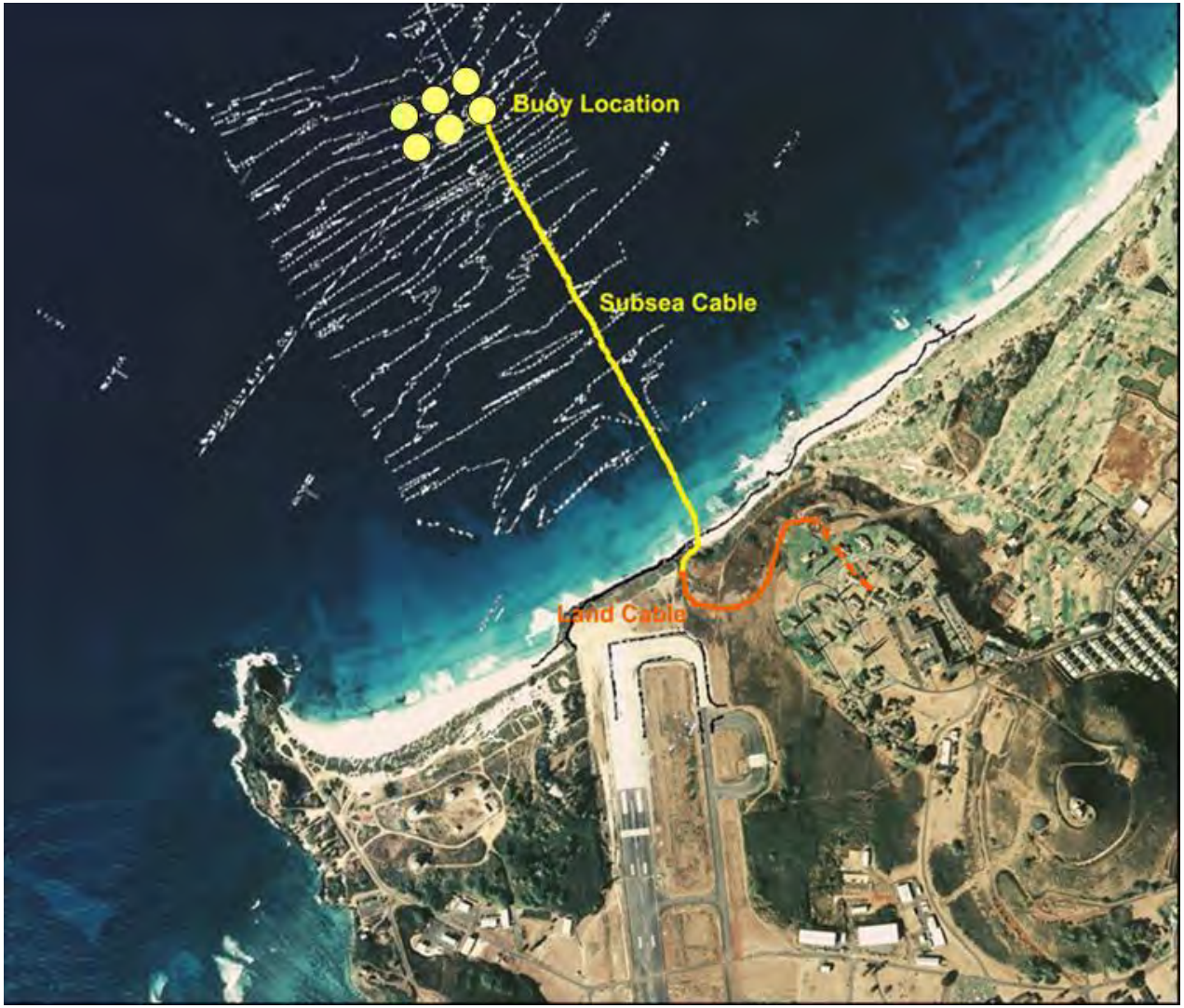
Examples of Wave Energy Converters

CorPower point absorber

Wello Penguin rotating mass

Marine Corps Base Hawai'i Test Site

- Hawaii National Marine Renewable Energy Center (HINMREC) has a Hawaii Wave Energy Test Site (WETS)
- Cooperative between Navy and DOE
- OPT tested a 40kW buoy, from 2003-2011, in 30m depth
- Now 3 test berths exist at depths of 30m, 60m, 80m



http://hinmrec.hnei.hawaii.edu/nmrec-test-sites/wave-energy-test-site/

WETS

- U.S. Marine Corps Base Hawaii, Kaneohe
- 30m, 60m, 80m berths in place, grid-connected
- First 2 devices deployed, more coming
- HNEI role
  - Acoustic, EMF, ecological, sediment transport measurements
  - Independent device durability and performance analysis
  - Site-dedicated support vessel/maintenance protocol development

NAVFAC Naval Facilities Engineering Command

APPLIED RESEARCH LABORATORY
UNIVERSITY OF HAWAI'I

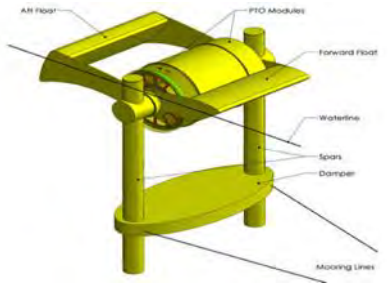
ONR Science & Technology

Data SIO, NOAA, U.S. Navy, NGA, GEBCO

Data LDEO-Columbia, NSF, NOAA

87 mi

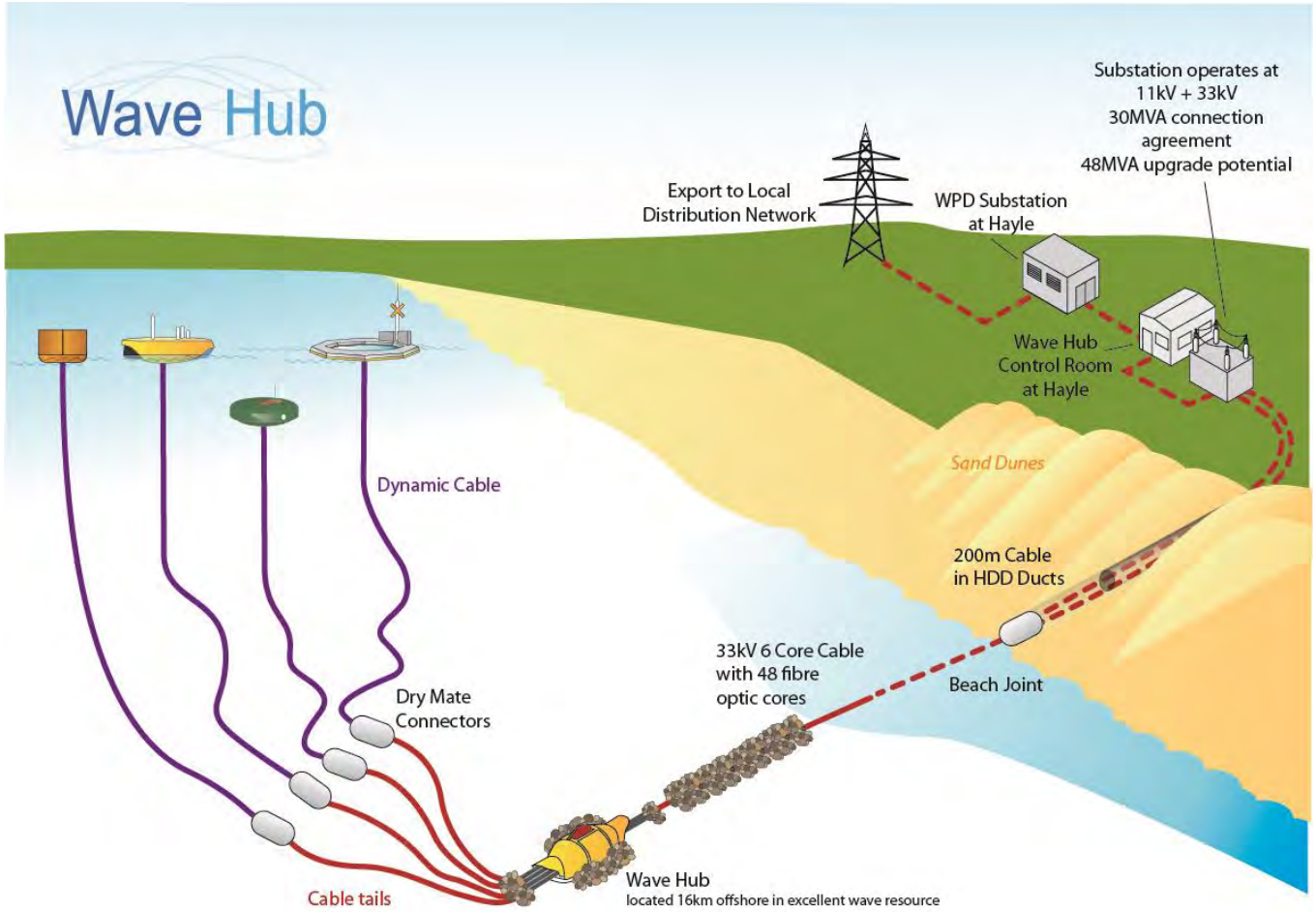
20° 35.173' N 157° 13.914' W elev -6494 ft eye alt 358.99



NWEI **Fred Olsen** **Ocean Energy** **Columbia Power**

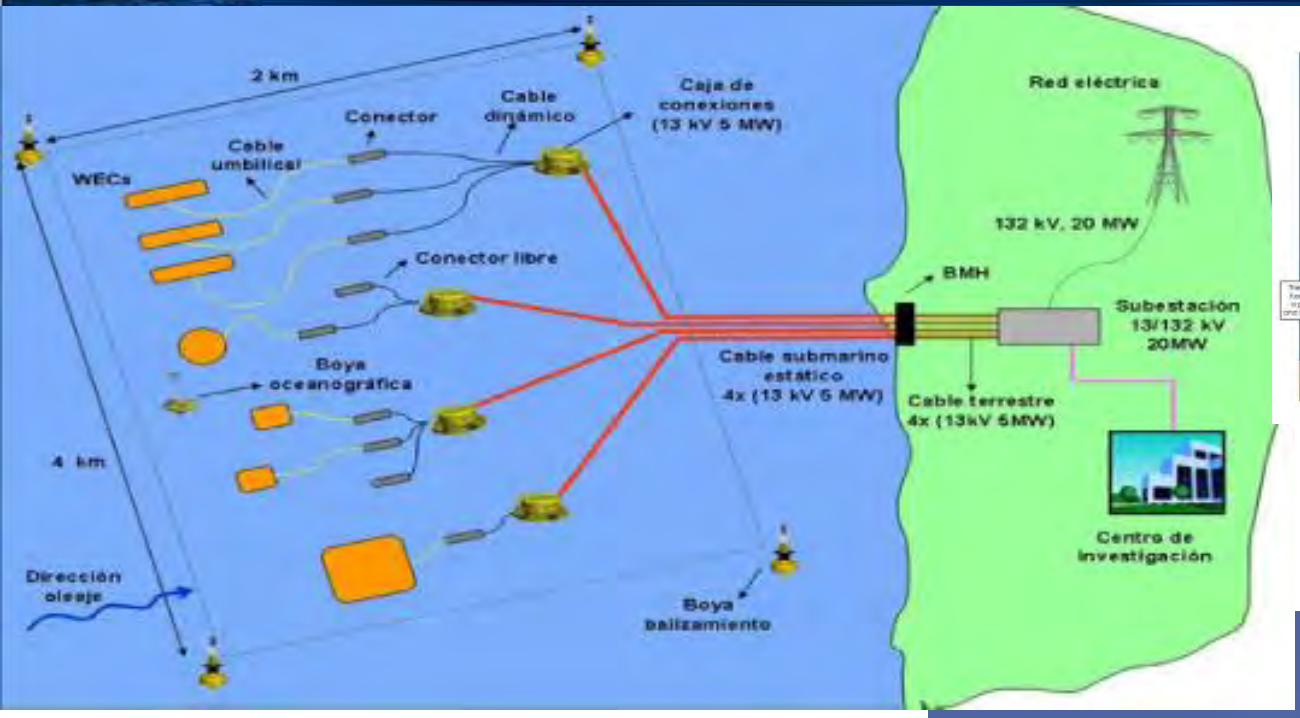
Wave Hub UK

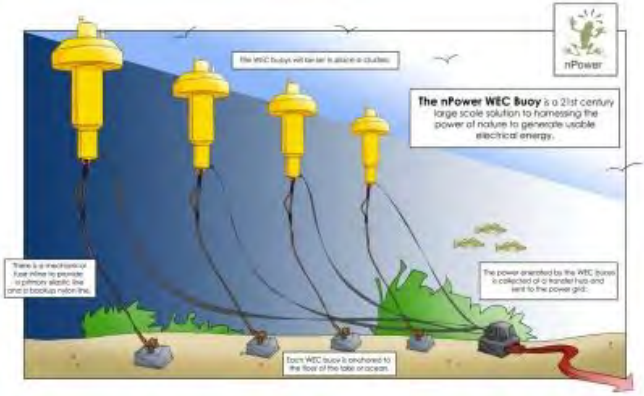
- Grid-connected wave energy test site in Cornwall
- 5 key objectives:
  - Accelerate, support development of offshore renewable technology
  - Drive research & innovation to address challenges of large-scale deployment
  - Overcome final hurdles to commercialization
  - Foster growing UK offshore renewables industry
  - Secure UK position as global leader in offshore renewables

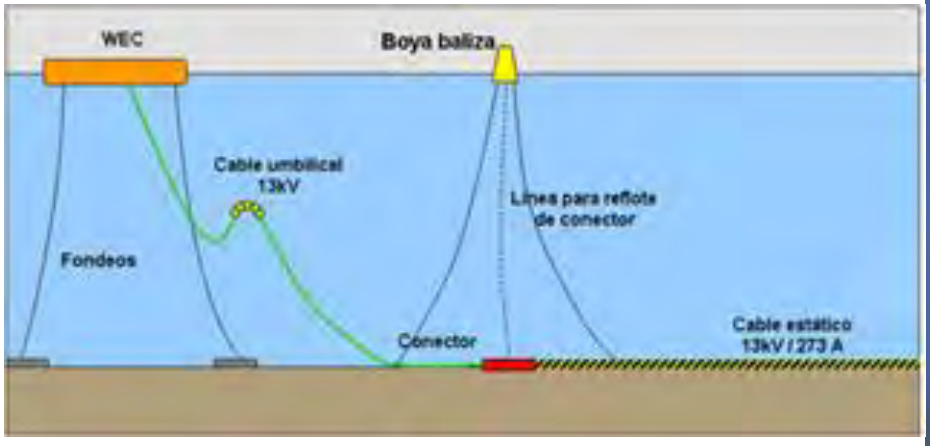


http://www.wavehub.co.uk/wave-hub-site

Biscay Marine Energy Platform (BIMEP)







Anchoring & Mooring Systems

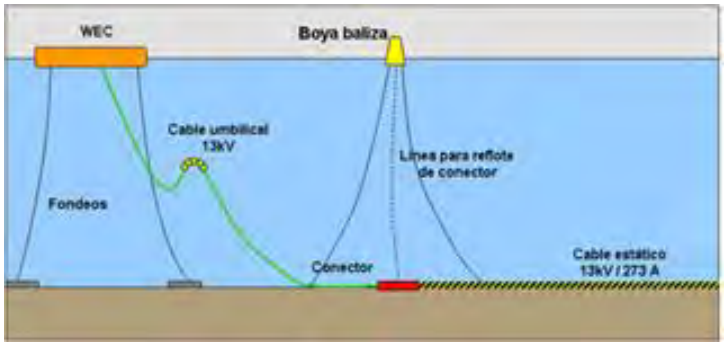
WEC Developers will provide their own properly engineered mooring, anchoring, dynamic cables, and riser cables to ensure a holistic system design.

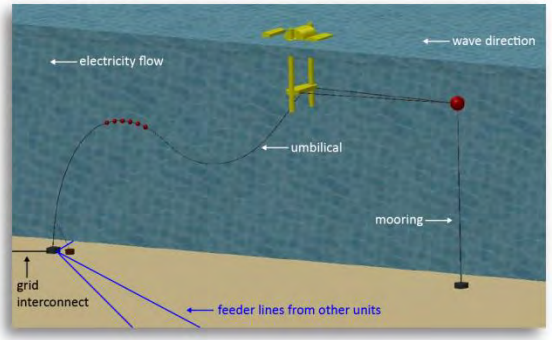
Moorings range from classic three point catenary (slack moors), with "scope" of 3 to 6 times depth, and conventional clump, drag or hybrid anchors.

Proven mooring alternatives: single point, semi-taut, or taut moor that require vertical reaction anchors and can reduce scope to 1 to 2 times water depth. Less space. More expensive.

Proven anchoring alternatives: clump, drag, and hybrid anchors with slack moors. Vertical reaction or embedment anchors enable semi-taut or taut moor.

Mooring lines: vary in composition and size, depending on the application.
The range of materials includes synthetic line, wire rope, and chain.
The range of mooring line **diameters** is 2 inches to 6 inches. (Note about mooring line circumference)



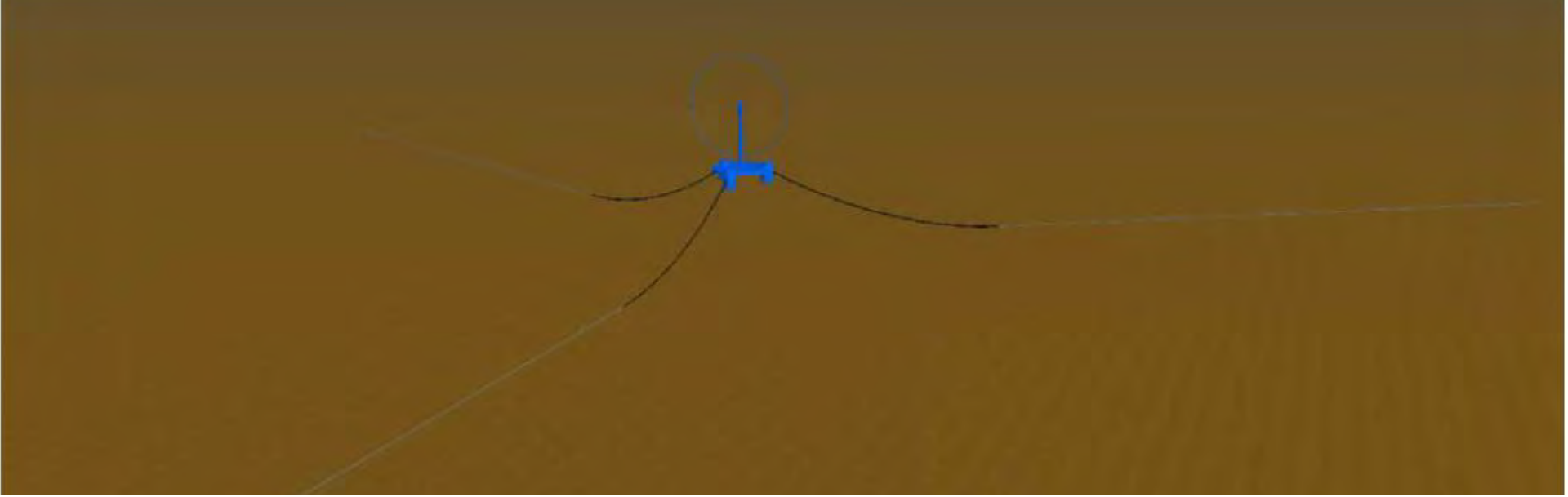


Mooring Typologies

The mooring arrangements for the moored devices under consideration can be classified within five categories: soft catenary, semi-taut, high vertical load, multi-point catenary, and single-point catenary.

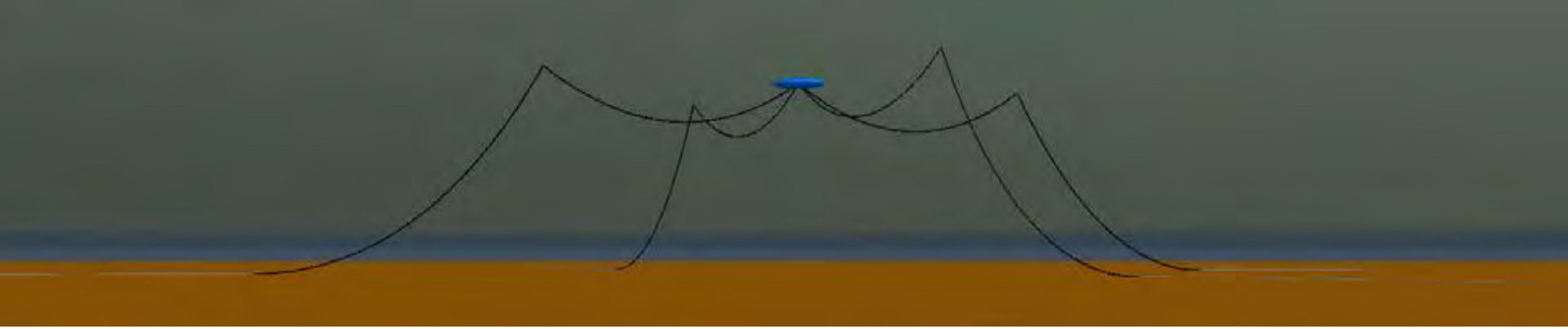
Mooring Type	Tension members			Anchors							
							Piles				
	Chain	Synthetic	Wire	Drag	Dead-weight	Plate	Suction	Driven	Torpedo	Drilled*	Micro*
Soft Catenary	•	•	•	•	•	•	•	•	•	-	-
Semi-taut	•	•	•	•	•	•	•	•	•	-	-
High Vertical Load		•	•		•	•	•	•		-	-
Multi-point Catenary	•	•	•	•	•			•	•	-	-
Single-point Catenary	•	•	•	•	•		•	•	•	-	-

* Hard bottom anchors not likely to be applicable off Pt Arguello

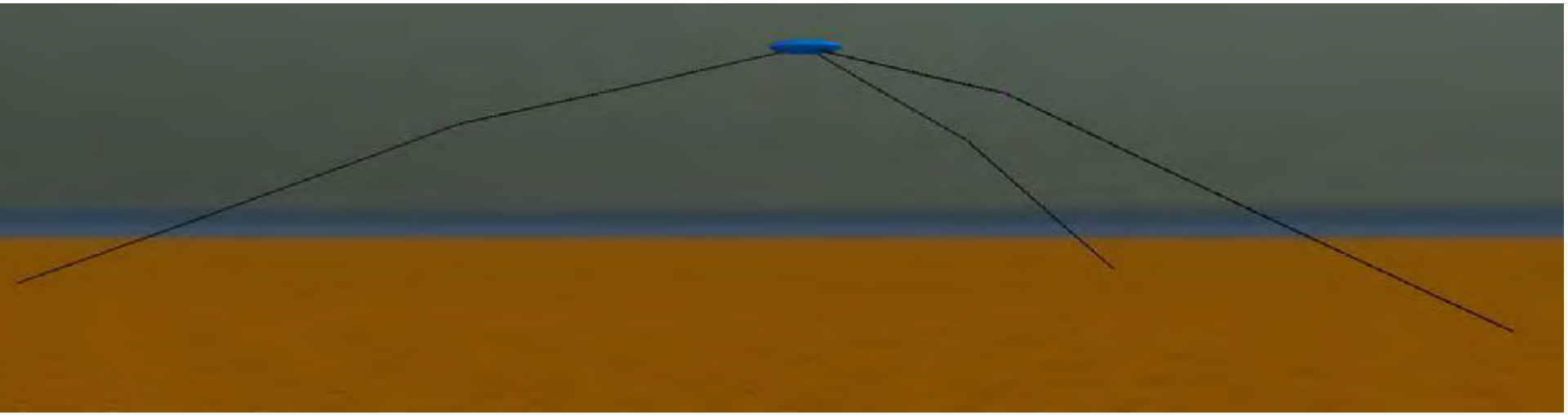


Surface WEC multi-point catenary

Surface Buoy single-point catenary single-point



Surface WEC Soft Catenary



Surface WEC Semi-Taut Catenary with subsurface spring buoys

Figure 15b High vertical load mooring: Floating foundation tension leg platform

Table 6 Behavioral Criteria for Evaluation and Selection of WEC Anchors

Seafloor Material	Deadweight	Pile	Plate	Drag
Soft clay, mud	++	+	++	++
Soft clay layer (0-20 ft) over hard layer	++	++	o	+
Stiff clay	++	++	++	++
Sand	++	++	++	++
Hard glacial till	++	++	++	+
Boulders	++	o	o	o
Soft rock or coral	++	++	++	+
Hard, massive rock	++	+	+	o
Seafloor Topography				
Slope < 10 deg	++	++	++	++
Slope > 10 deg	o	++	++	o
Loading Direction				
Omnidirectional	++	++	++	o
Unidirectional	++	++	++	++
Large uplift	++	++	++	o
Lateral Load Range				
To 100,000 lb	++	+	++	++
100,000 to 1,000,000 lb	+	++	+	++
Over 1,000,000 lb	o	++	o	o

++ Functions well
+ Functions, but not normally the best choice
o Does not function well

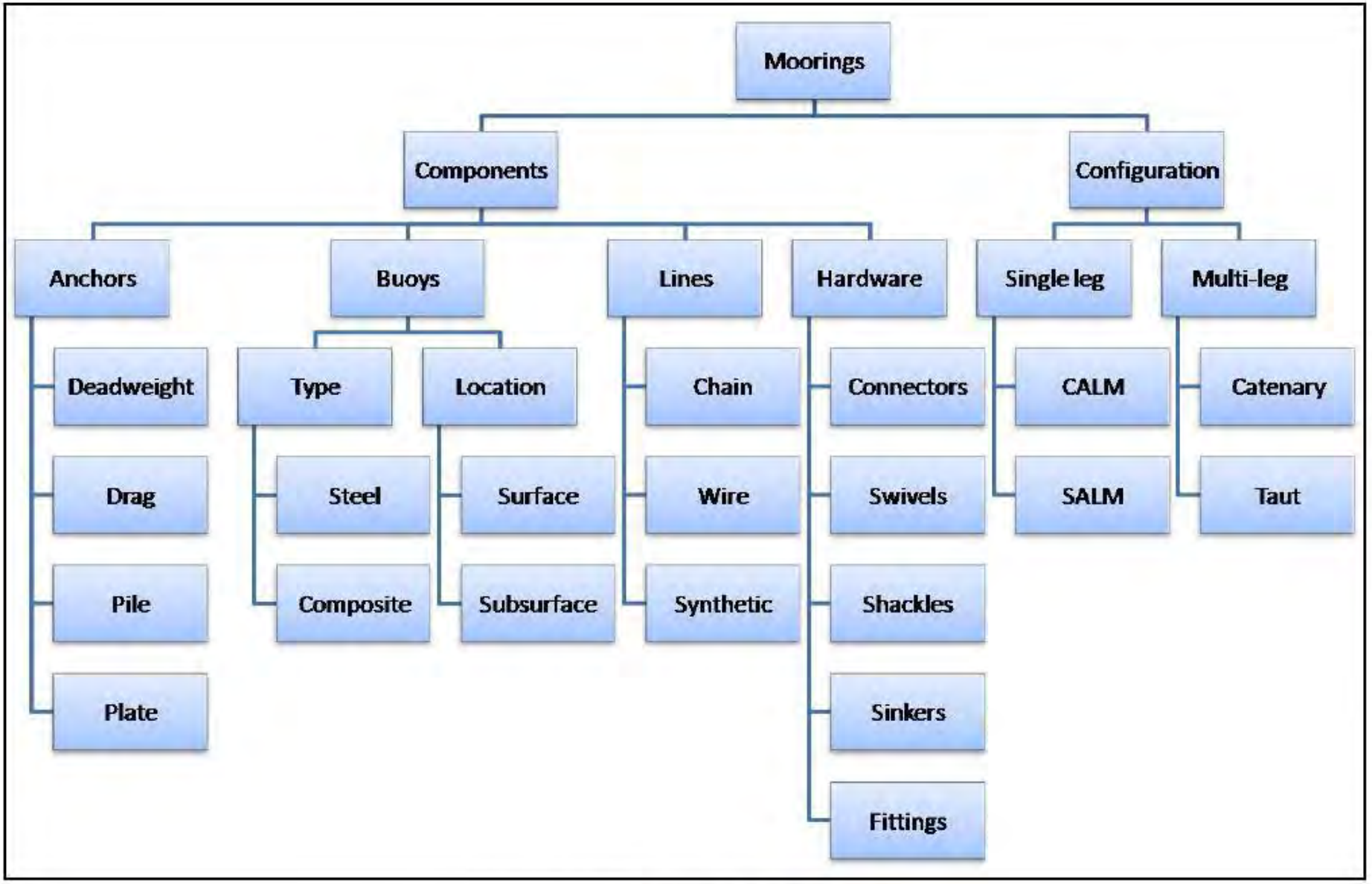


Figure 10 Mooring Technology

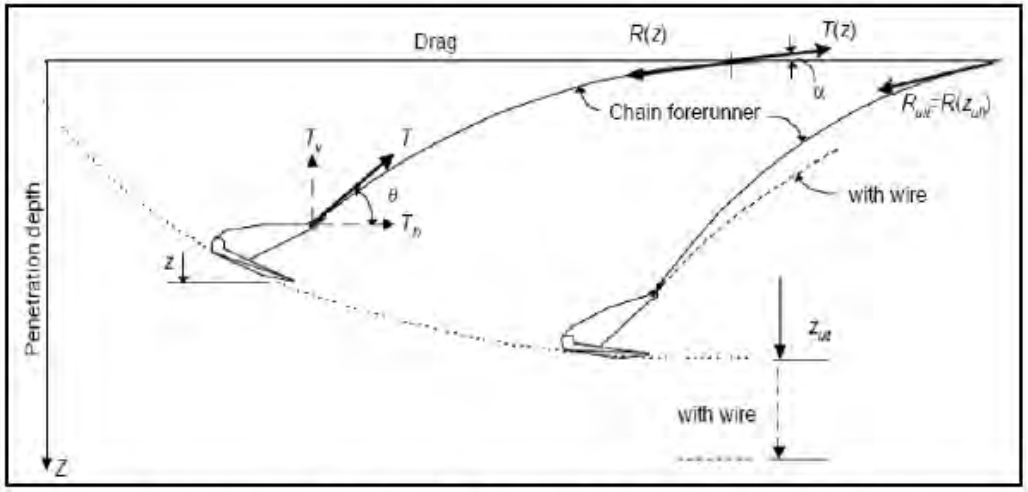


Figure 14 Anchor Penetration Behavior in Clay

Figure 15 Typical Drag Anchor

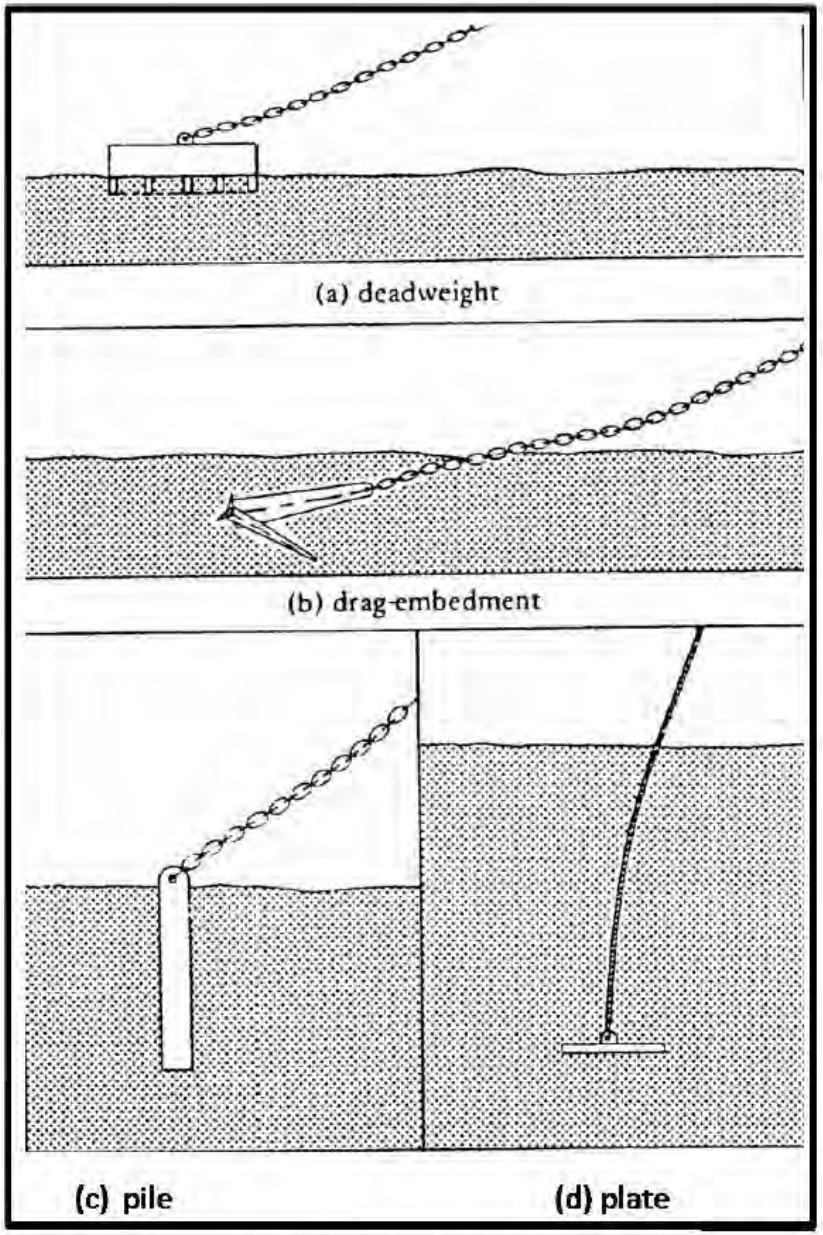


Figure 12 Generic Anchor Types

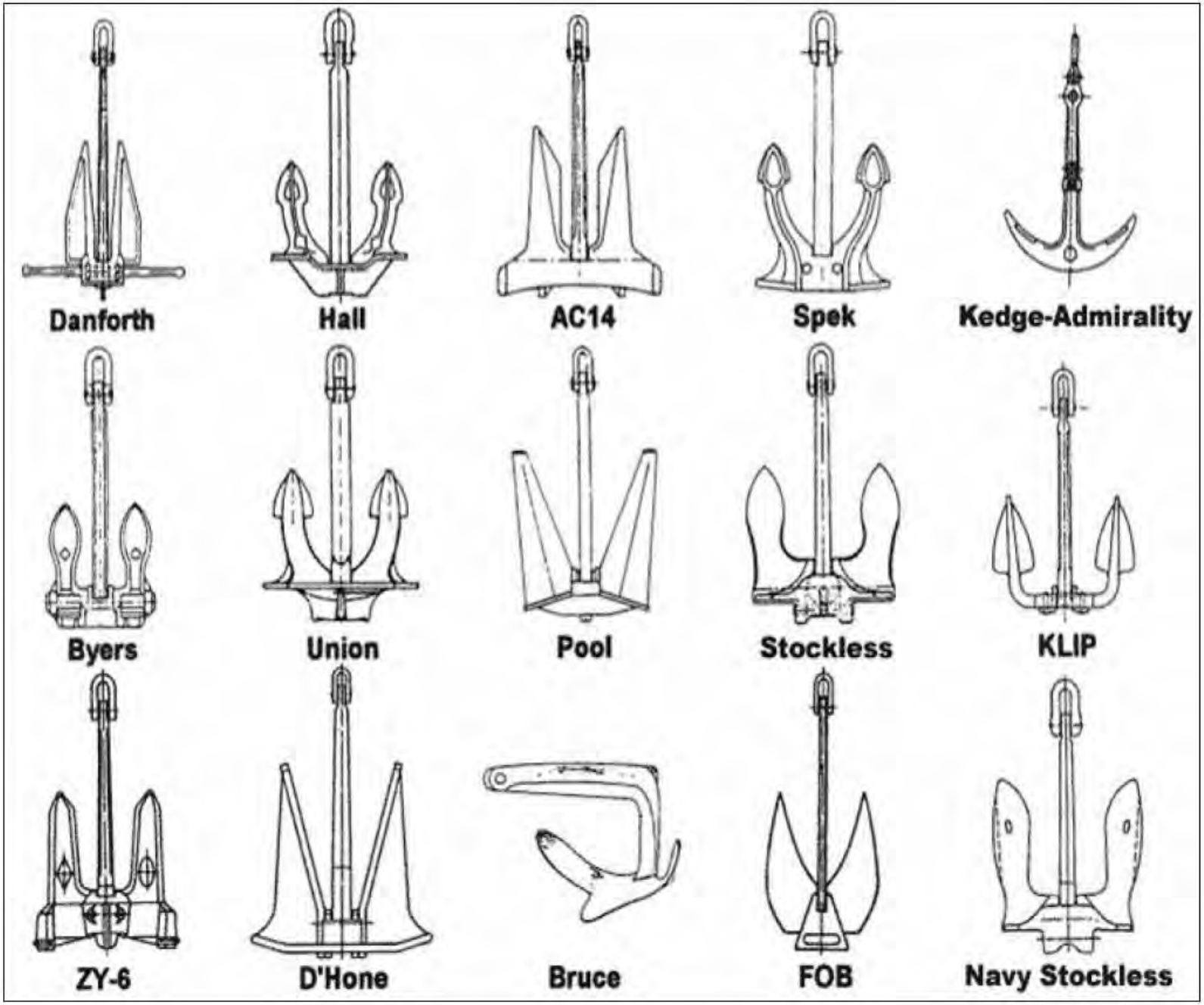


Figure 21 Conventional Anchor Types (after Waterman Supply)

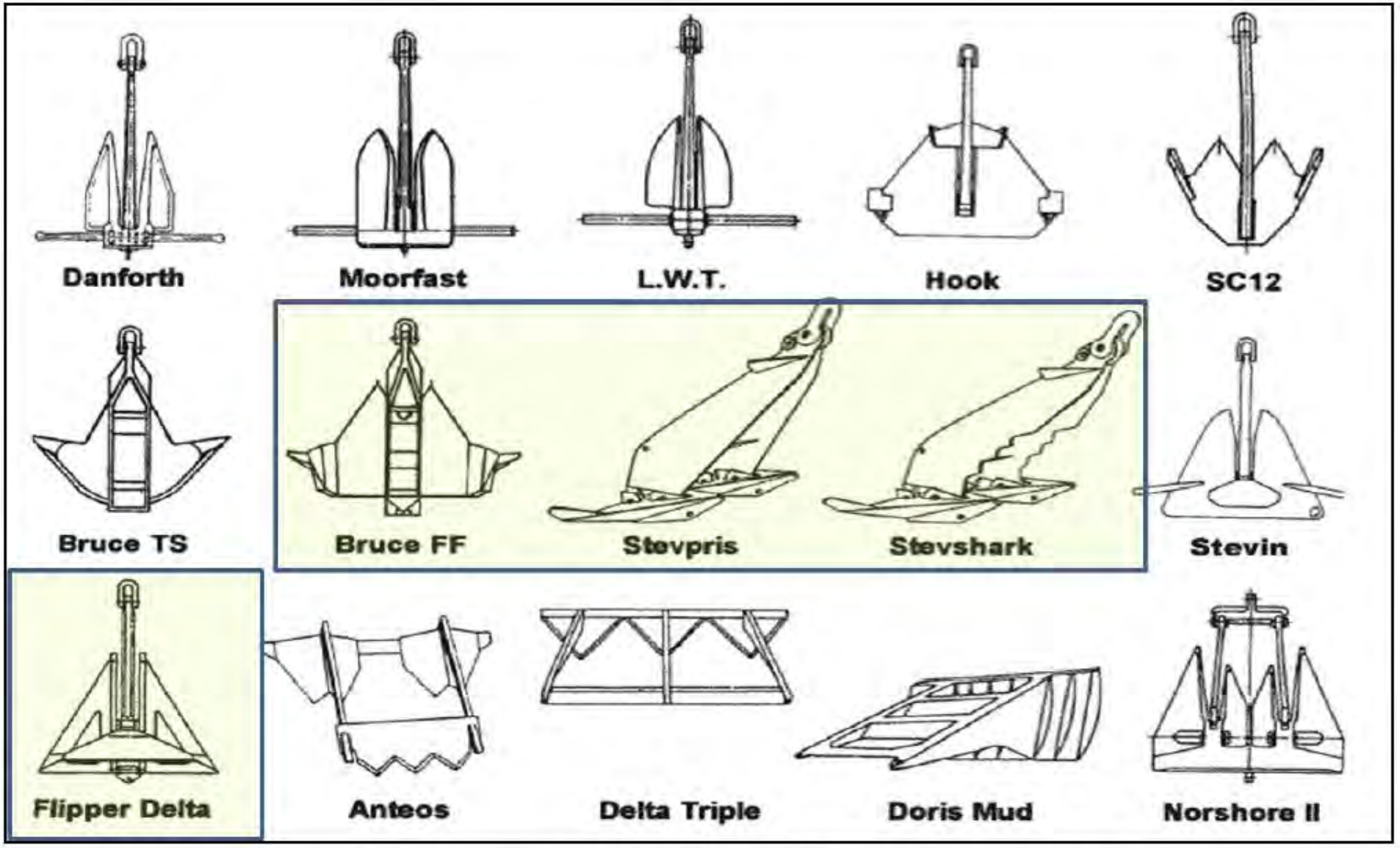


Figure 22 Mooring and Offshore Anchors (after Waterman Supply)

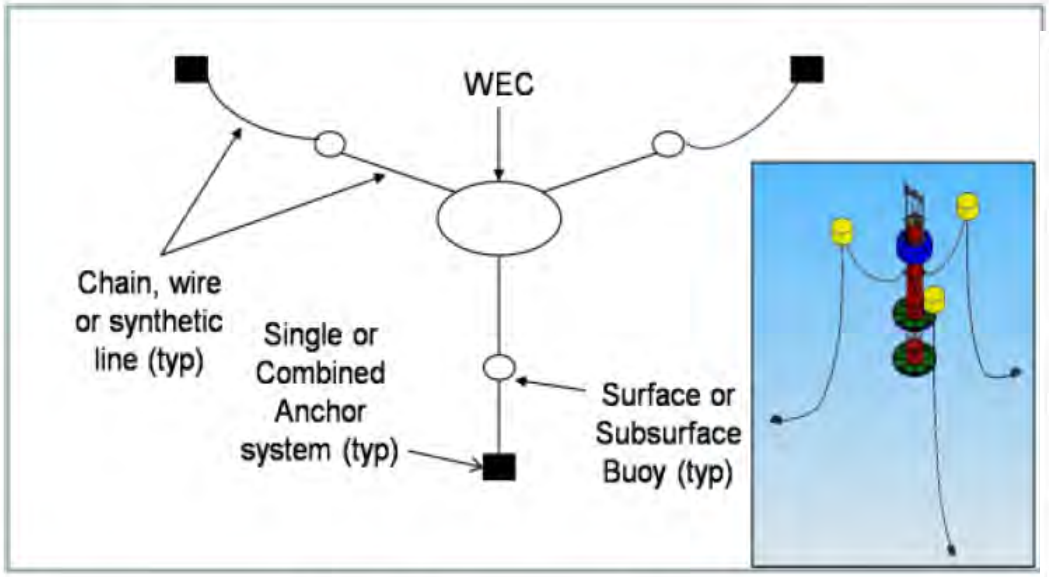


Figure 11 Example 3 Leg Mooring

Figure 13 Enhanced Deadweight Anchor

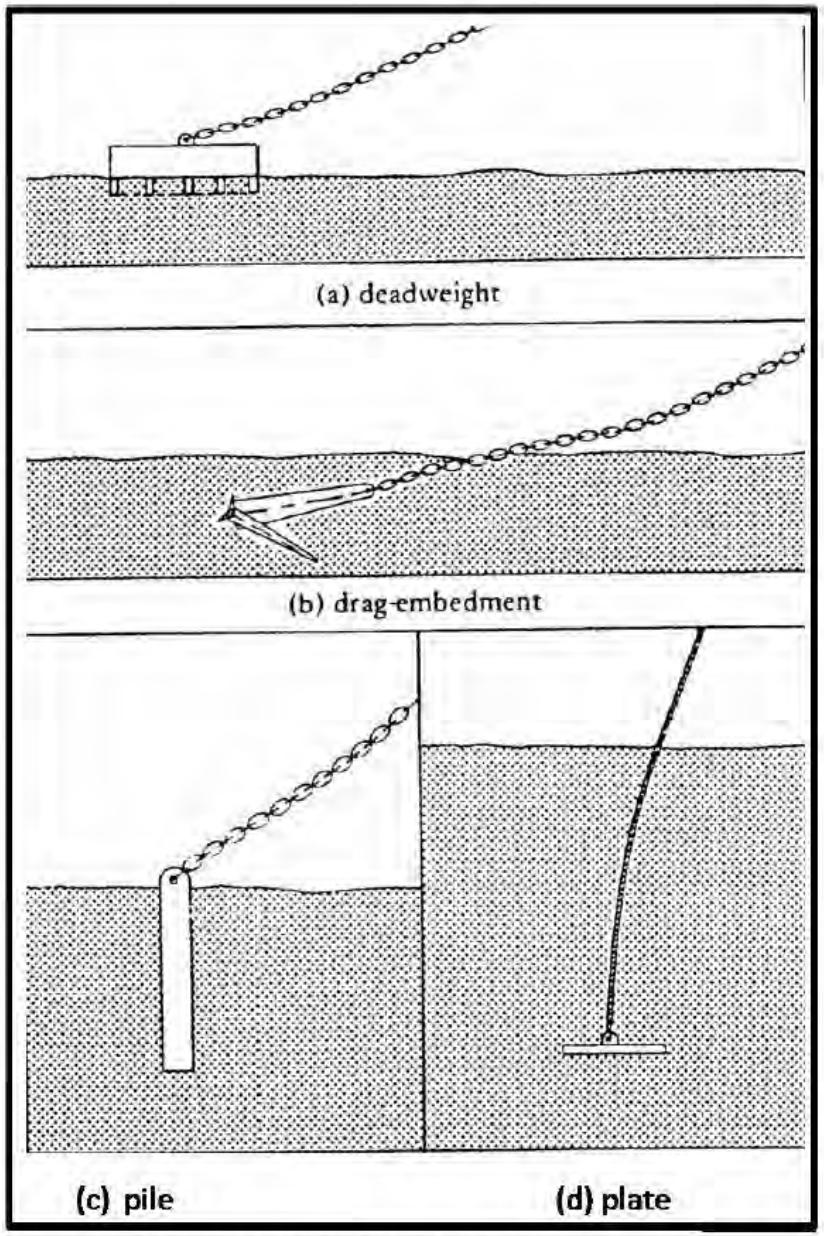
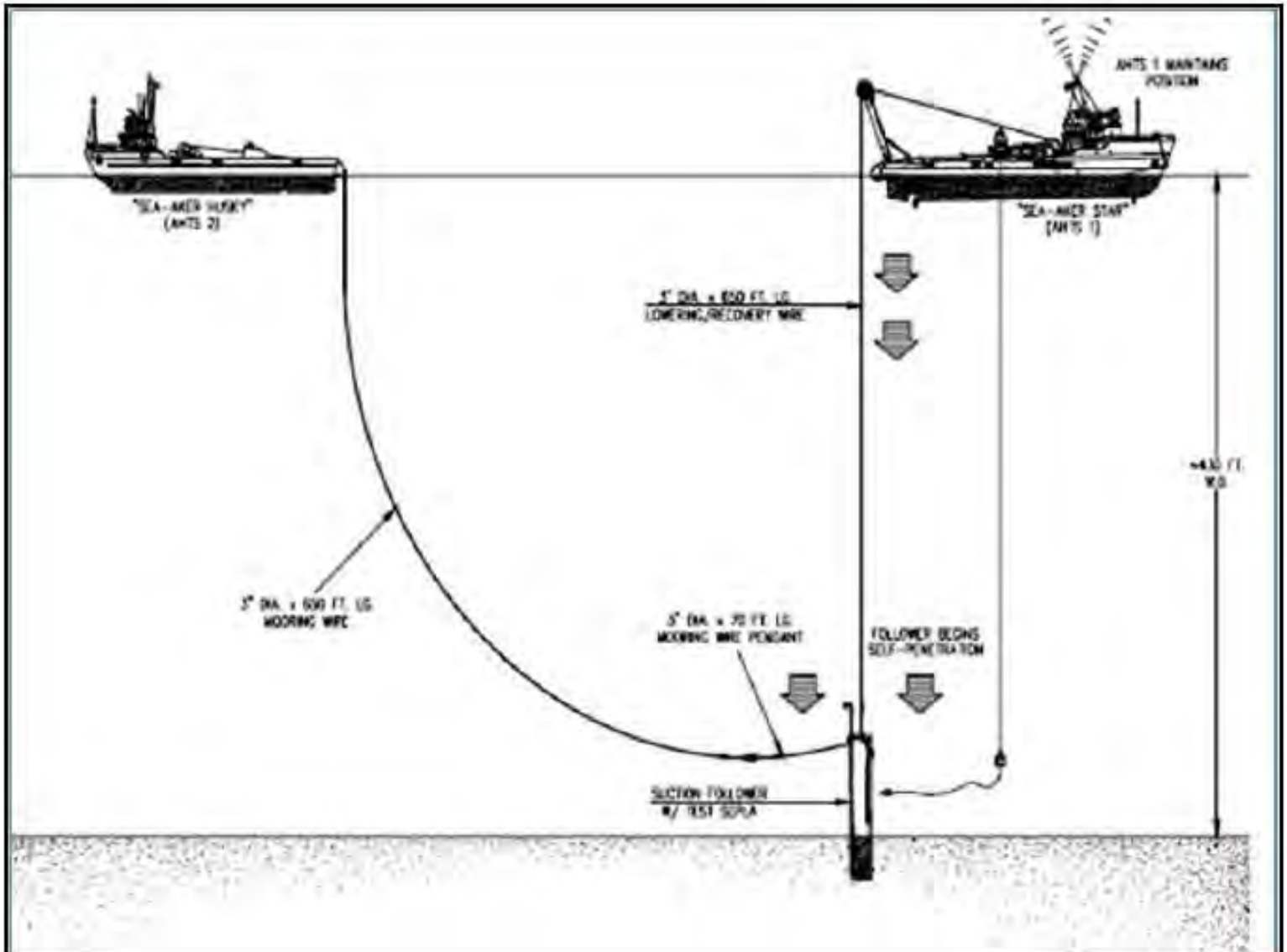


Figure 12 Generic Anchor Types

Suction Embedded Plate Anchor (SEPLA) www.Intermoor.com



Pile and Plate Anchors

Requires offshore crane/pile driver or underwater pile driver

Figure 17 Multiple Suction Piles Installed from Single Vessel

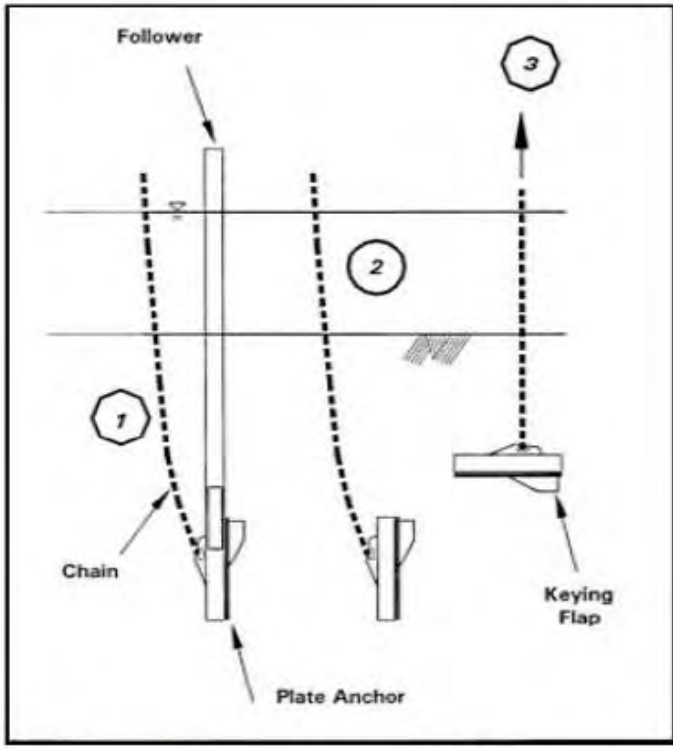


Figure 18 Driven Plate Anchor Installation

Figure 19 Coral Plate Driven Anchor

Exploring the "envelope"

The range of potential effects by WEC and mooring type

Introduce Matrices for Discussion Later

Wave Energy Converters (WECs)

CalWave^{SM} will host mature WECs

WEC developers will provide the WEC devices, with properly designed mooring and anchoring, dynamic umbilical cables with dry-mate connectors, and power conditioning modules ashore.

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Envelope Analysis in Permitting

- The permitting "envelope" is the collection of WEC and mooring design types in the permitting project description
- The "envelope" also defines the scale of the devices and equipment that are pre-permitted for the Test Center
- CalWave^{SM} permitting analyses will describe any unique environmental effects of each WEC and mooring type at the maximum scale considered
- Entities testing at CalWave^{SM} will be considered pre-permitted when they demonstrate that their WEC and mooring designs fit the "envelope"
- WECs/moorings not fitting the "envelope" would require some additional permitting to address any different effects
- Envelope also includes riser cables, dry mate connectors, & dynamic cable tail segments

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Recent Research on Electromagnetic Fields (EMF)

Ann Bull, BOEM

Potential Environmental Effect Risk Profiles

WEC Berths & Anchoring/Mooring Topics

Topic	Studies	Effects	Likelihood	Severity	Relative Risk	Actions	Info Needed
Noise/Acoustics	Varies by species	Behavioral, injury	Hi during construction, low during operation	Moderate	High for construction, low for operation	Plan to monitor construction	Noise levels of WECs permitted
Entanglement	Long-term data for fishing net entanglement	Injury/death of cetaceans, birds	Low for buoy cables – uncertain for fishing net	High	Moderate	Periodic check of buoy cables	Risk of buoy cable entanglement
Changes in Habitat/ Reefing	For some habitats	Increases habitat for some species	Very high	Very low	Very low	Consult NMFS	Analysis of species affected
Collision Risk	Whale studies, East Coast	Injury and death	Moderate	High	Moderate	Plan to monitor construction vessels	Frequency of occurrence
Fishing Effects	CDFW catch statistics	Loss of fishing access	High – WECs will displace some fishing	Low – fishing not intense in project area	Low	Consult fishing community	Additional information on catch, fishing areas

WEC Berths & Anchoring/Mooring Topics

Topic	Studies	Effects	Likelihood	Severity	Relative Risk	Actions	Info Needed
Wave Resource Effects, i.e. surfing, sediment transport	Model wave attenuation at shore	Attenuation of surfing waves, change of sediment transport	High	Very low – due to diffraction and refraction and distance	Very low at distance from shore	Model wave attenuation	Wave buoy data (available)
Fish Attraction	Some available	May increase predation on protected species	High	Low	Low	Consult NMFS regarding sensitive species	Which species susceptible
Visual Impacts to Jalama Beach	Visual simulation	Recreational viewers	High	Low	Low	None	Scale of WECs permitted
EMF	Available	Behavioral	High	Low	Low	Review studies	Subsea cable EMF levels
Submerged Cultural Resources (shipwrecks, etc.)	Side-scan sonar of cable routes	Damage to cultural resources (if not avoided)	Very low	Would vary (but avoidance possible)	Low to very low	Review sonar results	Side-scan sonar
Other							

Cable Route Topics

Topic	Studies	Impacts	Likelihood	Severity	Relative Risk	Actions	Info Needed
Near-shore Sensitive Habitats	Existing VAFB studies, dive surveys	Temporary disruption of habitat	Moderate (may be avoided)	High	High if not avoided	Pre-construction survey to avoid	Habitat mapping
Marine Habitat (esp. invertebrates)	Bathymetry and USGS habitat mapping	Temporary disruption	High	Low to very low	Low	Obtain USGS information	USGS habitat maps, video if available
Cultural Resources (shipwrecks, etc.)	Side-scan sonar of cable route	Damage to cultural resources (if not avoided)	Very low	Would vary (but avoidance possible)	Low to very low	Review sonar results	Side-scan sonar
EMF	Available	Behavioral	High	Low to very low	Low to very low	Review studies	Subsea cable EMF levels
Acoustics/Noise During Construction	Varies by species	Behavioral, possible injury	High for construction, low for operation	Moderate	High for construction, low for operation	Plan to monitor construction	Noise levels from WECs
Other?							

Onshore Landing Area Topics

Topic	Studies	Impacts	Likelihood	Severity	Relative Risk	Actions	Info Needed
Harbor Seal Haul-out	VAFB surveys	Temporary disruption during construction	High	Low	Low	Monitor beach during construction	Observe use of beach adjacent to shore station
Endangered/ Sensitive Species habitats	VAFB surveys	Habitat disruption, removal	Low	High	Low	Plan 70 kV route to avoid sensitive habitats	Pre-permitting survey of 70 kV route
Archaeological Resources	VAFB surveys	Damage to archaeological deposits	Moderate	Moderate to low, with mitigation	Moderate	Plan 70 kV route to avoid sites	Pre-permitting survey of 70 kV route
VAFB Coast Guard Station Viewshed	Visual simulation	Visual impact to recreational users of CG station	Low	Low	Low	Screen view of Shore Station with vegetation	Design of shore station
Wetlands	VAFB surveys	Disruption of wetland habitat	Low, with 70 kV route avoidance	High, unless avoided	Low	Plan 70 kV route to avoid wetlands	Pre-permitting survey of 70 kV route

Update from State of California

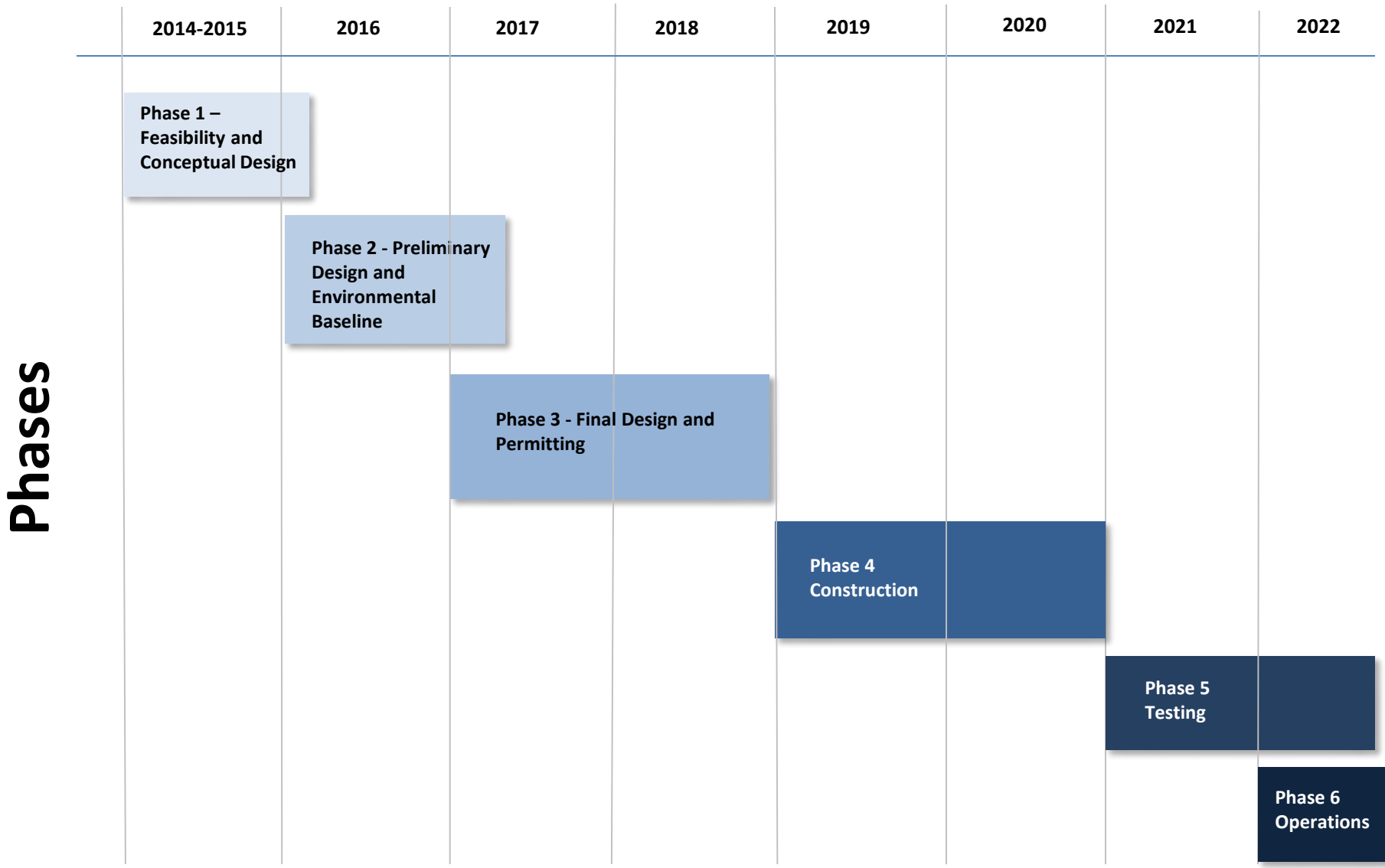
Offshore Renewable Energy Activities

Next Steps

Regulatory Agency Meeting 12/8/16

Topics for future meetings?

CalWave℠ Timeline



Contact CalWave℠

calwave@calpoly.edu

Dr. Sam Blakeslee, Principal Investigator

Bill Toman, Project Manager
(President, Protean Wave Energy, Inc)
707-731-9261 (m)

CalWave

Permitting Agency Meeting

EMF Environmental Effects & Risk

Ann Scarborough Bull, Ph.D.
Bureau of Ocean Energy Management, Pacific Region
Portland, Oregon
October 21, 2016

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Moving Electricity from Offshore to Onshore is a Common Global Technology

Accomplished via Power Transmission Cables

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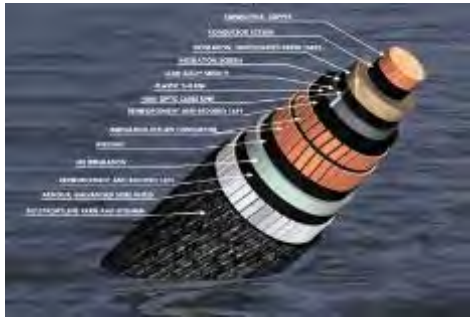
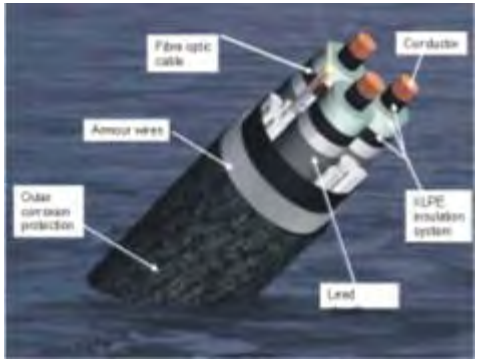
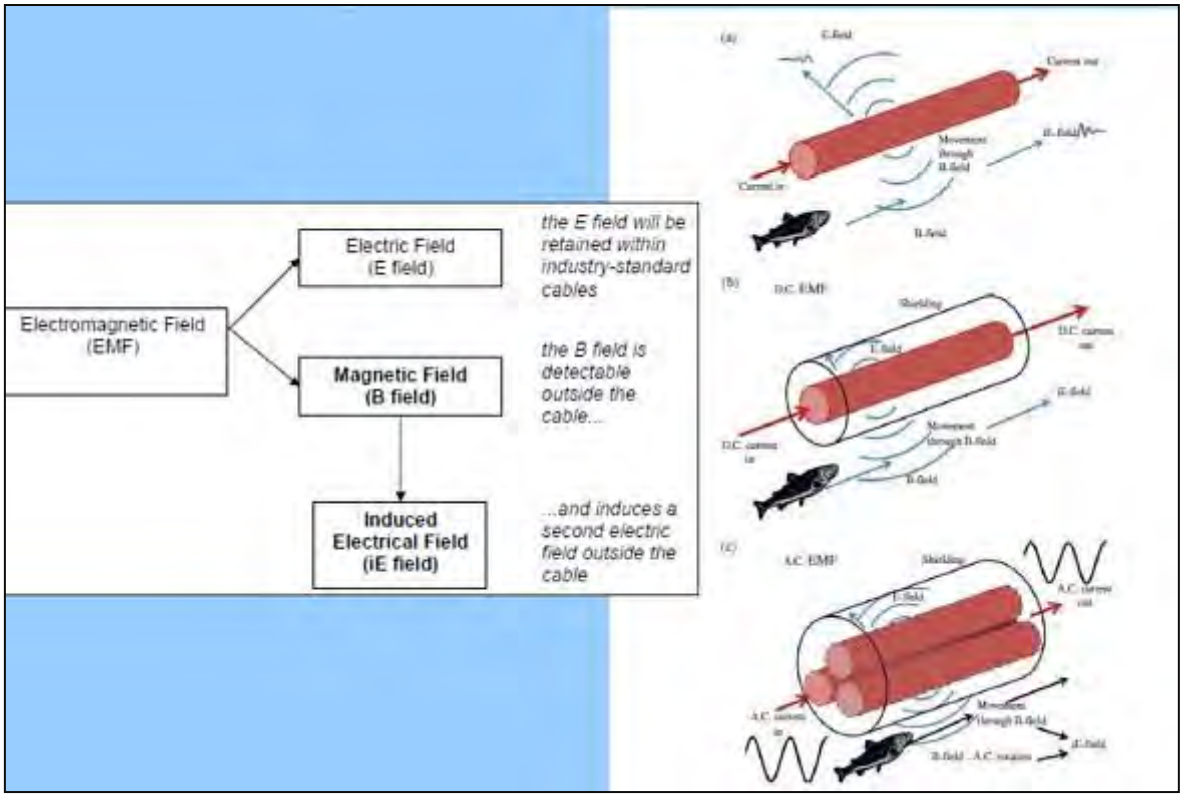
Defining Electromagnetic Fields for AC and DC Power Cables

DC Cable



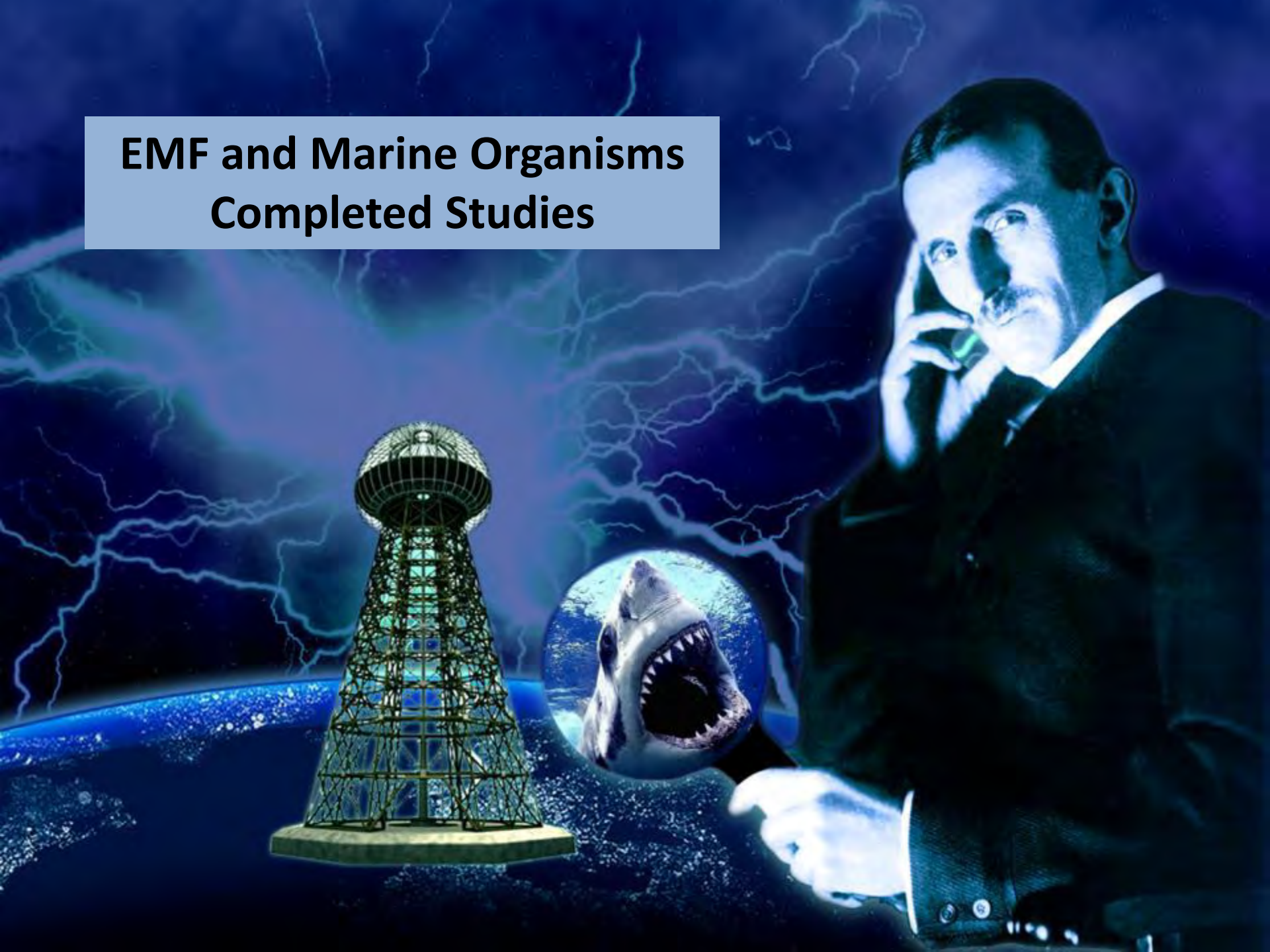
AC Cable





Gill A. et al. 2009

EMF and Marine Organisms
Completed Studies



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Some Completed Studies Related to EMF

https://tethys.pnnl.gov/stressor/emf

- Effects of EMFs from Undersea Power Cables on Elasmobranchs and Other Marine Species
  www.data.boem.gov/PI/PDFImages/ESPIS/4/5115.pdf

- Effects of Electromagnetic Fields on Fish and Invertebrates
  http://www.pnl.gov/main/publications/external/technical_reports/PNNL-22154.pdf
  http://www.pnl.gov/main/publications/external/technical_reports/PNNL-22154.pdf
  http://www.pnl.gov/main/publications/external/technical_reports/PNNL-22154.pdf

- Sensitive Fish Response to EMF from Sub-Sea Electric Cables
  https://www.thecrownestate.co.uk/media/5924/km-ex-pc-emf-032009-cowrie-20-electromagnetic-fields-emf-phase-2.pdf

- Sub-sea Power Cables and the Migration Behaviour of the European Eel
  https://tethys.pnnl.gov/publications/sub-sea-power-cables-and-migration-behaviour-european-eel

- Renewable Energy *in situ* Power Cable Observation http://www.boem.gov/2016-008/

- Annex IV State of the Science http://tethys.pnnl.gov/publications/state-of-the-science-2016

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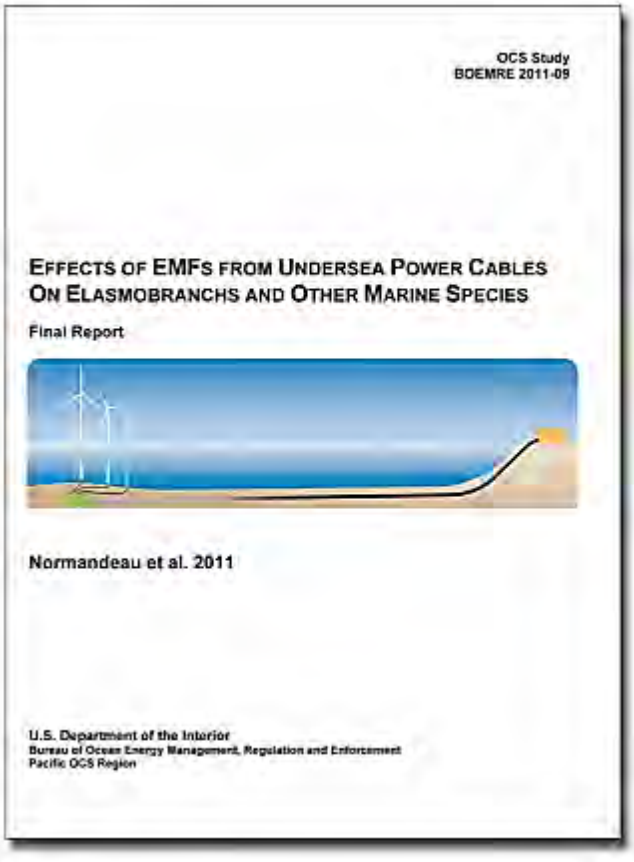
Effects of EMFs from Undersea Power Cables on Elasmobranchs and Other Marine Species

What does the literature say about EMF? Can the anticipated EMF fit a model?



Objectives:

- Describe and quantify predicted EMF from power cables connected to offshore renewable energy projects.
- Compile information on sensitive marine species that have the potential for exposure effects.
- Understand sensitive marine species and the potential effects of exposure to EMF from offshore power cables.

Normandeau et al. 2011

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Some Findings from Literature Study

- Anticipated EMFs from power cables can be modeled easily if specific information is available:
  - Cable design
  - Anticipated burial depth and layout
  - Magnetic permeability of the sheathing
  - Anticipated electrical loading range

- Behavioral responses to and some effects from electro- or magnetic fields are known for a few species; extrapolation to many other species or to population impacts is speculative.

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Effects of Electromagnetic Fields on Fish and Invertebrates

What do laboratory experiments say?

Objectives:

- Describe and quantify predicted EMF from power cables connected to offshore renewable energy projects.
- Compile information on sensitive marine species that have the potential for exposure effects.
- Understand sensitive marine species and the potential effects of exposure to EMF from offshore power cables.
- Perform experiments under tightly controlled conditions in the laboratory.

Schultz et al. 2010
Wilson and Woodruff 2011
Woodruff et al. 2013

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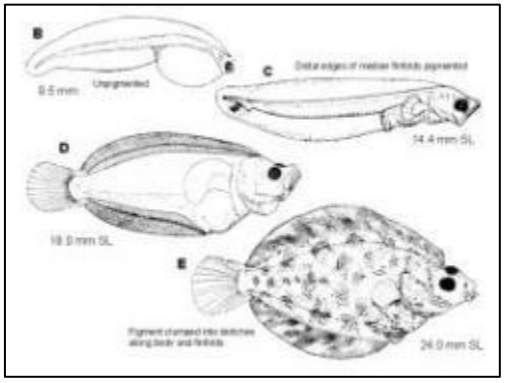
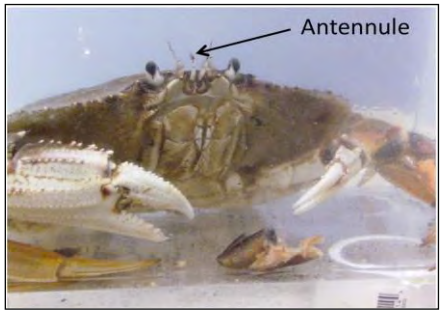
Some Findings from the Laboratory Studies

- Little evidence to indicate distinct or extreme behavioral responses in the presence of elevated EMF at 3 mT (3000 µT) for the species tested.
- Several developmental and physiological responses were observed in the fish exposures, although most were not statistically significant.
- Several movement and activity responses were observed in the crab experiments.
- There may be possible developmental and behavioral responses to even small environmental effects; however, further replication is needed in the laboratory as well as field verification.





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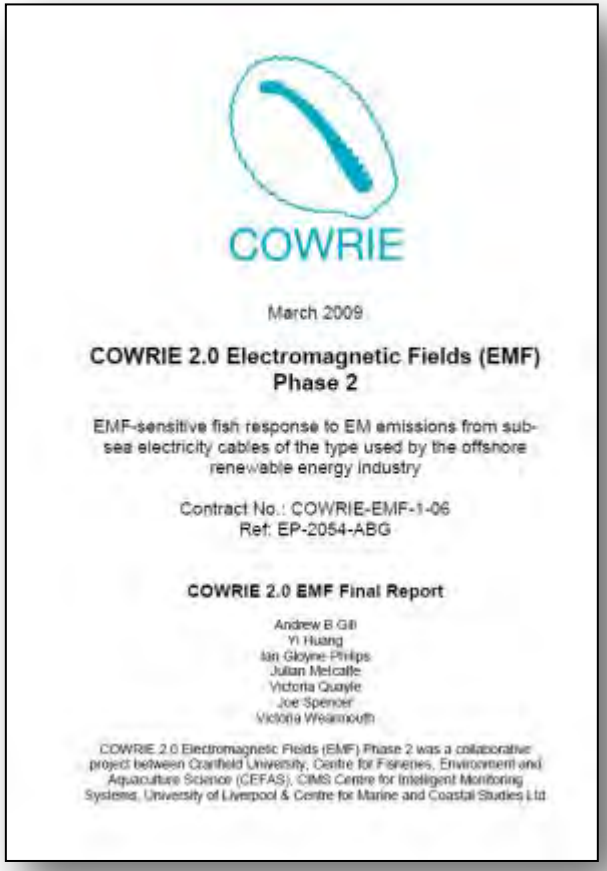
EMF-Sensitive Fish Response to EM Emissions from Subsea Electricity Cables of the Type Used by the Offshore Renewable Energy Industry

What does a mesocosm study say?


COWRIE

March 2009

COWRIE 2.0 Electromagnetic Fields (EMF) Phase 2

EMF-sensitive fish response to EM emissions from sub-sea electricity cables of the type used by the offshore renewable energy industry

Contract No.: COWRIE-EMF-1-06
Ref: EP-2054-ABG

COWRIE 2.0 EMF Final Report

Andrew B Gill
Yi Huang
Ian Gloyne-Phillips
Julian Metcalfe
Victoria Quayle
Joe Spencer
Victoria Wearmouth

COWRIE 2.0 Electromagnetic Fields (EMF) Phase 2 was a collaborative project between Cranfield University, Centre for Fisheries, Environment and Aquaculture Science (CEFAS), CIMS Centre for Intelligent Monitoring Systems, University of Liverpool & Centre for Marine and Coastal Studies Ltd

Objectives:

Determine response of electromagnetically sensitive organisms to anthropogenic EMF.

- Test if electromagnetically (EM) sensitive organisms respond to anthropogenic EMFs expected from offshore wind farms.
- Conduct the study under *in situ* controlled coastal conditions to improve its applicability to the actual offshore situation.
- Create a mesocosm experiment to mimic the EMF type and magnitude generated by offshore wind farms.

Gill et al. 2009

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Some Findings from Mesocosm Study

- There is no evidence from the study to suggest any positive or negative effect on elasmobranchs from the encountered EMF.
- The benthic elasmobranchs species did respond to the presence of EMF emitted by the sub-sea cable.
- Target monitoring would be considerably cheaper than a catch-all comprehensive fishery survey to determine changes in numbers, demographics of populations, and recruitment.
- The use of large-scale mesocosms (40m x 5m) with replicate studies and the inclusion of a control are a feasible way of understanding environmental effects at a scale appropriate to the marine renewable energy sector.

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Sub-sea Power Cables and the Migration Behaviour of the European Eel

What does a migration study say?

Fisheries Management and Ecology

Sub-sea power cables and the migration behaviour of the European eel

H. WESTERBERG & I. LAGENFELT

Introduction

Objectives:

- Investigate if the effects of 130 kV AC fields on fish behaviour could be demonstrated.
- Use acoustic tags and a receiver array to study the effect of a sub-sea AC cable on fish migration.
- Investigate possible effects of low-frequency EMF from AC cables on eel migration behaviour.

Westerberg and Lagenfelt 2008

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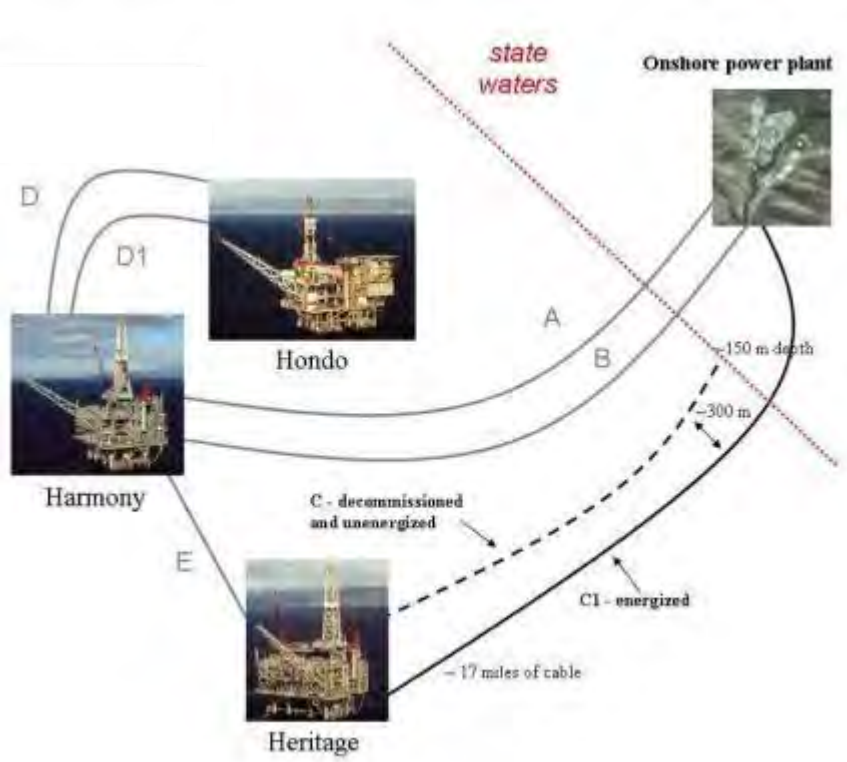
Some Findings from the Eel Migration Study

- Eels swam slower crossing an unburied 130 kV AC cable during migration and slower speed was related to EMF.
- The effect of the cable on eels was small.
- There was no evidence that the cable was an obstruction to eel migration.
- The experimental technique using sonic tags in an array with fixed receivers is able to detect even small environmental effects.

Renewable Energy *in situ* Power Cable Observation

What does an observational study say?



Identical 35 kV AC power cables carrying a usual load of 17 to 18 MW and occasionally as high as 26 MW

Objectives:

- Measure the strength, spatial extent, and variability of EMF along both energized and unenergized cables.
- Determine attraction/repulsion of fish and macroinvertebrates to the EMF from the power cables.
- Determine the effectiveness of the commonly proposed mitigation of cable burial.

Love et al. 2016

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Some Findings from *in situ* Study

- No response (attraction/repulsion) from fish or macroinvertebrates to EMF from a 35 kV AC *in situ* power transmission cable.
- At a usual electricity load of 17 to 18 MW, and occasionally as high as 26 MW, the mean value EMF was 109-120 µT (~0.11 - 0.12 mT) directly on the 35 kV energized cable.
- Carrying no electricity load, the mean value EMF was 0.5 µT directly on the unenergized cable.
- The scalar magnitude of the magnetic field diminishes to background levels at 1m from the energized cable.
- Actual EMF measured on and away from the cables closely fit the model results found in Normandeau 2011 EMF study.
- Apparent lack of response would indicate burial is not always essential for biological reasons; however, burial could be used as mitigation to further decrease potential exposure.

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2016 State of the Science Report

Environmental Effects of Marine Renewable Energy Development Around the World
What does a major literature update say about EMF?

Objectives:

- Summarize the state of the science of integrations and effects of marine renewable energy devices on the marine environment.
- Update and complement prior Annex IV reports.
- Present case studies that examine siting/permitting/consenting of marine renewables.

https://tethys.pnnl.gov/stressor/emf

EMF and Marine Organisms
Ongoing Studies

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Some Ongoing Field Studies Testing EMF Effects at AC and DC Power Cables on the Seafloor

https://tethys.pnnl.gov/stressor/emf

- Electromagnetic Field Impacts on Elasmobranch and American Lobster Movement and Migration from Direct Current Cables
  http://www.boem.gov/EMF-Impacts-on-Elasmobranch-and-American-Lobster/
- Potential Impacts of Submarine Power Cables on Crab Harvest
  http://www.boem.gov/pc-14-02/
- Assessment of Potential Impact of Electromagnetic Fields (EMF) from Undersea Cable on Migratory Fish Behavior
  http://energy.gov/sites/prod/files/2014/04/f14/CX-011385.pdf
- Characterization of EMF Emissions from Submarine Cables and Monitoring for Potential Responses of Marine Species
  https://tethys.pnnl.gov/publications/characterization-emf-emissions-submarine-cables-and-monitoring-potential-responses

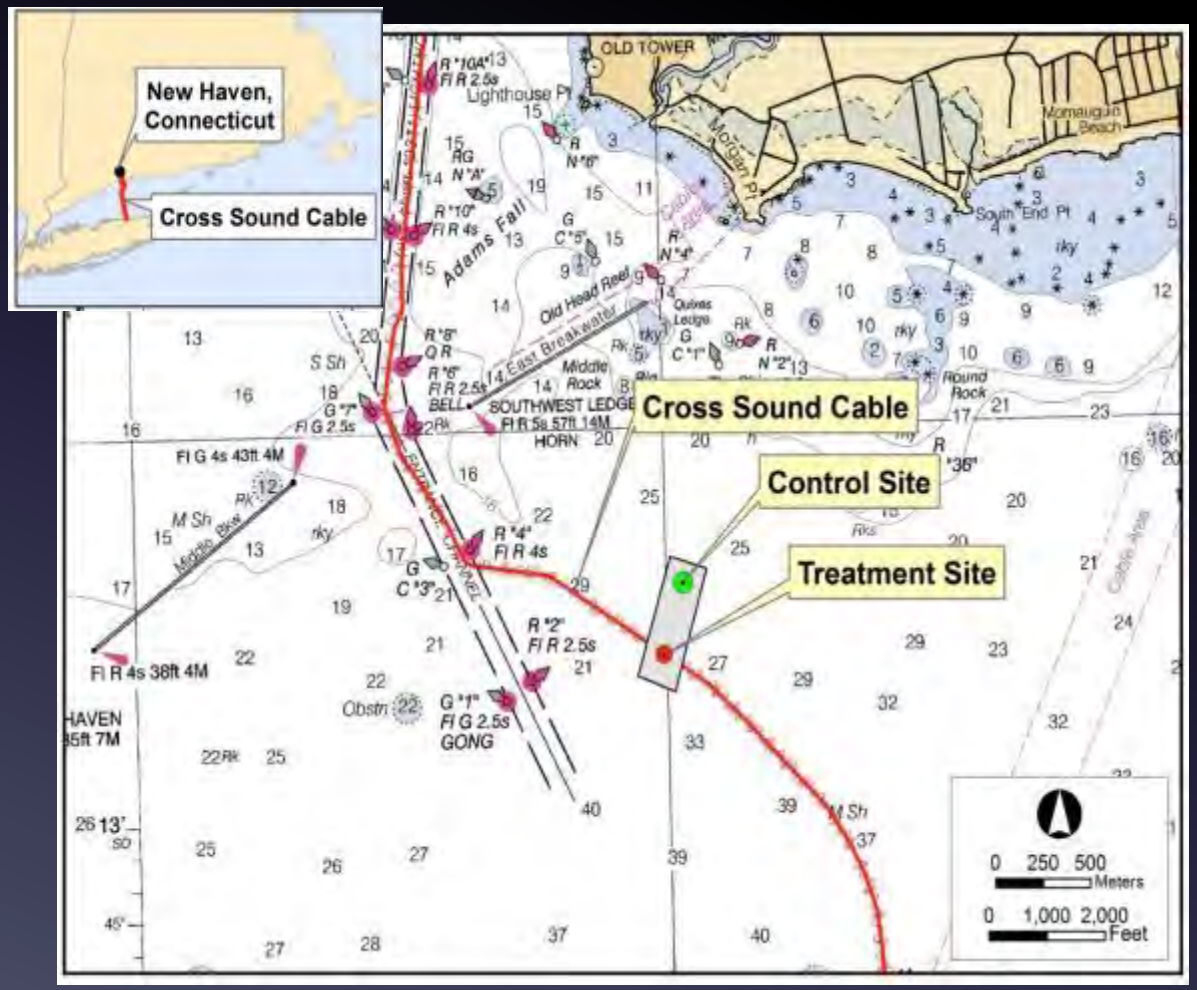
Electromagnetic Field Impacts on Elasmobranch and American Lobster Movement and Migration from Direct Current Cables

Objectives:

Determine if animals sensitive to EMF will behave abnormally near a HVDC cable.

- Synthesize existing information that updates BOEM report 2011-09 .
- Design and execute a field survey plan that will detect statistically significant, very small effects of EMF from HVDC cables on marine species of concern.
- Develop a model to predict EMF, compare the model predictions with field measurements, and evaluate whether the model can be extrapolated to future higher capacity cables.

Electromagnetic Field Impacts on Elasmobranch and American Lobster Movement and Migration from Direct Current Cables



- Map cable EMF with high resolution "SEMLA" sensor, consisting of 3-axis electrode and fluxgate magnetometer.
- Situate submerged animal enclosures at high EMF location and at a nearby control site.
- Release 5 animals (lobsters or skates) into enclosure; record animal movement using acoustic tags on organisms and a hydrophone-based telemetry system.

Electromagnetic Field Impacts on Elasmobranch and American Lobster Movement and Migration from Direct Current Cables

Deployment of Animal Enclosures and Electronics/Diving Platforms, August 2016

- Two enclosures: 1) “Treatment Site” on the Cross Sound Cable 2) “Control Site” (~ 360 meters from cable)
- Animal monitoring equipment housed on support platform moored at each location
- Divers assist with initial positioning of the submerged enclosure, and exchanging populations of test animals

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Potential Impacts of Submarine Power Cables on Crab Harvest

Will EMF from a power cable affect commercial crab harvest?

Objectives:

- Determine if rock crab and dungeness crab will cross a power cable and be caught in commercial baited traps.
- Expose rock crabs to 35 kV AC power cable with response choice in Santa Barbara Channel.
- Expose dungeness crabs to 69 kV AC power cables with response choice in Puget Sound.
- Determine likely impact on harvest for assessment documents and planning.

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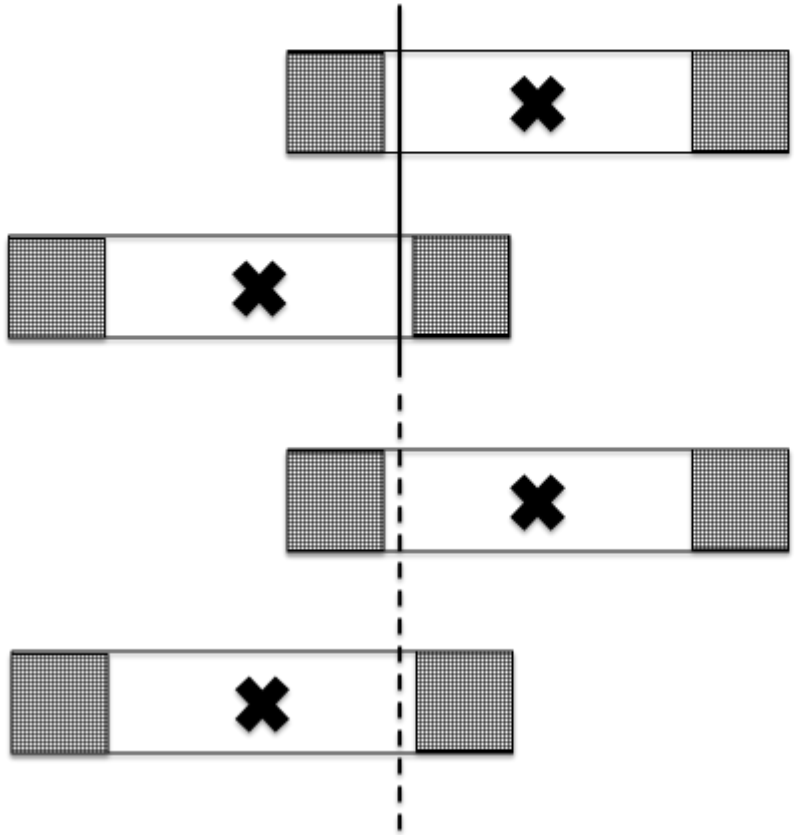
EXPERIMENTAL SET UP IN BOTH STUDY AREAS

12 units, 3 replicates of each of 4 test conditions, were randomly placed along the cable



Unit on EAST side of EXPOSED cable

Unit on WEST side of EXPOSED cable

Unit on EAST side of BURIED cable

Unit on WEST side of BURIED cable

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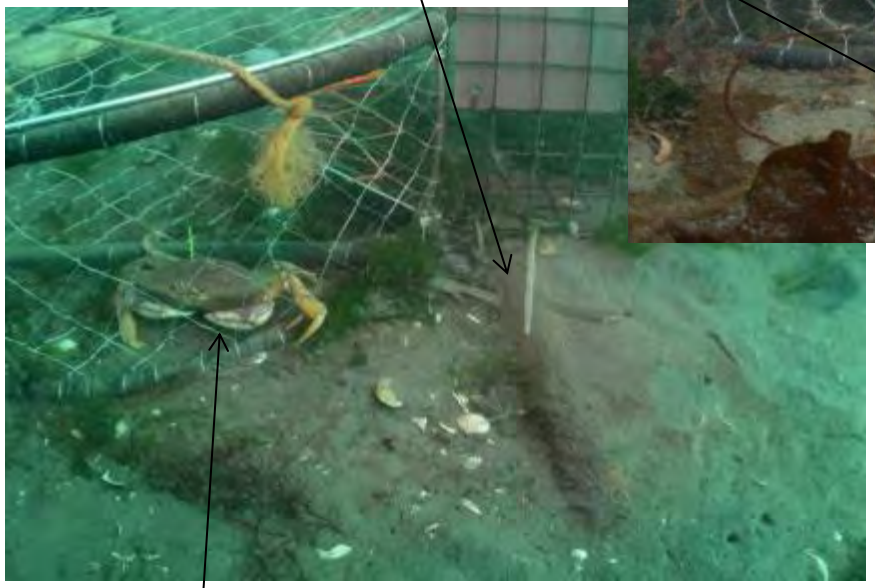
Crab Experimental Design for Puget Sound

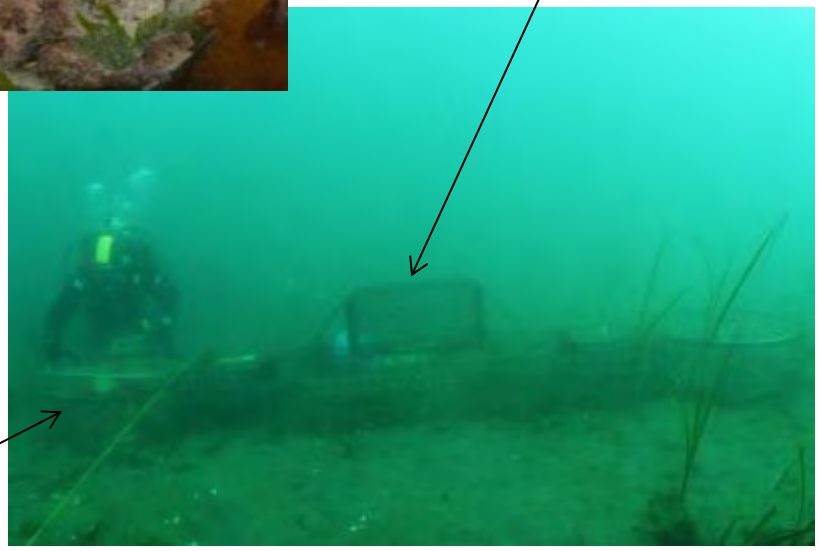
Give crabs a choice to decide if they will cross an energized power cable in response to a baited commercial fishing trap

Power Cable



Dungeness Crab in Trap

Crab Introduction Chamber



Baited Trap

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Preliminary Findings from Crab Harvest Study

Unpublished Results from Rock and Dungeness Crab Experiments

- Rock crabs will cross an unburied 35 kV AC power cable and Dungeness crabs will cross an unburied 69 kV AC power cable to enter baited commercial traps.
- Crabs tend to move into the current.
- Chemosensory response to bait in commercial traps is not impeded by energized power cables.

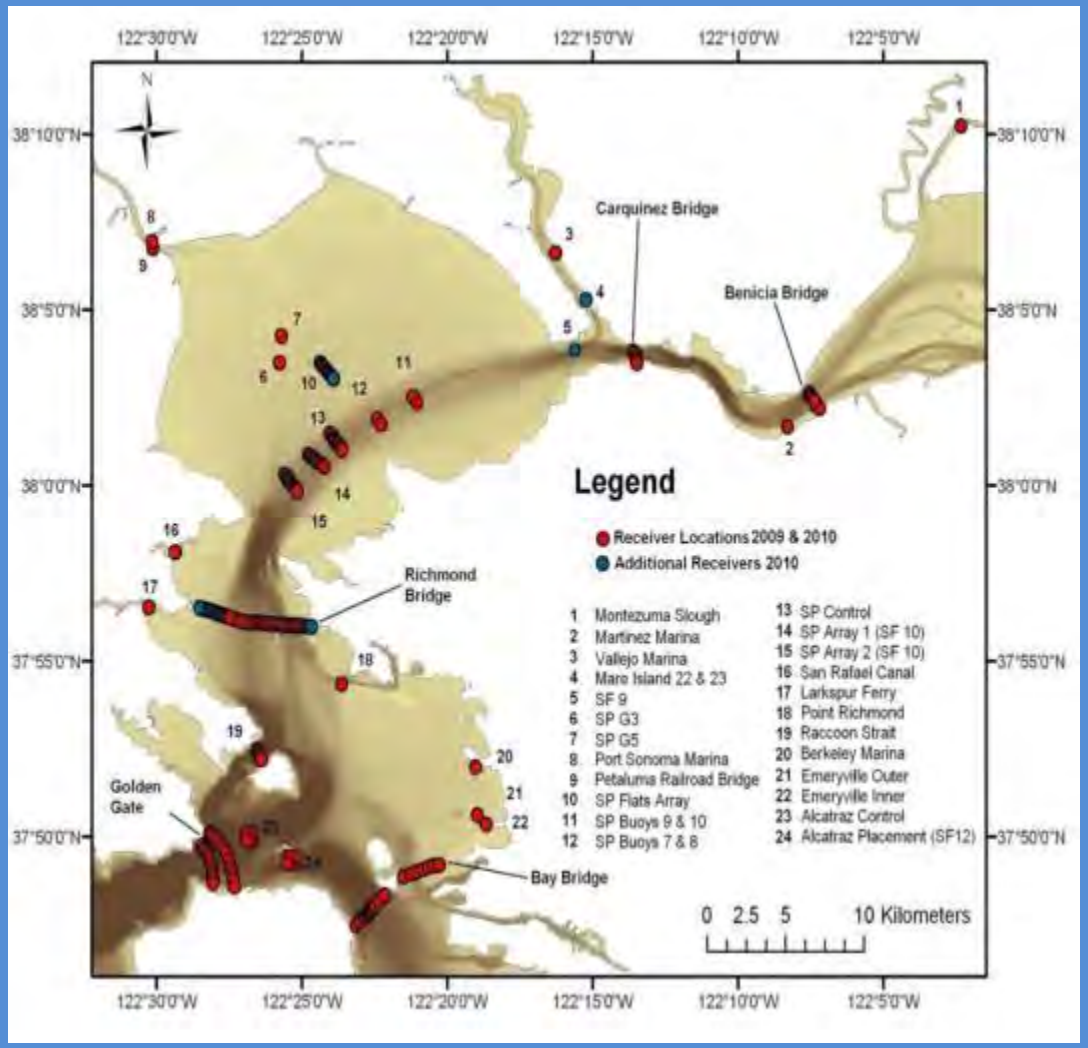
Assessment of Potential Impact of Electromagnetic Fields (EMF) from Undersea Cable on Migratory Fish Behavior

Wyman, Megan T.[1], A. Peter Klimley[1], and Robert Kavet[2]

[1]University of California, Davis, Davis, California

[1]Electric Power Research Institute, Palo Alto, California

San Francisco Bay Perfect Site to Study EMF



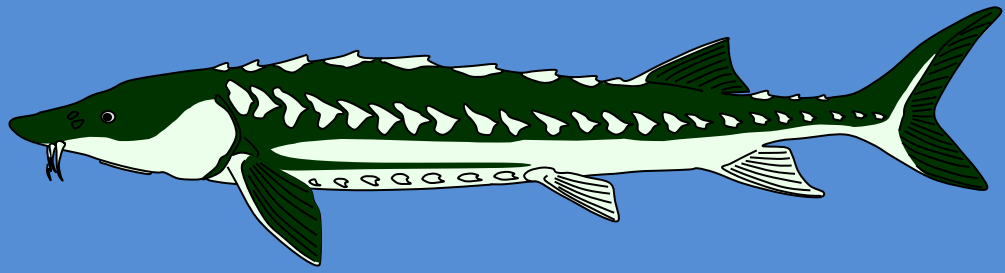
- High voltage, direct current Trans Bay Cable runs from Pittsburg through Suisun and San Pablo Bays, crosses San Francisco Bay, to San Francisco
- It is either parallel or perpendicular to the migratory pathways of green and white sturgeon, salmon, and steelhead smolts.
- Their movements have been well described by placing coded beacons on them and detecting their passage with an array of monitors (see red circles in map).

Methods

Electronic Tags and Monitors

- Tag detecting monitors (left)
- Smolt tags (right top)
- Moorings with acoustic releases (right bottom)

- Late-fall run Chinook smolts (top), and green sturgeon (bottom) with electronic tags were released before and after cable energized

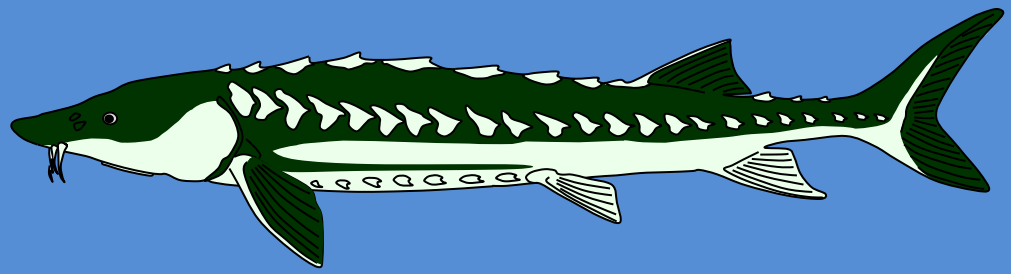


Tentative Results

- Chinook salmon and green sturgeon migrate through San Francisco Estuary and Bay despite large distortions in local magnetic fields

- Salmon smolts may be attracted to the cable after activation (more cable location crossings, more detections at Bay Bridge, high importance of distance to cable in predicting fish location)

- The smolts are not impeded from successfully migrating through the San Francisco Bay (similar proportions of successful exits, faster transit rates)



- Cable activity had opposite effects on outbound and inbound green sturgeon migrations: outbound migrations had significantly longer transit times while inbound migrations had significantly shorter migration times

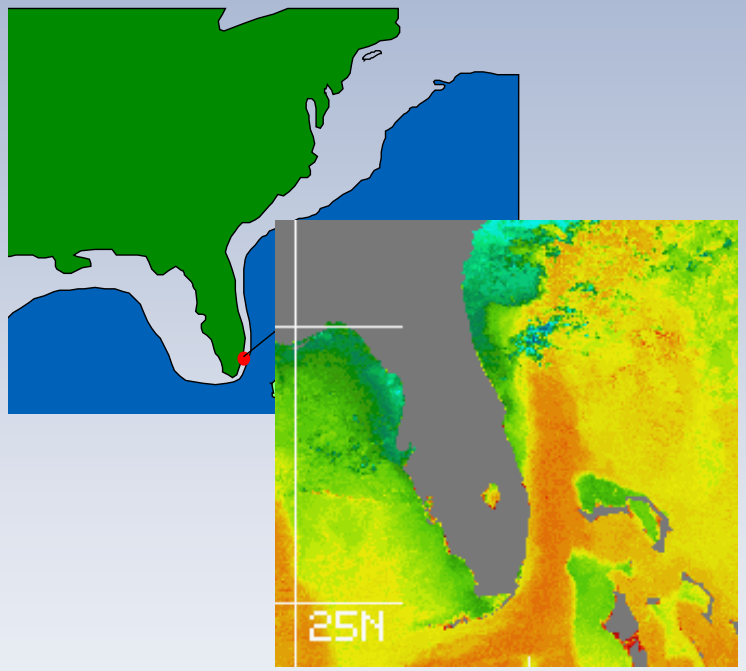
FLORIDA ATLANTIC UNIVERSITY

Characterization of EMF Emissions from Submerged Power Cables and Monitoring for Potential Responses of Marine Species

Manhar Dhanak,
Florida Atlantic University

Work Supported by the US Department of Energy

Location of EMF Surveys



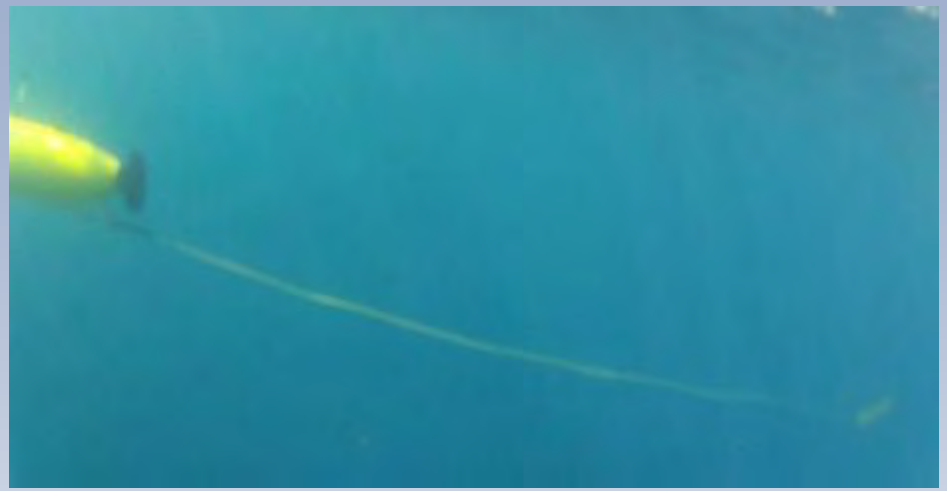
Naval Surface Warfare Center Carderock Division's
South Florida Ocean Measurement Facility

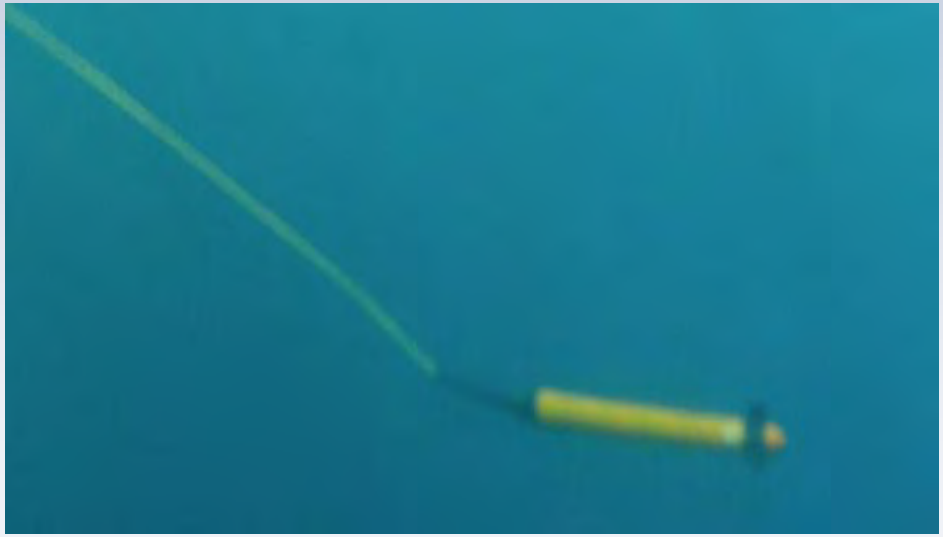
Objectives:

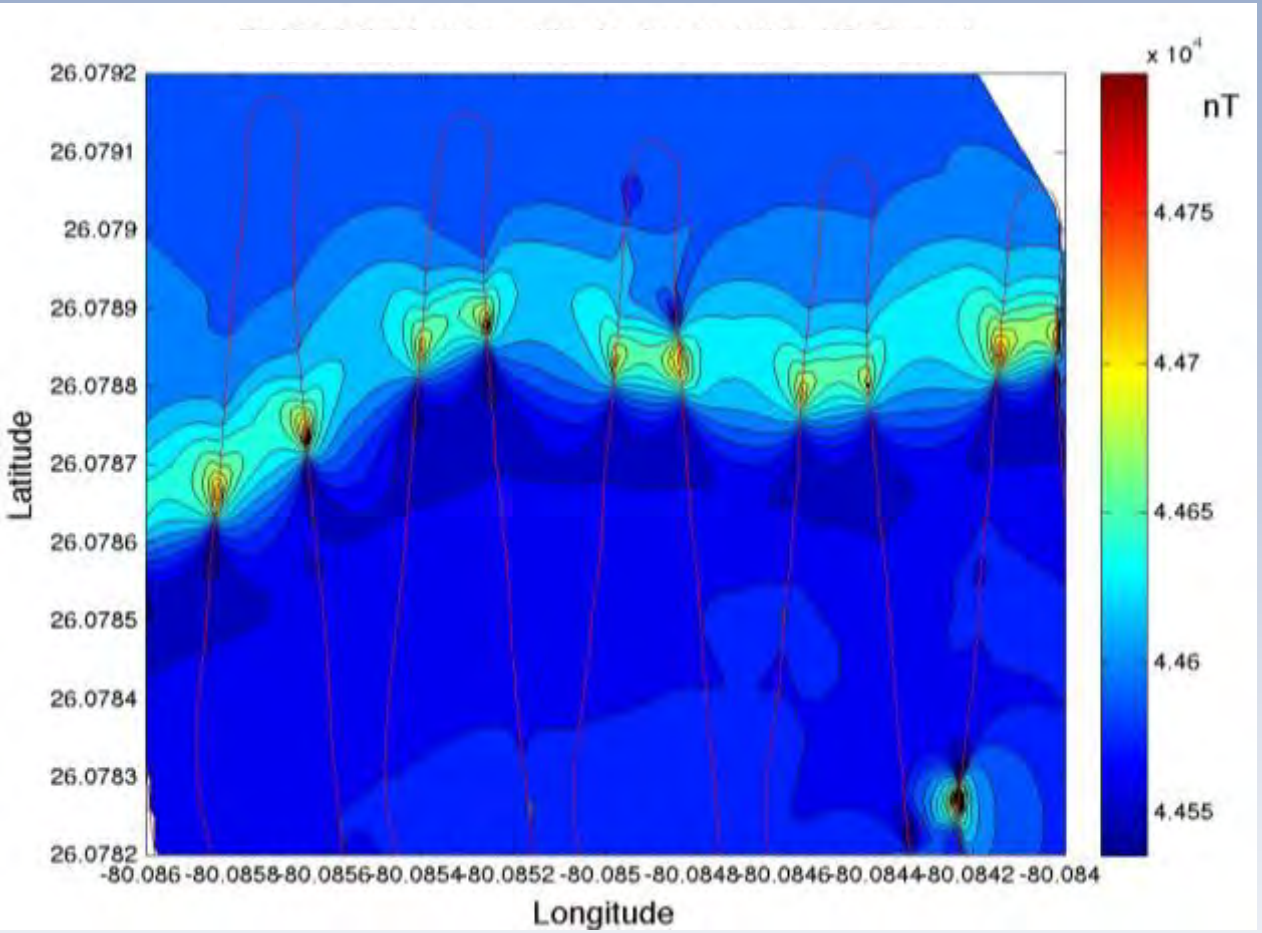
Characterize EMF emissions from subsea cables such as ones that may transmit power from offshore turbines to shore.

- Develop an AUV-based system for measuring and characterizing EMF levels in the water column.
- Determine the distribution and characteristics of the E and B field emissions in the region due to an energized submarine cable.
- Compare power cables in an energized and unenergized condition.
- Use results to compare with and help validate predictions from models.

AUV-towed magnetometer: Aerial view (top), and side views (right)







B-field at 2.2m altitude above a subsea cable energized with DC power. The lawn-mower pattern path of the AUV is superimposed on the contour map.

EMF and Environmental Risk

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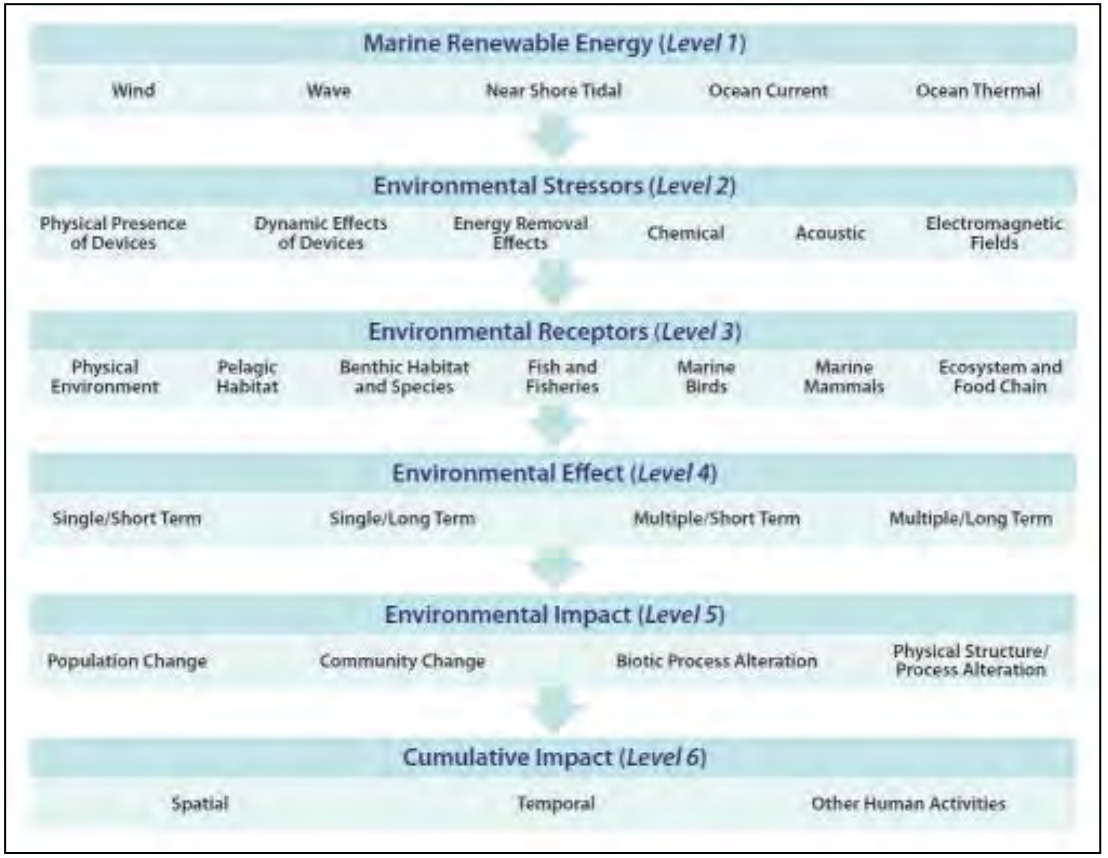
Uncertainty about Environmental Effects Increases Regulatory and Industry risk

Confidence about Environmental Effects Stabilizes Risk

- Framework for consideration of environmental effects of marine renewable energy encompassing different scales.
- The reaction of an animal at level four does not indicate that the animal is adversely affected.
- Level five makes the key distinction between biological response of an animal (level four) and environmental impact.



Boehlert and Gill 2010

BOEM
Bureau of Ocean Energy Management

Base on Results from the Completed and Ongoing Studies How Should We Perceive EMF Risk?

- There is no indication from scientific research that EMF from seafloor power cables is a significant risk to marine animals or their habitat, or that EMF from cables prevents movement within habitats.
- Research techniques are well understood and becoming standardized.
- Past and ongoing research likely provide an acceptable level of confidence about expected effects from EMF.
- Past and ongoing research suggest burial as a mitigation to further decrease exposure to and potential effects from EMF.

BOEM
Bureau of Ocean Energy Management

How Should we Treat EMF Risk?

- Based on scientific research data, EMF is a low-risk stressor.
- Commercial installations and test facilities can provide real-time opportunities for monitoring to provide additional data.
- Regulating agencies should move to higher priority interactions.

Contact Information

Ann Scarborough Bull, Ph.D.

Chief, Environmental Sciences Section

Bureau of Ocean Energy Management

Pacific OCS Region

805-384-6385

ann.bull@boem.gov

www.boem.gov

www.boem.gov/Pacific-Studies/

California OCEAN • RENEWABLE • ENERGY Conference

November 1–2, 2016

University of California, Davis

http://www.boem.gov/CORE_Conference/

CalWave℠ Wave Energy Test Center
Permitting Agency Meeting Summary
December 8, 2016, 10am-3pm
Residence Inn Oxnard River Ridge, Oxnard, CA

Participants:

Organization	Name
Bureau of Ocean Energy Management (BOEM)	Greg Sanders
Bureau of Ocean Energy Management (BOEM)	Jean Thurston
Bureau of Ocean Energy Management (BOEM)	Rick Yarde*
Bureau of Ocean Energy Management (BOEM)	Susan Zaleski
Bureau of Land Management (BLM)	David Ledig*
Bureau of Land Management (BLM)	Bill Standley*
California Department of Fish and Wildlife	Brian Owens*
California Department of Fish and Wildlife	Martin Potter*
California Department of Fish and Wildlife	Eric Wilkins
California Ocean Protection Council	Chris Potter*
California State Lands Commission	Maren Farnum*
California State Lands Commission	Cheryl Hudson*
California State Lands Commission	Mark LeClair*
California State Lands Commission	Jennifer Mattox
California State Lands Commission	Pat Mulcahy*
California State Water Resources Control Board	Joanna Jensen
California State Water Resources Control Board	Catherine Woody
Federal Energy Regulatory Commission (FERC)	Jim Hastreiter*
NOAA Fisheries	Bill Foster
NOAA Fisheries	Penny Ruvelas*
NOAA Office of National Marine Sanctuaries	Lisa Wooninck*
NOAA Office of Protected Resources	Jordan Carduner*
Pacific Gas and Electric Company (PG&E)	Brendan Dooher*
United States Air Force	Walter Schobel*
United States Army Corps of Engineers (USACE)	Ian Bordenave
United States Coast Guard (USCG)	Lieutenant Ernie Saponara*
U.S. Fish and Wildlife Service (USFWS)	Lilian Carswell*
U.S. Fish and Wildlife Service (USFWS)	Heather Tipton*
Vandenberg Air Force Base	Ken Domako

CalWave Team	
Cal Poly	Nick Osterbur
Protean Energy / Cal Poly	Bill Toman
CH2M	Doug Davy
CH2M	Chris Rein*
Kearns & West	Anna West
Kearns & West	Janet Thomson
Leidos	Rick Williams

*Participated by phone

Introductions and Session Overview

Bill Toman, Project Manager for the California Wave Energy Test Center (CalWave[SM]), welcomed the group and reminded the group of the overall project timeline. The CalWave[SM] effort is still in the preliminary design and environmental baseline phase currently led by California Polytechnic State University, San Luis Obispo (Cal Poly) under a grant from the U.S. Department of Energy (DOE) and cost share contributions from the State of California, PG&E and Protean Energy Ltd (CalWave[SM] II). The project team hopes that additional funding from DOE will become available in early/mid 2017 to enable the team to move forward on permitting. Construction would start in early 2019, testing in 2021, and full operations in 2022. Anna West, Kearns & West, opened the meeting and asked meeting participants on the phone and in the room to introduce themselves. Anna reviewed the agenda and meeting objectives.

CalWave[SM] Updates

Doug Davy, CH2M, provided updated information about the project based on the Draft Preliminary Application Document (PAD) that the CalWave[SM] team has prepared ("practice PAD"). The Draft PAD will be revised and submitted to DOE in early 2017 to fulfill DOE grant reporting requirements.

For the next phase, Doug noted that as soon as the CalWave[SM] team receives its next round of funding, the team will file a lease application with the U.S Bureau of Ocean Energy Management (BOEM). Once a lease is secured with BOEM, the CalWave[SM] team will initiate the Federal Energy Regulatory Commission (FERC) licensing process by filing a PAD in July 2017. This approach assumes that there is no competitive interest for the site. If there is competitive interest; the timeline will change as BOEM uses its competitive interest authorization process. The CalWave[SM] team has not yet determined whether it will be filing for a research or a commercial lease with BOEM.

- Comment (C): BOEM will likely have a 30-45-day comment period on the lease application, to determine whether or not there is competitive interest in the site. The timeline presented is optimistic, but not unrealistic.
- Question (Q): Will the CalWave[SM] team submit a right-of-way (ROW) application with the State Lands Commission simultaneously with the BOEM lease

application? The State Lands Commission will require geophysical studies for the cables and mooring, so it might be prudent for the team to conduct those studies at the same time as other environmental studies.
    - Response (R): The CalWave[SM] team expects to file the ROW application concurrently with filing the PAD with FERC.
    - Action (A): The team will follow up with the State Lands Commission and BOEM to determine the best approach.
- Comment (C): The project timing lines up well with presenting to the Pacific Fisheries Management Council (PFMC) in March of 2017.
    - A: The CalWave[SM] team will follow up with Eric Wilkins to get on the PFMC agenda for March 2017.

Rick Williams, Leidos, reviewed the CalWave[SM] conceptual diagram (slide 7 of the attached project team presentation) showing the location and interconnection of the wave energy converter (WEC) arrays with the cable routes and onshore landing and power system.

- Q: Have you considered bundling the cables?
    - R: Yes. The spacing of the cables is still to be determined, balancing the desire to take up less space (having the cables close together) while allowing sufficient distance between the cables to allow for their repair and maintenance (approximately 500 yards).
- Q: What is the maximum distance you anticipate between the northern-most and southern-most WEC?
    - R: About six miles. This will require further discussion with BOEM regarding available aliquots for leasing, and further conversation with the fishing community to understand whether they prefer to have a transit lane in the middle or not.

Rick described the WEC test berth envelopes as including four berths, enabling up to ten devices per berth. In total, the CalWave[SM] team hopes to permit a total of 40 devices across the project. These would be in a water depth of 90-120 meters (50-60 fathoms). The mooring footprint for each WEC would likely be elliptically shaped, based on the slope of the sea floor, 1000 meters major axis on the seafloor, with a 6:1 scope per device and a 100-300 meter “watch circle” per device.

Rick provided the following information about anticipated WEC device types and sizes:
- Point absorbers would not be larger than 30 meters in diameter, 15 meters above the water line, and 60 meters deep. These will likely employ drag embedment anchors, or dead weight anchors.
- Floating oscillating water columns would also likely use drag embedment or dead weight anchors and would be up to 60 meters by 100 meters in diameter, with 12 meters of draft.
- Internally rotating masses would be up to 50 by 70 meters with 20 meters of draft and would likely use drag embedment or dead weight anchors.
- The CalWave[SM] team is not seeking to permit devices that entrain water or could impinge marine biota, such as overtopping devices.

- Q: Does the floating oscillating water column entrain water?
    - R: No. Air flows through the turbine.

The CalWave[SM] team will provide the anchoring and mooring study from Glosten Associates to the permitting agencies. The team does not expect that developers will need to use pile driving into the seafloor, but will include pile driving as an option in permitting. Before the CalWave[SM] team moves into final design, we will reach out to developers to confirm anticipated device size and expected anchoring and mooring approaches.

- Q: Is there a likely combination of anchors and moorings that you expect to see?
    - R: The developers are likely to use a wire rope and chain pendant to bring the mooring line down into the water column, then a synthetic line to a subsurface buoy, and a synthetic line from the buoy to the chain anchor. The Glosten and Associates Study is a good summary. There is a more detailed anchoring and mooring study by Sound and Sea Technologies that shows several device combinations, http://oregonwave.org/oceanic/wp-content/uploads/2013/09/Advanced-Anchoring-and-Mooring-Study-November-2009.pdf.

Reviewing Potential Environmental Risk Matrices

Doug Davy explained that the CalWave[SM] team has come up with the project description for use in the practice PAD that will be submitted to DOE in early 2017. Based on the parameters described in this project description, the team is seeking help from the agencies to identify the potential environmental issues and the resulting necessary studies for the permitting process. Over the past few months, the team has gathered feedback from many of the agencies on the potential environmental effects, the level of risk, and the studies that would provide information for permitting and potential mitigation measures. The PAD that will be submitted to FERC around July 2017 will include an inventory of baseline studies, available data, and a list of known issues, as well as a list of anticipated study plans. Once the study plans are approved by FERC, the CalWave[SM] team will file an application with FERC and conduct the studies.

Shore Station

For the shore station, we anticipate that there is low level of concern about pinniped haul-out, with the potential exception of during the pupping season. For upgrade of the 70 kiloVolt (kV) transmission line there is a potential for impact to listed species; the concern is high, but the likelihood of risk low because it should be feasible to avoid Gaviota Tarplant, El Segundo blue butterfly habitat, and wetlands.

- C: The Water Board toured the site area December 7 and it looks as though the project can likely avoid impacts to wetlands.

Field studies will need to be done to determine where archaeological resources are near the transmission line so that siting can avoid known resources. The project team may do visual simulations of the shore station to ensure consistency with the visual environment

of the historic Coast Guard station. For the remaining potential issues of noise and light during construction of operation, the team may be able to look at what species may be sensitive to noise and light.

Cable Route

For the horizontal directional drill aspect of the cable route in the near-shore environment, there are potential concerns about disruption of sensitive habitat from drilling or frac-out. The team will work to understand how to best avoid disrupting benthic, kelp forest, and rocky bottom habitats. The area of the cable route further offshore should not be much of a concern, since benthic habitats can re-establish fairly quickly after any disturbances. USGS habitat maps will be helpful baseline information for this portion. The state has a database of shipwrecks, and our use of side-scan sonar can help us design cable runs to avoid shipwrecks. Regarding electromagnetic fields (EMF), the presentation given by BOEM during the last agency meeting indicates that EMF impacts from the cables are unlikely to be an issue. Lastly, regarding noise impacts during the cable lay, there are standard mitigation measures and best management practices that can be used to reduce impacts.

Test Berths

For the test berths, noise from WEC installation should be addressed fairly easily by best management practices and standard measures such as monitoring, avoidance, and shutdowns as needed. For the noise of operation, it may make sense to have a noise monitor during certain times. It is not anticipated that pile driving will be utilized in the construction or operation of CalWave^{SM} as water depths are too deep. The acoustics presentation this afternoon will help to clarify this issue further. We will compile more information about potential use of hazardous materials to avoid contamination of water due to lubricants or other substances.

Our preliminary research has not revealed many records of large marine mammal entanglement with mooring cables and large buoys; the BOEM presentation this afternoon can address that. It is possible that in spite of best efforts to coordinate with fishers, fishing gear could get entangled with the mooring cables, and various species could get entangled with the stranded fishing gear, so we will have to discuss how we might address that.

Regarding concerns about collisions between WEC support vessels and marine mammals, we do not anticipate impacts beyond that of support vessels that service the existing offshore oil platforms. We do not think impingement from moving parts of the WEC devices is likely to be an issue, since we are not permitting devices that entrain water; however, some WEC devices have moving exterior parts and we will need to look into whether impingement from that movement is possible. The WECs themselves do not have propulsion systems and could not travel faster than drift speed if disconnected from mooring lines.

There could be habitat changes from the WEC devices, such as colonization of a concrete anchor by invasive species; we can look into that. Pinniped haul-outs on the devices might occur; we will work with NMFS to understand if we need to try to prevent

this from happening or not. Similarly, we will work with NMFS to understand whether it is a concern if WECs serve as fish attraction devices.

We know that there are potential impacts to the commercial fishing industry, and we intended to have extended discussions with fishers, as well as review the California Department of Fish and Wildlife commercial fishing data and port landings.

We can look at wave refraction and diffraction to understand whether the wave reduction effects of WECs might be a concern for surfers at Jalama Beach, but preliminary analysis supports little to no impacts. Furthermore, we'll do visual simulations at Jalama Beach since that is one of the few coastal areas from which the project might be seen by the public. However, it is useful to note that the viewshed from that beach already contains three offshore oil platforms.

- Q: What kind of monitoring devices would you put on the WECs?
    - R: We will work through this process to understand what impacts we might be concerned about, and then work to figure out what if any issues we need to monitor.
    - R: Additionally, the developers will likely be doing their own periodic monitoring of the WECs.
- C: You should consider both commercial and recreational fishing impacts.
    - R: Yes, both types will be considered.
- Q: Will you need to clean mussels off the cables?
    - R: The dry mate connector is the end of the CalWave^{SM} system on the ocean floor, and we do not expect to need to clean the mussels off the dry mate connector.
- Q: Will you be using remote sensing and monitoring, such as a camera integrated into the WEC system?
    - R: It is not yet clear whether that is needed for environmental compliance. However, the WECs may have their independent needs and desires to use those devices.
    - A: We can inquire with the operating UK Wave Hub and the European Marine Energy Centre (EMEC) about whether remote sensing systems are used there.

We will circulate these matrices again to ensure that we have properly identified all the studies that the agencies anticipate needing in order to permit CalWave^{SM} (as opposed to those potentially needed for adaptive management and monitoring).

Presentation: Interactions with Marine Mammals, and Acoustics
Greg Sanders, BOEM, presented information about the potential interactions with marine mammals, as well as acoustics. The full presentation is appended to this summary, which includes references to the source studies, and a recording is available here.

Interactions with Marine Mammals

Most of the interactions with marine mammals would come from the submarine aspects of the project. Construction of WEC devices is a misnomer, as what is actually happening is the devices are fully constructed onshore and are towed or barged out to the site. The potential issue with construction would be the installation of cabling.

Maintenance would involve periodic visits to repair or adjust the devices. This may not be a substantial issue since these are test devices only installed for a limited period of time. BOEM also looks into decommissioning.

We do not anticipate interactions with harbor seals or with striped dolphins (because they exist fifty miles offshore). Common dolphins can be found everywhere. Humpback and blue whales are more common off Point Conception and are seasonally abundant. Blue whales are obligate krill feeders, and humpbacks consume krill as well as small fish. Gray whales will also need to be considered. Sea lions and elephant seals will both be present but they exist mostly at sea and are not likely to interact with the devices. Sea otters will only interact with the project at the cable lay portion.

BOEM is entering into a cooperative agreement with NMFS and the US Navy to do system-wide stock assessments of large whales in California in 2018.

When we evaluate the risk of species entanglement we look at the physical characteristics of the material. Given the type of cable used, including its width and weight, it would be very difficult if not impossible for entanglement to occur. The bigger issue with the cable is the Dungeness crab fishery, as the crab pots could get entangled. Reports out of Scotland indicate that the lowest risk of entanglement comes with taut configurations of moorings; the highest category of potential entanglement comes from catenary with chains and nylon ropes and accessory buoys. However, the studies indicate that sea lions or small dolphins could not get trapped, the question is whether large whales might and might require further study. The question has to do with the inter-array cables: heavy cables will interfere with the WEC device, but flexible and light cables may pose the risk of entanglement. This should be further considered to determine at what diameter and configuration entanglement with large cetaceans is possible to occur. Horizontal cables might pose a higher risk of entanglement, and that is not likely to be an issue for these cables and moorings.

- C: The CalWave^{SM} team has been in touch with the U.S. Coast Guard and NOAA national data buoy center, and both indicate that they have no documented occurrences of entanglement with mammals with that scale of buoy. Furthermore, any subsurface buoys can be located directly underneath the WEC device so as to reduce the risk of having a horizontal cable that might become entangled.
- A: The CalWave^{SM} Team will inquire with UK Wave Hub and EMEC about entanglement information.
- Q: What size cable would it take for marine mammals to see that they are there?
    - R: Medium range species such as orcas and dolphins have high acuity and can probably see these lines. The problems could be with larger whales that do not have echolocation. In Oregon at PMEC SETS there

was a concern about the northern migration of cows and calves, but it is clear that there is likely no interaction at all.
    - Q: Would it be possible to make the cables more detectable?
    - R: I'm not sure.

We do not anticipate any collisions with vessels used for this project and marine mammals; there are no records of strike with these types of vessels and at the speeds they are operating. Operators are also required to have awareness training. Observers can be used to deal with collision risk, but we should be intelligent about it and use observers where there are areas with more risk.

Acoustics

I'm covering slides from a colleague regarding acoustics. There are all sorts of sounds existing in the ocean, from natural noises of fish and marine mammals to high energy sources such as the Navy's active sonar, or seismic surveys from air guns. The noises can range from relatively benign to those causing acute injuries (e.g., a temporary vessel shift in the ear or loss of hearing).

Marine mammals have a large range of received hearing, and mammals vary in the whether they are sensitive to ultra-low frequencies or not. Sound does not travel in a linear fashion in the water, and its movement depends on salinity, temperature, reflections on the sea surface, and other factors. This project should focus on considering those noises that have a potential to cause acute injury. If pile driving may be used, it will need to be analyzed. However, if there will be no pile driving, there is no need to analyze that issue. As another example, the splash of deploying an anchor is not likely to be an acute source of injury; therefore, noise impacts from cable and mooring installation should not be a concern.

Some work has been done in Europe to understand how much noise WEC devices make. One study suggested that WEC devices are unlikely to affect marine mammals; another suggested that the noise levels are sufficiently above ambient level that animals could hear them, but that more studies are needed to understand whether there are behavioral impacts. However, studies have not indicated acute injury resulting from WEC operation. Furthermore, studies related to the offshore oil industry indicate that vessel traffic supporting those operations would be the primary noise source, but those noise levels have not caused concern for regulatory agencies.

- Q: Will HDD cause noise impacts?
    - R: The drilling would be under soft sediment that can really mask the sound. It hasn't been a document issue in the oil and gas industry, although the drilling there is much deeper. That could be an issue to look into.
- Q: Is cumulative noise from multiple WEC devices an issue?
    - R: There is probably a lot of variability; however, based the physics of sound, multiple sources can contribute to a higher noise level, but noise is not directly additive. This question would also depend on a variety of circumstances, such as the existing environment, the species involved,

whether the species adapt to the area, how many devices are employed. This would not be easy to predict.

- Q: Is there a standard way to monitor sound for these devices?
    - R: There are models, but it is a complex issue and hard to know how accurate the models are. To be clear, we are not anticipating high impact sounds such as air guns and high intensity seismic testing.
    - A: The CalWave℠ Team will inquire with UK Wave Hub and EMEC about any data they may have on WEC device noise.

Overall, it is likely that WEC devices would be audible to marine mammals, but the opportunity for injury would be low; behavioral changes to the sound are an outstanding question. As a reminder, although offshore renewables are new off the Pacific coast, many of the component parts are familiar and have been used in the ocean for quite a while.

- Q: Do you plan to get background noise information around where the test berths would be?
    - R: That work was done in Oregon for the PMEC NETS project but they did not get a lot of information.
    - R: We plan to do a screening analysis to understand whether these devices would rise to the level of being a concern; then if that were the case, we might do ambient noise monitoring.
- C: NOAA recently issued new guidelines on acute impacts to marine mammals from different types of sound sources; the agency is still working on revisions to level B, the behavioral harassment guidelines. For this project NOAA would be asking about expected sound source levels and assessment of how far out those received levels could be. All of this would be used to determine whether we have reason to be concerned.
- Q: Do you have species profiling or transit rates in this area to know what specific species you're concerned about impacting?
    - R: BOEM has a lot of studies and there is a lot of additional information about species in the area.
- Q: Could you use acoustic devices to see what is transiting through the area?
    - R: Yes, but the challenge is determining what species to listen for and how to set up the devices. It can be especially difficult to detect low frequency animals, as you can hear one 1000 miles away. It's difficult to set up and results in a huge quantity of data that needs to be reviewed.
- Q: Would it be reasonable to get anecdotal data from the oil and gas industry about species at and near the site?
    - R: Yes, in terms of collisions with oil and gas platforms.

Next Steps

Once future funding is secured, the CalWave℠ team will notify the agencies about the schedule and agenda for future meetings.

Actions

1. After this project has been selected for future funding by the U.S. Department of Energy we will follow up with the State Lands Commission and BOEM to determine the best approach for submitting a ROW application.
2. The CalWave^{SM} team will follow up with Eric Wilkins to get on the Pacific Fisheries Management Council agenda for March 2017.
3. We will inquire further with UK Wave Hub and the European Marine Energy Centre (EMEC) about information on entanglement, whether remote sensing systems are used there, and whether they have data on WEC device noise.
4. The CalWave^{SM} team will provide an update to the agencies about whether this project has been selected for future funding by the U.S. Department of Energy.

CalWave^{SM} Update

CalWave^{SM} Regulatory Agency Meeting

December 8, 2016
Oxnard, California

CalWave^{SM}

Cal Poly San Luis Obispo

U.S. Department of Energy

Meeting Objectives

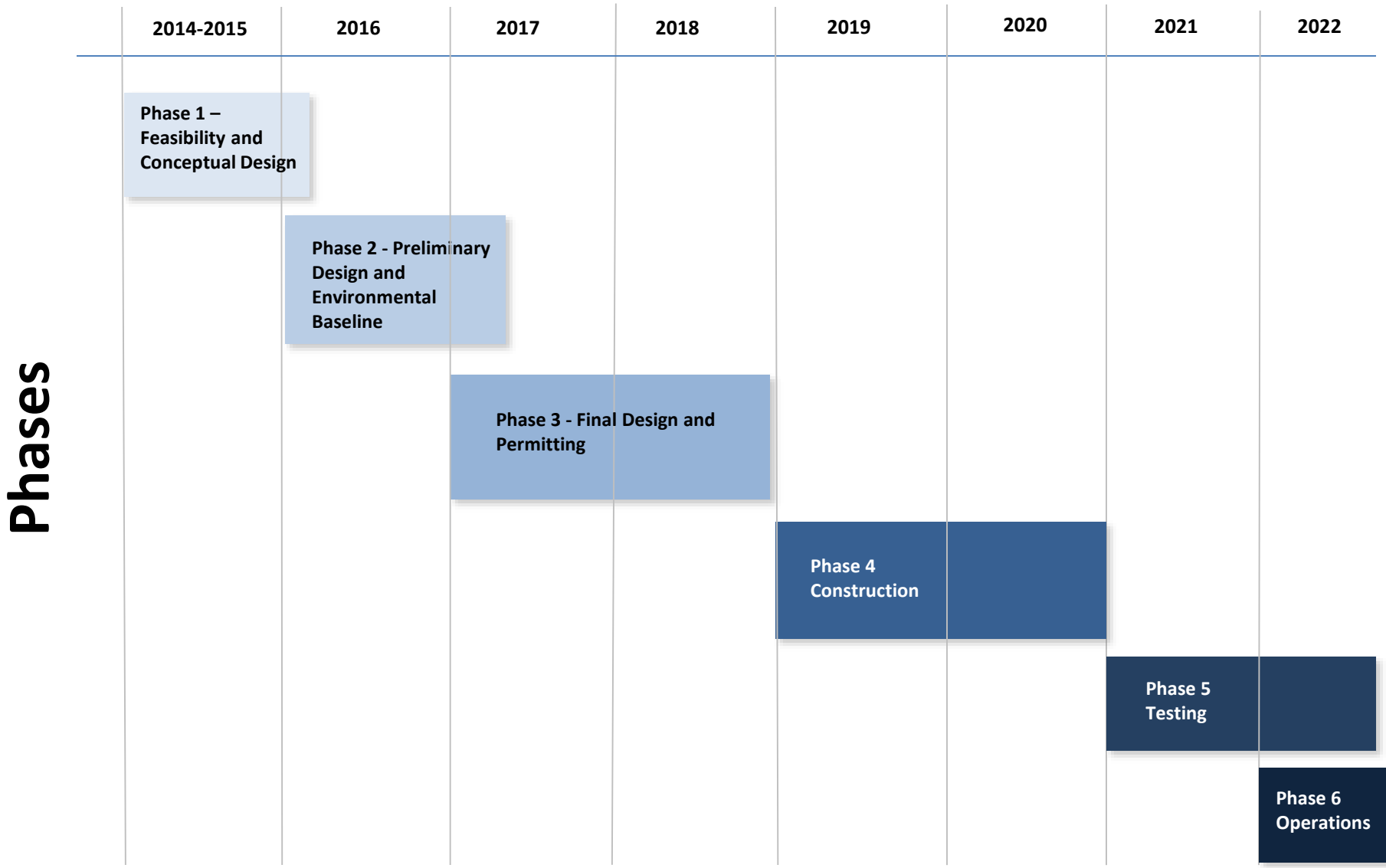
- Provide updates on CalWave^{SM}
- Review updated project description
- Discuss initial feedback on environmental effect matrices
- Review/discuss recent research on interactions with marine mammals & acoustics

Agenda

- Introductions/Session Overview
- CalWave^{SM} Project Updates – Updates to project description
- Feedback on Potential Environmental Effect Matrices – Review and discuss key issues matrices
- *Lunch*
- Presentation: Interactions with Marine Mammals – Greg Sanders, BOEM
- Presentation: Acoustics – TBD (BOEM invited and coordinating)
- Next Steps and Anticipated Timeframes – 2017 plans
- *Adjourn*

3

CalWave^{SM} Timeline



Permitting Schedule Update

- BOEM Lease Application – March 2017
- Respond to BOEM RFI – April 2017
- BOEM Request for Competitive Interest – May 2017
- BOEM Determination of No Competitive Interest – June 2017 (assuming no competitive interest)
- File Notice of Intent and Preliminary Application Document and Study Plans with FERC – July 2017
- Conduct environmental studies – March 2017 to March 2018 (est.)

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CalWave^{SM} Project Updates

- Updates to Project Description
  - Subsea Cable
  - Test Berth
  - WEC Envelope
  - Anchoring and Mooring Envelope

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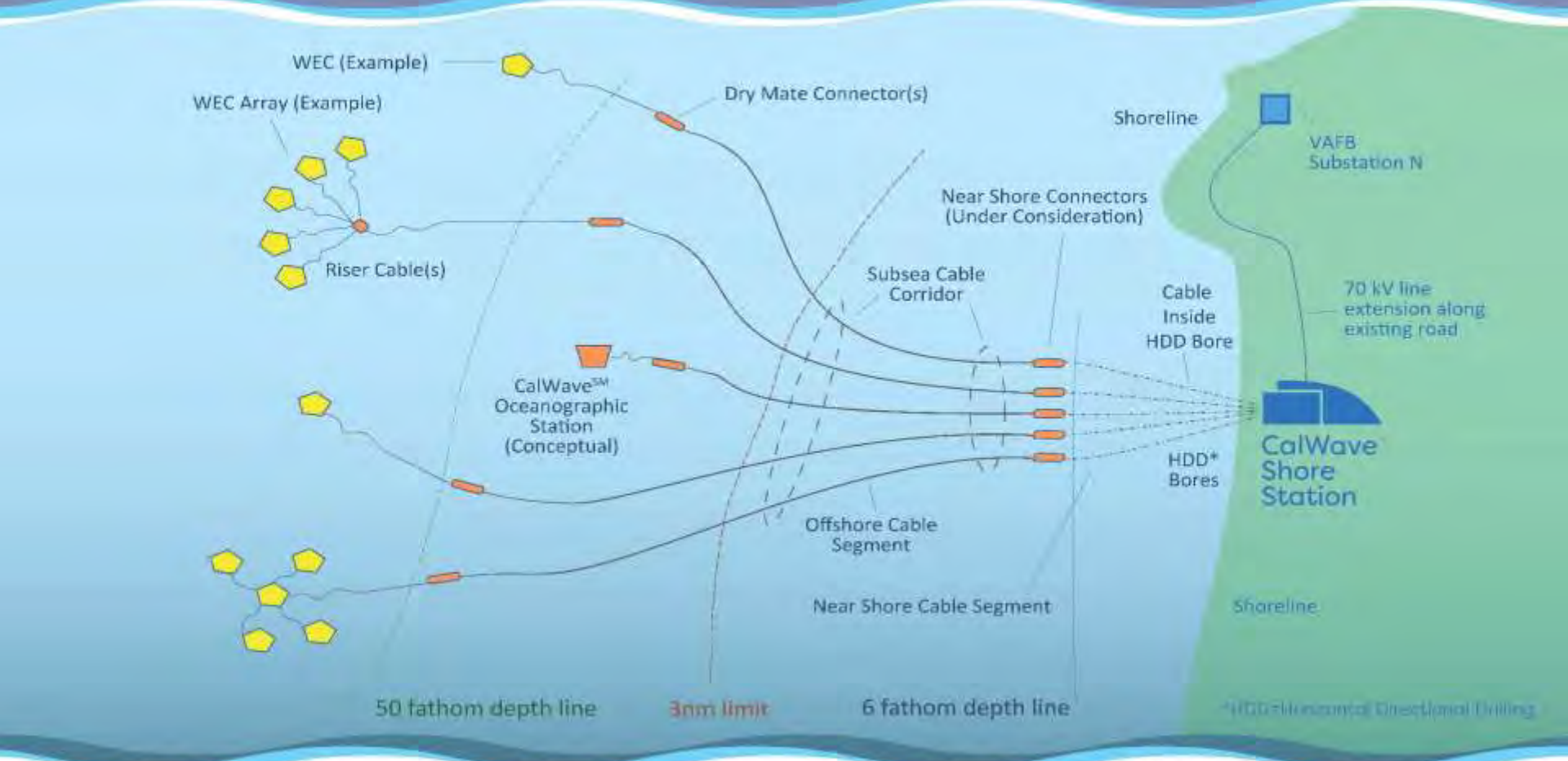
CalWave℠ System Concept



CalWave℠ is envisioned to have four test berths, each with a submarine cable to the shore station. Each test berth hosting Wave Energy Converter (WEC) Arrays will operate independently.

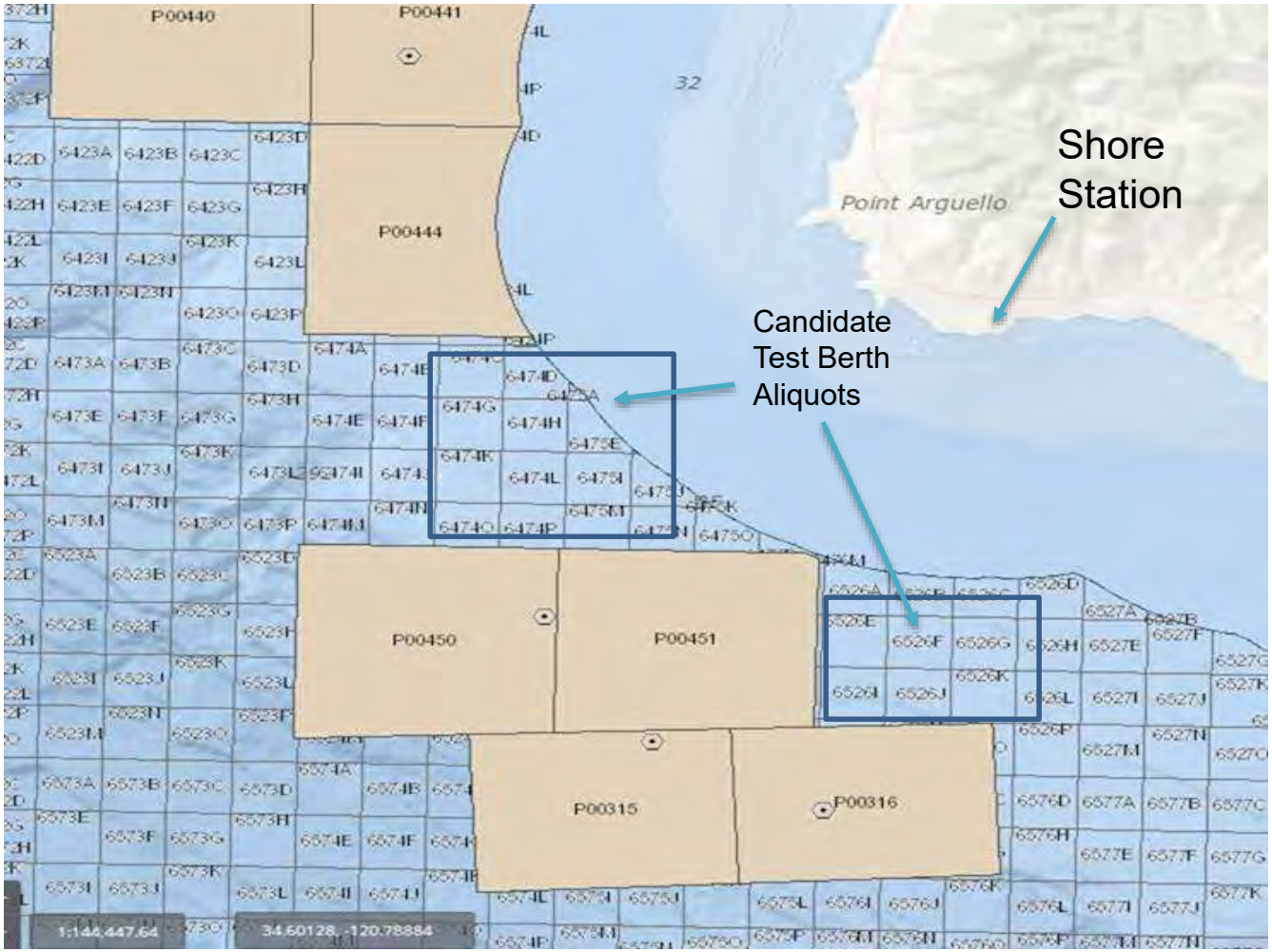
Conceptual: Not to scale

CALWAVE℠

CAL POLY SAN LUIS OBISPO

U.S. DEPARTMENT OF ENERGY

Test Berth Sites



Test Berth Envelope

- Test Berths (Preliminary Draft)
  - Four berths of flexible dimension
  - Up to 10 devices per berth
  - Total devices: 40
  - Water depth: 90 to 120 meters (50 to 60 fathoms)

- WEC mooring footprint
  - 120 meters in diameter seafloor with 6:1 scope per device
  - 100-300 meter diameter “watch circle’ per device

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WEC Envelope – Device Types (Preliminary Draft)

Point Absorber:

- Buoy with subsurface pylon, round or rectangular
- Scale: On surface – 30 meters in diameter and 15 meters above water line
- Below surface – up to 60-meter-long substructure
- Anchoring: Drag embedment or dead weight most likely at CalWave^{sm}

Floating Oscillating Water Column:

- Barge with air turbines mounted over air columns, variable shape
- Scale: Up to 60 meters by 100 meters in diameter, 12 meters draft
- Anchoring: Drag embedment or dead weight most likely at CalWave^{sm}

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WEC Envelope – Device Types 2

Rotating mass

- Barge with eccentric weight or gyroscope internal
- Scale: Up to 50 by 70 meters with 20 meters draft
- Anchoring: Drag embedment or dead weight most likely at CalWave^{sm}

Linear attenuator

- Cylinder or other long and narrow shape
- Scale: Up to 250 meters long, 10 meters draft
- Anchoring: Drag embedment or dead weight most likely at CalWave^{sm} – could be 2 or 3-point

Not permitted: Devices that entrain water and may entrain or impinge marine biota (such as overtopping devices)

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Anchoring and Mooring Envelope

Drag embedment

- Fluke deploys and buries anchor in seafloor
- Seafloor disturbance: Up to 50 square meters
- Installation: placed and dragged into place

Dead weight

- Large concrete or steel device holds by weight
- Seafloor disturbance: Up to 80 square meters
- Installation: placed

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Anchoring and Mooring Envelope 2

Pile

- Piles driven into seafloor
- Scale: 1 to 3 m in diameter, 10 to 30 m in length
- Installation: pile driving

Plate

- Pile with a ‘wing’ that opens under the seafloor for greater holding power
- Scale: up to 30 square meters
- Installation: pile driving, jetting, augering, shooting (ballistic)

Most likely anchors at CalWave^{sm} – drag embedment and dead weight

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Feedback on Potential Environmental Effect Matrices

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Shore Station

Issue	Level of Concern	Possible Mitigation	Studies
Pinniped haulout during construction	Low	Monitor, avoid	Survey of beach use, analysis pupping seasonality
Listed species habitat on 70 kV upgrade route	High	Avoid and monitor construction	Field surveys for habitat
Wetlands on 70 kV upgrade route	High	Avoid and monitor construction, LID to avoid indirect impact	Field surveys for wetlands
Archaeological resources	Moderate (w/Mit)	Avoid and monitor construction	Field survey, consult Tribes
Viewshed from CG Station	Low	Screening vegetation	Landscape plan, visual simulation
Noise, light during construction and operation	Moderate	Lighting design	Species inventory, sensitivity analysis

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Cable Route

Issue	LOC	Possible Mitigation	Studies
Near-shore habitat disruption by drilling, frac-out	High	Avoidance, monitor drilling for frac-out	Dive studies for habitat surveys, nearshore bathymetry
Off-shore habitat (esp. invertebrates)	Low	Monitor re-establishment	USGS habitat maps, video
Shipwrecks	High if not avoided	Avoidance by re-route	Side-scan sonar of cable routes
EMF exposure to marine biota	Low		Review of controlled studies on EMF
Construction noise – (cable lay)	High	Monitoring, shutdown zones	Analysis of construction noise re: marine biota sensitivities
Collision during construction	High	Monitoring, shutdown zones, avoidance plan	Analysis of successful avoidance policies

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Test Berths, Part 1

Issue	LOC	Possible Mitigation	Studies
Noise of WEC installation	Moderate	Monitoring, shutdown zones, avoidance plan	Analysis of construction noise re: marine biota sensitivities
Noise of WEC operation	Moderate	Engineering attenuation of WECs	Measure WEC noise generated, analysis of marine biota noise sensitivities
WEC lighting, bird attraction, collision	Moderate		Analysis of susceptible species
Contamination of water by anti-fouling materials or WEC lubricants	Low	BMPs, monitoring, regular maintenance	Analysis of WEC hazardous material use
Entanglement with cables or in fishing or crabbing gear fowling cables (cetaceans, turtles, pinnipeds, birds)	High	Periodic removal, remote sensing (?)	Assessment of cetacean migration and avoidance behavior, feasibility of remote sensing

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Test Berths, Part 2

Issue	LOC	Possible Mitigation	Studies
Collision with WECs or construction/support vessels	High to Moderate	Monitor construction	Frequency of occurrence, expected vessel speed of support vessels
Impingement in/injury from WEC moving parts	High	WEC design, barriers, monitoring	Literature review, analysis of WEC designs
Habitat changes (reefing)	Low (BLM very high)		Analysis of invasive species and risks of colonization
WECs as fish attraction devices	Low		Analysis of species that may be adversely affected by predation
Pinneped haulout on WECs	Low	WEC deck design, remote sensing, monitoring	Review of deck designs that discourage pinniped haulout
Commercial fishing	High	Consult fishing community	Historical data on commercial catch in project area, interview fishers
Attenuation of wave resource near-shore and on-shore, waves and kelp beds	Low		Modeling of wave attenuation "re-filling" by refraction and diffraction using wave buoy and WEC production data
Visual impacts	Low		Visual simulation from Jalama Beach of largest WECs permitted

18

Presentation: Interactions with Marine Mammals and Acoustics

- Greg Sanders, BOEM

19

Next Steps and Anticipated Timeframes

- 2017 plans

20

Contact CalWave℠

calwave@calpoly.edu

Dr. Sam Blakeslee, Principal Investigator

Bill Toman, Project Manager
(President, Protean Wave Energy, Inc)
707-731-9261 (m)

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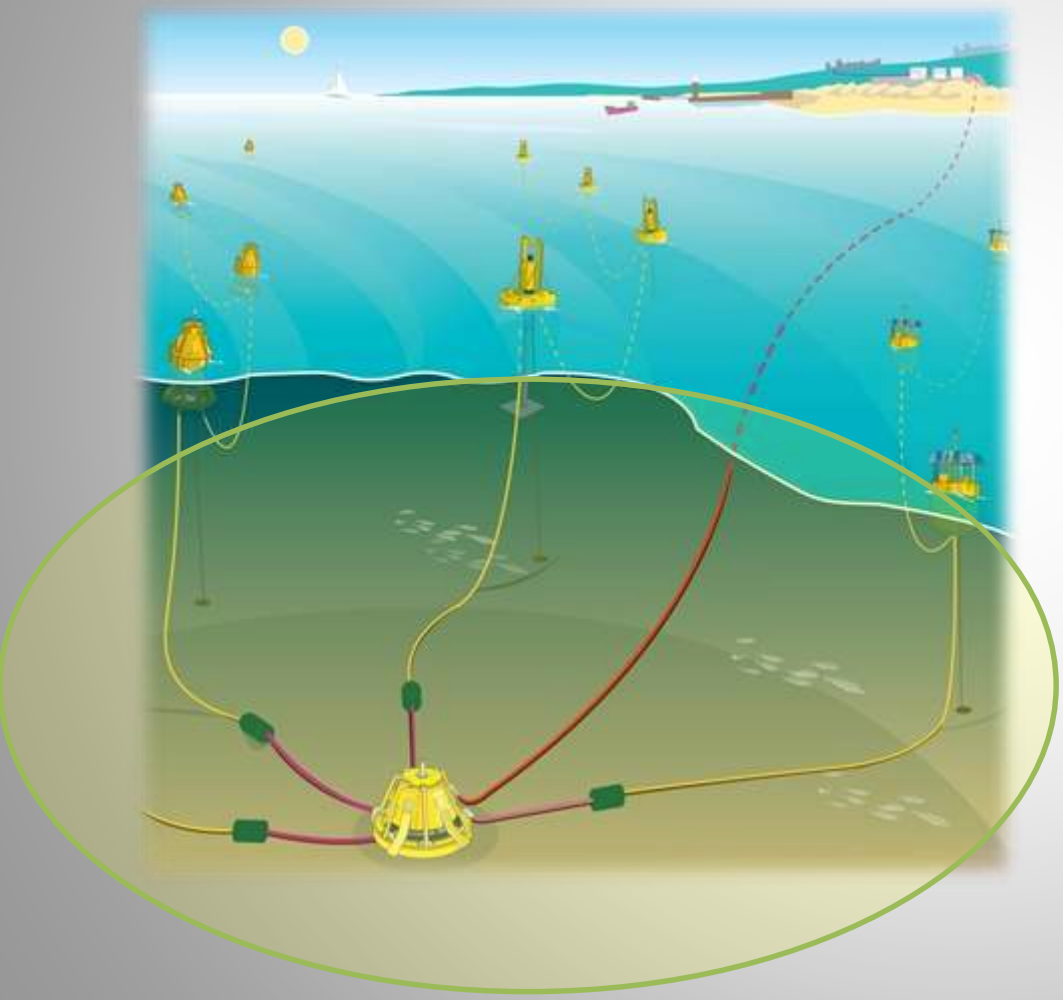
Potential Interactions Between Offshore Renewable Energy Activities, Marine Mammals and Sea Turtles

Understanding Proposed Activities

- Floating Devices
- Mooring Lines
- Anchoring System
- Cabling



Understanding Proposed Activities

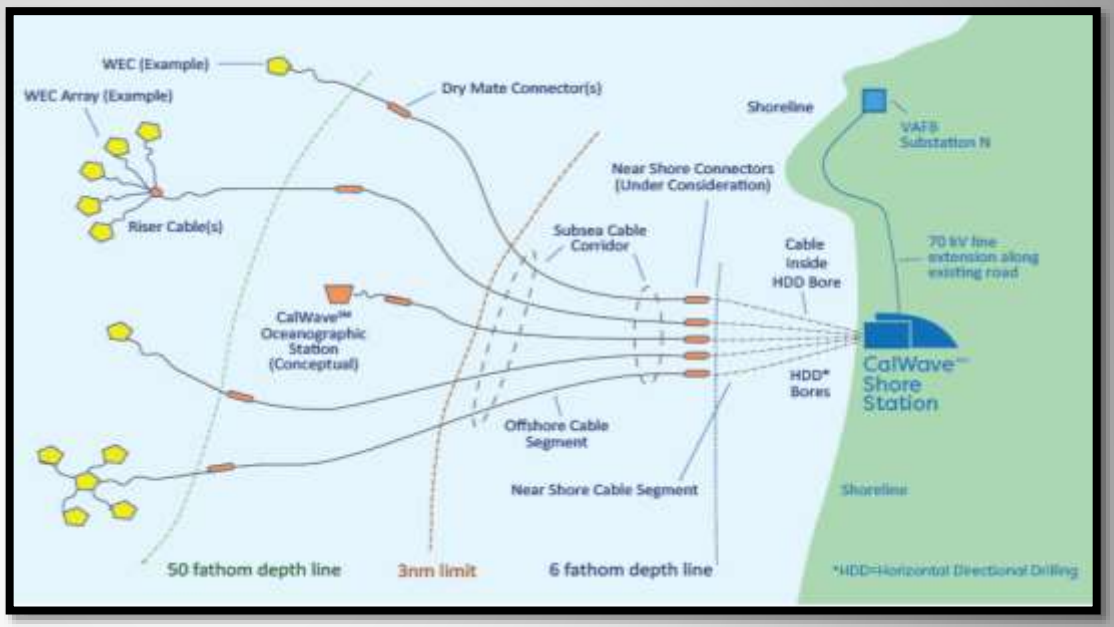
Construction:

- Cable
- Assembly
- Moorings
- Towing
- Array Connections

Understanding Proposed Activities

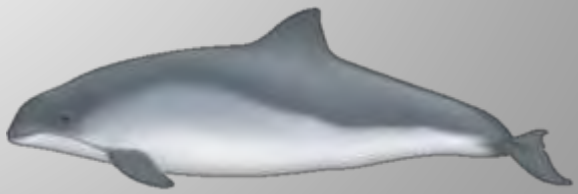
Operation:

- Monitoring
- Repair
- Maintenance
- Decommissioning



Understanding the Species

- Distribution
- Life History
- Vulnerabilities



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Understanding the Species

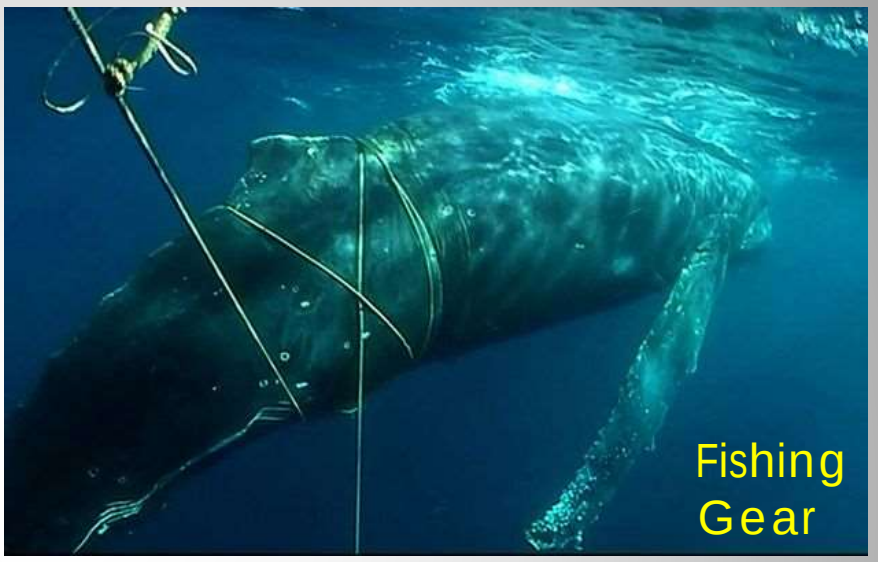
Potential Interactions

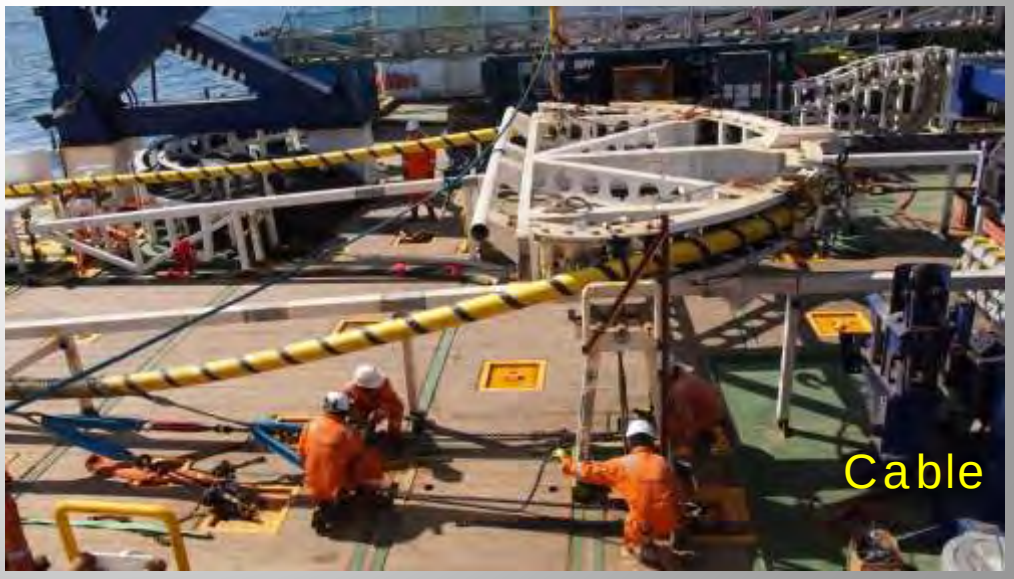
- Entanglement
- Collision
- Noise
- Displacement

Entanglement – Cable Installation

Evaluating Risk

- Physical Characteristics of Materials
- Species Characteristics

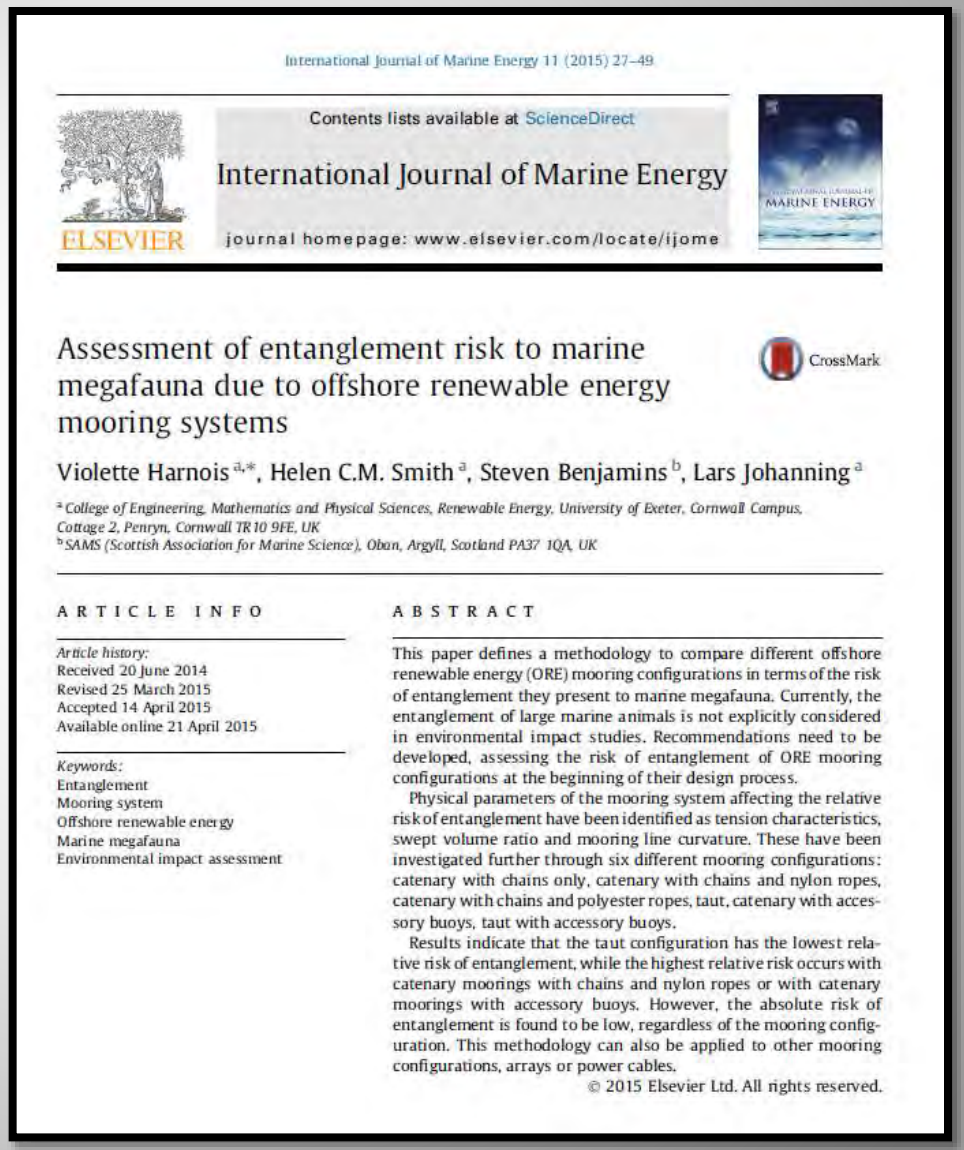




Entanglement – Moorings/Cables

Evaluating Risk

- Tension
- Swept Volume
- Curvature



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Assessment of entanglement risk to marine megafauna due to offshore renewable energy mooring systems

Violette Harnois [a,*], Helen C.M. Smith [a], Steven Benjamins [b], Lars Johanning [a]

[a] College of Engineering, Mathematics and Physical Sciences, Renewable Energy, University of Exeter, Cornwall Campus, Cottage 2, Penryn, Cornwall TR10 9FE, UK
[b] SAMS (Scottish Association for Marine Science), Oban, Argyll, Scotland PA37 1QA, UK

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ABSTRACT

This paper defines a methodology to compare different offshore renewable energy (ORE) mooring configurations in terms of the risk of entanglement they present to marine megafauna. Currently, the entanglement of large marine animals is not explicitly considered in environmental impact studies. Recommendations need to be developed, assessing the risk of entanglement of ORE mooring configurations at the beginning of their design process.

Physical parameters of the mooring system affecting the relative risk of entanglement have been identified as tension characteristics, swept volume ratio and mooring line curvature. These have been investigated further through six different mooring configurations: catenary with chains only, catenary with chains and nylon ropes, catenary with chains and polyester ropes, taut, catenary with accessory buoys, taut with accessory buoys.

Results indicate that the taut configuration has the lowest relative risk of entanglement, while the highest relative risk occurs with catenary moorings with chains and nylon ropes or with catenary moorings with accessory buoys. However, the absolute risk of entanglement is found to be low, regardless of the mooring configuration. This methodology can also be applied to other mooring configurations, arrays or power cables.

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Entanglement – Derelict Fishing Gear

Evaluating Risk

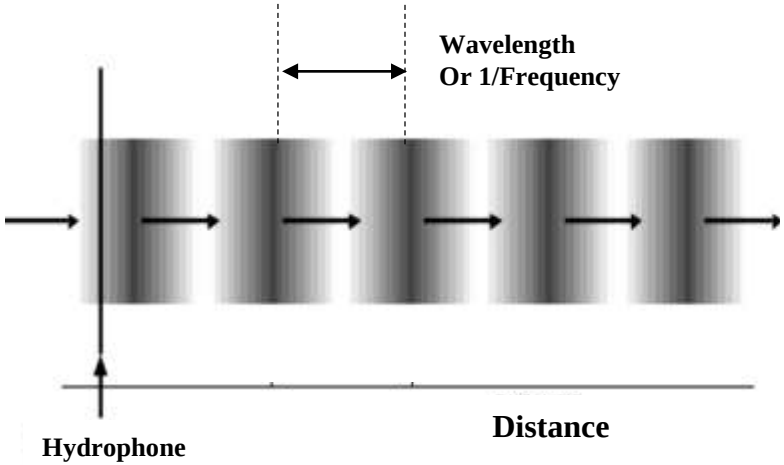
- Available fishing gear
- Gear loss rate
- Opportunity to be captured in mooring lines

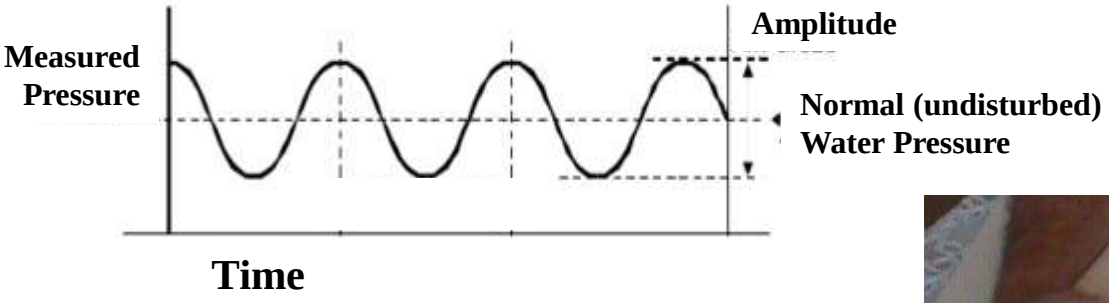
Collisions: Vessels

Evaluating Risk

- Vessel Size and Speed
- Species Vulnerability

Acoustic Energy Propagates as a Compressional Wave in Water





Sources of "Noise" in the Ocean

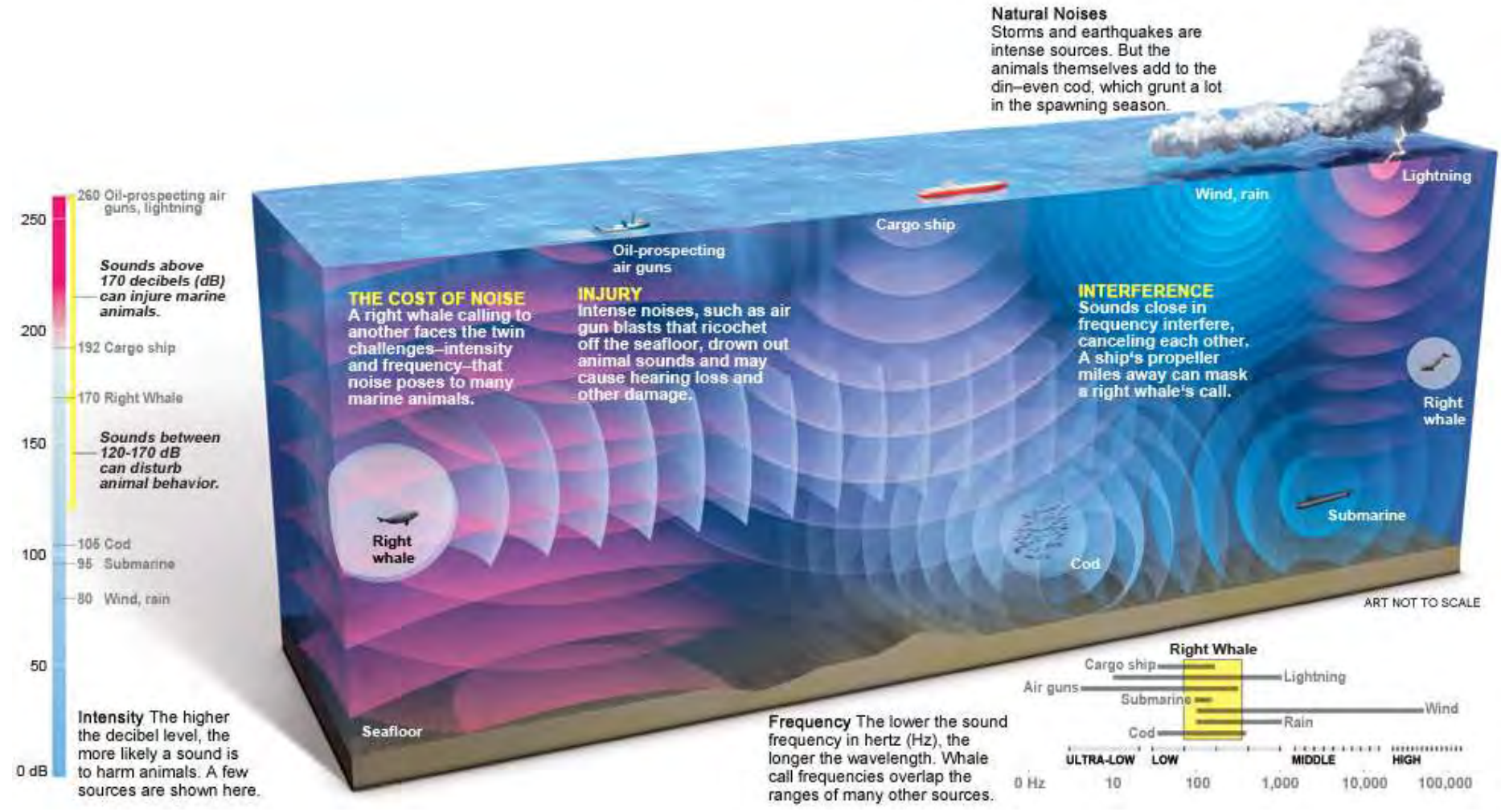


Image: National Geographic, 2011

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Issues with Interpreting Acoustic Impacts in the Ocean

- **Very large range of Received Level (RL) values**
  - Quietest to Loudest sound a human can hear in water is 100 to about 31,600,000,000,000 μ Pa (3 billion times as large)
- **Strong dependency of impacts on range from source**
  - Source level isn't enough.
- **Frequency content of signal is critical and often broad**
  - Humans only use a small portion (~10%) of the frequency spectrum
  - Other species use and are sensitive to much larger spectrum, low-mid-high frequency specialists.
  - Propagation changes with frequency
- **Most underwater acoustic properties are not linear**
  - Sound generally does not travel in a straight line
  - Sound absorption, reflection, etc. are not linear

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Noise: Construction

Evaluating Risk

- Cable Installation
- Mooring Installation
- Towing

Noise: Operations

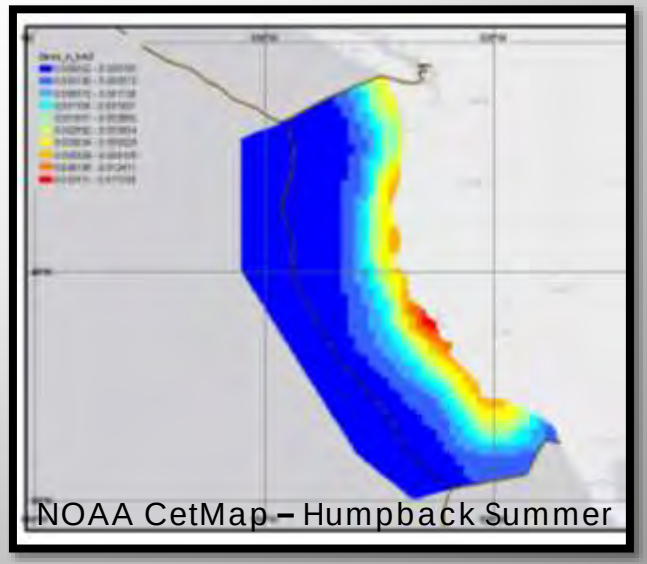
Evaluating Risk

- Device Noise
- Moorings
- Vessels

Displacement: Construction and Operation

Evaluating Risk

- Displacement Type
- Location, Duration and Timing
- Species Reaction


NOAA CetMap – Humpback Summer

Summary

Although offshore renewable energy is new along the Pacific Coast, many of its component parts are familiar. Understanding **both** the proposed activities and specific species distribution and behavior will be critical to characterizing potential effects and assigning risk.

Greg Sanders

Wildlife Biologist

Bureau of Ocean Energy Management

Pacific OCS Region

805-384-6396

greg.sanders@boem.gov

www.boem.gov

Discussion Topics?

- Onshore Landing (nearshore)
  - Location, drilling specifics, timing
  - Pinnipeds, sea otters, gray whales
- Cables, shore to berth and intra-array
  - Location, dimensions (bundling?), placement and orientation, vessel types and capabilities, timing
  - Pinnipeds, cetaceans
- Berth Sites and Mooring
  - Location, device types, materials and mooring design, transport and vessel expectations
  - Large whales (other than gray), sea lions

CalWave℠ Wave Energy Test Center
Stakeholder Advisory Group – Invited Organizations

Academic
Bren School, UCSB – Steve Gaines, Grace Chang
CSU Channel Islands – Sean Anderson
Southern California Marine Institute – Dan Pondella

Economic/Business
Chamber of Commerce of the Santa Barbara Region – Ken Oplinger
Morro Bay Harbor – Eric Endersby
Port Hueneme – John Demers
Port San Luis Harbor District – Andrea Lueker
Santa Maria Valley Chamber of Commerce – Glenn Morris

Environment
Community Environmental Council – Jefferson Litten, April Price
Environmental Defense Center – Linda Krop, Kristen Hislop
Natural Resources Defense Council – Sandy Aylesworth
Sierra Club – Andrew Christie
Surfrider – Brad Snook
The Nature Conservancy – Michael Bell, Sarah Newkirk

Fishing
California Sportfishing Alliance – Ken Franke
California Sportfishing Protection Alliance – John Buettler
Central Coast Fisheries Conservation Coalition – Mel de la Motte, Bob Hather
Commercial Fishermen of Santa Barbara – Chris Voss, Kim Selkoe
Morro Bay Commercial Fishermen's Organization – Jeremiah O'Brien
Port San Luis Commercial Fishermen's Association – Tom Capen
Southern California Trawlers Association – Mike McCorkle

Labor
Coalition of Labor, Agriculture and Business – Andy Caldwell
IBEW Local 413 – Bryan Gregory

Local/Regional Government and Site Managers
City of Lompoc – Bob Lingl
Lois Capps' Office – Greg Haas
San Luis Obispo County – Supervisors
Santa Barbara County – Doreen Farr
Vandenberg Air Force Base – Ken Domako

Marine Industry

Associated Pacific Constructors – Paul Gillen
Castagnola Tug Service Inc. – Danny Castagnola
Trac Tide Marine Fuels – Captain John BelChere
Vessel Operations, Morro Bay – Frank Loving

Tribes

Barbareño Chumash Council – Deborah Sanchez
Coastal Band of the Chumash Nation – Roberta Cordero, Michael Cordero, Chair Gino Altamirano
Northern Chumash Tribal Council – Fred Collins
Santa Ynez Band of Chumash Indians – Freddie Romero, Sam Cohen
Yak Tityu Tityu Northern Chumash – Mona Olivas Tucker, Haylee Bautista

CalWave^{SM} Wave Energy Test Center
Stakeholder Advisory Group – Invited Organizations

Agency	Person
Army Corps of Engineers	Antal Szijj
Army Corps of Engineers	Crystal Huerta
Army Corps of Engineers	Ian Bordenave
Bureau of Land Management, California Coastal National Monument	Bill Standley
Bureau of Land Management, California Coastal National Monument	Dave Ledig
Bureau of Ocean Energy Management	Doug Boren
Bureau of Ocean Energy Management	Jean Thurston
Bureau of Ocean Energy Management	Jennifer Golladay
Bureau of Ocean Energy Management	Joan Barminski
Bureau of Ocean Energy Management	Susan Zaleski
CA Office of Historic Preservation	Brendon Greenaway
CA Office of Historic Preservation	Julianne Polanco
California Coastal Commission	Tom Luster
California Department of Fish and Wildlife	Andrew Valand
California Department of Fish and Wildlife	Brian Owens
California Department of Fish and Wildlife	Eric Wilkins
California Department of Fish and Wildlife	Martin Potter
California State Lands Commission	Cheryl Hudson
California State Lands Commission	Jennifer DeLeon
California State Lands Commission	Jennifer Lucchesi
California State Lands Commission	Maren Farnum
California State Lands Commission	Mark LeClair
California State Lands Commission	Patrick Mulcahy
Channel Islands National Marine Sanctuary	Jessica Morten
Channel Islands National Marine Sanctuary	Sean Hastings
Edwards Air Force Base RCT Rep	Scott Kiernan
Federal Energy Regulatory Commission	Jim Hastreiter
Federal Energy Regulatory Commission	Tim Konnert
Marine Mammal Commission	Vicki Cornish
National Marine Fisheries Service	Bill Foster
National Marine Fisheries Service	Penny Ruvelas
National Marine Fisheries Service	Steve Edmondson
NOAA - Renewable energy POC for MMPA compliance	John Fiorentino
NOAA - Renewable energy POC for MMPA compliance	Jordan Carduner
NOAA Office of National Marine Sanctuaries	Bill Douros
NOAA Office of National Marine Sanctuaries	Lisa Wooninck
Ocean Protection Council/Marine Renewable Energy Working Group	Chris Potter

Pt Mugu NAWC-WD Sea Range Sustainability	John Burke
State Water Resources Control Board	Catherine Woody
State Water Resources Control Board	Joanna Jensen
U.S. Air Force AFSPC 30 SW/CD	Ronald Cortopassi
U.S. Coast Guard	Brandon Link
U.S. Coast Guard	CDR James Williamson
U.S. Coast Guard	Darryl Harvey
U.S. Coast Guard	James Morgia
U.S. Coast Guard	LT Ernie Saponara
U.S. Department of Defense point for Trident Project	Sarah Delisle
U.S. Department of Energy	Roak Parker
U.S. Fish and Wildlife Service	Dou Yang
U.S. Fish and Wildlife Service	Heather Tipton
U.S. Fish and Wildlife Service	Lilian Carswell
U.S. Fish and Wildlife Service	Rachel Henry
U.S. Marine Corps MCI-W RCT Rep	Ned McKinley
U.S. Navy	Steve Duboyce
U.S. Navy Pacific Fleet POC/RCT Rep	Robert "Shorty" Nowak
U.S. Navy RCT Rep	Steve Chung
Vandenberg Air Force Base	Ken Domako
Vandenberg Air Force Base	Walt Schobel

Potential Topics for Onshore Landing

Topic	What studies do we have?	What are the potential impacts?	Likelihood of effects? (High, Medium, Low)	Level of Concern? (High, Medium, Low)	Relative risk compared to other energy sources or other infrastructure?	Potential actions to avoid, minimize, monitor, or mitigate?	• What information needed to permit? • Monitoring needed?
1. Harbor Seal Haul-out (CWT) Pinniped/Harbor Seal Haul-out	VAFB surveys (CWT)	Temporary disruption during construction (CWT)	High (CWT)	Low (CWT)	Low (CWT)	Monitor beach during construction (CWT) Monitor beach during construction; construct outside breeding season Monitor beach during construction; avoid landing locations at known pupping sites; avoid construction during pupping season	Observe use of beach adjacent to shore station (CWT) Observe use of beach adjacent to shore station; info needed: pinniped pupping seasons and locations; monitoring needed; PSOs needed during construction; long term monitoring to determine if abandonment haulout occurs.
2. Endangered/Sensitive Species Habitats (CWT) Migratory/Endangered/Species Habitats Endangered/Sensitive Species Habitats (eelgrass, sea otters, etc.)	VAFB surveys (CWT)	Habitat disruption, removal (CWT) Temporary or permanent Habitat disruption, degradation or removal	Low(CWT) High to low	High (CWT)	Low (CWT)	Plan 70 kV route to avoid sensitive habitats (CWT) Plan 70 kV route to avoid sensitive habitats survey, fencing, flagging	Pre-permitting survey of 70 kV route (CWT)
3. Archaeological Resources (CWT)	VAFB surveys (CWT)	Damage to archaeological deposits (CWT)	Moderate (CWT) High to Moderate	Moderate to low, with mitigation (CWT)	Moderate (CWT)	Plan 70 kV route to avoid sites (CWT)	Pre-permitting survey of 70 kV route (CWT) Pre-permitting survey of 70kV route Coordinate with Tribes/SHPO
4. VAFB Coast Guard Station Viewshed (CWT)	Visual simulation (CWT) Visual simulation/Visual values	Visual impact to recreational users of CG station (CWT) Visual impact to human/recreational users of CG station	Low (CWT)	Low (CWT)	Low (CWT)	Screen view of Shore Station with vegetation (CWT)	Design of shore station (CWT)
5. Wetlands (CWT) Wetlands and drainages	VAFB surveys (CWT)	Disruption of wetland habitat (CWT) Temporary and permanent Disruption of wetland habitat, change in drainage patters, erosion/siltation, water quality impacts	Low, with 70 kV route avoidance (CWT)	High, unless avoided (CWT)	Low (CWT)	Plan 70 kV route to avoid wetlands (CWT) LID features for parking lots and other structures	Pre-permitting survey of 70 kV route (CWT)

Commented [ZB1]: Why only harbor seal? Other pinnipeds also haulout a VAFB. If landing location is a known harbor seal haulout but not a haulout for other species please ignore).

Commented [ZB2]: Staff would like to see the VAFB surveys, which beach areas would be affected and why? How can potential impacts be minimized?

Commented [ZB3]: Staff would like to see the VAFB surveys

Commented [ZB4]: Staff would like to see the VAFB surveys. A delineation is needed to determine location and type of wetlands or drainages if the beneficial uses of a wetland or drainage will potentially be impacted, a CRAM assessment of the feature should be made. Water quality monitoring as necessary.

Topic	What studies do we have?	What are the potential impacts?	Likelihood of effects? (High, Medium, Low)	Level of Concern? (High, Medium, Low)	Relative risk compared to other energy sources or other infrastructure?	Potential actions to avoid, minimize, monitor, or mitigate?	• What information needed to permit? • Monitoring needed?
6. Noise/Lighting	Varies by proximity of human and other wildlife species Dark Skies, Wildlife Studies Pinniped/seabird/migratory birds	Behavioral/habitat loss Potential bird and pinniped impact during construction	Moderate? low except during construction (SWRCB) light pollution - ????	Moderate? Minimize lighting, no nightwork	????	BMPs, muffling, shielding of lights/no constant exterior lighting Construct outside breeding season, flagging, fencing (SWRCB)	
7. EMF			Low	Low			
8. Frac-outs during drilling		Temporary habitat degradation	High	Medium		BMPs	SWRCB staff would like to see the VAFB surveys. Which areas would be affected and why?
9. Federal regulation							
10. Horizontal directional drill (HDD) related design and construction requirements, if applicable	Geotechnical/geological information	Geo-hazards	High for design and construction	High	High	Avoid fault and existing utilities	Engineering design documents, contractor work plan including HDD installation plan, anchoring plan, operation and maintenance plans, etc.
11. Public Access						Working during non-peak use times/seasons (perhaps less of an issue within the AFB)	

Commented [ZB5]: Will the facility or vessels be subject to being federally regulated?

Commented [ZB6]: Expect to use HDD to avoid impacts to the beach/nearshore/surf zone.

Legend

CWT – CalWave Team

Potential Topics for Cable Routes

Topic	What studies do we have?	What are the potential impacts?	Likelihood of effects? (High, Medium, Low)	Level of Concern? (High, Medium, Low)	Relative risk compared to other energy sources or infrastructure types?	Potential actions to avoid, minimize, monitor, or mitigate?	• What information needed to permit? • Monitoring needed?
1. Near-Shore Sensitive Habitats (CWT)	Existing VAFB studies, dive surveys (CWT) Existing VAFB studies, dive surveys, university Limpets/MARINe	Temporary disruption of habitat (CWT) Temporary or permanent habitat disruption or degradation disruption of habitat Temporary disruption of habitat, similar to comment below but cable proposed to be drilled to go under intertidal/part sub nearshore, area?	Moderate (may be avoided) (CWT) Low	High (CWT)	High if not avoided (CWT)	Pre-construction survey to avoid (CWT)	Habitat mapping (CWT) Habitat mapping, coordinate with CDFW Staff would like to see the VAFB surveys. Which areas would be affected and why? Habitat mapping. If avoidance infeasible, monitoring would be required to assess impacts and contingency mitigation plan may be appropriate
2. Marine Habitat (esp. invertebrates) (CWT) Soft bottom? Marine Habitat (esp. invertebrates)	Bathymetry and USGS habitat mapping (CWT)	Temporary disruption (CWT) Temporary disruption and cable on surface will develop hard surface biota (different than soft bottom) could be beneficial?	High (CWT)	Low to very low (CWT)	Low (CWT)	Obtain USGS information (CWT)	USGS habitat maps, video if available (CWT) USGS habitat maps, video if available, Coordinate with CDFW
3. Cultural Resources (shipwrecks, etc.) (CWT)	Side-scan sonar of cable route (CWT)	Damage to cultural resources (if not avoided) (CWT)	Very low (CWT)	Would vary (but avoidance possible) (CWT)	Low to very low (CWT)	Review sonar results (CWT)	Side-scan sonar (CWT) Side-scan sonar Coordinate with Tribes/SHPO
4. EMF (CWT)	Available (refer to Ann Bull/BOEM presentation) (CWT)	Behavioral (CWT)	High (CWT)	Low to very low (CWT) Low	Low to very low (CWT)	Review studies (CWT) Stringing method, undergrouding, insulation	Subsea cable EMF levels (CWT)
5. Acoustics/Noise During Construction (CWT) Acoustics/Noise/Light During Construction	Varies by species (CWT)	Behavioral, possible injury (CWT)	High for construction, low for operation (CWT)	Moderate (CWT)	High for construction, low for operation (CWT)	Plan to monitor construction (CWT) Plan to monitor construction; marine mammal mitigation/shutdown zones if injurious sound sources are identified for cable-laying activities; avoid cable-laying activities for certain biologically important areas (geographical	Noise levels from WECs (CWT) Noise/Light levels from WECs Noise levels from WECs; potential marine mammal monitoring, onsite PSOs

Commented [ZB1]: SLC – Revised PRC 412 Recommissioning Project (Venoco Inc) EIR
Exxon Mobil Santa Ynez Unit (SYU) OPSR - B Phase 2 Project MND
Ellwood Pipeline (Venoco) Line 96 Modification Final EIR
Venoco South Ellwood Field Project Draft EIR
Platform Irene, power cables, SLC Lease Staff Report
Platform Irene, general lease, SLC Lease Staff Report
Platform Irene, crude oil pipeline, SLC Lease Staff Report

Commented [ZB2]: Please see the MBNMS action plan for submerged cables and the NOAA/ONMS policy on cables (attached to email).

Commented [ZB3]: Avoid hard bottom habitat and other sensitive habitat types (e.g., kelp, sea grasses, etc.) to the extent feasible, and expect to mitigate for any unavoidable impacts.

Commented [ZB4]: Shipwreck spreadsheet

Commented [ZB5]: Recent paper showed little effect on behavior.

Commented [ZB6]: Recent papers show low to no effects

Commented [ZB7]: General paper: Scientific Review: Acoustics and Low Energy Geophysical Surveys and Their Potential for Impacts

Topic	What studies do we have?	What are the potential impacts?	Likelihood of effects? (High, Medium, Low)	Level of Concern? (High, Medium, Low)	Relative risk compared to other energy sources or infrastructure types?	Potential actions to avoid, minimize, monitor, or mitigate?	• What information needed to permit? • Monitoring needed?
						and/or temporal) (e.g. blue whale feeding BIA June-Oct)	
6. Paleo shorelines		Near-shore Sensitive Habitats					
7. Collisions/entanglement with protected species during cable installations	Risk varies by species	Injury, entanglement, and possible mortality if interactions are not avoided	Low (could be avoided)	High if not avoided	Similar to any other cable laying operations that would occur	Plan to monitor during construction; schedule construction during time periods to avoid high concentrations of sensitive species (avoid summer/fall although details may vary by species); vessel speed restrictions; shutdown and notification/reporting requirements if vessel strike.	Schedule of construction; monitoring and avoidance plan.
8. Engineering design and construction requirements within State Lands Commission jurisdictions	Pre-construction and post-construction sea floor surveys, geotechnical/geological information	Geo-hazards, sensitive seafloor features	High for design and construction	High	High	Avoid fault, existing utilities and seafloor features	Engineering design documents, anchoring plan, contractor work plan, operation and maintenance plans, etc.
9. Commercial and recreational fishing						Timing restrictions on construction, possibly burying or trenching cables instead of installing on the seafloor surface (may depend on the habitats that may be affected and the types of fishing expected in the area)	

Legend

CWT – CalWave Team

Commented [ZB1]: SLC – Revised PRC 412
Recommissioning Project (Venoco Inc) EIR
Exxon Mobil Santa Ynez Unit (SYU) OPSR - B Phase 2 Project MND
Ellwood Pipeline (Venoco) Line 96 Modification Final EIR
Venoco South Ellwood Field Project Draft EIR
Platform Irene, power cables, SLC Lease Staff Report
Platform Irene, general lease, SLC Lease Staff Report
Platform Irene, crude oil pipeline, SLC Lease Staff Report

Commented [ZB8]: See http://oceanexplorer.noaa.gov/explorations/02quest/background/paleo/paleo.html

Potential Topics for WECs/Test Berths and Anchoring/Mooring

Topic	What studies do we have?	What are the potential impacts?	Likelihood of effects? (High, Medium, Low)	Level of Concern? (High, Medium, Low)	Relative risk compared to other energy sources or infrastructure types?	Potential actions to avoid, minimize, monitor, or mitigate?	• What information needed to permit? • Monitoring needed?
1. Noise/Acoustics (CWT)	Varies by species (CWT) Varies by proximity of human and other wildlife species	Behavioral, injury (CWT) Behavioral injury,, open space/wilderness values Temporary or permanent habitat degradation	High during construction, low during operation (CWT) High-during construction, high-to-low during operations	Moderate (CWT) High-to-Moderate Moderate (concerns gets progressively larger as the size, duration of the affected area increases)	High for construction, low for operation (CWT) ????	Plan to monitor construction (CWT) Plan to monitor construction plan to monitor during operation also monitor in water noise of the WEC for a set time period Plan to monitor construction, use of attenuation for construction and/or operation, plan construction to avoid biologically important areas and seasons. Mitigation/shutdown zones depending on expected SPLs	Noise levels of WECs permitted (CWT) Species dependent (ESA Marine Mammal….concerns) Noise levels of WECs permitted, study of behavioral response in situ, potential monitoring needed: PSOs on site during construction, PAM
2. Entanglement (CWT)	Long-term data for fishing net entanglement (CWT) Long term data for fishing net entanglement. Crab buoy entanglement data Long-term data for fishing net entanglement; entanglement records from various fixed gear fisheries from Stranding Program	Injury/death of cetaceans, birds (CWT) Injury/death of cetaceans, birds, pinnipeds Injury/death of cetaceans, sea turtles, birds, pinnipeds	Low for buoy cables – uncertain for fishing net (CWT) Low for buoy cables – uncertain for fishing net– uncertain for wildlife Low for buoy cables (contingent upon design and number) – uncertain for fishing net.	High (CWT)	Moderate (CWT) ????	Periodic check of buoy cables (CWT) Monitoring and periodic check of buoy cables, WECs Periodic check of buoy cables and/or use of remote sensing to determine when mooring is compromised, design to minimize extent of mooring system seems logical, design to minimize slackness of cables/lines, cameras to monitor potential interactions? (i.e. http://www.ocean.washington.edu/story/Tidal,+wave+energy+monitoring)	Risk of buoy cable entanglement (CWT) Species dependent (ESA, Marine Mammal… concerns) Risk of buoy cable entanglement, final designs, study of potential detection and avoidance behavior in situ, study of magnitude of gray whale migration that passes within the project area
3. Changes in Habitat/Reefing (CWT) Changes in Habitat/Reefing from mooring & WECs	For some habitats (CWT)	Increases habitat for some species (CWT) Decreases/Increases habitat for some species Decreases/Increases habitat	Very high (CWT)	Very low (CWT) Very high Low/medium (	Very low (CWT) ????	Consult NMFS (CWT) Consult NMFS/USFWS/CDFW Avoidance of reef areas for mooring Consult NMFS/CDFW Consult NMFS. Monitor for non-native/invasive species associations	Analysis of species affected (CWT) Analysis of species affected, species dependent (ESA, Marine Mammal… concerns)

Commented [ZB1]: Comment for all matrices –address most of these issues at a very site-specific level, depending on the type of coastal resources involved, so some of the issues identified in the matrices may require substantially greater evaluation that reflected in these general comments or in the matrix descriptions. One key measure applicable to all the issues is to avoid potential impacts to the extent feasible, particularly for the more sensitive issue areas.

Commented [ZB2]: Low Energy Offshore Geophysical Permit Program MND
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Commented [ZB5]: comment for all matrices – Relative risk of what? Also, what other energy sources (e.g. solar, wind, hydroelectric, powerplant (gas/oil/coal) or their infrastructure

Commented [ZB7]: Does this include the WEC?

Commented [ZB8]: general paper: Scientific Review: Acoustics and Low Energy Geophysical Surveys and Their Potential for Impacts

Commented [ZB9]: Dan, I do not see how nets come into play here???

Commented [ZB11]: May require increased risk consideration due to invasive species associations.

Commented [ZB10]: Very low, reefing effect will create some hard habitat in soft areas, but might be a benefit, but what is attracted to that then? Emerging research on oil platforms suggest they may be facilitating non-native/invasive species establishment due to 'novel' habitat. Thus, the level of concern may be better characterized as low/medium.

Topic	What studies do we have?	What are the potential impacts?	Likelihood of effects? (High, Medium, Low)	Level of Concern? (High, Medium, Low)	Relative risk compared to other energy sources or infrastructure types?	Potential actions to avoid, minimize, monitor, or mitigate?	• What information needed to permit? • Monitoring needed?
		for some species Decreases/Increases habitat for some species temporary or permanent					Analysis of species affected Including commercially important and highly important prey species Analysis of species affected. Review of invasive species literature and associations with novel structures.
4. Collision Risk (CWT)	Whale studies (east coast) (CWT) Cetacean/pinniped/seabird/migratory bird studies (west and east coast)	Injury and death (CWT)	Moderate (CWT) High – Moderate	High (CWT)	Moderate (CWT) ????	Plan to monitor construction vessels (CWT) Plan to monitor construction vessels/WEC/USFWS/NMFS/CA F&W	Frequency of occurrence (CWT) Frequency of occurrence analysis of species affected. Species dependent (ESA, Marine Mammal… concerns) Frequency of occurrence, expected vessel speed of support vessels
5. Fishing Effects (CWT)	CDFW catch statistics (CWT)	Loss of fishing access (CWT)	High – WECs will displace some fishing (CWT)	Low – fishing not intense in project area (CWT)	Low (CWT)	Consult fishing community (CWT) Consult fishing community and CDFW Consult Pacific Fisheries Council?? Timing restrictions on construction	Additional information on catch, fishing areas (CWT)
6. Wave Resource Effects, i.e. surfing, sediment transport (CWT)	Model wave attenuation at shore (CWT) Model wave attenuation at shore and between shore and WECs (	Attenuation of surfing waves, change of sediment transport (CWT) Potential impacts to kelp beds depending on distance from shore	High (CWT)	Very low – due to diffraction and refraction and distance (CWT) ???? Very low	Very low at distance from shore (CWT) ????	Model wave attenuation (CWT) Surfrider Foundation USGS and Coastal Sediment Management Workgroup. Conduct work during non-peak use times/seasons (though perhaps less of an issue within the AFB?)	Wave buoy data (available) (CWT)
7. Fish Attraction (CWT)	Some available (CWT)	May increase predation on protected species (CWT) May increase predation on protected species or commercially important and/or highly important prey species May increase predation on protected species, may bring protected species (cetaceans,	High (CWT)	Low (CWT) High to low	Low (CWT) ???? ????	Consult NMFS regarding sensitive species (CWT) Consult NMFS and CDFW regarding sensitive species Consult NMFS and CDFW regarding sensitive species (Consult with BOEM on research it has done in this area	Which species susceptible (CWT) Which species susceptible, analysis of species affected, species dependent (ESA, Marine Mammal… concerns)

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Commented [ZB12]: Shouldn't this also include vessel collision risk?

Commented [ZB13]: Sport fishing should be considered as well. While more difficult to quantify, some effort does occur in the area.

Commented [ZB16]: Sampling using ADCPs and modeling once WECs are in the water would also be useful

Commented [CP15]: USGS and Coastal Sediment Management Workgroup could provide expertise on sediment transport and circulation patterns

Commented [ZB14]: Wave attenuation impacts kelp and seagrass growth as well.

Commented [ZB18]: monitor what shows up? Use camera/rovs?

Commented [CP17]: BOEM has sponsored research on oil and gas platforms that could be analogous/relevant

Topic	What studies do we have?	What are the potential impacts?	Likelihood of effects? (High, Medium, Low)	Level of Concern? (High, Medium, Low)	Relative risk compared to other energy sources or infrastructure types?	Potential actions to avoid, minimize, monitor, or mitigate?	• What information needed to permit? • Monitoring needed?
		Conspinnipeds) into greater contact with WEC if attracted by prey					
8. Visual Impacts to Jalama Beach (CWT)	Visual simulation (CWT) Visual simulation/Visual values	Changes for recreational viewers (CWT) Changes for human/recreational viewers	High (CWT)	Low (CWT) High to low	Low (CWT) ????	None (CWT) Stakeholders, county Tribes – confer with CEC tribal liaison San Luis Council of Governments	Scale of WECs permitted (CWT)
9. EMF (CWT)	Available (CWT)	Behavioral (CWT)	High (CWT)	Low (CWT)	Low (CWT) ????	Review studies (CWT)	Subsea cable EMF levels (CWT)
10. Submerged Cultural Resources (shipwrecks, etc.) (CWT)	Side-scan sonar of cable routes (CWT)	Damage to cultural resources (if not avoided) (CWT)	Very low (CWT) High to low	Would vary (but avoidance possible) (CWT)	Low to very low (CWT) ????	Review sonar results (CWT) Review sonar results Tribal consultation	Side-scan sonar (CWT)
11. Other? Lighting	Dark Skies, Wildlife Studies Cetecean/Pinniped/seabird/migratory birds	Behavioral/Impact Potential bird impact	Unknown – Moderate ???	Moderate	???? Minimize lighting, No nightwork	Review studies, coordinate with NMFS/USFWS/CDFW	Which species susceptible analysis of species affected species dependent (ESA, Marine Mammal,...) concerns
12. Water Quality impacts due to anti-fouling paints/coatings and corrosion inhibitors compounds used on equipment including WECs						BMPs, monitoring	Leaching of biologically active chemicals (e.g. from paints and antifouling coatings) such as butyltins, cadmium, copper, manganese, nickel and zinc is a concern for water quality
13. Effects of water circulation patterns and sediment transport and WEC potentially altering integrity of water column				Low	Low	USGS and Coastal Sediment Management Workgroup .	
14. Increase in vessel traffic for maintenance of renewable energy devices and infrastructure							

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Commented [CP19]: CEC has done extensive outreach to tribes on MRE issues

Commented [ZB20]: based on recent studies seems now that it is low.

Commented [ZB21]: Shipwreck spreadsheet

Commented [CP22]: USGS and Coastal Sediment Management Workgroup could provide expertise on sediment transport and circulation patterns

Topic	What studies do we have?	What are the potential impacts?	Likelihood of effects? (High, Medium, Low)	Level of Concern? (High, Medium, Low)	Relative risk compared to other energy sources or infrastructure types?	Potential actions to avoid, minimize, monitor, or mitigate?	• What information needed to permit? • Monitoring needed?
15. WEC and HDD leaking operational fluids						BMPs, monitoring	
16. What if any effect does the harnessing of wave energy have on the concentration of chemicals due to upwelling in an area							
17. Do WEC cause an upwelling effect							Potential changes in hydrodynamic forces (drag, lift, acceleration and impingement) due to breaking wave action on objects in the surf zone
18. Spills and contaminants during construction and from WECs							
19. Marine Mammal haulout/injury and bird nesting on WEC							
20. Impingement (depending on WEC)							
21. Settlement of sessile species on anchoring/mooring/cable lines. Will these need to be cleaned due to weight and drag? If cleaned where will the shells go? Impact to seafloor?							
22. Potential for invasive species							
23. Pinniped attraction	See history of just about anywhere a floating platform exists, pinniped deterrence workshops?	Behavioral, damage to WEC	Very high	Low, although contingent to any actions taken to respond	Low	Design to prevent pinniped haulout, monitor during operation (remote?)	Pinniped deterrence and monitoring plan

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Commented [ZB23]: Devices that involve seawater intake/pumping will likely require entrainment/impingement studies, possible redesign to avoid/reduce impacts, possible compensatory mitigation depending on type and extent of impacts.

Topic	What studies do we have?	What are the potential impacts?	Likelihood of effects? (High, Medium, Low)	Level of Concern? (High, Medium, Low)	Relative risk compared to other energy sources or infrastructure types?	Potential actions to avoid, minimize, monitor, or mitigate?	• What information needed to permit? • Monitoring needed?
24. Collisions with moving parts	Varies by species, Europe or other experience around the world?	Injury/death of cetaceans, sea turtles, fish, birds, pinnipeds	Low depending on designs, detectability of moving parts	High if there are risks	Low?	Design to avoid using moving parts that expose animals and may not be easily detectable	Study of potential detection and avoidance behavior in situ, monitor local area for strandings and signs of potential incidents
25. PATON Configuration							
26. Impact to waterways once a site is identified and approved							

Legend

CWT – CalWave Team

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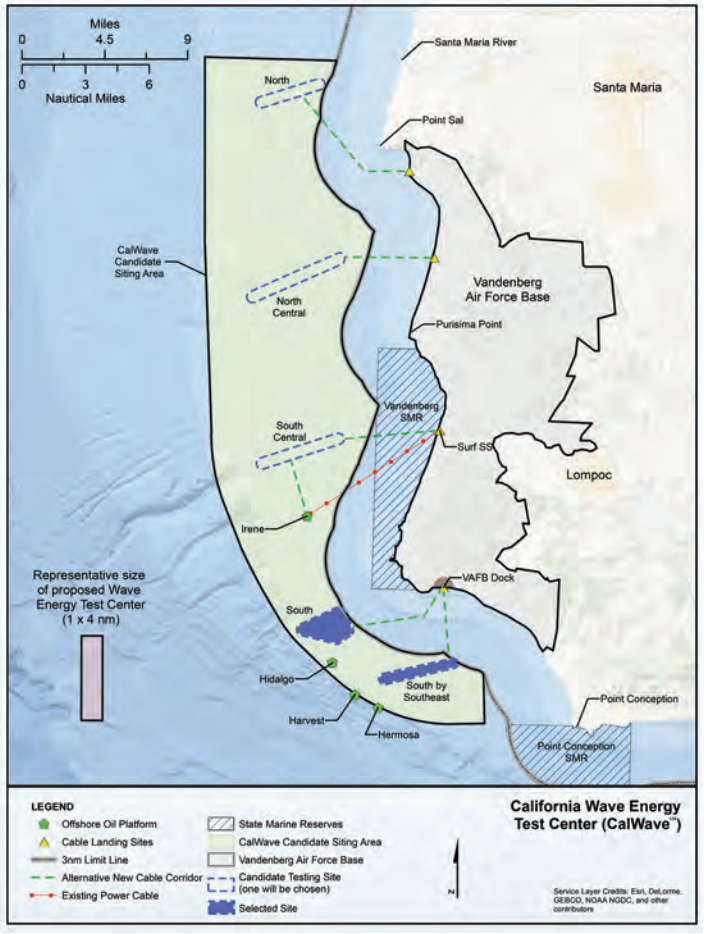
CalWave[SM] Project Fact Sheet

What is CalWave[SM]?

CalWave[SM] is proposed to be a national wave energy test center, located in California, providing an opportunity for leading wave energy converter manufacturers to test their devices in an open ocean environment. The project has been funded by the U.S. Department of Energy and led by the California Polytechnic State University (Cal Poly) Institute for Advanced Technology and Public Policy, with numerous expert academic, government, research, and consultant partners.

CalWave[SM] will meet an existing international need for additional wave energy test facilities. The national test center will provide the wave energy industry with a foundation in California, and foster marine renewable energy innovation in the United States. The four CalWave[SM] test berths will be located approximately 5 miles offshore of Vandenberg Air Force Base and power will be carried on-shore through sub-sea transmission cables. Wave energy devices will provide power directly to Vandenberg and will also interconnect to the broader California electric grid. CalWave[SM] will be designed to test different marine energy technologies in each of the four test berths.

CalWave[SM] will provide manufacturers with an opportunity to test in an **open ocean** environment, giving the wave energy industry a **foundation** in California.



The CalWave[SM] team originally proposed five sites; based on stakeholder feedback the team has now selected the two dark-blue southern sites depicted above.

The development of the facility has been largely supported by the U.S. Department of Energy, with matching funds from Pacific Gas & Electric Company, the State of California, Cal Poly, Humboldt State University, Virginia Tech, Protean Wave Energy, Columbia Power Technologies, and Burns & McDonnell.

Why is CalWave[SM] Being Developed?

The CalWave[SM] facility will provide the following benefits:

- Accelerates renewable energy production in California to meet state renewable goals
- Effectively delivers electric power directly to coastal users
- Is a predictable energy source, as wave energy can be reliably forecast days in advance, complementing land-based renewable energy sources that are prevalent only at specific times of day
- Supports the Department of Defense's aim to boost renewable energy and increase energy security at military facilities
- Builds upon existing infrastructure at Vandenberg AFB, reducing the need to construct additional facilities
- Positions the United States to be a key player in the evolving wave energy industry

CalWave[SM] supports a **consistent and renewable** form of electric power, directly serving coastal users and positioning the U.S. as a **key player** in wave energy.

CalWave℠ Project Fact Sheet

The California Energy Commission estimates that across California's 745 miles of coastline, the state could produce up to about 7,400 megawatts of electricity with ocean energy.

When Might CalWave℠ Become a Reality?

The CalWave℠ project team has been developing this test facility concept for the Central Coast since 2008. Pending continued funding support from the U.S. Department of Energy, the CalWave℠ team anticipates completing environmental permitting by the end of 2018, constructing the facility in 2019-2020, gradually bringing the facility online in 2021-2022, and beginning full operations in 2022.

CalWave℠ System Concept

CalWave℠ is envisioned to have four test berths, each with a submarine cable to the shore station. Each test berth hosting Wave Energy Converter (WEC) Arrays will operate independently.

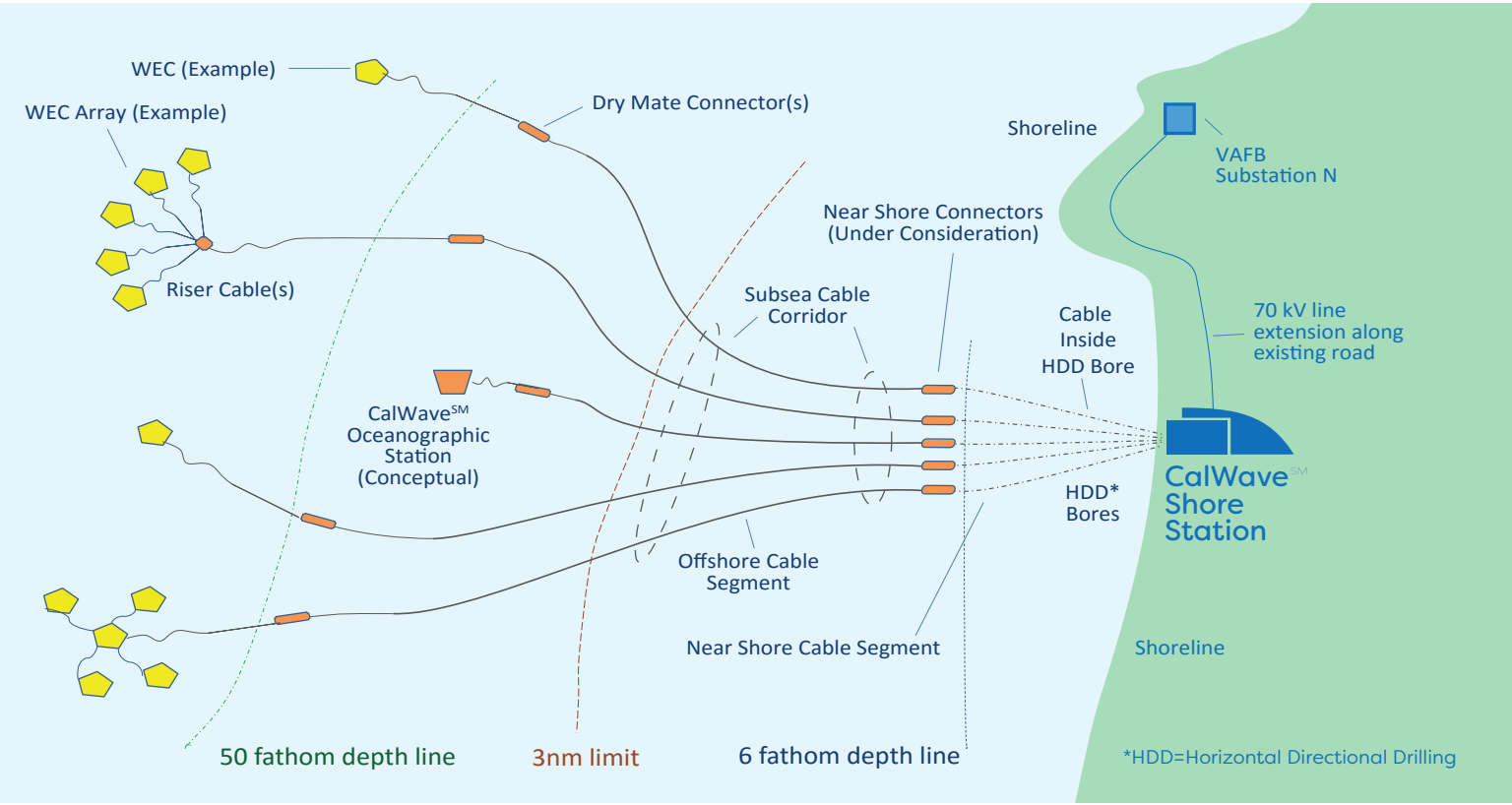
How Can I Become Involved?

The project team has been working with Central Coast stakeholders since the initial project concept was developed. The siting of the current proposed test facility reflects feedback from fishermen, regulatory agencies, environmental groups, recreation groups, and other stakeholders, along with engineering considerations. The project team is passionate about ensuring that CalWave℠ works harmoniously within the existing environment and collaborates with existing ocean users.

You can participate in CalWave℠ by:

- Providing feedback directly through our email portal **calwave@calpoly.edu**
- Joining our mailing list to learn about public meeting opportunities
- Checking our project website for updates: **http://bit.ly/2bCBPm2**

We look forward to hearing from you!



For questions or more information on the CalWave℠ project, send an email to **calwave@calpoly.edu** or visit **http://bit.ly/2bCBPm2**

CalWave Phase 2: Final Report on Stakeholder Participation and Public Involvement

Introduction

Outreach and engagement for this phase of CalWave was designed to support continued project development by informing stakeholders about key concepts related to project design, engineering, and permitting, and incorporating their feedback into these activities.

Goals for Outreach and Engagement

At the outset, the Project Team set the following goals for outreach and engagement:

- Transparent, robust, and clear information-sharing
- Early, inclusive engagement and outreach with all affected/interested stakeholder groups
- Meaningful response to inquiries
- Inclusion of stakeholder interests, where possible

Above all, the engagement and outreach efforts aimed to incorporate information received from stakeholders and agencies early and throughout the process, ultimately leading to better project engineering and development as well as quality and efficient permitting and licensing.

Outreach and Engagement Approach

During CalWave Phase II, the project team conducted outreach and engagement with the following categories of stakeholders:

- Federal, state, and local permitting agencies
- Tribes (both federally- and non-federally-recognized)
- Local business interests
- Local coastal communities
- Fishing communities
- Recreation and environmental interests
- Navigation and marine interests
- Academic institutions
- Power industry
- Labor

Outreach and Engagement Activities

During CalWave Phase II, the Project Team placed emphasis on continued collaborative work with the regulatory agencies, convened a project advisory group comprised of representatives from all stakeholder categories, and engaged a group of experts to inform future project operations. Engagement focused on understanding and limiting potential impacts to existing ocean uses including navigation, shipping, fishing, recreation, and tourism.

Regulatory Agency Group

The Project Team initiated engagement with the Regulatory Agency Group during the first phase of CalWave. During this second phase of effort, work with the Regulatory Agency Group was part informational in nature and part discussion- and feedback-oriented.

Informational activities with the Regulatory Agency Group included: presentations about wave energy device types, including anchoring and mooring mechanisms; information about relevant existing studies in the project area; and scientific presentations about any potential impacts of electromagnetic fields (EMF) from subsea transmission cables to species in the area, potential impacts to marine mammals, and potential acoustic impacts from wave energy devices to species.

The Project Team sought feedback from regulatory agencies regarding siting parameters, issues that would need to be addressed during permitting, sources of available information for permitting, and information to be included in the FERC Pre-Application Document (PAD).

The Regulatory Agency Group met three times during this phase of the project, in July, October, and December 2016. The group was highly engaged, with nearly every relevant agency participating in each meeting either by webinar or phone. Meeting summaries are included in the appendices.

Stakeholder Advisory Group

In September-October 2016, the Project Team convened a Stakeholder Advisory Group comprised of a cross-section of interested stakeholders such as fishing, environmental, recreation, local business, local policy leaders, tribes, and state and federal regulatory agencies, to provide input on siting, issue identification, and other topics of interest. This group held its first meeting in October 2016 to review its charter, learn about current project design, engineering, and permitting, and provide feedback on potential resource effects and information that will be needed for permitting. The meeting was open to the public and had more than 40 participants.

Operational Advisory Group

The CalWave Operational Advisory Group (OAG) is composed of local mariners and marine operators and those who employ marine services in the CalWave area. The purpose of the OAG is for CalWave to benefit from the decades of ocean engineering projects associated with oil and gas as well as experience and collaboration with fishermen. The OAG spans a range of geography and industry from Los Angeles/Long Beach Basin to Morro Bay. The OAG currently has 12 members, but will be expanded in the future to ensure access to the following skill sets and ranges:

- Shore side (ports, cranes, land transportation, rail);
- Water side (vessels, barges, landing craft, divers, ROVs); and

- Those in the middle (marine operations, marine constructors, HDD, cable installers, and geotechnical/bathymetric surveyors).

The Co-Chairs span the geographic catchment for marine services. The Co-Chairs attended the October 2016 Stakeholder Advisory Group meeting to provide marine operations input. In 2016, OAG members reviewed the project Conceptual Design and determined that it is both realistic and executable.

Outreach Materials

In order to support information-sharing to a broad array of interested stakeholders, the Project Team created and maintained the following outreach documents:

- Project website, with information about CalWave, the wave energy industry, and project milestones;
- Fact sheet, with information about CalWave's purpose, development, and milestones, as well as public engagement opportunities;
- Email updates to stakeholders; and
- Ongoing development of a stakeholder contact database.

Key Issues Addressed During Phase II

The Regulatory Agency Group made significant progress during CalWave Phase II. The group reviewed and discussed existing information available and underway that is relevant for understanding potential land-based and marine resource impacts. Strong relationships have been established between the project team and the regulatory agencies given the almost two-year effort associated with CalWave, as well as the previous WaveConnect project in both Humboldt and Central Coast. Also, given the co-funding efforts by the State of California, including the State Lands Commission and the Natural Resources Agency (which includes the California Department of Fish and Wildlife and the Ocean Protection Council) the groundwork has been laid to work closely through an efficient permitting process together with the state and federal agencies involved.

The 2016 Regulatory Agency Group meetings showed that the group is comfortable with using an "envelope" approach for permitting WEC devices and anchoring and mooring systems. The group will aim to permit WEC devices and anchoring and mooring systems that fall within a given set of parameters or boundaries; if a project developer wants to participate in CalWave, those project elements must fall within the "envelope" or be subjected to additional permitting activities. Future permitting activities will focus on defining that "envelope," including appropriate mitigation and adaptive management measures, where appropriate.

The meetings during this phase also clarified the information that the agencies think they will need in order to complete permitting activities. At these meetings, the permitting team shared a matrix listing possible environmental permitting issues by project "zone" (shore station, cable run, and test berths) with the regulatory agencies and asked them to comment on or add to the list from the perspective of their particular agency. The consolidated list of issues was discussed at the December meeting, with the

goal of trying to define studies that could be conducted during a later permitting phase to address the issues. These matrices are included in the appendices.

Lastly, agency personnel gave useful presentations on recent studies on the effects of electro-magnetic frequency (EMF) emissions from subsea power cables (Ann Bull of the Bureau of Ocean Energy Management [BOEM]) and whale entanglement and acoustics issues (Greg Sanders of BOEM). The agencies generally concurred, after learning more about recent EMF studies, that EMF is not likely to be a major issue for permitting CalWave.

Initial work with the Stakeholder Advisory Group showed that the diverse membership is engaged, interested, and ready to discuss aspects of project design, engineering, permitting, and ultimately, avoidance, minimization, and mitigation measures. The October 2016 discussions focused on understanding parameters of the scope of the project (footprint of the devices, parameters of the cable lay), interaction between fishing gear and the project, project location in reference to existing fishing grounds, decommissioning, and potential environmental studies. The participants were very involved in the discussions and requested additional meetings in early 2017.

Recommendations for Future Work

Topics for Outreach and Engagement

The first two phases of CalWave identified an array of topics that must be addressed in greater detail in future phases. These include:

- Potential impacts to military operations in the area
- Navigational safety review of activities in the area
- Siting of wave energy devices to minimize impacts to existing fishing operations
- Potential future mitigation for lost fishing gear

Additionally, further discussion will be needed on the following regulatory items:

- Defining and clarifying the “envelope” for permitting
- Concurring on the list of studies needed for permitting, and subsequently for adaptive management and monitoring
- Defining the regulatory roadmap, including jurisdictions/responsibilities and corresponding timeframes

Approaches for Outreach and Engagement

Based on the information gathered during this phase, the Project Team recommends the following approaches for engagement and outreach for future phases of the project.

- **Continued group meetings**. The Regulatory Agency Group, Stakeholder Advisory Group, and Operational Advisory Group are comprised of highly engaged and interested participants. These groups will provide crucial information for continued project engineering and development, permitting, and serving a broader outreach/liaison function with additional stakeholders.

- **Public meetings.** At project milestones, host one or two public meetings in the project area to provide updates, solicit feedback on project siting and other characteristics, and share next steps. These meetings serve as an important bridge between Advisory Group members and citizens who are also interested in participating in project development.
- **Small group and one-on-one meetings.** Holding individual meetings with interested stakeholder groups, policy leaders, and others can be a highly effective way of listening to concerns, sharing information, and coming to agreement about preferred options for project development. Where possible, the project team should reach out to individual communities, most importantly the local fishing communities, local elected officials, and individual tribes (both federally-recognized and non-federally-recognized).

To achieve the goals listed above, we recommend placing a high priority on maintaining an up-to-date, clear project website and sending quarterly electronic updates to stakeholders. These activities will enable stakeholders to understand the public engagement and outreach process and timeline, and how to participate, if desired. To leverage these resources, we also recommend that each advisory group member and project team member/affiliate (as appropriate) reach out to his/her respective constituents to more directly share informational updates and seek feedback.

We recommend updating and continuing to use the following outreach materials:

- **Fact Sheet**. A fact sheet can be used to effectively brief stakeholders and legislators about the project, including major development milestones and unique aspects of the project.
- **PowerPoint Presentation**. A single presentation can be used to explain the project highlights and development process to any group seeking a briefing on the project.
- **Detailed Project Maps**. These maps should contain not only the anticipated project location, but also overlays showing existing ocean uses and ranges of key species of concern.
- **Stakeholder Database and Comments**. As project development continues, develop and maintain a stakeholder database as well as gather a list of major stakeholder comments and concerns and publish a document that explains how each comment has been, or will be, addressed as the project is developed. This enables greater transparency and helps all stakeholders to see how concerns are being addressed.
- **Frequently Asked Questions**. These questions and answers will enable stakeholders to understand more about particular aspects of project development including how siting decisions are made, who is involved in the environmental review process, how the potential project would be laid out and operated, and others.

Appendices

The following documents were developed during CalWave Phase II and are included as appendices:

1. July 2016 Regulatory Agency Meeting Summary
2. July 2016 Regulatory Agency Meeting Presentation
3. October 2016 Stakeholder Advisory Group Meeting Summary
4. October 2016 Regulatory Agency Meeting Summary
5. December 2016 Regulatory Agency Meeting Summary
6. December 2016 Regulatory Agency Meeting Presentation
7. December 2016 Regulatory Agency Meeting Presentation from Greg Sanders
8. Stakeholder Advisory Group Members
9. Regulatory Agency Group Members
10. Matrix of Onshore Landing Topics of Interest
11. Matrix of Cable Route Topics of Interest
12. Matrix of WEC Test Berth Topics of Interest
13. CalWave Fact Sheet

Attachment 14-1 - CalWave Metocean Forecasting for Test Berth Access

Reliable offshore metocean forecasting is required for planning offshore test berth construction (i.e., mooring and cable installation), as well as for planning the deployment, servicing, and recovery of wave energy devices being tested. CalWave will utilize offshore wind, wave, and surface current forecasts issued by the Los Angeles Regional Forecast Office of the National Weather Service under the Nearshore Wave Prediction System.

The Nearshore Wave Prediction System (NWPS) provides high-resolution nearshore wave forecast guidance to all US coastal National Weather Service (NWS) Regional Forecast Offices (RFOs), triggered in real time by forecast wind grids prepared and submitted to the National Centers for Environmental Prediction (NCEP) by each RFO. The system was implemented on NCEP's operational supercomputer for NWS's Southern and Eastern Regions in February 2016, with the remaining US regions following in October 2016.

NWPS grids have a nominal resolution of 1.8 km, with further nesting down to 500 m or less in high-impact areas (e.g. port and harbor entrances).

Animations of selected NWPS forecast products off Point Arguello can be viewed at the following links:

- Significant wave height, with wave direction vectors
  http://polar.ncep.noaa.gov/nwps/nwpsloop.php?site=LOX&loop=sigwaveheight&cg=3

- Peak wave period, with wave direction vectors
  http://polar.ncep.noaa.gov/nwps/nwpsloop.php?site=LOX&loop=waveperiod&cg=3

- Mean surface wind speed, with wind direction vectors
  http://polar.ncep.noaa.gov/nwps/nwpsloop.php?site=LOX&loop=wind&cg=3

- Surface current speed, with direction streamlines
  http://polar.ncep.noaa.gov/nwps/nwpsloop.php?site=LOX&loop=cur&cg=3

Note that you may want to contact the Los Angeles RFO to see if they would be willing to produce an animation for a much smaller rectangular area encompassing the Vandenberg AFB dock and the test berths.

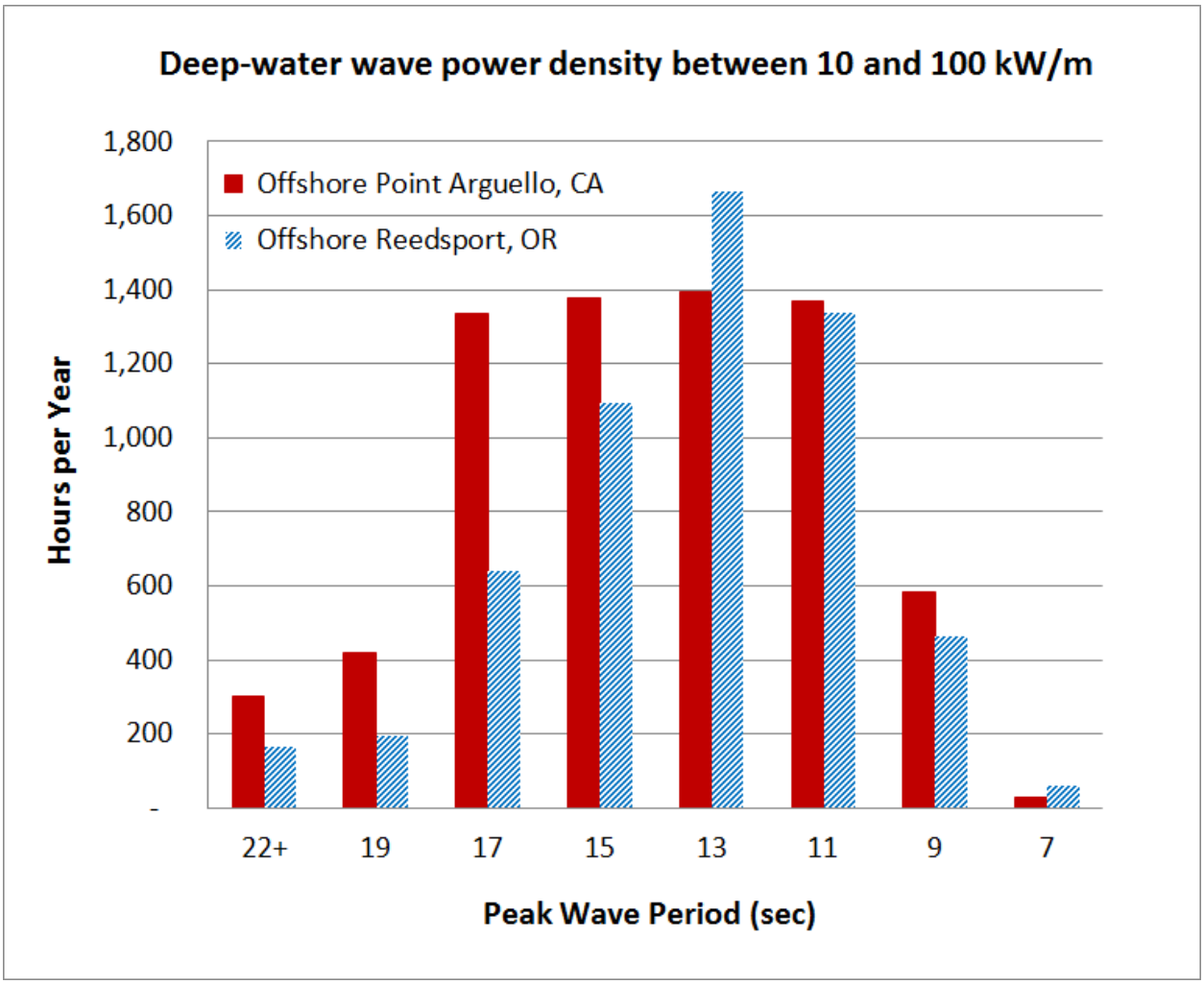
Make sure that this custom domain also includes the NOAA data buoy at NDBC Station 46218 (www.ndbc.noaa.gov/station_page.php?station=46218), which is a Waverider owned and operated by Scripps Coastal Data Information Program, for which Wavewatch III (WW3) forecasts are also streamed on-line (at http://cdip.ucsd.edu/?nav=recent&sub=observed&units=metric&tz=PDT&pub=public&map_stati=1,2,3&stn=071&stream=p1&xitem=buoy_ww3). Note that the WW3 forecasts represent the offshore boundary conditions for the NWPS, which is a nearshore implementation of SWAN.

Attachment 14-2: Virginia Tech- Range of Conditions Available for Testing

Analysis by George Hagerman of Virginia Tech Advanced Research Institute via email dated 2/22/17

Comparison of the wave power density (WPD) distribution across peak period bins at deep-water measurement stations operated by Scripps Coastal Data Information Program off Reedsport, Oregon and Point Arguello, California. This shows that offshore Point Arguello has a much more uniform period distribution of operational sea states, defined as having a WPD between 10 and 100 kW/m. Moreover, such operational sea states occur more than three-quarters of the year (78%) off Point Arguello, but less than two-thirds of the year (64%) off Reedsport. The above distribution covers the same 3500-day period, from 01 Aug 2006 through 29 Feb 2016, with >95% data recovery over this period at each station.

Although hindcast sources of data cover a longer time period, the 30-year hindcasts from the Army Corps of Engineers Wave Information Studies program and the National Centers for Environmental Prediction re-analysis project funded by National Ocean Partnership Program are both based on Wavewatch III, which is known to substantially underestimate local wind-driven seas. Therefore it was more accurate to utilize wave measurements in making this comparison.


Deep-water wave power density between 10 and 100 kW/m
Hours per Year
1,800
1,600
1,400
1,200
1,000
800
600
400
200
-
Offshore Point Arguello, CA
Offshore Reedsport, OR
22+
19
17
15
13
11
9
7
Peak Wave Period (sec)

	Tp (sec)									
Hs (m)	22+	19	17	15	13	11	9	7	5	
8.71 - 9.0+	-	0	1	1	1	0	0	-	-	
8.41 - 8.70	-	0	0	1	0	0	-	-	-	
8.11 - 8.40	-	0	1	1	0	0	0	-	-	
7.81 - 8.10	-	0	1	2	0	1	0	-	-	
7.51 - 7.80	-	0	1	2	1	1	0	-	-	
7.21 - 7.50	-	0	2	3	1	2	0	-	-	
6.91 - 7.20	-	1	2	4	2	3	1	-	-	
6.61 - 6.90	0	1	2	5	3	4	1	-	-	
6.31 - 6.60	-	1	2	7	5	5	3	-	-	> 100 kW/m
6.01 - 6.30	0	2	3	10	6	6	4	-	-	< 100 kW/m
5.71 - 6.00	0	2	5	14	11	9	6	-	-	
5.41 - 5.70	0	3	4	16	16	10	8	-	-	
5.11 - 5.40	0	3	6	24	21	15	11	0	-	
4.81 - 5.10	-	3	6	25	26	22	15	1	-	
4.51 - 4.80	-	4	6	33	39	30	20	2	-	
4.21 - 4.50	0	4	8	42	56	47	27	3	-	
3.91 - 4.20	0	6	11	53	74	65	28	6	-	
3.61 - 3.90	0	7	13	58	87	88	36	10	-	
3.31 - 3.60	0	9	15	64	108	119	44	12	-	
3.01 - 3.30	0	14	17	72	130	150	60	23	0	
2.71 - 3.00	1	18	22	85	134	197	97	42	1	
2.41 - 2.70	1	21	23	81	155	247	142	64	4	
2.11 - 2.40	1	21	22	80	150	283	227	114	15	> 10 kW/m
1.81 - 2.10	2	21	23	80	126	272	288	190	41	< 10 kW /m
1.51 - 1.80	2	23	29	86	116	246	369	227	57	
1.21 - 1.50	1	21	42	93	90	185	367	236	67	
0.91 - 1.20	1	27	45	122	64	103	213	186	58	
0.61 - 0.90	0	11	22	78	37	18	40	62	18	
0.31 - 0.60	-	0	2	9	4	1	1	2	0	**All Tp from**
0.01 - 0.30	-	-	-	-	-	-	-	-	-	**7 to 19 sec**
Hours per year		167	193	640	1,095	1,667	1,338	465	62	5,628
Annual probability		**2%**	**2%**	**7%**	**12%**	**19%**	**15%**	**5%**	**1%**	**64%**

	Tp (sec)									
Hs (m)	22+	19	17	15	13	11	9	7	5	
8.71 - 9.0+	-	0	0	0	-	-	-	-	-	
8.41 - 8.70	-	-	-	0	0	-	-	-	-	
8.11 - 8.40	-	0	-	0	0	-	-	-	-	
7.81 - 8.10	-	0	0	0	0	-	0	-	-	
7.51 - 7.80	-	0	0	0	0	-	-	-	-	
7.21 - 7.50	-	0	0	0	0	0	0	-	-	
6.91 - 7.20	-	0	1	0	0	0	-	-	-	
6.61 - 6.90	-	1	1	1	1	1	0	-	-	
6.31 - 6.60	-	1	1	1	1	2	0	-	-	> 100 kW/m
6.01 - 6.30	-	1	2	2	2	2	0	-	-	< 100 kW/m
5.71 - 6.00	0	1	3	3	3	3	1	-	-	
5.41 - 5.70	0	2	2	4	4	5	1	-	-	
5.11 - 5.40	-	2	3	5	5	6	2	-	-	
4.81 - 5.10	0	3	6	10	9	9	3	0	-	
4.51 - 4.80	0	5	8	20	14	16	7	0	-	
4.21 - 4.50	0	6	12	35	21	19	15	0	-	
3.91 - 4.20	0	8	15	45	32	31	26	1	-	
3.61 - 3.90	0	11	19	66	47	43	35	3	-	
3.31 - 3.60	1	17	18	82	75	70	53	9	0	
3.01 - 3.30	1	21	22	100	120	97	89	20	0	
2.71 - 3.00	2	29	32	127	152	135	136	42	1	
2.41 - 2.70	2	38	41	134	183	190	192	88	2	
2.11 - 2.40	3	44	58	144	205	256	234	184	5	> 10 kW/m
1.81 - 2.10	2	50	76	182	201	294	278	236	20	< 10 kW /m
1.51 - 1.80	2	50	95	268	199	279	302	181	53	
1.21 - 1.50	4	46	79	300	198	203	257	79	49	
0.91 - 1.20	1	26	45	189	119	88	83	18	11	
0.61 - 0.90	0	2	3	21	23	14	5	1	-	
0.31 - 0.60	-	-	-	-	0	-	-	-	-	**All Tp from**
0.01 - 0.30	-	-	-	-	-	-	-	-	-	**7 to 19 sec**
Hours per year	303	420	1,337	1,379	1,394	1,368	583	28	6,811	
Annual probability	**3%**	**5%**	**15%**	**16%**	**16%**	**16%**	**7%**	**0%**	**78%**	

Final Report

Revision Status				
Rev	Prepared By	Date	Purpose of Issue	Reviewed By
02	SH	6/29/17	Final report to CalWave	CG

Purpose of Report

This report is provided as the concluding work package provided by Wave Hub Limited (WHL), and forms part of the overall project requirements of SOPO DE-EE0006517.005 'California Wave Energy Test Center'. The report provides a summary of the deliverables provided during face to face meetings in July 2016 and detailed in the Sponsored Programs Purchase Agreement Statement of work (Attachment A) and complies to the requirements and timelines specified in Amendment #1 dated 22nd March 2017. It is a factual report based on the development and operation of Wave Hub, the purpose built wave energy test facility in Cornwall, UK. While every effort has been made to ensure that the information provided is correct at the time of writing, WHL accepts no responsibility for any errors or omissions within the report.

1. Wave Hub Design and Construction

Wave Hub History

Wave Hub Limited manages the world's largest and most technologically advanced site for testing and development of wave energy arrays. Key dates relating to the development and build of the Wave Hub site are listed below;

2003 - Review of ocean energy potential in the local area
2004 - Detailed Feasibility Study
2005 - Building the financial case
2006 - Consent applications
2007 - Consents approved, financial closure, tenders
2008 - Design review
2009 - Final design and tendering of key work packages
2010 - Build and commissioning
2011 – Local office opened
2012 – Navigation buoys installed
2014 – First wave device deployed

Original Drivers

The following were the main drivers for funding and construction when the option of constructing the Wave Hub site was being assessed in 2004.

The UK government had committed to increasing the amount of electrical energy generated by renewable energy sources to 10% by 2010 and 15% by 2015. The drivers for this included addressing increasingly important environmental and energy issues including global warming, resource depletion, energy prices, security of supply and environmental pollution.

The South West of England Regional Development Agency (SWRDA) had identified the opportunity for the South West to become a leader in renewable energy. In 2002 it set up RegenSW, the renewable energy agency for the South West, and commissioned a report 'Renewable Energy Strategy for the South West' that was published in April 2003. Wave, tidal and biomass energy were identified as particular technologies of interest to the region that required early support.

Wave and tidal energy were identified in a 2004 government sponsored review as key renewable energy technologies for maximising future UK benefits. The benefits identified included;

- The UK building on its leading position internationally in this early stage technology and substantial resource targeting a potentially global market.
- Current leading wave/tidal projects being close to demonstration and need to be proven as both technically and commercially viable
- Addressing a gap in the demonstration to commercial phase of wave technology development.

SWRDA identified the following additional drivers relating to the local region;

- The South West taking a prominent position in marine renewable energy.

- The region's potential to generate substantial amounts of renewable energy from its wave and tidal stream resources.

- The region's existing skills and facilities to support development of the industry.

In 2003 the Seapower South West expert panel was established. The group included national experts in seapower, developers, government representatives and academics. The Seapower South West Report October 2003 was written with input from the Seapower South West expert panel and made a number of recommendations including;

- To carry out a review of the region's marine energy resources

- To develop the Wave Hub concept.

The marine energy resource study was commissioned and confirmed that the region has very good wave and tidal energy resources and outlined the issues that might affect exploitation.

In 2004, the SWRDA funded a detailed feasibility study to investigate all aspects of the proposed Wave Hub.

Site Overview/ Design Options

Initial design and costing studies identified two options as the most environmentally, economic and technically attractive. The 2 options were either a 'wet hub' with a single cable to shore or a purpose built steel jacket or concrete platform.

The possibility that a hybrid design combining these two options was also considered. The preferred option needed to address several requirements including the need to be technically sound and achievable, have minimum environmental impact, be cost-effective and not present significant safety and operation issues.

The final recommended 'wet hub' concept consisted of a 6 Core 33kV Cable – initially operating at 11kV delivering 16MW then operating at 33kV delivering 48MW. Although the design was subsequently refined, Figure 1 shows the final recommended Wave Hub concept.

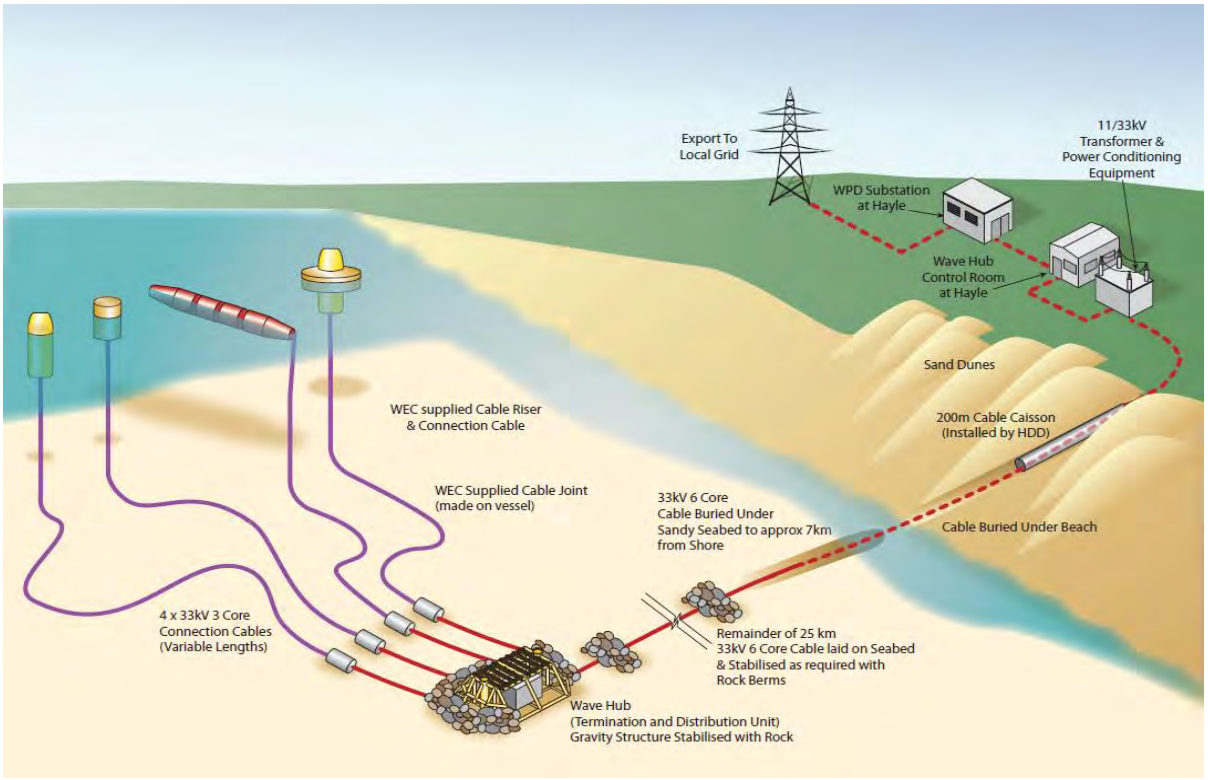


Figure 1 – Recommended Wave Hub Concept

The option to install 4 separate cables was considered but subsequently rejected due to the significant increase in cost of cable procurement and installation. The final electrical infrastructure design included a 6 core export cable configured to be operated as 2 separate 3 phase circuits. A cross-section of the cable is illustrated in Figure 2.

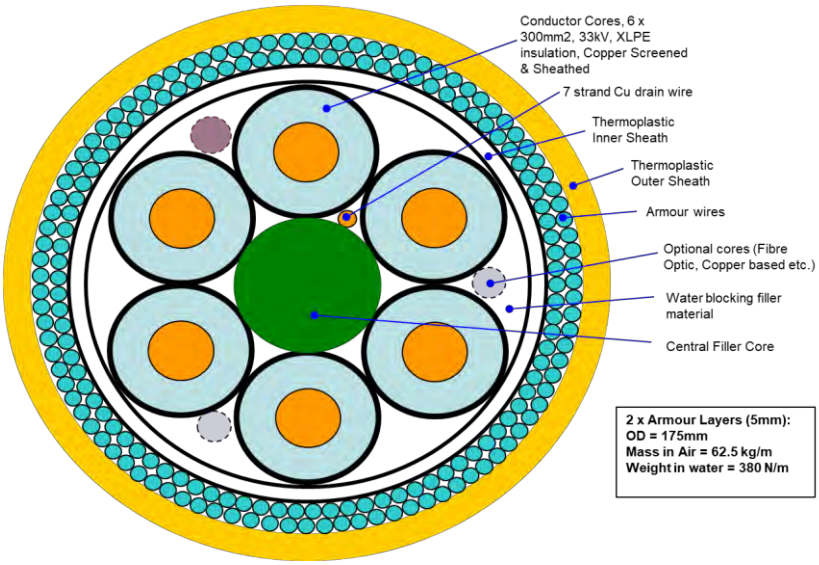


Figure 2 – Final Wave Hub Cable Design

The 6 core export cable terminates in a purpose built hub. Each of the 2 three phase circuits within the export cable connects to 2 separate ‘cable tails’ within the hub.

Site Overview/ Location Selection

To encourage the development of wave power technology in the South West region, the north Cornwall coast was selected as the most appropriate area for the Wave Hub site. Critical constraints included the wave climate, grid connection and sea areas excluded by a variety of other established users.

It was established that some devices needed to be situated between 10 and 25 km offshore, in a water depth around 50 to 60m and other devices worked better closer inshore but preliminary discussions with wave device developers identified a more pressing need for a deep-water site.

The initial site selection also considered environmental and stakeholder constraints on sea usage. Preliminary consultations took place with fishermen, Ministry of Defence, Maritime and Coastguard Agency and the Crown Estate. The position of shipping lanes and existing subsea cable routes were additional considerations.

Four possible options were initially identified as suitable for connection to the land based National Grid system. Hayle, situated near St Ives on the north Cornwall coast, was chosen as the most suitable location as it was close to an area of substantial wave activity and had suitable infrastructure for connection to the National Grid.

Site Overview/ Environmental Considerations

The environmental impact assessment involved an analysis of potential impacts on all environmental receptors. This included the effects of laying the cable and the impacts of the likely arrays of wave energy devices on marine ecology, fisheries and navigation.

Infrastructure and Installation Funding Sources

The Wave Hub infrastructure and cost of installation was funded by several organisations including the European Union, the UK Government Department of Energy and Climate Change, the UK Government Department for Business Innovation and Skills and SWRDA. The cost of design, development and construction was in the region of 35 million GBP.

Initial Installation Management

In 2008, SWRDA selected J P Kenny as its engineering and management contractor for the Wave Hub project. J P Kenny had almost 30 years of subsea engineering and project management experience and a track record for controlling costs and managing risk. JP Kenny managed all aspects of the design, procurement and installation of Wave Hub and the onshore works on SWRDA’s behalf.

Design and manufacture of the cable was commissioned in 2009 due to the long lead time, with construction of the onshore and offshore infrastructure starting in May 2010. The substation and onshore electrical works at Hayle were started first, followed by the onshore horizontal directional drilling to construct a duct under the coastal sand dunes. The 25km of subsea cable and hub were then installed from the shore to the leased offshore deployment site. In order to provide protection and stabilisation, 80,000 tonnes of rocks were placed on the cables and hub. The facility was then commissioned and the cable was finally energized in November 2010.

Figure 3 – Wave Hub Construction

Economic Case

An independent economic impact assessment commissioned by SWRDA concluded that Wave Hub could create 1,800 jobs and £560 million in the UK economy over 25 years. Almost 1,000 of these jobs and £332 million could be generated in South West England.

Ownership

The Wave Hub infrastructure is owned by Cornwall Council, a local government organisation in the UK. Cornwall Council is also the shareholder of Wave Hub Limited, the seabed leaseholder and operating company for Wave Hub.

2. Wave Hub Operation and Maintenance

Operations and Maintenance Overview (offshore/ onshore operations, maintenance and monitoring)

Wave Hub maintenance procedures can be categorized into planned and unplanned activities. More details relating to Wave Hub planned and unplanned activities are provided below.

Site Operations Procedures and Costings

Onsite operations relating to device deployment, maintenance or recovery are carried out by the wave energy developer or their appointed contractors. WHL's Marine Operations Manager monitors activities onsite using a suite of tools to ensure all activities are carried out in a safe manner. Method statements relating to developer operations are provided to Wave Hub for review. All costs relating to developer operations are covered by the developer. Wave Hub Limited does not operate vessels and Wave Hub Limited staff do not carry out offshore operations. Onshore electrical operations relating to device connection are carried out by the Wave Hub Electrical Engineer or Wave Hub appointed electrical contractors.

The costs associated with the ongoing management of the Wave Hub test site are as follow;

AIS Monitoring System

The Automatic Identification System (AIS) is a mandatory requirement for the Wave Hub test site. The Wave Hub position is automatically reported using an AIS system and Wave Hub uses AIS to track the position of vessels in the vicinity of the site. (indicative cost = $40k annually)

Wave Monitoring – Wave Rider Buoy

Wave Hub Limited uses a Wave Rider Buoy to constantly measure the wave resource at the site. The buoy is not owned by Wave Hub Limited but a contract is in place with a specialist company to ensure the buoy remains operational and live data is provided throughout the year. (indicative cost = $50k annually)

Site Maintenance Procedures and Approximate Costs

Facility Costs – Planned Activities

In order to keep the facility in good working order and/or to comply with the requirements of stakeholders, a number of planned maintenance activities are carried out. The planned activities are detailed below;

Facility Costs

Wave Hub Facility costs can be categorised into the following elements;

- Adminstration Costs

    - Including Office/ Cleaning/ IT/ Comms/ Security etc

- Legal and Insurance Costs
    - Including Office and offshore site insurance. Legal Services

- Offshore Operations
    - Including AIS provision/ Navigational Buoy Maintenance/ Infrastructure surveys

- Onshore Operations (Electrical)
    - Including Electrical technical support/ Storage of large electrical equipment/ Substation rates/ Electricity charges

Cable Survey

A cable survey is carried out at least every 5 years or after a major 1 in 100 year storm. A survey is also carried out after a major Wave Hub system change or when any significant concern arises. (indicative cost = $200k)

Traffic Surveys and Fishing Behaviour Monitoring Report

28 day surveys to be commissioned at least every 5 years or when any significant concern arises. (indicative cost = $7k)

Cable Risk Assessment Review

Annually, after major system changes or when new developer connecting. (indicative cost $7k)

Electrical System Tests

A number of Electrical System tests are carried out annually. They include the following tests on the export cable;

- Conductor Resistance
- Insulation Resistance
- HV AC (VLF) Withstand
- Time Domain Reflectometry (TDR)
- Tan Delta testing
- Fibre Optic testing using Optical Time Domain Reflectometry (OTDR)

(Indicative cost $15k)

Wave Hub has spare export cable stored locally. This cable is visually inspected annually.

Fishing Chart Updates

Any updates are carried out annually.

Maintenance of Aids to Navigation

An annual pre-service inspection and subsequent annual service is carried out on all marker buoys and other aids to navigation. Mooring chains have a finite lifetime and are replaced when deemed necessary.

Port Services and Equipment Storage

Spare cable and connector spares are stored at the nearby port of Falmouth. There is a charge for use of the storage facility.

Facility Costs - Unplanned Maintenance

A number of events have occurred that have required unplanned maintenance to be arranged. These have included;

- Faults in Navigational markings
- Remedial cable protection measures

3. Wave Hub Developer Selection

Due Diligence

Before Wave Hub Limited seeks Board approval to allow a developer to secure a reservation at the site, a third party consultancy is instructed to conduct financial and technical due diligence of the wave energy developer and their technology. The due diligence exercise covers many different aspects of the proposed deployment including the experience of the developer's project team and the financial model to support deployment/ operations but the main focus is on safety related aspects of the design and the ability of the moorings to remain effective during storm conditions. Before the developer can access the Wave Hub site, an independent assessment of the moorings and attachment points needs to be conducted to verify that the moorings are fit for purpose.

Marine Licence Application

Wave Hub Limited has a blanket Section 36 electricity consent covering the Wave Hub site but each developer must secure their own Marine Licence from the UK Marine Management Organisation (MMO) before deploying a device. Any fees relating to the marine licence application are paid directly by the wave energy developer.

Grid Stability Studies

In order to ensure the deployment and grid connection of wave energy technology does not interfere with the stability of the local grid, a study is carried out by an independent electrical consultancy. A computer model of the wave energy converter electrical generation system is combined with a standard model of the Wave Hub

cable and substation to analyse the electrical characteristics of the combined system. The modelled combined electrical characteristics have to fall within parameters defined by the local grid operator in order for the device to be permitted to connect to the Wave Hub cables.

The grid stability study is conducted up to a year before the device deployment and the costs are covered by the wave energy developer.

Independent 3rd Party Verification

An independent assessment of safety critical parameters must be carried out to verify that the wave energy device and its moorings are fit for purpose. The assessment must be carried out by a competent independent third party organisation that has not been involved in the design process.
The independent 3rd party verification of specific critical device parameters is conducted up to a year before the device deployment and the costs are covered by the wave energy developer.

Decommissioning Programme Requirements

The terms of the Wave Hub headlease include several mandatory requirements. A decommissioning programme relating to the Wave Hub installed infrastructure (cables/hub etc) is a requirement of the headlease and this formed part of the original Section 36 consent application. In addition, each developer is required to provide a decommissioning programme relating to their own installed infrastructure. An estimate of the cost to decommission the wave energy developer's infrastructure is agreed before deployment and a bond or bank guarantee is secured from the developer to cover the cost of the decommissioning.

Berthing Agreement Negotiations

The Berthing Agreement is the main legal document that defines the terms, conditions and commercial arrangements between Wave Hub Limited and the wave energy developer. A standard agreement is used as the starting point for negotiations but this evolves with specific requirements negotiated between the parties. A developer is not permitted to enter the Wave Hub site until a Berthing Agreement has been signed.

The Berthing Agreement key terms include;

- Operational Term
- Conditions Precedent
- Deployment Programme
- Indemnities
- Berthing Fee
- Limits to Liability
- Maintenance
- Electrical Connection Terms
- Modifications
- Insurance Requirements
- Confidentialty

- Force Majeure
- Termination
- Decommissioning
- Dispute Resolution
- Intellectual Property

4. Device Test Program Requirements and Costings

Electrical Connection Procedures

Onshore electrical operations relating to device connection are carried out by the Wave Hub Electrical Engineer or Wave Hub appointed electrical contractors. The table below lists the typical operations carried out by Wave Hub electrical engineering staff or contractors to support installation

Electrical Operation	Scheduled	Notes
SCADA Deployment support	During Installation	Ensure SCADA functionality during connection
HV Switching support	During Installation	Authorise person conducting HV switching
HV Support Testing	During Installation	Test of power cables during/after installation
OTDR testing	During Installation	Test of fibre optic comms
Post install test of trips/switching/ restarts	1 month after installation	Authorised Person conducting tests

Power Import Costs and Commercial Arrangements

The cost of power imported to a wave energy device is charged to the developer using the power at the rate agreed with the Wave Hub power provider. SCADA compatible meters installed on the developer's device and at the Wave Hub substation are used to calculate the power imported to a device. Commercial arrangements relating to charges for power are detailed in agreements signed before a developer deploys at the Wave Hub site.

Commercial Costs Including PPA/ Legal Support

Wave Hub Limited conducted a competitive tender process for the provision of the Wave Hub Power Purchase Agreement (PPA). The PPA provides for purchase of any generated power at a rate close to the standard UK market rate. Any revenue generated by the sale of power is passed through to the developer after subtracting a small management fee charged by Wave Hub Limited. Wave Hub legal services are provided by a contracted legal services company. As well as providing general legal

support, the legal firm provides support during the negotiation of Berthing Agreements and other legal contracts with wave energy developers.

Insurance – Site Insurance/ Device Insurance/ Vessel Insurance/ CBI

The UK seabed to a distance of 12 nautical miles from the shore is largely owned by the Crown and managed on its behalf by the Crown Estate Commissioners as is much of the foreshore. The Wave Hub site is the subject of a lease from the Crown Estate and the terms of that lease detail certain mandatory requirements including third party liability insurance.

The following insurance requirements apply to Wave Hub Limited and wave energy developers deploying at the site;

- Wave Hub – Third Party Liability Insurance for the site
- Wave Hub – Asset insurance for the site
- Developer – Third Party Liability Insurance
- Developer – Insurance for works, Any Additional Works, all vessels used to access the site, equipment to be placed within the berth/ deployment site. All risks physical damage policy covering reinstatement value of developers works (ie device), all additional works and developer's ancillary equipment.

Note: - The full reinstatement value can be appropriated to Estimated Maximum Loss (EML) in line with normal insurance practices.

Emergency Response Procedures

Operational Management System

Wave Hub Limited has established the Wave Hub site as a safe, efficient facility that meets the needs of offshore renewable energy device developers. In order to achieve and maintain this, Wave Hub Limited has developed an Operational Management System (OMS) to ensure the proper management of the facilities and activities.
The OMS applies to the management of all activities within the Wave Hub marine and onshore areas and with the associated infrastructure. This also includes the management of activities undertaken by developers when on site and contractors and visitors, who may, from time to time, visit the facilities.

Management System Standards

The OMS is designed to satisfy the requirements of:

- OHSAS 18001:2007 - Occupational Health and Safety Management Systems
- ISO 9001:2008 – Quality Management Systems
- ISO 14001:2004 – Environmental Management Systems

- Maritime and Coastguard Agency Marine Guidance Notice 371 (M+F) Annexes 4 and 5

The OMS is a detailed management system comprising policies, procedures, plans and an OMS manual. The basic structure of the OMS is shown in Figure 4.

Wave Hub Operational Management System – Structure

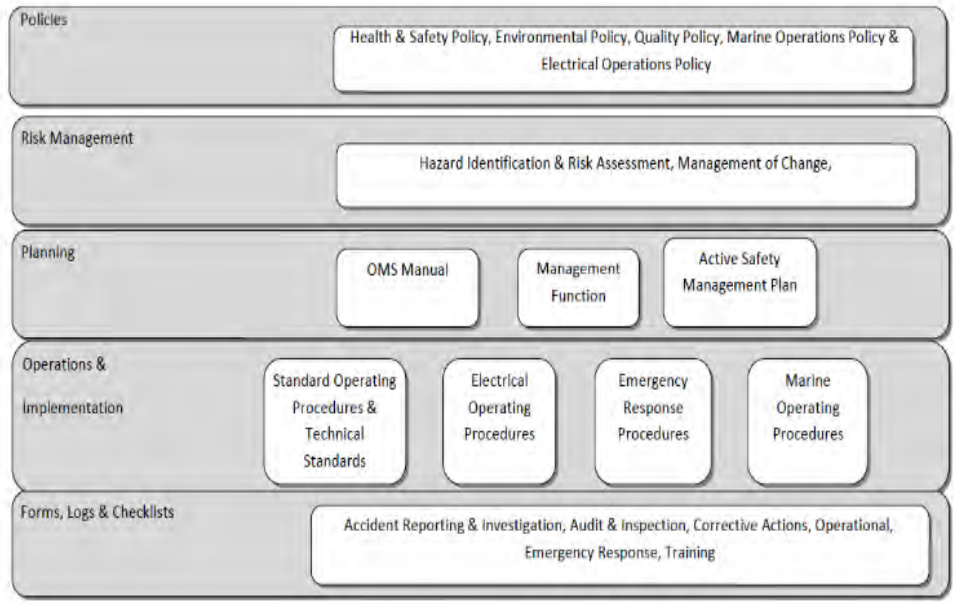


Figure 4 – Wave Hub Operational Management System (OMS)

Emergency Response Coordination Plan

Wave Hub Limited has a fully developed Emergency Response Coordination Plan (ERCoP) which has been approved by the UK Maritime and Coastguard Agency.

The ERCoP covers the following key aspects of Emergency Response;

- Key Emergency Contacts
- Roles and Responsibilities
- The Wave Hub Site (includes exact position of marker buoys/ infrastructure)
- Emergency Shutdown procedures
- Marine Operations and Online Resources
- Emergency Response Coordination

Active Safety Management System

Wave Hub has developed an Active Safety Management System (ASMS). The ASMS describes the measures taken to ensure the risks to other marine users posed by the offshore elements of the Wave Hub test facility are as low as reasonably practicable. The ASMS is regularly reviewed by Wave Hub Limited and amended as the number of device deployments increase.

Permit to Operate

Wave Hub Marine Safety Manual (including Permit to Operate)

The Marine Safety Management System utilises a set of minimum requirements named Marine Operation Requirements (MORs) for setting out how operations at the Wave Hub Offshore Site are to be managed safely. These essentially set out the legal framework, minimum standards and levels of co-operation required to ensure a safe site for all users. The Permit to Operate system ensures that appropriate MORs and standards are applied to all contractor or developer operations on site.

The absolute legal duties that all operators (developers and contractors) must always comply with are those identified by the legal framework (particularly the UK Health and Safety at Work Act 1974, the Management of Health and Safety at Work Regulations 1999, and the Merchant Shipping Act 1995). These notably include requirements to:

- Competently risk assess all activities to identify and mitigate or control hazards as far as is reasonably practicable
- Use only well trained and competent personnel and fit for purpose equipment
- Preparation of and training in emergency response plans
- These more generic work place duties imposed and enforced through UK legislation are added to by Wave Hub site and activity specific safety requirements enforced through legal agreements or contracts with all permitted Operators.

There are a number of forms and management systems that support the marine safety system in both the permitting and operational phases. Where operational Wave Hub forms are proposed, a contractor or developer equivalent may be accepted but in all cases Wave Hub Limited's requirements should be the minimum.

Notice to Mariners

Notices to Mariners (NTMs) advise mariners of important matters affecting navigational safety. Current active NTMs exist for the current Wave Hub site and installed infrastructure. New NTMs are issued when a wave energy developer is installing infrastructure or carrying out other work on the Wave Hub site

Deployment Costs/ HV Tech Support/ Marine Support/ Offshore Operations and Offshore Electrical Support Costs

Activities scheduled to support a wave energy developer's deployment at the Wave Hub site are detailed in the table below along with the approximate timing of the event in relation to the device deployment date. The indicative overall cost for these activities is $70k.

Activity	Scheduled	Notes
Cable and Connector Study/Due Diligence	12 months before installation	Assess cable lifting stresses etc
Cable Installation methodology	6 months before installation	Assess cable installation methodology
Equipment Audit	Just prior to installation	
Offshore Representative	During Installation	
Electrical FEED study	12 months before installation	Checking electrical interfaces
Detailed electrical design review	4 months before installation	Detailed electrical interface check
SCADA Interface test	3 months before	Simulate SCADA interface using laptop
SCADA Deployment support	During Installation	Ensure SCADA functionality during connection
HV Switching support	During Installation	Authorise person conducting HV switching
HV Support Testing	During Installation	Test of power cables during/after installation
OTDR testing	During Installation	Test of fibre optic comms
Post install test of trips/switching/ restarts	1 month after installation	Authorised Person conducting tests

5. Wave Hub Lessons Learned

Test Site Instrumentation and Controls

Electrical Instrumentation and SCADA System

Some electrical systems within the Wave Hub substation have local displays to show parameters such as voltage and frequency but the overall electrical system is generally monitored and controlled using the SCADA system. Figure 5 below is a schematic diagram of the Wave Hub SCADA and communications system.

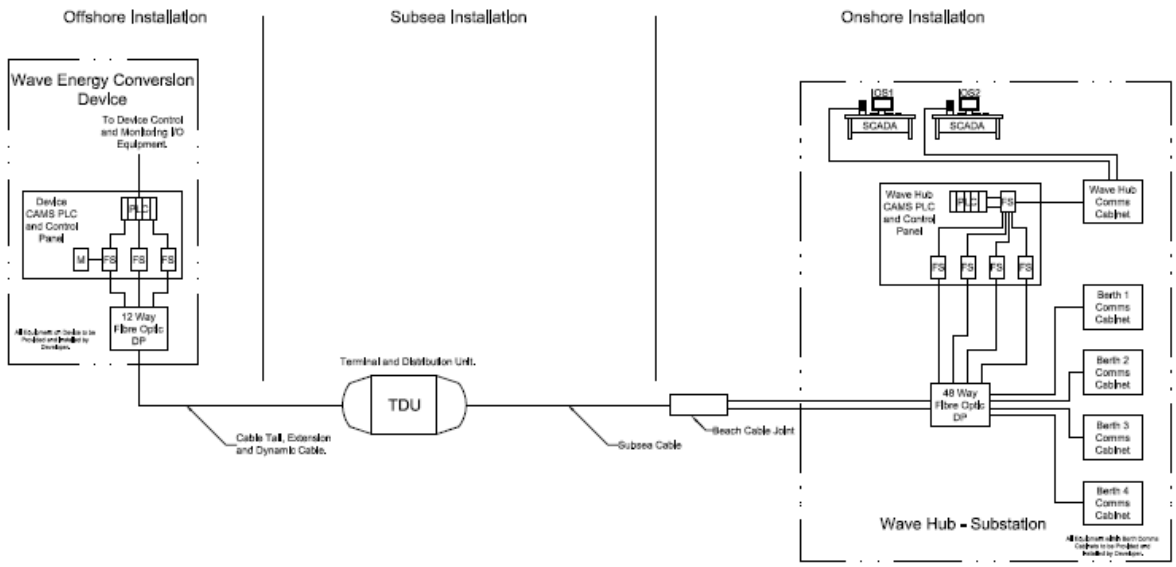


Figure 5 – Wave Hub SCADA and Communications

The SCADA system can be monitored and controlled from PCs situated in the Wave Hub substation. Alternatively, the SCADA system can be accessed and controlled using a remote laptop connected to the internet.

Wave Resource Instrumentation.

Wave Hub Limited has a Wave Rider buoy deployed on the site which, instead of owning Wave Hub Limited pays an annual fee for the data and is not therefore involved with the deployment or service of the buoy.

Business Models

The following provides a d escription of the business model underpinning the Wave Hub operation including berth charging arrangements, reservation fee options, tariff support, ongoing liabilities, de-energisation events, IPR, FM, production rent, PPAs, management fees, R&D projects and involvement in publically funded programmes.

Berth Charging Arrangements

The berthing fee has been set at a level that will cover Wave Hub Limited's operating costs if 3 of the 4 berths are occupied, allowing for a reserve to be built up as a contingency fund.

Reservation Fee Options

Wave Hub Limited has historically charged a reservation fee to allow a developer to reserve a berth at the Wave Hub site. The reservation had a term of 18 months with the option to extend by 6 months if Wave Hub approved an extension.

Tariff Support

The UK has a tariff support mechanism in place for wave energy developers. This was in the form of a Renewable Obligation Certificate (ROC) scheme which provided

a revenue subsidy for each Mega Watt Hour (MW Hr) generated and was a contract for 20 years. This was closed to all new generating capacity on 31 March 2017. The UK government has replaced the ROC scheme with a new Contracts for Difference (CFD) mechanism which provides a similar level of revenue subsidy for each MW Hr generated but the contract term is 15 years.

Ongoing Liabilities

Ongoing liabilities are defined in the Berthing Agreement between Wave Hub Limited and the developer. The main ongoing liability relates to electricity trading and requires the developer to provide information to support the electricity trading transactions between Wave Hub Limited, the Wave Hub power provider, the wave energy developer and the generated power offtaker (Power Purchase agreement provider)

De-energization Events

Terms relating to de-energization events are defined in the Berthing Agreement. These terms describe the circumstances that give Wave Hub Limited the right to switch off power to a wave energy developer's berth, the associated notification arrangements and any indemnities associated with the de-energisation event.

Intellectual Property Rights (IPR)

The way that IPR associated with Wave Hub projects is handled is defined in the Berthing Agreement. In summary, the following principles apply;

- Neither party shall acquire an interest in the IPR of the other party.
- Any IPR developed in the Wave Energy device will be the property of the wave energy developer.
- Any IPR created by WHL shall be owned by WHL.

Any other specific requirements related to IPR will be negotiated and agreed before the projects commences.

Force Majeure (FM)

Standard FM terms are included in the Berthing Agreement. These terms include notification requirements and the procedure to adopt if damage caused by an FM event exceeds pre-defined monetary levels or the damage will exceed a pre-defined length of time to remedy.

Production Rent

In addition to the standard Berthing Fee, Wave Hub Limited has introduced an additional Production Rent to be paid by a developer when a project starts to export power to the grid. The production rent is defined as a certain monetary payment for each MW.Hr of power produced. This additional income is used to pay for mitigation measures that can be called upon if a major repair of the facility is required.

Power Purchase Agreement (PPA)

WHL managed a competitive tender process for the selection of a PPA provider. A preferred PPA provider has been identified and negotiations are ongoing to prepare a

mutually agreeable contract. The PPA provider will purchase the power generated by developers deployed at the Wave Hub site. The income generated from the purchase of generated power will be passed through to the wave energy developers after Wave Hub Limited has taken a small management fee to cover costs of recording power data and preparing generation reports for the PPA provider.

R&D projects and involvement in publicly funded programs.

The Wave Hub Limited business entity recently restructured to become a research organisation. Wave Hub Limited also has a wholly owned commercial arm to conduct business on a purely commercial basis. As a research organisation, Wave Hub Limited actively seeks opportunities to either lead or become a partner in research projects that are aligned with its core business objectives and is able to bid for public funding to support research activity.