



CALIFORNIA
ENERGY
COMMISSION

NEW GEOTHERMAL SITE IDENTIFICATION AND QUALIFICATION

CONSULTANT REPORT

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Public Interest Energy Research Program

Prepared By:

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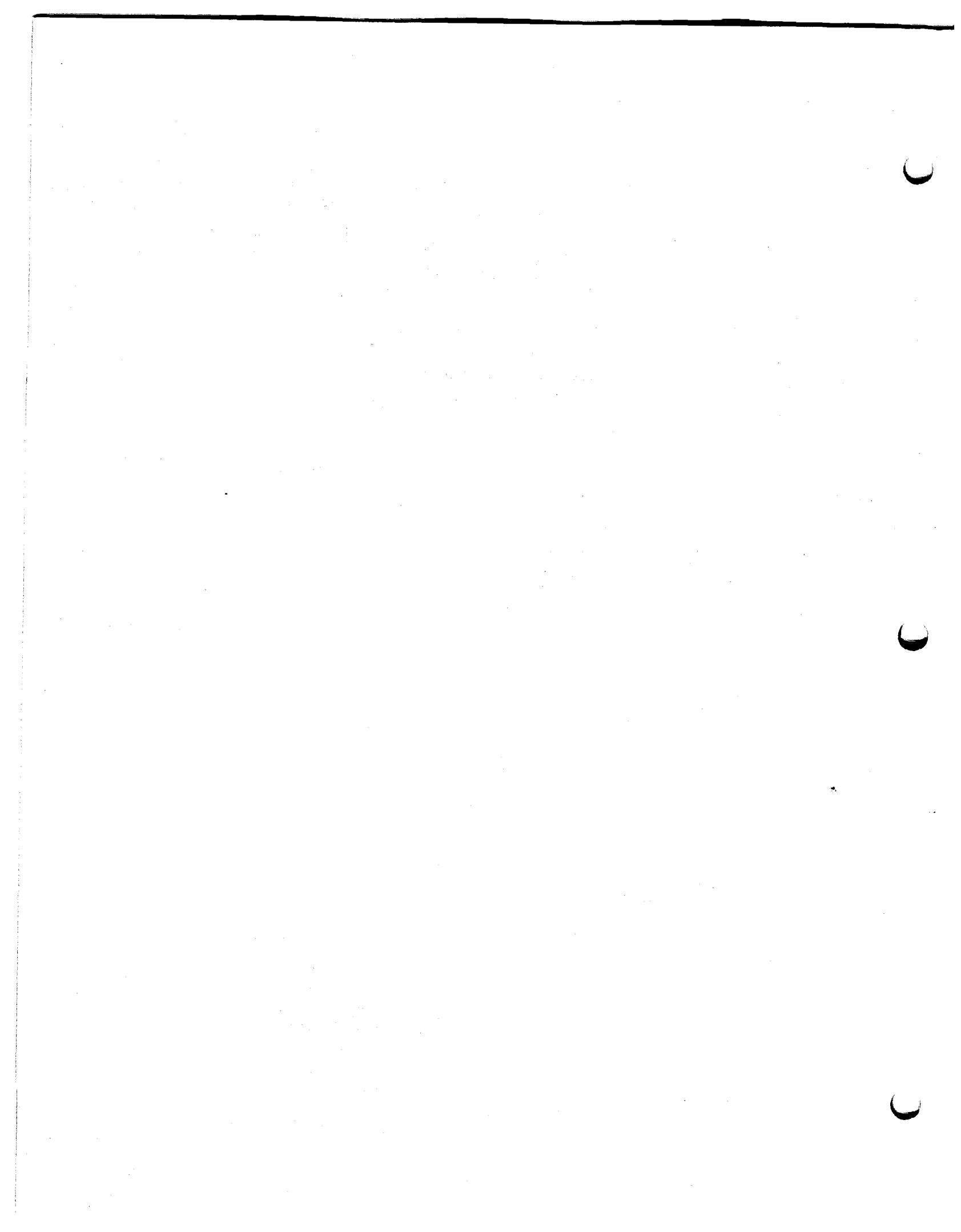
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Preface

The Public Interest Energy Research (PIER) Program supports public interest energy research and development that will help improve the quality of life in California by bringing environmentally safe, affordable, and reliable energy services and products to the marketplace.

The PIER Program, managed by the California Energy Commission (the Commission, Energy Commission), annually awards up to \$62 million to conduct the most promising public interest energy research by partnering with Research, Development, and Demonstration (RD&D) organizations, including individuals, businesses, utilities, and public or private research institutions.

PIER funding efforts are focused on the following six RD&D program areas:

- Residential and non-residential buildings end-use energy efficiency
- Industrial, agricultural, and water end-use energy efficiency
- Renewable energy technologies
- Environmentally preferred advanced generation
- Energy-related environmental research
- Strategic energy research

What follows is the final report for the New Geothermal Site Identification and Qualification Project, part of the Hetch Hetchy/SFPUC Programmatic Renewable Energy Project.

GeothermEx, Inc., has prepared this report under contract to the City and County of San Francisco (the City), San Francisco Public Utilities Commission, Hetch Hetchy Water and Power Division, pursuant to Agreement Number CS-706.D between GeothermEx and the City. The Energy Commission has funded the work pursuant to the PIER Program Contract Number 500-01-042 between the City and the Energy Commission.

For more information on the PIER Program, please visit the Commission's web site <http://www.energy.ca.gov/pier/reports.html> or contact the Commission Publication Unit at (916) 654-5200.

Table of Contents

Section	Page
Executive Summary.....	1
Abstract.....	3
1 Introduction.....	5
1.1 Background and Overview	5
1.2 Project Objectives	5
1.2.1 Introduction to Project 1.3	5
1.2.2 Project Goals.....	5
1.2.3 Project Objectives	5
1.3 Report Organization.....	6
2 Project Approach	7
2.1 Prior Research.....	7
2.2 Baseline Conditions	7
2.3 Project Work Plans	8
2.4 Resource Sites and Geographic Areas	10
2.5 Task List.....	11
2.6 PIER Geothermal Database (MS Access©).....	11
2.6.1 General description and organization of the data	11
2.6.2 Instructions for use.....	12
3 Project Outcomes.....	13
3.1 Resource Data	13
3.1.1 Methodology	13
3.1.2 Results.....	13
3.2 Generating Potential.....	14
3.2.1 Methodology	14
3.2.2 Results.....	15
3.3 Statistical Correlations For Drilling Costs.....	16
3.3.1 Drilling costs versus depth.....	16
3.3.2 Well productivity versus temperature.....	18
3.4 Exploration and Resource Confirmation Costs.....	18
3.4.1 Methodology	18
3.4.2 Results.....	19
3.5 Development Costs.....	20
3.5.1 Methodology	20
3.5.2 Results.....	21

4	Conclusions and Recommendations	25
4.1	Conclusions.....	25
4.2	Commercialization Potential.....	25
4.3	Recommendations.....	26
4.4	Benefits to California.....	26
5	Endnotes.....	27
6	References.....	29
6.1	General references	29
6.2	Project-specific references	31
7	Glossary	41
7.1	Database data abbreviations and definitions.....	41

List of Figures

Figure

- Figure 1. Locations of geothermal resource areas
- Figure 2. Startup window for PIER Geothermal Database in MS Access[©]
- Figure 3. "PROJECTS" window (example) from the PIER Geothermal Database in MS Access[©]
- Figure 4. "REPORTS AND DOCUMENTS" window from the PIER Geothermal Database in MS Access[©]
- Figure 5. Local site area map (example)
- Figure 6. Local site downhole temperature graph (example)
- Figure 7. Probabilistic calculation of geothermal energy reserves (example)
- Figure 8. Correlation of drilling cost vs. well depth
- Figure 9. Correlation of well productivity vs. production-zone temperature
- Figure 10. Producer Price Index for Drilling Oil and Gas Wells (Onshore Drilling)

List of Tables

Table

- Table 1. Projects List**
- Table 2. Projects by Area**
- Table 3. Estimated Generation Capacities**
- Table 4. Comments to Estimated Generation Capacities**
- Table 5. Estimated Generation Capacities – by Exploration-Development Category**
- Table 6a. Data for Statistical Correlation of Drilling Costs vs. Depth**
- Table 6b. Data for Statistical Correlation of Well Productivity vs. Temperature**
- Table 7. Details of Exploration Programs**
- Table 8. Exploration, Confirmation and Site Development Cost Estimates – Summary with Cost Totals**
- Table 9. Comments on Confirmation Cost Estimates**
- Table 10. Comments on Site Development Cost Estimates**
- Table 11. Confirmation and Site Development Cost Estimates – Drilling Details**
- Table 12. Exploration, Confirmation and Site Development Cost Estimates - per kW**
- Table 13. Transmission Line Cost Estimates**
- Table 14. Site Development, Transmission Line and Total Cost Estimates – Totals and per kW**
- Table 15. Total and Incremental Generation Capacities for Selected Areas**

List of Appendices

- Appendix I. Database Figure List by Project**
- Appendix II. Project Data Summary Report (example)**
- Appendix III. Methodology of Estimating Generation Capacities (Geothermal Energy Reserves), including**
 - Table III-1: Physical characteristics of producing geothermal fields**
- Appendix IV. Methodology of Estimating Exploration and Confirmation Costs, including**
 - Table IV-1: Unit costs and other factors for exploration and confirmation**
 - Table IV-2: Totals of full-diameter, production and injection wells at geothermal fields in California and Nevada**
- Appendix V. Exploration, Confirmation and Development Costs – Detail by Project (example)**
- Appendix VI. Methodology of Estimating Development Cost**
 - Table VI-1: Summary of estimated costs of site substations, transmission lines and collector/line substations and taps for geothermal projects in Nevada (from Woodford, 2003)**
- Appendix VII. How to Use the Database / Technical Information**

Attachment

PIER Geothermal Database (MS Access©)

...CD in pocket

Executive Summary

The Hetch Hetchy Water and Power Division of the San Francisco Public Utilities Commission (Hetch Hetchy/SFPUC) has retained GeothermEx, Inc., to provide a portfolio of well-characterized geothermal resources within California and western Nevada that could supply additional power to the California market. This project (Project 1.3) is the geothermal component of the Hetch Hetchy/SFPUC Programmatic Renewable Energy Project, a set of PIER-funded studies to evaluate the potential of a variety of renewable energy sources and options for energy transmission.

The objective of Project 1.3 is to quantify each geothermal resource in terms of its minimum and most-likely generation capacity, estimated costs of exploration and confirmation, and estimated total development costs and unit development costs (\$/kW installed), including transmission-line costs as determined by other Hetch Hetchy/SFPUC project participants. Project 1.3 has relied on information in the public domain and such other information as private developers have agreed to contribute. A principal outcome of the work has been the creation of a database (referred to herein as the PIER Geothermal Database) in MS Access®, included on a computer CD accompanying this study. The PIER Geothermal Database includes information about the resource characteristics of 155 separate geothermal projects at 83 resource areas. It also includes embedded documents describing the methodology of the study and tables summarizing results.

To establish a quick way of ranking geothermal projects at varying stages of maturity, this study has defined four development categories as follows:

- A – Existing power plant operating
- B – One or more wells tested with a potential greater than or equal to (\geq) 1 MW, but no power plant in operation
- C – Minimum 212°F logged downhole, but no well tests at \geq 1 MW
- D – Other exploration data and information available (\geq 212°F not proven)

The geothermal projects have also been classified geographically into four areas to facilitate consideration of options for transmission of power to the California market:

- Area 1 – Greater Reno, Nevada (including nearby California sites at Honey Lake)
- Area 2 – Nevada sites with direct access to the California grid (the Dixie Corridor)
- Area 3 – Other Nevada locations
- Area 4 – All California locations (excluding Honey Lake)

The results of this study are presented by grouping fields according to these areas. Results are also summarized by state (that is, all California fields and all Nevada fields). Minimum and most-likely estimates of electrical generation capacity have been made for 58 resource areas that have sufficient information in the public domain. The estimates are based on a methodology that has been used by GeothermEx over the past two decades. This methodology is a volumetric reserve estimation approach introduced by the U. S. Geological Survey, modified to account for uncertainties in some input parameters by using a probabilistic basis (Monte Carlo simulation).

Based on the reserve estimates of this study, the electrical generation capacity available to the California market from geothermal sources in California and Nevada has a minimum value of about 4,700 gross MW and a most-likely value of about 6,200 gross MW. After allowances for

generation capacity already on line, the incremental generation capacity available from geothermal sources in both states has a minimum value of about 2,800 gross MW and a most-likely value of about 4,300 gross MW. These estimates may be conservative to the extent that they do not take into account resources about which little or no public-domain information is available.

The generation capacity available from fields within California alone has a minimum value of about 3,700 gross MW and a most- likely value of about 4,700 gross MW. The incremental generation capacity available from fields within California alone has a minimum value of about 2,000 gross MW and a most-likely value of about 3,000 gross MW. Geothermal sites in California alone account for about 70% of the combined incremental generation capacity available from both states. Within California, 90% of the incremental generation capacity identified in this study comes from three areas: the Imperial Valley, The Geysers, and Medicine Lake. The Imperial Valley alone accounts for about 65% of the incremental capacity available in California.

For the geothermal sites in both states, the capital cost of incremental generation capacity averaged about \$3,100 per kW installed. For California sites alone, the average capital cost of incremental generation capacity was somewhat lower: about \$2,950 per kW installed. These cost estimates include the following components:

- Exploration (up to the siting of the first deep, commercial-diameter hole);
- Confirmation drilling (up to achieving 25% of required capacity at the wellhead);
- Development drilling (up to achieving 105% of required capacity at the wellhead);
- Construction of the power plant (including ancillary site facilities); and
- Transmission-line costs.

The capital cost estimates are only approximate, because each developer would bring its own experience, bias, and opportunities to the development process. Nonetheless, the overall costs per project estimated in this study are believed to be reasonable.

The capital cost for specific geothermal projects ranged from about \$1,000/kW (for a small expansion at an existing project) to values in excess of \$6,000/kW (for deep, low-temperature resources at remote locations). Of the 4,300 gross MW of most-likely incremental capacity available from both California and Nevada, about 2,500 gross MW is available at a capital cost less than the average of \$3,100/kW. Considering just fields within California, about 2,000 gross MW of incremental generating capacity is available at a capital cost below the average of \$2,950/kW.

For the purposes of this study, a capital cost of \$2,400/kW or less is considered competitive with other renewable resources, both for the California/Nevada study area and for the state of California alone. The amount of incremental geothermal capacity available at or below \$2,400/kW is about 1,700 gross MW for the California/Nevada study area, and the same amount (after rounding to the nearest increment of 50 gross MW) for the state of California alone. This amount of geothermal capacity available represents a significant opportunity for commercial development to meet the needs of the California electricity market. Resources with higher estimated costs may also be attractive, depending on market conditions and the mechanisms for implementing California's renewable portfolio standard.

Abstract

This study identifies remaining undeveloped geothermal resources in California and western Nevada, and it estimates the development costs of each. It has relied on public-domain information and such additional data as geothermal developers have chosen to make available. Reserve estimation has been performed by volumetric analysis with a probabilistic approach to uncertain input parameters. Incremental geothermal reserves in the California/Nevada study area have a minimum value of 2,800 gross MW and a most-likely value of 4,300 gross MW. For the state of California alone, these values are 2,000 and 3,000 gross MW, respectively. These estimates may be conservative to the extent that they do not take into account resources about which little or no public-domain information is available. The average capital cost of incremental generation capacity is estimated to average \$3,100/kW for the California/Nevada study area, and \$2,950/kW for the state of California alone. These cost estimates include exploration, confirmation drilling, development drilling, plant construction, and transmission-line costs. For the purposes of this study, a capital cost of \$2,400/kW is considered competitive with other renewable resources. The amount of incremental geothermal capacity available at or below \$2,400/kW is about 1,700 gross MW for the California/Nevada study area, and the same amount (within 50-MW rounding) for the state of California alone. The capital cost estimates are only approximate, because each developer would bring its own experience, bias, and opportunities to the development process. Nonetheless, the overall costs per project estimated in this study are believed to be reasonable.

1 Introduction

1.1 Background and Overview

There are several obstacles to new geothermal development in California and Nevada. One of the most significant is a perception that the largest and most accessible resources (such as The Geysers, Salton Sea, and Coso) have already been developed. The majority of known resource sites that remain in California and Nevada either have smaller capacities or present special economic challenges. These remaining projects have been historically of less interest to developers due to associated high up-front costs.

1.2 Project Objectives

1.2.1 Introduction to Project 1.3

The Hetch Hetchy Water and Power Division of the San Francisco Public Utilities Commission (Hetch Hetchy/SFPUC) has retained GeothermEx, Inc., to provide a portfolio of well-characterized geothermal resources within California and western Nevada that could supply additional power to the California market. Project 1.3 is the geothermal component of the Hetch Hetchy/SFPUC Programmatic Renewable Energy Project, a set of PIER-funded projects that are gathering data and evaluating the potential of a variety of renewable energy sources (geothermal, wind, solar, biomass, etc.) and options for energy transmission in California and parts of Nevada that have the potential to supply the California market. A companion to Project 1.3 is Project 2.1 (Existing Geothermal Facility Improvements), which is scheduled for completion in November 2004.

1.2.2 Project Goals

The goal of Project 1.3 has been to compile the most accurate information available in the public domain on remaining undeveloped geothermal resources in California and western Nevada. The intention is to make this information easily accessible to entities interested in developing or purchasing geothermal power, including municipal power agencies and investor-owned utilities. In combination with other studies in the Hetchy/SFPUC Programmatic Renewable Energy Project, Project 1.3 is intended to facilitate aggregation of undeveloped renewable resources so as to achieve greater economies of scale. It is hoped that this information will help make possible a significant new phase of geothermal resource development in the United States and an increase in the number of entities participating in geothermal projects.

It is anticipated that the portfolio of geothermal projects described in this report will be evaluated with other potential energy sources in the same geographic areas, to seek options for the collocation of power generation facilities with shared transmission facilities and coordinated base-load and peaking power generation. The result will be an increase in renewable generation and further diversification of the power mix.

1.2.3 Project Objectives

The objective of Project 1.3 has been to quantify the geothermal resources in California and western Nevada in terms of minimum and most-likely generation capacities, estimated costs of exploration and confirmation, and estimated total development costs and unit development costs (\$/kW installed), including transmission tie-in costs as determined by other participants in the Hetch Hetchy/SFPUC Programmatic Renewable Energy Project. The portfolio of geothermal

resources described in this study (referred to herein as the Project Portfolio) includes areas both with and without existing power plants. For those resources with existing plants, Project 1.3 includes an estimate of the quantity and cost of the incremental generation capacity available.

1.3 Report Organization

Chapter 2 of this report describes the specific background and baseline conditions of Project 1.3, along with Project work plans, the geographic area of interest, the Project Task List, and the MS Access© database of geothermal resource information (referred to herein as the PIER Geothermal Database).

Chapter 3 describes the project outcomes, including overviews of the resource data compiled, the methodologies employed, and estimates of generation capacities and development costs.

Chapter 4 provides the conclusions and recommendations obtained from the project outcomes, along with comments regarding commercialization potential and benefits to California.

Chapter 5 contains endnotes from Chapters 1 to 4.

Chapter 6 contains project references in bibliographic format, divided into (1) general references (relevant to background information and methodologies) and (2) the geo-technical references that are specific to the various geothermal projects¹.

Chapter 7 is a glossary of terms, abbreviations and definitions used in the text of this report and in the PIER Geothermal Database.

This is followed by figures, tables, appendices, and (on an attached computer CD) the PIER Geothermal Database.

The PIER Geothermal Database in MS Access© contains embedded illustrations and automated reports that allow the user to view and print geotechnical data and calculated results for each geothermal resource site in the Project Portfolio. The text of this report includes only one illustrative example of the following²:

- a. a Project Data Summary Report
- b. a local site area map
- c. a local site downhole temperature graph
- d. a Probabilistic Calculation of Geothermal Energy Reserves
- e. a cost summary entitled Exploration, Confirmation and Development Costs – Detail by Project

Summaries and documents describing methodology are included as tables and appendices to this report, and are accessible as reports within the PIER Geothermal Database. The narrative content of Chapters 2 through 4 provides an overview of each topic and results, with reference to the full detail contained in corresponding tables and appendices.

2 Project Approach

2.1 Prior Research

This project has used prior research, exploration, and development results in the public domain to the fullest extent possible. This includes:

- Published sources such as technical, trade and academic journals and reports of government-sponsored projects and research (see References in Chapter 6)
- Information available at a number of internet locations, including vast collections of temperature data from shallow and deep holes in California and Nevada that have been compiled by the USGS³ (USGSOF99-425) and by Southern Methodist University (SMUWGD), as well as fluids chemistry information compiled by the USGS (GEOTHERM)
- Public domain information on several projects available from the files of INEEL
- Data and information received from developers of some of the geothermal projects and released into the public domain specifically in connection with this study. All known developers of projects within the geographic area of the study were contacted with information about the PIER project and a request for data and information. To various degrees, some chose to supply previously unavailable data and information, whereas others did not.

To the full extent of GeothermEx's knowledge, proprietary (unpublished, privately held) information and data have not been included in the database, and do not contribute in a direct way to any of the conclusions and recommendations of this study. However, GeothermEx has used its extensive experience in the geothermal industry to help guide the methodologies used and selections made between some of the alternative possible conclusions and recommendations.

2.2 Baseline Conditions

There have been three baseline conditions for inclusion of a geothermal resource area in the portfolio of projects with electricity generation potential. These are geographic location, resource temperature, and evidence of a discrete resource.

The PIER Geothermal Database is confined to resources within the geographic area that is described below, but it does list some resources that have been excluded from the portfolio (*i.e.*, generation capacity and exploration-to-development costs have not been estimated). In such cases either: (a) the area in question is a geographic (or technical/economic) subdivision of another area, for which estimates *are* made, or (b) one or both of the temperature and discrete resource criteria were found to be lacking. These latter usually are resource areas that have been listed by others as having interest for exploration and/or development, but which did not meet the criteria of this project.

Geographic location

The subject area of Project 1.3 (see Figure 1 and section 2.4) has been:

- the entire State of California, and
- the western part of the State of Nevada (extending as far east as the Beowawe project near Battle Mountain).

At the start of Project 1.3, resource areas in Nevada were included only if located within 50 miles of the High-Voltage Direct-Current (HVDC) transmission line ("HVDC intertie") that runs north from Los Angeles into eastern California, through western-most Nevada, and into Oregon (see Figure 1 and section 2.4). (The HVDC intertie is also known as the Pacific Direct-Current Intertie, or PDCI). It was later decided to include other locations in western Nevada, because some are along or very close to other transmission lines that could provide access to the California market. Because it would be arbitrary to select an exact cut-off distance from existing transmission, all resources as far east as Beowawe were eventually included.⁴

Section 2.4 describes subdivisions of the subject area.

Resource temperature

An estimate of generation capacity and exploration-to-development cost has been made only if it has been concluded that the average temperature of the resource is reasonably likely to be at least 212°F. This low cut-off temperature results in the inclusion of a number of marginal, very small resources. However, these resources can be economically viable: witness the Wabuska project in Nevada (WAB00⁵), which started production in 1984 and continues to generate electricity from a resource at about 220°-227°F.

There are some projects that have not been drilled enough to establish the resource temperature, and in such cases it is assumed than an average of temperatures found elsewhere can be applied (this is described in Appendix III). However, if there is relatively good evidence that 212°F is not attained, then the area has been excluded from further consideration.

Evidence of a discrete resource

To be included in the Project Portfolio, it is necessary that a resource be somehow discretely defined in terms of proven or probable geographic extent (even if fairly uncertain). The database lists a few geothermal resource areas that have been listed by others as having interest for further exploration and development. Some of these are fairly broad regions in which anomalous temperatures exist at scattered locations, but no specific anomaly has yet attracted focused exploration and development. Examples are the Carson Sink in Nevada and Westmorland in California. Generation capacity and exploration-to-confirmation cost estimates have not been made for these areas, so they are not considered to be part of the portfolio.

2.3 Project Work Plans

Estimated Generation Capacity (see section 3.2 and Appendix III)

The amount and quality of technical data available from the various geothermal resource areas is highly variable. Some areas have existing facilities with long production histories that can allow a reasonably accurate assessment of the ultimate potential of the field, setting the stage for possible capacity expansion, or indicating that further expansion is unlikely. Others have enough drilling information to prove the existence of commercial production conditions, and even with no production history it is possible to determine the resource criteria needed to estimate probable generation capacity. At the other end of the spectrum are sites where a geothermal resource has been identified from surface exploration, but no deep drilling has been conducted to confirm the presence of a commercial reservoir.

To carry out the resource assessment in the face of this database disparity, the project has quantified for each site a uniform set of required resource criteria that determine commercial

feasibility. For some projects these criteria can be estimated with a good degree of confidence. At the other extreme are projects that have been minimally explored, for which criteria values can only be assumed, based on averages at other fields in similar settings (see Appendix III and Table III-1).

The criteria are:

- Reservoir temperature
- Reservoir area
- Reservoir thickness
- Reservoir porosity, and
- Resource recovery factor

To rigorously consider the uncertainties in these criteria, each is assigned an "error bar" by selecting a most-likely value, together with a minimum value and a maximum value that define an approximately normal probability distribution around the most-likely⁶ value.

The minimum, most-likely and maximum values of each criterion are then used in probabilistic simulation (based on Monte Carlo random-number sampling) to calculate estimated generation capacity based on the accessible heat in place at the resource area. Results are expressed in terms of MW capacity for 30 years. Because a probabilistic method of calculation is used, the results can be expressed in terms of a Minimum result (90% cumulative probability), Most-likely (modal) result, Mean result, and the standard deviation of the Mean.

It must be emphasized that the generation capacity estimate is based on calculated heat in place. This does not guarantee that a given resource in which there has been little or no drilling will have the reservoir permeability required to allow commercial production of hot water or steam to a power plant. That can be established only by drilling and testing the production zone.

Exploration costs (see section 3.4 and Appendices IV and V)

Once the generation capacity of an incompletely explored resource area is estimated, this is used in combination with the available set of exploration data to estimate the costs of further exploration (total and per kW). Standard costs for a number of exploration methods have been assumed, based on experience elsewhere, and a work program has been assigned. The exploration programs assigned herein are not necessarily the programs that will be chosen by developers, but are considered reasonable estimates of the total likely costs.

Drilling costs (see section 3.3)

Beyond exploration, the costs of resource confirmation and development depend greatly upon the costs of drilling deep wells. For Project 1.3, drilling costs have been estimated using statistical correlations of drilling cost versus depth, and well productivity versus temperature.

Confirmation costs (see section 3.4 and Appendices IV and V)

Confirmation is the process of drilling and proving enough resource at the wellhead to satisfy the requirements of a lending institution for funding development. For this study, it is assumed that 25% of the desired development capacity must be proven, and the cost of this is calculated using the statistical correlations of drilling cost versus depth and productivity versus temperature, plus certain standard assumptions regarding further costs such as administration, well tests and

environmental compliance. A confirmation estimate is made for both the Minimum and the Most-likely estimated generation capacity.

Development costs (see section 3.5 and Appendices V and VI)

Development costs cover the process of drilling and proving the remaining amount of the estimated resource capacity, constructing power production facilities, and constructing the transmission line. The drilling costs are estimated by an amplification of the method used for confirmation costs. Power plant and other facilities costs are based on a standard value per kW, derived from information in a variety of published sources. Transmission-line costs have been estimated using input from another contractor to the Hetch Hetchy/SFPUC Programmatic Renewable Energy Project (Electranix Corporation). Development costs are estimated for both the Minimum and the Most-likely estimated generation capacity.

Operational constraints

Each resource area has certain associated operational constraints, which can be difficult to quantify. These are typically associated with fluids chemistry (e.g., scaling, corrosion, non-condensable gas management), terrain, access, and other institutional or infrastructure factors. A list of notable operational constraints that may occur in each area is included in the PIER Geothermal Database, to assist a qualitative assessment of how operational constraints may be mitigated and how they may affect exploration, confirmation and development costs.

2.4 Resource Sites and Geographic Areas

Sites

Table 1 is a list of all geothermal resource projects in the PIER Geothermal Database. In the usage of this report, a "project" is loosely defined to mean either a single resource area (site), or a subdivision of a resource area. If a given resource area has subdivisions, there is also a "project" that is a "field-wide summary" of the set.⁷

Most subdivisions have historically been geographic; *i.e.*, they represent separate parts of a geothermal anomaly (separate leaseholds) that were explored, confirmed or developed at different times, sometimes by different developers. Over time, many of these subdivisions have been consolidated under the control of a single developer or operator, and in some cases there are even pipelines that now interconnect the wells in different subdivisions.

The actual portfolio of real and potential development projects, in terms of estimated generation capacities and costs, comprises single resource areas and field-wide summaries of subdivided resource areas. This subset of the entire database is indicated in Table 1 by a check box under the heading "Gen(eration) Cap(acity) Estimated".

Geographic areas

At the start of Project 1.3, the geothermal resource sites in the subject area (section 2.2) were divided into two geographic areas. Area 1 comprised a corridor of 50 miles on either side of the HVDC intertie (including resource sites in both California and Nevada, and later expanded to include all of Nevada as far east as Beowawe). Area 2 comprised the remaining portions of California more than 50 miles from the HVDC intertie. Areas 1 and 2 were referred to as the HVDC and non-HVDC areas, respectively.

It subsequently developed that the broader Hetch Hetchy/SFPUC Programmatic Renewable Energy Project could more conveniently use a different geographic breakdown, and this final report now uses the following:

Area 1 – Greater Reno, Nevada (including nearby California sites at Honey Lake)

Area 2 – Nevada sites with direct access to the California grid

Area 3 – Other Nevada locations

Area 4 – All California locations (excluding Honey Lake)

An example of Area 2 is Dixie Valley, Nevada, which sends power to Southern California Edison via a transmission line that extends south into California. Other locations along or close to this route are included in Area 2, which is also referred to in this report as the Dixie Corridor.

2.5 Task List

The formal Task List of separate defined activities and deliverables for Project 1.3 has been:

Task 1.3.1	Acquire and assess resource data for Area 1
Task 1.3.2	Estimate generating potential for Area 1
Task 1.3.3	Develop statistical correlations required to estimate drilling costs
Task 1.3.4	Estimate exploration and resource confirmation costs for Area 1
Task 1.3.5	Estimate development costs for Area 1
Task 1.3.6	Acquire and assess resource data for Area 2
Task 1.3.7	Estimate generating potential for Area 2
Task 1.3.8	Estimate exploration and resource confirmation costs for Area 2
Task 1.3.9	Estimate development costs for Area 2
Task 1.3.10	Final Project Report

(Areas 1 and 2 of this list refer to the HVDC and non-HVDC areas as originally defined. In this report, Areas 1 and 2 have been superceded by Areas 1 to 4, as described in section 2.4.)

Some of these Tasks have been carried out sequentially, while others have been carried out simultaneously. All of Tasks 1.3.1 – 1.3.9 have been subject to continuous revision and update during the course of the project, to enable refinement of the database and the final product, which is represented by this report.

2.6 PIER Geothermal Database (MS Access©)

2.6.1 General description and organization of the data

The PIER Geothermal Database contained on the CD attached to this report is a compilation of geothermal data and information developed to meet the objectives Project 1.3. It has evolved as work on Project 1.3 has progressed. The database on the attached CD synthesizes and replaces all previous versions of the database.

The database is not (and is not intended to be) comprehensive, either with respect to all possible geothermal projects, or with respect to all available data and information. Rather, it is intended to provide:

1. a portfolio of reasonably well-characterized geothermal resources that are located within the subject geographic area;
2. a brief overview of each resource area with respect to exploration and development history, well drilling and well characteristics, and the physical and chemical characteristics of the resource; and,
3. at least the minimum amount of information needed to:
 - a. characterize each resource in terms of minimum and most-likely generating capacity;
 - b. estimate the costs of exploration and development that will be required to reach those capacities, if not already met; and,
 - c. calculate the associated total development costs and unit development cost.

The information in the database has been obtained from the sources described in section 2.1. Citations to significant sources of published information are included, but there has been no attempt to make the citations or the bibliography all-inclusive. Proprietary sources (data released for this project) are acknowledged. GeothermEx has endeavored to make the database as free of errors and mis-information as is possible, but cannot be responsible for errors and omissions in either published or previously proprietary sources of data that have been used.

The database includes a combination of numeric data and text, embedded figures, and reports in tabular and narrative format. This information is contained in a set of data tables that are linked in relational format by the unique project ID number (5-character code) that identifies each project, and by ID codes that identify each separate reference.

The user interface of the database includes three principal windows: the Startup window (Figure 2), the Projects window (Figure 3), and a Reports and Documents window (Figure 4). All of the data, figures, and reports are available via command buttons that open other windows dedicated to subsets of the data, or that preview the reports or figures on-screen so that they may be sent to a printer.

2.6.2 Instructions for use

Instructions for using the database, including the printing of reports or figures, are contained in Appendix VII.

3 Project Outcomes

3.1 Resource Data

3.1.1 Methodology

In a manner consistent with the goals and objectives of Project 1.3, geothermal resource data have been compiled using published sources, information from GeothermEx's files of non-proprietary resource information, and responses from developers who chose to assist the process of data acquisition for this study.

The data of principal interest have been: resource size (depth, area, and thickness), temperature, fluids chemistry, well productivity, and operational constraints (corrosion, scaling, access, terrain, and possible usage restrictions such as wetlands). These data have been used to prepare the PIER Geothermal Database (in MS Access[©]) that is included on the CD attached to this report and described in section 2.6 and Appendix VII.

3.1.2 Results

The PIER Geothermal Database contains information on 155 separate geothermal projects in the states of California and Nevada, which represent a total of 83 different resource areas. Six of the 83 areas are represented by name only, because they were found listed by others as having some degree of interest for geothermal exploration, but little to no further information could be found, or they did not meet all of the resource criteria that are outlined in section 2.2. Of the 77 remaining resource areas, 58 have been selected for estimation of generation capacity (section 3.2); others did not meet all of the criteria of section 2.2.

Table 1 contains a list of all projects, with basic identification, location, exploration-development category (see this section, below) and an indication of whether generation capacity has been estimated. The separate resource areas are those with an ID number that ends in 00 (see section 2.4).

Table 2 is the same list, organized by the geographic areas described in section 2.4.

Figure 1 shows the locations of the resource areas for which generation capacity has been estimated (section 3.2).

Chapter 6 contains a list of all references cited in the database (also available within the database, as a report).

Chapter 7 contains a list of data abbreviations used in the database (also available within the database).

Appendix I is a list of all figures in the database, organized by project (also available within the database, as a report).

Appendix II is an example of a "Project Data Summary Report", which contains all of the database information for a project, except for the figures associated with it as Adobe Acrobat[©] (*.pdf) files embedded in the database.

Nearly all resource areas in the project are illustrated by a local site area map, of which Figure 5 is an example. These contain topography, roads, power lines, lease boundaries (where available), hot springs, locations and depths of wells, temperature gradients and bottom-hole temperatures, and (as possible) the outlines of temperature anomalies.

Where possible, each resource area is also illustrated by a downhole temperature graph, which illustrates or summarizes the available information from temperature gradient and/or deep drill holes. Figure 6 is an example.

Many areas are also illustrated by additional figures, as listed in Appendix I.

Exploration – Development Category

The amounts of information for a given resource area vary widely, from quite complete, to very limited, depending on whether the resource has been explored, confirmed or developed, and how much information has been released. To assist a quick evaluation of the status of a project and how confidently it can be characterized, each has been assigned to a development category, as follows:

A – Existing power plant operating (16 of 83 resource areas)

B – One or more wells tested with a potential greater than or equal to (\geq) 1 MW, but no power plant in operation (7 of 83 resource areas)

C – Minimum 212°F logged downhole, but no well tests at \geq 1 MW (29 of 83 resource areas)

D – Other exploration data and information available (\geq 212°F not proven) (25 of 83 resource areas)

No category assigned – in cases of areas not meeting the criteria of section 2.2 (6 of 83 resource areas).

This information is not sufficient to rank the attractiveness of any individual project, especially in categories B and C, but it does assist the process.

3.2 Generating Potential

3.2.1 Methodology

As described briefly in section 2.3, generation capacities of the resource areas have been estimated using a probabilistic (Monte Carlo) method applied to a calculation of heat in place. The resource parameters used for each calculation are listed and annotated in the database under Reservoir Physical Properties, and results are listed and annotated under Generation Capacity (see Figure 3). The theoretical basis for the calculation of generation capacities and the rationale for assigning resource parameters are described in Appendix III.

Appendix III includes Table III-1, which presents a summary of reservoir characteristics at 11 well-characterized, producing geothermal fields in Nevada and eastern California. As explained in Appendix III, the averages of these characteristics have been used, on a case-by-case basis, to assign default values to the unconfirmed characteristics of resource areas which remain inadequately explored and drilled.

3.2.2 Results

Estimated generation capacities of 58 resource areas, grouped by geographic areas, are listed in Table 3. Several of the resource areas have subdivisions with separate capacity estimates, such that the total number of capacity estimates listed is 65. Comments associated with each capacity estimate are presented in Table 4. Table 5 presents the generation capacities listed by Exploration-Development Category. Each calculation of generation capacity (with associated input parameters) produces a tabular and graphical summary of the results, of which Figure 7 is an example. Individual estimates range from as small as a minimum (Min) value of 3.6 MW (Sespe Hot Springs, California) to as large as a most-likely (Mlk) value of 1,750 MW (Salton Sea, California). The totals by area (Table 3) and by state are:

Area	Installed MW (2003)			Estimated Total Generation Capacity (MW – 30 years)			
	Gross	Net	Net / Gross Ratio	Min (90% prob.)	Most- likely (modal)	Mean	Std. Dev. of Mean
1 Greater Reno (NV + Honey Lake, CA)	184	139	.75	552	787	1,169	129
2 NV with direct access to CA	66	56	.85	363	572	780	136
3 Other NV	0	0	-	91	141	220	51
4 CA excluding Honey Lake	1,863	1,661	.89	3,638	4,723	5,321	480
All California	1,869	1,664	.89	3,644	4,731	5,334	480
All Nevada	244	192	.79	1,000	1,492	2,156	194
TOTALS	2,113	1,856	.88	4,644	6,223	7,490	518

The incremental totals (Estimated New Gross Power Plant Capacity, calculated as Estimated Total Generation Capacity minus Installed Gross MW) are:

Area	Installed Gross MW (2003)	Estimated New Gross Power Plant Capacity (MW – 30 years)	
		Minimum (90% probability)	Most-likely (modal)
1 Greater Reno (NV + Honey Lake, CA)	184	368	603
2 NV with direct access to CA	66	297	506
3 Other NV	0	91	141
4 CA excluding Honey Lake	1,863	1,775	2,860
All California	1,869	1,775	2,862
All Nevada	244	756	1,248
TOTALS	2,113	2,531	4,110

Public records that list the installed gross and net capacities of existing installations do not always agree in detail, so the total capacities in these tabulations are uncertain by a few percent. The ratios of net to gross have corresponding uncertainties, but it is probable that the relatively low net/gross ratio in Area 1 reflects a dominance of binary power plants with pumped wells, and the high net/gross ratio in Area 4 reflects dominance of The Geysers, Coso and Salton Sea fields, where wells are not pumped.

If it is assumed that the future new power installations in Areas 1, 2 and 4 will have the same average net/gross ratios as existing plants, and that Area 3 (likely all binary) will have the same net/gross ratio as Area 1, then the estimated new net power plant capacities, by resource area and by state, are:

Area	Estimated New Net Power Plant Capacity (MW – 30 years)	
	Minimum (90% probability)	Most-likely (modal)
1 Greater Reno (NV + Honey Lake, CA)	276	452
2 NV with direct access to CA	252	430
3 Other NV	68	106
4 CA excluding Honey Lake	1,580	2,545
All California	1,580	2,547
All Nevada	596	986
TOTALS	2,176	3,533

The estimates of new gross and new net power capacity in the previous two tables are based on the simple difference between estimated total resource capacity and nominal installed power plant capacity. In sections 3.4 and 3.5, these figures are refined by: (a) considering actual generation (cases of under-utilized plant capacity), (b) considering unused but available wellhead capacity (cases of un-used wells), and (c) excluding a few projects for which confirmation and development costs are not estimated (for reasons given in the PIER Geothermal Database).

3.3 Statistical Correlations For Drilling Costs

Two statistical correlations have been developed to estimate drilling costs in geothermal development for the purposes of this study:

1. Drilling costs vs. depth
2. Well productivity vs. temperature

These correlations are expressed graphically in Figures 8 and 9. The statistical data underlying the correlations are included in Tables 6a and 6b.

3.3.1 Drilling costs versus depth

The correlation of drilling costs vs. depth (Figure 8) is based on data from 182 wells in eight fields. We have relied on two primary sources for geothermal drilling costs within the United States:

- A database of Geysers wells drilled between 1985 and 1995, provided with the cooperation of Calpine Corporation and Sandia National Laboratory.

- A database of wells drilled between 1985 and 1993 in the East Mesa, Heber, and Salton Sea fields, provided by the California Energy Commission (CEC) from the Geothermal Cost Survey (GCS) conducted in 1993. The GCS information had a confidentiality window of 10 years and is now in the public domain. The CEC also made available drilling cost data for a well at Medicine Lake (88A-28) that Calpine drilled in 2002 with partial CEC funding.

Because of proprietary concerns of several geothermal operators and the relatively small amount of recent geothermal drilling within the United States, we have also incorporated data from representative geothermal wells completed between 1997 and 2000 in Central America and the Azores. To account for inflation, the costs of all wells have been escalated to equivalent US dollars as of 1 July 2003, using the Producer Price Index (PPI) for onshore oil and gas drilling from the US Department of Labor, Bureau of Labor Statistics, Series PCU1381#9 (N). Figure 10 shows a plot of the monthly PPI factors used for this escalation. Table 6a shows the completion date, depth, cost, and escalation factor for each well used in the correlation. The table does not show actual well names, but the wells are listed by field with an assigned sequence number (for instance, Geysers 1 to Geysers 13).

The wells used in the correlation have included a mix of production and injection wells. Wellbore diameters within the reservoir were generally 12-1/4-inch or 8-1/2-inch. Slim holes and temperature gradient holes were not included in the data set. For wells with multiple legs (forked completions), an attempt was made to consider just the cost of the first leg. Where segregating the cost of the first leg was not possible, the deepest leg was used to correlate with the total well cost. An attempt was also made to include pad construction costs and the costs of mobilization and de-mobilization (mob and de-mob) of the drilling rig. However, pad construction costs may not be included if a well was drilled from an existing pad. Mob and de-mob costs can vary widely, depending on the terms negotiated with the rig contractor and the distance from previous and subsequent wells. These factors, as well as the variability of the geologic formations drilled, lead to considerable scatter in the data set.

Despite the scatter, there is a rough correlation between drilling cost and well depth, as Figure 8 illustrates. In this figure, GCS data points actually represent average values for several wells, because well costs reported in the GCS data sheets were aggregated by project. Figure 8 includes a curve fit to the data set using a second-order polynomial. The GCS data points have been weighted based on the number of wells in the average for each point. The curve fit includes all wells in the data set except for 32 production wells in the Salton Sea field (represented by five points in Figure 8 from averaged GCS data). These Salton Sea producers are above the general cost trend, probably because the GCS averages include some wells with above-average diameters and non-standard metallurgy (such as titanium casing). Salton Sea injection wells plot within the band of data scatter, and they have been included in the curve-fit calculation. The formula for the curve fit is:

$$\text{Drilling cost (in US\$)} = 240,785 + 210 \times (\text{depth in feet}) + 0.019069 \times (\text{depth in feet})^2$$

The quality of the curve fit can be expressed as the square of the sample correlation coefficient (r^2 or R-squared). R-squared can range from 0 to 1, and values closer to 1 indicate a higher degree of correlation. The R-squared value for the curve fit is 0.558, which indicates that 55.8% of the variance in drilling cost is accounted for by depth.

3.3.2 Well productivity versus temperature

The correlation of well productivity vs. temperature was estimated based on 17 fields with sufficient data to be considered (Table 6b). For each field, the productivity per well was estimated by dividing the plant capacity (gross megawatts) by the number of active production wells. This value was correlated with the average temperature of the main permeable zone in the reservoir.

As shown in Figure 9, there is a roughly linear correlation between well productivity and temperature for geothermal resources below about 400°F. In this temperature range, geothermal production wells are often pumped, and the productivity of wells is strongly affected by pump capacity over a narrow range of well diameters. Above about 400°F, commercial resources are generally self-flowing, and the productivity of individual wells is strongly affected by the permeability of the formation, which can vary widely.

An additional factor leading to scatter in the correlation is the fact that well productivities are calculated for all active producers, including wells that may have declined significantly from their initial potentials. For instance, the right-most data point in Figure 9 comes from the Coso field, which calculates an average productivity of just 3.2 MW (gross) despite a permeable-zone temperature averaging above 520°F. If initial potentials were used for Coso wells, the average productivity would be much higher. Conversely, the highest point in Figure 9 comes from Dixie Valley, where declines in productivity have been relatively low.

In addition, a number of reservoirs have high temperatures that do not correlate at all with high well productivity; these are candidates for development by enhanced geothermal system (EGS) techniques. Thus, in planning the number of wells required for a new geothermal development or expansion of an existing field, the use of a correlation based strictly on temperature is of limited utility, especially for higher-temperature fields. Resource-specific information from well testing must be taken into account whenever possible.

3.4 Exploration and Resource Confirmation Costs

3.4.1 Methodology

In the context of Project 1.3, the exploration of a resource consists of geotechnical activity up to and including the point of siting a first, deep, commercial-diameter hole. The exploration costs of a project are estimated by assigning a likely program of activities, and applying to this program a set of assumptions and standard costs that are described in Appendix IV and in Table IV-1, with cost adjustments applied for specific cases.

The two most expensive exploration activities considered herein are drilling intermediate-depth (ID) slim holes (usually to at least 2,000 ft), and magneto-telluric (MT) or direct-current (DC) resistivity surveys. One or more ID slim holes are almost always included if no holes to similar depths have already been drilled. Resistivity surveys are included only rarely, because it has been our experience that these surveys have had limited success in yielding drilling targets at medium-temperature, non-volcanic geothermal systems.

Confirmation consists of doing enough deep drilling, well testing and reservoir testing to confirm at the wellhead 25% of estimated generation capacity. This is the approximate percentage that is likely to be required by a lending institution for funding development. Some injection capacity is also required, to dispose of the fluids from production tests, but drilling of dedicated injection

wells is not included in the confirmation estimates. Instead, it is assumed that test fluids can be injected into other production wells (successful or unsuccessful) or existing ID slim holes. At a few very small projects, where one confirmation well might suffice, the number is adjusted to two, so that injection capacity will be available.

If a resource is already being produced, then confirmation is the process of proving 25% of the difference between the total estimated capacity and capacity already being exploited. If there are idle but proven production wells, then the capacities of these wells are subtracted from the 25% requirement before the confirmation program is estimated.

As with exploration, confirmation is estimated using a set of assumptions and standard costs. The cost of deep drilling is a function of: (a) reservoir depth, (b) typical drilling cost per foot (described in section 3.3), (c) expected well productivity as a function of resource temperature (also in section 3.3), (d) the total MW that must be proven, and (e) an assumed percentage of unsuccessful holes compared to total holes drilled. To the drilling cost are added such additional costs as well and reservoir testing, reporting and administration. Complete details of the confirmation method, unit costs and background information are contained in Appendix IV and in Tables IV-1 and IV-2.

3.4.2 Results

The details of the exploration programs are contained in Table 7, and the combined detail of exploration, confirmation and development at any individual project can be obtained as a report in the PIER Geothermal Database (use the “Expl-Conf-Dev Programs & Costs” button at the bottom of the Projects window, Figure 3). (Development costs are discussed in section 3.5.) Total exploration costs, confirmation costs, and development costs are listed in Table 8 (summary with cost totals), Table 11 (drilling details), and Table 12 (costs per kW). Comments on the confirmation costs for each separate project are contained in Table 9.

For each geographic area, the total exploration and confirmation costs (from Table 8) and total new gross MW being developed (from Table 12) are as follows:

Area		Exploration Costs (thousands)	Confirmation			
			New Gross MW being developed (Min)	Confirmation Costs (thousands)	New Gross MW being developed (Most-likely)	Confirmation Costs (thousands)
1	Greater Reno (NV + Honey Lake, CA)	\$8,684	419	\$142,255	643	\$213,154
2	NV with direct access to CA	\$4,056	297	\$115,896	506	\$182,706
3	Other NV	\$7,968	91	\$37,499	141	\$58,253
4	CA excluding Honey Lake	\$7,077	1,990	\$609,942	3,041	\$984,765
	All California	\$7,077	1,995	\$611,658	3,048	\$988,014
	All Nevada	\$20,708	802	\$293,934	1,283	\$450,864
	TOTALS	\$27,785	2,797	\$905,592	4,331	\$1,438,878

The totals per kW in each geographic area are as follows (from Table 12; E = Exploration, C = Confirmation):

Area		Exploration and Confirmation Costs / kW							
		Min MW	\$/kW			Mlk MW	\$/kW		
			E	C	E+C		E	C	E+C
1	Greater Reno (NV+ Honey Lake, CA)	419	\$21	\$339	\$360	643	\$14	\$332	\$345
2	NV with direct access to CA	297	\$14	\$391	\$405	506	\$8	\$361	\$369
3	Other NV	91	\$88	\$412	\$500	141	\$57	\$413	\$470
4	CA excluding Honey Lake	1,990	\$4	\$306	\$310	3,041	\$2	\$324	\$326
	All California	1,995	\$4	\$307	\$310	3,048	\$2	\$324	\$326
	All Nevada	802	\$26	\$366	\$392	1,283	\$16	\$351	\$367
	TOTALS/Averages	2,797	\$10	\$322	\$332	4,331	\$6	\$331	\$338

Note that the values of new gross MW listed here differ somewhat from the estimates of new gross power plant capacity in Section 3.2.2. The values listed here (and in Table 12) take into account both underutilized plant capacity and productive but unused wells. Because projects can be constrained by either insufficient plant capacity or insufficient power at the wellhead, the numbers listed here are more representative of the actual incremental output that would be achieved if the minimum or most-likely estimates of generation capacity were fully developed.

3.5 Development Costs

3.5.1 Methodology

For every project with an estimation of generation capacity, development cost is estimated as the sum of three components:

1. Drilling Cost
2. All other On-site Capital Costs, and
3. Transmission-line Cost.

Drilling cost is estimated using a method similar to that applied to confirmation drilling, except that injection wells are included using temperature criteria that distinguish between binary, flash-steam, and dry-steam projects. Another difference in estimating development costs is that there is a more differentiated handling of the drilling success rate, using both the historic averages of a number of projects and the particular drilling histories of individual projects. In addition, the drilling program for the development cost estimate is designed to establish 105% of needed wellhead capacity, which provides a 5% reserve. Complete details of the method are described in Appendix VI.

Other On-site Capital Cost is calculated as the aggregate cost of capital components (all pipelines and pumps, the power plant, pollution abatement, substation and transmission-line connection, roads, legal, regulatory, reporting and documentation, etc.), described simply as the cost of the power plant and gathering system. The value used herein is US\$1,500/kW installed, which is multiplied times the difference between Estimated Generation Capacity in MW (resource

capacity) and the lesser of existing plant capacity (if any) or power available at the wellhead, in gross MW. The basis for the aggregate value of \$1,500/kW is described in Appendix VI, which includes a tabulation of various capital cost estimates that have been made by others since 1995 (along with citations). Actual costs of power plants and gathering systems vary over a range based on a number of site-specific factors, including topography and the temperature and chemistry of the resource. Approximate ranges for different plant technologies (estimated based on the references in Appendix VI) are as follows:

Plant Technology	Capital Cost of Plant and Gathering System (\$/kW installed)
Dry Steam	\$1,000 - \$1,500
Single Flash	\$1,100 - \$1,600
Double Flash	\$1,200 - \$1,700
Binary	\$1,400 - \$1,900

The value of \$1,500/kW for plant and gathering system falls within the approximate ranges for all plant technologies and has been used across the board for the capital cost estimates in this study.

Transmission-line cost is estimated on the basis of estimates provided by Woodford (2003) (listed in section 6.1 as Woo03a) for the development of a new transmission grid in Area 1 (Greater Reno) that connects to the Pacific Direct-Current Intertie (PDCI), and a connection from the Salton Sea area (Imperial Valley) to the PDCI. The estimates in Woodford (2003) represent 16 specific geothermal projects in northern Nevada. Estimates of the transmission-line costs for other projects are made by applying cost-per-mile data (including substations and taps) from Woodford (2003) to the approximate distance from the project to the nearest point along Woodford's hypothetical expanded grid or an existing transmission line (available capacity for new transmission not confirmed). Complete details of the transmission line cost estimation method are provided in Appendix VI.

3.5.2 Results

The detailed exploration-confirmation and development program of each individual project can be viewed as a report in the PIER Geothermal Database (use the "Expl-Conf-Dev Programs & Costs" button at the bottom of the Projects window, Figure 3).

Total exploration costs, confirmation costs, and site development costs are listed in Table 8 (summary with cost totals), Table 11 (drilling details), and Table 12 (costs per kW). Comments on the development costs for each separate project are contained in Table 10.

Per geographic area, total on-site development costs (Table 8) and total new MW being developed (from Table 12) are as follows:

Area		Site Development (thousands)			
		New Gross MW being developed (Min)	Site Development Costs	New Gross MW being developed (Most-likely)	Site Development Costs
1	Greater Reno (NV + Honey Lake, CA)	419	\$1,196,299	643	\$1,807,471
2	NV with direct access to CA	297	\$ 898,788	506	\$1,521,022
3	Other NV	91	\$ 279,389	141	\$ 442,601
4	CA excluding Honey Lake	1,990	\$4,947,784	3,041	\$7,695,796
	All California	1,995	\$4,958,152	3,048	\$7,711,606
	All Nevada	802	\$2,364,107	1,283	\$3,755,284
	TOTALS	2,797	\$7,322,259	4,331	\$11,466,890

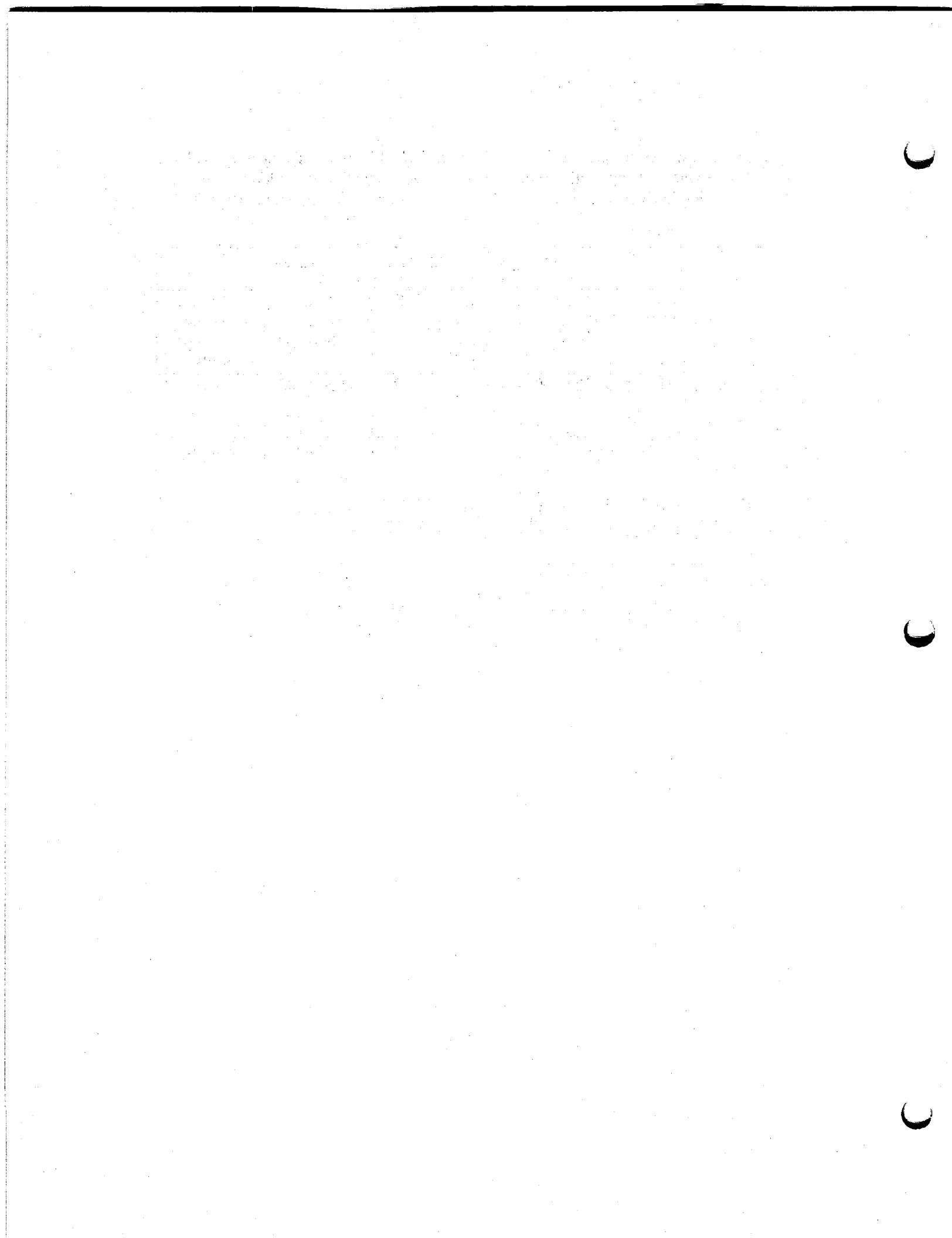
The totals per kW of new development in each geographic area for site development (SD) and the combination of exploration + confirmation + site development (E+C+SD) are:

Area		Site Development and Exploration+Confirmation+Site Development Costs / kW					
		Min MW	SD \$/kW	E+C+SD \$/kW	Mlk MW	SD \$/kW	E+C+SD \$/kW
1	Greater Reno (NV + Honey Lake, CA)	419	\$2,855	\$3,214	643	\$2,811	\$3,157
2	NV with direct access to CA	297	\$3,026	\$3,436	506	\$3,006	\$3,377
3	Other NV	91	\$3,070	\$3,570	141	\$3,139	\$3,609
4	CA excluding Honey Lake	1,990	\$2,486	\$2,796	3,041	\$2,531	\$2,857
	All California	1,995	\$2,485	\$2,795	3,048	\$2,530	\$2,857
	All Nevada	802	\$2,948	\$3,340	1,283	\$2,927	\$3,295
	TOTALS	2,797	\$2,611	\$2,944	4,331	\$2,644	\$2,982

Transmission line costs per project are listed in detail in Table 13, and tabulated along with total development costs and total exploration+confirmation+development costs per kW in Table 14. With the transmission line cost estimates included, the development costs per area (total and per kW) are:

Area	<u>Total Development Costs (thousands) and Total Development Costs / kW</u>					
	Min MW	Total Devel- opment	Total Devel- opment \$/kW	Mlk MW	Total Devel- opment	Total Devel- opment \$/kW
1 Greater Reno (NV+Honey Lake, CA)	419	\$1,527,000	\$ 3,643	643	\$2,209,000	\$ 3,437
2 NV with direct access to CA	297	\$1,033,000	\$ 3,483	506	\$1,722,000	\$ 3,405
3 Other NV	91	\$ 359,000	\$ 3,944	141	\$ 543,000	\$ 3,850
4 CA excluding Honey Lake	1,990	\$5,853,000	\$2,941	3,041	\$8,976,000	\$ 2,951
All California	1,995	\$5,865,000	\$2,940	3,048	\$8,995,000	\$ 2,951
All Nevada	802	\$2,907,000	\$3,625	1,283	\$4,454,000	\$3,472
TOTALS	2,797	\$8,772,000	\$ 3,136	4,331	\$13,449,000	\$ 3,106

In this table, total development costs have been rounded to the nearest million dollars.



4 Conclusions and Recommendations

4.1 Conclusions

1. A review of geothermal sites in California and western Nevada indicates that the electrical generation capacity available to the California market from geothermal sources has a minimum value of about 4,700 gross MW and a most-likely value of about 6,200 gross MW. After allowances for generation capacity already on line, the incremental generation capacity available from geothermal sources has a minimum value of about 2,800 gross MW and a most-likely value of about 4,300 gross MW. These estimates are based on information in the public domain or contributed by geothermal developers for the purposes of this study. The estimates may be conservative to the extent that they do not take into account resources about which little or no public-domain information is available.
2. Geothermal sites in California account for about 70% of the incremental generation capacity available. Within California, 90% of the incremental generation capacity identified in this study comes from three areas: the Imperial Valley, The Geysers, and Medicine Lake. The Imperial Valley alone accounts for about 65% of the incremental capacity available in California. Table 15 shows the breakdown of total and incremental generation capacity by specific areas within California and Nevada.
3. For the geothermal sites in the combined California/Nevada study area, the capital cost of incremental generation capacity averaged about \$3,100 per kW installed. Considering just California sites, the average capital cost of incremental generation capacity was somewhat lower: \$2,950 per kW installed. These cost estimates include the following components:
 - Exploration (up to the siting of the first deep, commercial-diameter hole);
 - Confirmation drilling (up to achieving 25% of required capacity at the wellhead);
 - Development drilling (up to achieving 105% of required capacity at the wellhead);
 - Construction of the power plant (including ancillary site facilities); and
 - Transmission-line costs.

The capital cost estimates are only approximate, because each developer would bring its own experience, bias, and opportunities to the development process. Nonetheless, the overall costs per project estimated in this study are believed to be reasonable.

4. The capital cost for specific geothermal projects ranged from about \$1,000/kW (for a small expansion at an existing project) to values in excess of \$6,000/kW (for deep, low-temperature resources at remote locations). Of the 4,300 gross MW of most-likely incremental capacity in the California/Nevada study area, about 2,500 gross MW is available at a capital cost less than the average of \$3,100/kW. Considering just California sites, about 2,000 gross MW is available at less than the average of \$2,950/kW.

4.2 Commercialization Potential

For the purposes of this study, a capital cost of \$2,400/kW or less is considered competitive with other renewable resources, both for the California/Nevada study area and for the state of

California alone. The amount of incremental geothermal capacity available at or below \$2,400/kW is about 1,700 gross MW for the California/Nevada study area, and the same amount (after rounding to the nearest increment of 50 gross MW) for the state of California alone. This amount of geothermal capacity available represents a significant opportunity for commercial development to meet the needs of the California electricity market. Resources with higher estimated costs may also be attractive, depending on market conditions and the mechanisms for implementing California's renewable portfolio standard.

4.3 Recommendations

1. The information in this report should be disseminated among potential purchasers of electrical power in California, including municipal power agencies and investor-owned utilities. This will help ensure that parties entering into contracts for the supply of power from geothermal sites will have a basic understanding of the character of the geothermal resource and the risks associated with development. This understanding will help avoid non-performing contracts.
2. The information in this report should be used to facilitate the aggregation of geothermal projects with other energy sources to achieve lower per-unit costs for transmission from remote sites. A study of options for shared transmission resources is already part of the program of PIER-funded projects being conducted by other contractors in conjunction with Project 1.3.
3. The information in the PIER Geothermal Database should be updated periodically as more information comes into the public domain. This will help ensure that parties relying on the database will be acting on the basis of current information.

4.4 Benefits to California

1. The compilation of geothermal resource data using an objective and consistent methodology should help build momentum for the utilization of these resources and should allow California to benefit from the environmental advantages of this renewable energy source.
2. The PIER Geothermal Database has been created using widely available software (MS Access©) to allow broad dissemination and easy updating as more information comes in to the public domain. This will minimize future programming costs required to keep the database current.

5 Endnotes

1. The two lists of references that comprise Chapter 6 are copies of the references contained in the PIER Geothermal Database, and are available also therein. Each reference has a unique code number, such as Bal03a or USGSOF99-425, which begins with the first few letters of the name of the primary author, followed by either the year of publication (e.g. 03 = 2003), or other identifying information (e.g., OF99-425 indicates Open File Report 99-425). Most citations within the database refer to this code number, which is usually shorter than the normal bibliographic convention of citing author's surname(s) and year. To conform to the database, these code numbers are also used in this report.
2. If paper copies of these items were to be included for all projects, the length of this report would increase by at least several hundred pages.
3. Acronyms and abbreviations of institutional names and other terms are listed in Chapter 7.
4. The database does include one resource east of Beowawe, which is Hot Sulphur Springs (also known as Tuscarora) in Elko County. This area is probably capable of generating electricity, but it is included by name only: geotechnical data regarding Tuscarora have not been compiled, and its generation capacity has not been estimated. On March 6, 2003, the Public Utilities Commission of Nevada (PUCN) approved a contract between Earth Power Co. and Nevada Power Co., for a 25-MW geothermal power plant at this location (GRCB 32/2 Mar/Apr 2003, p.52).
5. Projects in the database each have a unique 5-character ID code. The first three characters are letters that abbreviate the name of the resource area. The last two characters are a two-digit number that identifies separate projects (development entities or geographic subdivisions) within the resource area. If the number is 00, then the resource area has no more than one (and perhaps no) active development project.
6. In a few cases it is very difficult to assign a most-likely value, so only the minimum and maximum values are assigned, and an equal probability distribution is assumed.
7. The 5-character ID code that is unique to each project is described in Note 5.

6 References

6.1 General references

General references are those relevant to methodologies, background data, and regional data and information for California and Nevada. Each reference has a code number that is used for citations made within the PIER Geothermal Database, but these code numbers are not linked to any specific resource area. If a reference has a web address, it is included in the description.

Code	Description
Bru96a	Brugman, J., M. Hattar, K. Nichols, and Y. Esaki (1996). Next Generation Geothermal Power Plants, CE Holt Co., Pasadena, CA: February, 1996. Report EPRI TR-106223 (Project 3657-01). Research supported in part by Office of Geothermal Technologies, U.S. Department of Energy.
CADOGGR	Public records at website (www.consrv.ca.gov/dog) of the California Division of Oil, Gas and Geothermal Resources. These include a database of geothermal wells (exploration and development, all depths), and monthly well production/injection records.
Ent03a	Entingh, D.J., and J.F. McVeigh (2003). Historical improvements in geothermal power system costs. <i>Geothermal Resources Council Transactions</i> , v. 27, October 12-15, 2003, pp.533-537.
Ent97a	Entingh, D.J. (1997). Geothermal Hydrothermal Electric Systems. In: <i>Renewable Energy Technology Characterizations</i> , U. S. Department of Energy, Washington D.C., and Electric Power Research Institute (EPRI), Palo Alto, CA. EPRI-TR-109496 (Pleasant Hill, CA).
Fre00a	Fredriksens, M., M. Glucina, and R. McMahon (2000). Utilization of second-hand plant to reduce capital investment and project lead times. <i>Proceedings of the World Geothermal Congress 2000</i> , Kyushu-Tohoku, Japan, May 28 - June 10, 2000, pp.3155-3160.
Gaw00a	Gawlik, K., and C. Kutscher (2000). Investigation of the opportunity for small-scale geothermal power plants in the western United States. <i>Geothermal Resources Council Transactions</i> , v.24, September 24-27, 2000, pp.109-112.
GEOTHERM	U.S. Geological Survey GEOTHERM thermal fluids chemistry database (note: this database was maintained by the U.S.G.S until 1983 and does not contain data since that date)
GEx	GeothermEx company files, information in the public domain.
GHCB, ##, yr	Geo-Heat Center Quarterly Bulletin, volume/number, year
Gir95a	Girelli, M., M. Parini, and P. Pisani (1995). Economic evaluation of alternative strategies of geothermal exploitation. <i>Proceedings of the World Geothermal Congress</i> , 1995, v.4, pp.2843-46.
GRCB, ##, yr	Geothermal Resources Council Bulletin, volume/number, year
GRCweb	Databases of the internet site of the Geothermal Resources Council, www.geothermal.org .
Gri98a	Greider, R. (1998). Cost factors in geothermal production of electricity. <i>Geothermal Resources Council Bulletin</i> , January/February 1998, pp.14-17.
Hir00a	Hiriart, G., and J.I. Andaluz (2000). Strategies and economics of geothermal power development in Mexico. <i>Proceedings of the World Geothermal Congress 2000</i> , Kyushu-Tohoku, Japan, May 28 - June 10, 2000, v.2, pp.799-802.
Jen96a	Jenkins, A.F., R.A. Chapman, and H.E. Reilly (1996). Tax barriers to geothermal and other renewable generation technologies. <i>Geothermal Resources Council Transactions</i> , v.20, September/October 1996, pp.173-182.
Lig95a	Liguori, P.E. (1995) Economics of geothermal energy. <i>Proceedings of the World Geothermal Congress</i> , 1995, v.4, pp.2837-41. Table 1 - Initial hypothesis.

Mil96a	Miller, S.A. (1996). Incorporating economic and environmental externalities of geothermal and natural gas generation technologies. <i>Geothermal Resources Council Transactions</i> , v.20, September/October 1996, pp.187-193.
NBMGOF94-2	Nevada Bureau of Mines and Geology Open-File Report 94-2 (Nevada low-temperature geothermal resource assessment, by L. Garside) http://www.nbmq.unr.edu/dox/ofr94_2/942.htm
NBMGOG	Oil and gas well database of the Nevada Bureau of Mines and Geology: ftp://ftp.nbmq.unr.edu/pub/web/oil.htm .
NVDM or NVDIVMIN	Data files of the Nevada Division of Minerals, Carson City, NV. Geothermal well data that are reported to the Division become public 5 years after the completion date of the well. Much of this information is included in or listed in NVGEOWEL.
NVGEOWEL	Index to geothermal wells housed at the Nevada Bureau of Mines and Geology: ftp://ftp.nbmq.unr.edu/pub/web/nvgeowel.txt . Much of the original data listed in this index is also available at NVDM.
Owe02a	Owens, B. (2002). An economic valuation of a geothermal production tax credit. <i>Geothermal Resources Council Transactions</i> , v.26, September 22-25, 2002, pp.467-471.
Pet93a	Petty, S., and B. Livesay, (1993). Database of hydrothermal sites in the US with potential for electric power generation. Prepared for: National Renewable Energy Laboratory, Golden, Colorado. By: Susan Petty (Susan Petty Consulting) and Bill Livesay (Livesay Consultants, Inc.). March 23, 1993.
Pra82a	Prats, M. (1982). Thermal Recovery. <i>Society of Petroleum Engineers of AIME</i> , New York/Dallas.
She00a	Shevenell, L., L.J. Garside, and R.H. Hess (2000). Nevada Geothermal Resources (map at scale 1:1,000,000). Nevada Bureau of Mines and Geology Map 126.
Sif00a	Sifford, A., and R.G. Bloomquist (2000). Geothermal electric power production in the United States: a survey and update for 1995-1999. <i>Proceedings of the World Geothermal Congress 2000</i> , Kyushu - Tohoku, Japan, May 28 - June 10, 2000, pp.441-453.
SMUWGD	Southern Methodist University Western Geothermal Database: http://www.smu.edu/geothermal/georesou/usa.htm .
Ste02a	Stefánsson, V. (2002). Investment cost for geothermal power plants. <i>Geothermics</i> , v.31, pp.263-272.
Tia96a	Tiangco, V., P. McCluer, and E. Hughes (1996). Investigation of geothermal energy technologies and gas turbine hybrid estimates. <i>Geothermal Resources Council Transactions</i> , v.20, September/October 1996, pp.195-201.
USDOEGT ### date	U. S. Department of Energy Geothermal Technologies (newsletter), Volume/Issue, Month and year. (Note: this newsletter is occasionally released as an insert to the GRCB).
USGSC790	U. S. Geological Survey (1979). Assessment of Geothermal Resources of the United States - 1978. <i>Geological Survey Circular 790</i> . L.J.P. Muffler, Ed.
USGSOF79-1135	Nehring, N.L., R.H. Mariner, L.D. White, and others (1979). Sulfate Geothermometry of Thermal Waters in the Western United States. U. S. Geological Survey Open-File Report 99-425, Menlo Park, CA.
USGSOF99-425	U. S. Geological Survey Open-File Report 99-425: http://geopubs.wr.usgs.gov/open-file/of99-425/webmaps/home.html .
Whe95a	Wheble, J., and N. Islam (1995). Recent experience with BOO and BOT geothermal developments. <i>Proceedings of the World Geothermal Congress</i> , 1995, v.4, pp.2895-97.

Woo03a	Woodford, D. (2003). Deliverable D1.1.5: Report on AC Collector Grid Configuration and Options. Task 1.1.5: Investigate AC Collector Grid Configuration and Options. Project Team: Electranix Corp, Western Area Power Administration, Winfield Enterprise LLC. Project: Feasibility of Interconnecting to the Pacific HVDC Intertie. Part of the Hetch Hatchy/SFPUC Programmatic Renewable Energy Project. Preliminary and incomplete report - Nov.14th, 2003, by Project Contractor Electranix Corporation and Project Leader Dennis Woodford, and email of related transmission costing data from Woodford to GeothermEx, Dec.4, 2003.
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6.2 Project-specific references

Project-specific references contain data and information for specific project areas, and are linked to projects within the database using the reference code (REFS_ID).

Code	Description
Ada84a	Adams, M.C. (1984). Geochemistry of the Wendel-Amedee geothermal system, California. Geothermal Resources Council Transactions, v.8, pp.363-371, August 1984.
Bar76a	Barkman, J.H., D.A. Campbell, J.L. Smith, and R.W. Rex (1976). East Mesa – geology, reservoir properties and an approach to reserve determination. Proceedings, Second Workshop on Geothermal Reservoir Engineering, Stanford University, Stanford, California, December 1 - 3, 1976. SGP-TR-20, pp.116-125.
Bea01a	Beall, J.J., M.C. Adams, and J.L.B. Smith (2001). Geysers reservoir dry out and partial re-saturation evidenced by twenty-five years of tracer tests. Geothermal Resources Council Transactions, v.25, August 26-29, 2001, pp.725-729.
Bea85a	Beall, J.J. (1985). Exploration of a high temperature, fault localized, nonmeteoric geothermal system at the Sulphur Bank Mine, California. Geothermal Resources Council Transactions, v.9, part I, pp.395-401.
Ben82a	Benoit, W.R., J.E. Hiner, and R.T. Forest (1982). Discovery and geology of the Desert Peak geothermal field: a case history. Nevada Bureau of Mines and Geology, Bulletin 97, University of Nevada, Reno.
Ben84a	Benoit, W.R. (1984). Initial results from drill holes PLV-1 and PLV-2 in the western moat of the Long Valley Caldera. Geothermal Resources Council Transactions, v.8, pp.397-402.
Ben93a	Benoit, D., and D. Stock (1993). A case history of injection at the Beowawe, Nevada geothermal reservoir. Geothermal Resources Council Transactions, v. 17, October 10-13, 1993, pp. 473-480.
Ben94a	Benoit, D., and P. Hirtz (1994). Non-condensable gas trends and emissions at Dixie Valley, Nevada. Geothermal Resources Council Transactions, v. 18, pp.113-119.
Ben97a	Benoit, D. (1997). Injection-driven restoration of the Beowawe geothermal field. Geothermal Resources Council Transactions, v. 21, October 12-15, 1997, pp. 569-575.
Bir75a	Bird, D.K., and W.A. Elders (1975). Hydrothermal alteration and mass transfer in the discharge portion of the Dunes geothermal system, Imperial Valley of California, USA. Proceedings, Second United Nations Symposium on the Development and Use of Geothermal Resources, San Francisco, California, USA, 20-29 May, 1975, v. 1, pp.285-296.
Bla00a	Blackwell, D. D., B. Gollan, and D. Benoit (2000). Temperatures in the Dixie Valley, Nevada geothermal system. Geothermal Resources Council Transactions, v. 24, September 24-27, 2000, pp. 223-228.
Bla02a	Blackwell, D. D., M. Leidig, R. P. Smith, S. D. Johnson, and K. W. Wisian (2002). Exploration and development techniques for Basin and Range geothermal systems: examples from Dixie Valley, Nevada. Geothermal Resources Council Transactions, v. 26, September 22-25, 2002, pp. 513-518.
BLM00a	BLM (ND). Comment sought on proposed geothermal drilling in Mammoth Lakes area (Posted 10 June 2002). http://www.ca.blm.gov/bishop/geodrilling.htm

BLM01a	BLM (2001). Geothermal drilling in Mammoth Lakes area approved (For Release: February 22, 2001). http://www.ca.blm.gov/news/2002/02/nr/USFS_BLMnews_mammoth_geothermal
BLM02a	BLM (2002). BLM seeks comments on Geothermal Projects (For Release: 6 December 2001). http://www.ca.blm.gov/news/2001/12/nr/mammoth_geothermal
BLM76a	BLM (1976). Susanville Geothermal Investigations, California. Special Report, June 1976. United States Department of the Interior, Bureau of Reclamation, 67 pp., 11 plates.
BLM81a	BLM (1981). Proposed Competitive and Non-Competitive Leases for Geothermal Exploration / Development. Glamis/Dunes Draft Environmental Assessment. United States Department of the Interior, Bureau of Land Management, Riverside, California.
BLM98a	BLM (1998). Telephone Flat Geothermal Development Project, Draft, Environmental Impact Statement, Environmental Impact Report, Executive Summary. California State Clearinghouse Number 97052078. May 1998. U.S. Department of the Interior, Bureau of Land Management, Alturas Resource Area; U.S. Department of Agriculture, Forest Service, Modoc National Forest; U.S. Department of Energy, Bonneville Power Administration; Siskiyou County.
BLM98b	BLM (1998). Calpine - Fourmile Hill Geothermal Development Project - Environmental Impact Statement - Environmental Impact Report, Final EIS/EIR. State Clearinghouse Number 96062042. Executive Summary and Volumes 1 - 4. U.S. Department of the Interior, Bureau of Land Management, Alturas Resource Area; U.S. Department of Agriculture, Forest Service, Modoc National Forest; U.S. Department of Energy, Bonneville Power Administration; Siskiyou County. http://www.ca.blm.gov/alturas/nepa_pre-99.html
BLM99a	BLM (1999). Telephone Flat Geothermal Development Project, Environmental Impact Statement, Environmental Impact Report, Final. February 1999. U.S. Department of the Interior, Bureau of Land Management, Alturas Resource Area; U.S. Department of Agriculture, Forest Service, Modoc National Forest; U.S. Department of Energy, Bonneville Power Administration; Siskiyou County. SCH #97052078; DOI/FEIS-99-6; USFS/MDF/FEIS-99-6; DOE/EIS-0298. http://www.ca.blm.gov/alturas/telephone/index.html
Bro81a	Brook, C.A., and C.W. Mase (1981). The hydrothermal system at the East Brawley KGRA, Imperial Valley, California. Geothermal Resources Council Transactions, v.5, October 1981, pp.157-160.
Bro82a	Brook, C.A., Server, G.T., and Michelson, R.W. (1982). Definition of the South Brawley Known Geothermal Resources Area, Imperial County, California. U.S. Geological Survey, California KGRA Minutes No.39.
Bur72a	Bureau of Reclamation (1972). Geothermal Resource Investigations, Imperial Valley, California, January 1972. Developmental Concepts. Bureau of Reclamation.
Bur74a	Bureau of Reclamation (1974). Geothermal Resource Investigations, East Mesa Test Site, Imperial Valley, California. Status Report November 1974. U.S. Bureau of Reclamation, Lower Colorado Region.
CDC02a	CDCDOGGR (2002). 2001 Annual Report of the State Oil and Gas Supervisor. California Department of Conservation, Division of Oil, Gas and Geothermal Resources. Publication No. PR06.
CDC02b	CDCDOGGR (2002). Well location and status map G2-3. Imperial County, Brawley. Scale 1:20,000. California Department of Conservation, Division of Oil, Gas and Geothermal Resources. June 1, 2002.
CDC02c	CDCDOGGR (2002). Well location and status map G2-2 Imperial County, Salton Sea (south half) Scale 1:20,000. California Department of Conservation, Division of Oil, Gas and Geothermal Resources. June 1, 2002.
CDM80a	CDMG (1980). Geothermal Resources of California (map at scale 1:750,000). California Geologic Data Map Series, Map No.4. California Divisions of Mines and Geology.

CDM83a	CDMG (1983). Technical Map of the Geothermal Resources of California (map at scale 1:750,000). California Geologic Data Map Series, Map No.5. Compiled by H.H. Majmundar. California Divisions of Mines and Geology.
CEC86a	California Energy Commission (1986). Calistoga Geothermal Resource Assessment, Final. Staff Report P500-86-017. Contract No. 912-82-051. Development Division, Research and Development Office. Kent S. Murray, Author. October 1986. (Available on CD ROM from the CEC.)
Ced81a	Cedillo, R., and R.N. Yamasaki (1981). The Brawley 10 MWe power plant, Unit 1. Geothermal Resources Council Transactions, v.5, October 1981, pp.397-399.
CEO02a	CE Obsidian Energy, LLC (2002). Application for Certification of Salton Sea Unit 6. Submitted to the California Energy Commission, 22 July 2002.
Com80a	Combs, J. (1980). Heat flow in the Coso geothermal area, Inyo County, California. Journal of Geophysical Research, v. 85, n. B5, pp. 2411-2424.
Com95a	Combs, J., F.C. Monastero, K. R. Bonin, Sr., and D.M. Meade (1995). Geothermal exploration, drilling and reservoir assessment for a 30 MW power project at the Naval Air Station, Fallon, Nevada, USA. Proceedings of the World Geothermal Congress 1995, v.2, pp.1371-1375.
Cop74a	Coplen, T.B., and P. Kolesar (1974). Investigations of the Dunes Geothermal Anomaly, Imperial Valley, California: Part 1. Geochemistry of Geothermal Fluids. Institute of Geophysics and Planetary Physics, University of California, Riverside, California 92592. IGPP-UCR-74-18.
Cra87a	Crane, G., and H. Ben Chu (1987). Lessons learned from the Brawley geothermal pilot plant program. Proceedings, Tenth Annual Geothermal Conference and Workshop. Electric Power Research Institute (EPRI), Palo Alto, California. pp.9-23 to 9-34. EPRI AP-5059-SP.
DOE02a	U.S. Department of Energy (2002). Update on geothermal resource exploration and definition program (new GRED II projects). In: Geothermal Technologies, U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, v.7, issue 4, December 2002. Contained in: Geothermal Resources Council Bulletin, v.31, n.6, November/December 2002.
Duf80a	Duffield, W. A., C. R. Bacon, and G. B. Dalrymple (1980). Late Cenozoic volcanism, geochronology, and structure of the Coso Range, Inyo County, California. Journal of Geophysical Research, v. 85, n. B5, pp. 2381-2404.
Eba03a	Ebasco Services (1991). Assessment of the Electrical Generating Capacities of Liquid Dominated Geothermal Fields in California. Final Report. Report for the California Energy Commission under WA 83-B-91 of Technical Assistance Contract 500-89-001, 25 November 1991.
Edm84a	Edmiston, R.C., and W.R. Benoit (1984). Characteristics of Basin and Range geothermal systems with fluid temperatures of 150°C to 200°C. Geothermal Resources Council Transactions, v.8, pp.417-424.
Eld83a	Elders, W.A., and L.H. Cohen (1983). The Salton Sea Geothermal Field, California, as a Near-Field Natural Analog of a Radioactive Waste Repository in Salt. Technical report. Institute of Geophysics and Planetary Physics, University of California, Riverside. Prepared for Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH. BMI/ONWI-513. Distribution Category UC-70.
EPA02a	U.S. Environmental Protection Agency (2002). Sulphur Bank mercury mine. http://www.yosemite.epa.gov/rq/sfund/overview.nsf
Ett92a	Ettinger, T., and J. Brugman (1992). Brady Hot Springs geothermal power plant. Geothermal Resources Council Bulletin, August 1992, pp.258-260.
Fai00a	Fairbank Engineering Ltd. (2000). Report on the Blue Mountain Geothermal Area, Humboldt County, Nevada. By: Fairbank Engineering Ltd. 570-589 West Pender Street, Vancouver, BC. V6C 1H2. October 31, 2000. For: NORAMEX Corp., 1535 East Lake Boulevard, Carson City, NV, 89704. Submitted to U.S. DOE Geothermal Resource Exploration & Definition Program.

Fai02a	Fairbank Engineering Ltd. (2002). Blue Mountain Geothermal Project, Deep Blue No.1 Test Hole, Blue Mountain, Humboldt County, Nevada, USA. Cooperative Agreement No. DE-FC04-00AL66972, Geothermal Resource Exploration & Definition Program. Prepared for: U.S. Department of Energy, Albuquerque Operations Office, P.O. Box 5400, Albuquerque, NM 87185-5400. By: NORAMEX Corporation, 1535 East Lake Boulevard, Carson City, NV 89704.
Fai99a	Fairbank, B.D., and H.P. Ross (1999). Geology and temperature gradient surveys, Blue Mountain geothermal discovery, Humboldt County, Nevada. Geothermal Resources Council Transactions, October 17-20, 1999, v.23, pp.513-517.
Far85a	Farrar, C., M.L. Sorey, S.A. Rojstaczer, C.J. Janik, R.H. Mariner, T.L. Winnett, and M.D. Clark (1985). Hydrologic and geochemical monitoring in Long Valley caldera, Mono County, CA, 1982-1984. U.S. Geological Survey Water Resources Investigations Report 85-4183, 137 pp.
Fau97a	Faulder, D. D., S. D. Johnson, and W. R. Benoit (1997). Flow and permeability structure of the Beowawe, Nevada hydrothermal system. Proceedings, Twenty-second Workshop on Geothermal Reservoir Engineering, Stanford University, Stanford, California, January 27 - 29, 1997. SGP-TR-155, pp. 63-73.
FLG03a	FLGPC (Fish Lake Green Power Company) (2003). Letter from J. Deymonaz, FLGPC, to J. Lovekin, GeothermEx, with respect to Fish Lake, Emigrant and Silver Peak geothermal projects, January 13, 2003.
FLG03b	FLGPC (Fish Lake Green Power Company) (2003). Computer spreadsheet of minerals exploration and temperature gradient hole data and information. Personal communication from J. Deymonaz, January 2003.
For95a	Forrest, R.T., S.E. Johnson, and S.D. Johnson (1995). An injection turnabout success at Stillwater, Nevada. Geothermal Resources Council Transactions, v.19, pp.485-491.
Fou80a	Fournier, R. O., J. M. Thompson, and C. F. Austin (1980). Interpretation of chemical analyses of waters collected from two geothermal wells at Coso, California. Journal of Geophysical Research, v. 85, n. B5, pp. 2405-2410.
Gal90a	Gallup, D.L., G.R. Anderson and D. Holligan (1990). Heavy metal sulfide scaling in a production well at the Salton Sea geothermal field. Geothermal Resources Council Transactions, v.14, part II, August 1990, pp.1583-1590.
Gar02a	Garside, L.J., L.A. Shevenell, J.H. Snow, and R.H. Hess (2002). Status of Nevada geothermal resource development - spring 2002. Geothermal Resources Council Transactions, v.26, September 22-25, 2002, pp.527-532.
Gar79a	Garside, L.J., and J.H. Schilling (1979). Thermal Waters of Nevada. Nevada Bureau of Mines and Geology, Bull. 91, Mackay School of Mines, University of Nevada, Reno, 163 pp., 1 plate.
Gar94a	Garside, L. (1994). Nevada Low-temperature Geothermal Resource Assessment. Nevada Bureau of Mines and Geology, Open-File Report 94-2. http://www.nbmge.unr.edu/942.htm
Gib84a	Gibbs & Hill, Inc. (1984). Heber Double-Flash Geothermal Power Plant - A Fast Track Project. Reprinted from Proceedings, Eighth Annual Geothermal Conference and Workshop, Electric Power Research Institute (EPRI).
Gof95a	Goff, F., C.J. Janik, and J.A. Stimac (1995). Sulphur Bank mine, California: an example of a magmatic rather than metamorphic hydrothermal system. Proceedings of the World Geothermal Congress, 1995, v.II, pp.1105-1110.
Gol76a	Goldstein, N.E., H. Beyer, R. Corwin, D.E. di Somma, E. Majer, T.V. McEvilly, and others (1976). Open-file Report Geoscience Studies in Buena Vista Valley, Nevada. Lawrence Berkeley Laboratory, University of California, Berkeley. LBL-5913, UC-66b, TID-4500-R65. December 1976, 41 pp.
Gol79a	Goldstein, N.E., and B. Paulsson (1979). Interpretation of gravity surveys in Grass and Buena Vista Valleys, Nevada. Geothermics, v.7, pp.29-50.
Gol86a	Goldstein, N.E., and S. Carle (1986). Faults and gravity anomalies over the East Mesa hydrothermal-geothermal system. Geothermal Resources Council Transactions, v.10, September 1986, pp.223-228.

GPO02a	GPO (Geothermal Program Office) (2002). An Evaluation of the Geothermal Resource Potential at HWAD, Hawthorne, Nevada. Geothermal Program Office, Naval Air Weapons Station (NAWS), China Lake, CA, November 2002. (presentation in Microsoft PowerPoint)
GPO93a	GPO (Geothermal Program Office) (1993). Geothermal power generation at Coso Hot Springs. Originally published as Coso Geothermal Development (GPO brochure, TS 93-65), Geothermal Program Office, Naval Air Warfare Center, Weapons Division (NAWCWD), China Lake, CA. http://www.nawcwpns.navy.mil/techtransfer/whitpaps/geotherm.htm
GRI81a	GRI (Geothermal Resources International, Inc.) (1981). Final Report, Darrough Hot Springs Prospect, Nevada, GTS Job No.9-81. In public files at Idaho National Engineering Laboratory (INEL). Report of logging hole D1803. INEL files also include drilling log, lithologic log and misc. copies of temperature surveys.
Hel68a	Helgeson, H.C. (1968). Geologic and thermodynamic characteristics of the Salton Sea geothermal system. <i>American Journal of Science</i> , v.266, March 1968, pp.129-166.
Hes01A	Hess, R. H. (2001). Geothermal energy. http://unr.edu/homepage/rhess/geotherm00.pdf
Hil79a	Hill, D.G., E.B. Layman, C.M. Swift and S.H. Yungal (1979). Soda Lake, Nevada, thermal anomaly. <i>Geothermal Resources Council Transactions</i> , v.3, pp. 305-308.
Hod79a	Hodder, D.T., J. Green, P.S. Chandler, and K.E. Mathias (1979). An extension of the Mono-Bodie KGRA by combined geostatistical satellite photogeologic analysis. <i>Geothermal Resources Council Transactions</i> , v.3, September 1979, pp.313-316.
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7 Glossary

7.1 Database data abbreviations and definitions

The following table is also available in the PIER Geothermal Database, at the command button Abbreviations and Definitions.

Abbreviation	Definition
AMT	Audio-MagnetoTelluric resistivity survey. A method of geophysical exploration at the land surface that determines resistivity within the earth.
BL (or bl)	Blank well liner (no slots) (uncemented unless otherwise annotated)
BLM or USBLM	United States Bureau of Land Management
CADOGGR	California Division of Oil, Gas and Geothermal Resources
Energy Commission or CEC	California Energy Commission (the abbreviation CEC is used in the database only, not in narrative sections of the final report.)
CSAMT	Controlled-Source Audio-MagnetoTelluric resistivity survey. A method of geophysical exploration at the land surface that determines resistivity within the earth.
Csg	Well casing (cemented)
DC (Resistivity)	Direct Current. In reference to any one of several types of DC resistivity surveys (e.g. Dipole, roving dipole, Schlumberger). A method of geophysical exploration at the land surface that determines resistivity within the earth.
GCS	Geothermal Cost Survey, conducted by the California Energy Commission in 1993.
HFU	Heat Flow Units (1 HFU = 10^6 calories per $\text{cm}^2\text{-sec.}$). A measurement of heat flow from the earth.
ID	Intermediate Depth or Internal Diameter (used to describe the design of a well)
ID Slim	Intermediate-Depth Slim hole. In this database, loosely refers to a hole with TD greater than 2,000 ft (see further), but too narrow to support a commercial level of flow if permeability is encountered. Such a hole may or may not have been designed to allow injection tests or flow tests. TD may reach 4,000 to 5,000 ft, but is rarely deeper. Includes deep core holes, relatively deep TG (temperature gradient) holes, and so-called "Strat Tests" (stratigraphy tests). At some projects, a hole or a set of holes between 1,000 and 2,000 ft deep has been classified as ID Slim, if other holes in the same area are all decidedly shallower (say, $=<500$ ft). This is because exploration often starts with drilling holes that are a maximum 500 ft deep (for cost and regulatory reasons), then later (at selected targets) includes holes that are 1,000 to 2,000 ft deep. In addition, a set of holes may be classified as ID Slim holes, even if it includes some that are less than 1,000 ft deep, if the number of deeper holes in the set is regarded as significant, and there is no particular reason to separately classify and describe the shallower holes in the set. See also the definition of TG hole.
INEL/INEEL	Idaho National Engineering Laboratory. Later renamed to Idaho National Engineering and Environmental Laboratory
ISO	Isothermal (used to refer to a condition of constant temperature between two different levels in the subsurface (in a reservoir)).

KGRA	Known Geothermal Resource Area (Per Section 4 of the Federal Geothermal Steam Act). An area designated by the USGS as having potential for beneficial exploitation of the geothermal resource suspected to exist in the area.
LC	Lost Circulation (loss of drilling fluid circulation during drilling). Indicates that drilling fluid must be entering the formation.
Lith	Lithology (the kind of rock drilled by a well or exposed at the land surface)
LLNL	Lawrence Livermore National Laboratory
Max	Maximum (referring to the maximum value of an estimate)
Min	Minimum (referring to the minimum value of an estimate). In the case of generation capacity, this refers to the Monte Carlo estimate with a cumulative probability of 90% (see Appendix III).
Mlk	Most-likely (referring to the most-likely value of an estimate). In the case of generation capacity, this refers to the Monte Carlo most-frequently estimated value (see Appendix III for how this is determined.)
msl	Mean sea level (elevation above or below)
MT	MagnetoTelluric resistivity survey. A method of geophysical exploration at the land surface that determines resistivity within the earth.
N or Note	Refers to a numbered comment in the same record
N/A	Not Applicable or Not Available
OH	Open Hole. The bottom portion of a well, which is not cased (lined with cemented casing) or lined (lined with uncemented casing). Some wells may not have any open hole, particularly if lined at the bottom with a slotted liner.
P&A	Plugged and Abandoned (said of a well)
PB or pb	Plugged Back. A drilling operation in which the lower-most portion of a well is plugged back to some specified level.
PIER	Public Interest Energy Research. A program of the California Energy Commission.
power density	Generation capacity expressed as MW/square mile.
PZ	Permeable Zone or Production Zone. A depth zone in a well that is permeable (can receive or give fluid to the formation), or produces fluid to the wellhead.
RD	Re-drill (of a well), usually following the development of mechanical problems or scale deposition. Usually involves plugging the well at some level and "kicking-off" to establish a new hole adjacent to the abandoned portion.
SFPUC	San Francisco Public Utilities Commission
SIWHP	Shut-in wellhead pressure. The wellhead pressure of a well that is shut-in (not flowing).
SL (or sl)	Slotted well liner (uncemented unless otherwise annotated)
SP (or ESP)	(Electrical) Self-Potential survey. A type of geophysical survey at the land surface that measures rock properties in the subsurface.
T	Temperature. All temperatures in the PIER Geothermal Database are expressed in degrees Fahrenheit.
TD	Total Depth or Total Discharge. With respect to total depth, used herein to refer to drilled depth, which is greater than the true vertical depth (TVD) in a deviated well.

TDEM	Time-Domain ElectroMagnetic survey. A method of geophysical exploration at the land surface that determines resistivity within the earth.
TDS	Total Dissolved Solids
TG	Temperature gradient. The relationship between temperature and depth, moving downwards in the earth. Expressed in this database as °F/100ft.
TG hole	Temperature-gradient hole. In this database, loosely refers to a hole less than 1,000 ft deep, drilled only (or primarily) to measure temperature gradient and not designed for flow tests. Most often equal to or less than 500 ft deep but occasionally in the range 1,000 to 2,000 ft. Most TG holes deeper than 1,000 ft have been classified herein as ID Slim holes (see), to distinguish them from shallower holes usually drilled during an earlier phase of exploration.
TMF	Total mass flow. The combined flow of water and steam from a well.
TVD	True vertical depth. Used to distinguish elevation difference, as opposed to drilled distance, in a deviated hole.
USBLM or BLM	United States Bureau of Land Management
USGS (or U.S.G.S.)	United States Geological Survey
WHP	Wellhead pressure

Figures

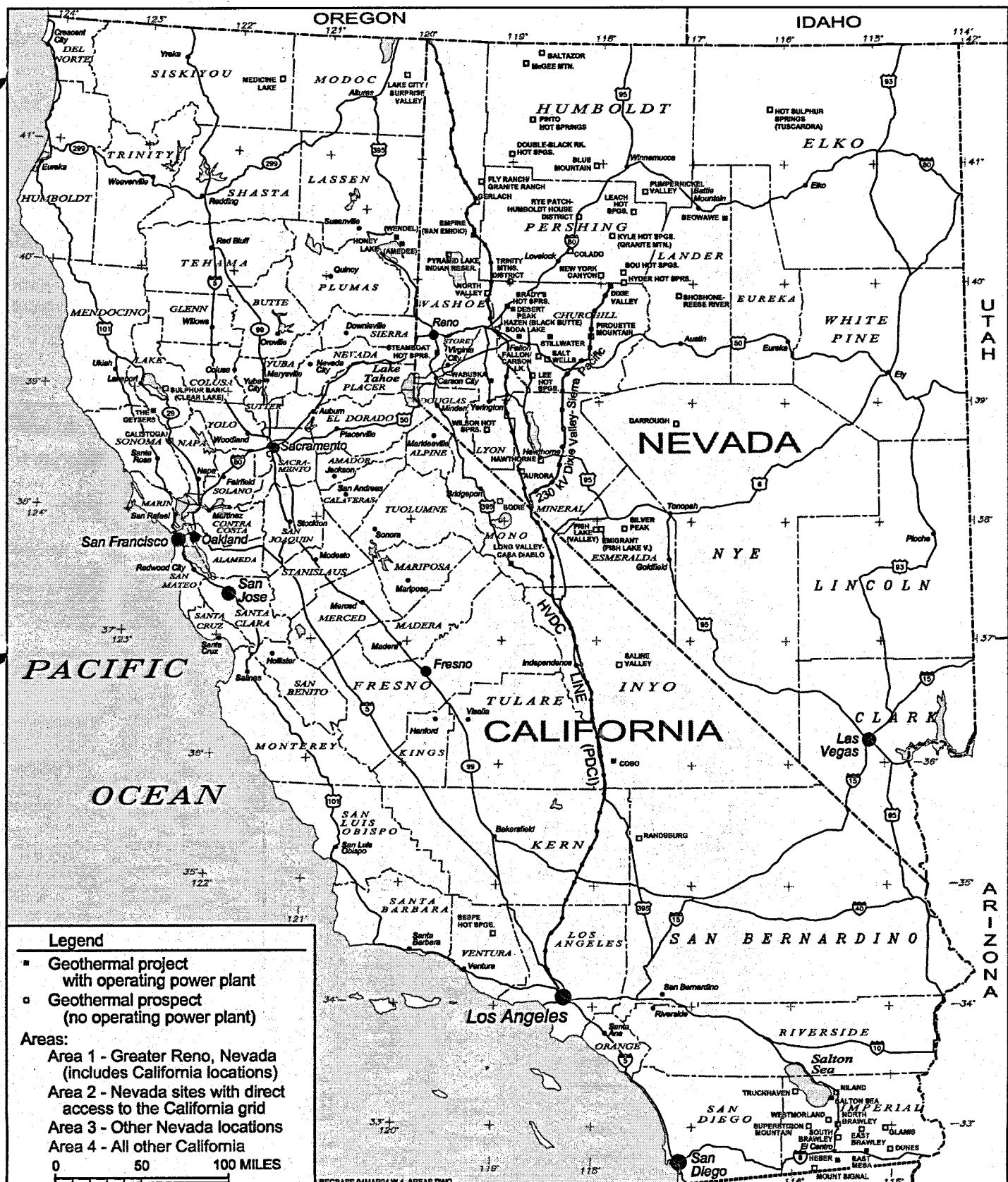


Figure 1: Locations of geothermal resource areas

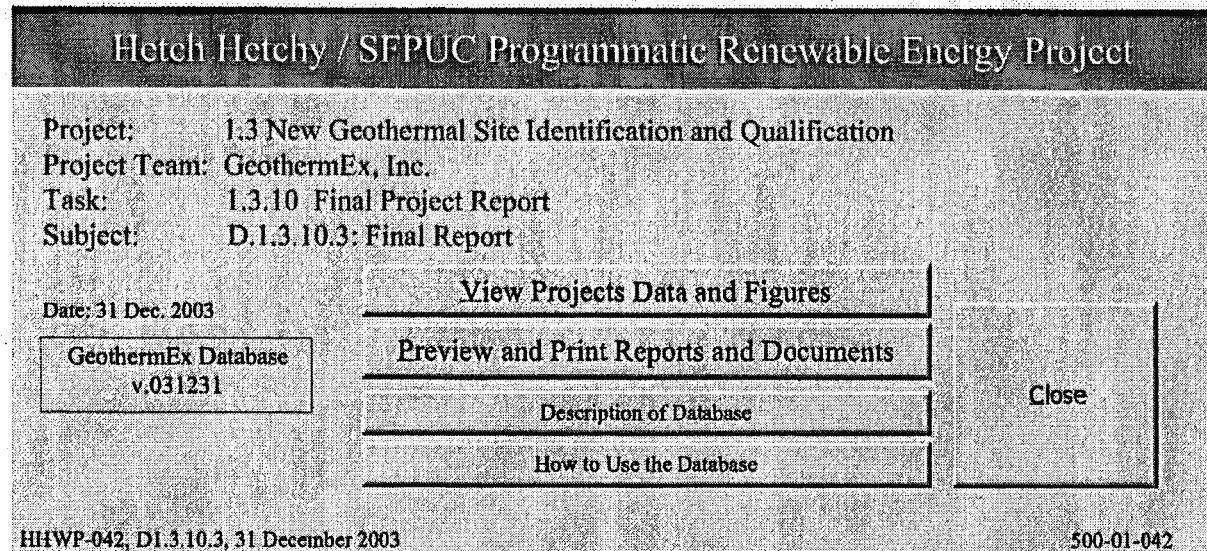


Figure 2: Startup window for PIER Geothermal Database in MS Access©

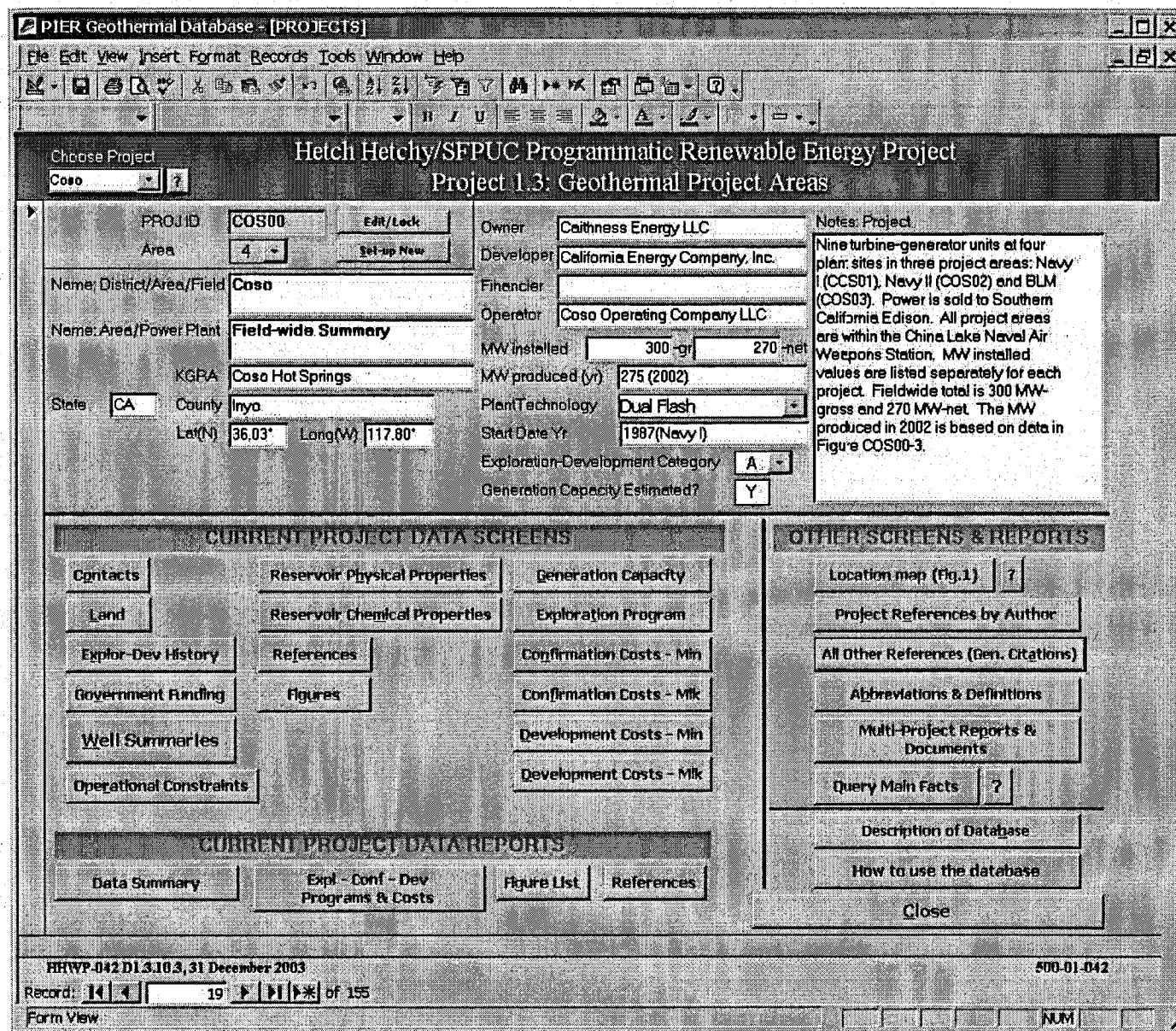


Figure 3: “PROJECTS” window (example) from PIER Geothermal Database in MS Access©

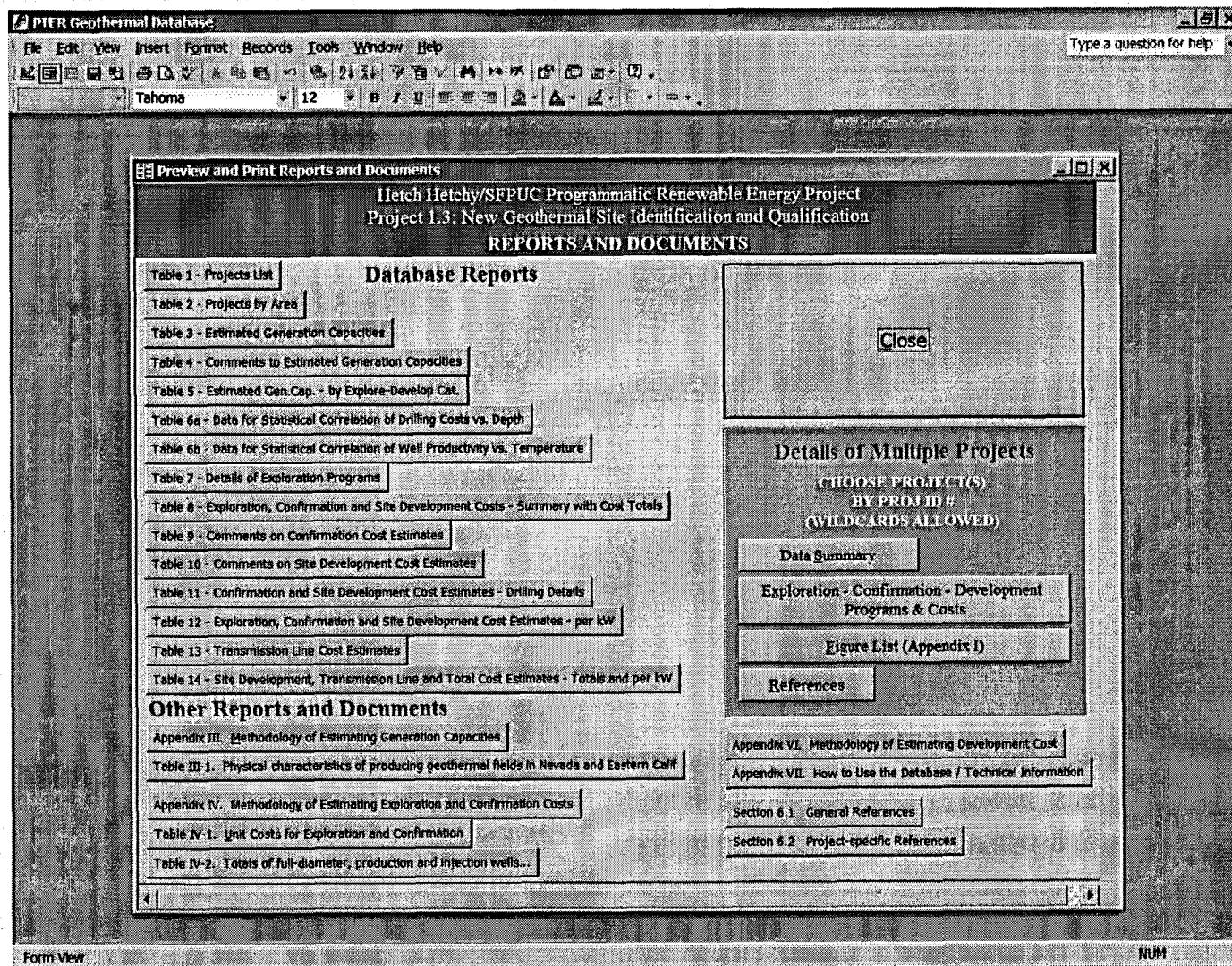


Figure 4: "REPORTS AND DOCUMENTS" window from the PIER Geothermal Database in MS Access©

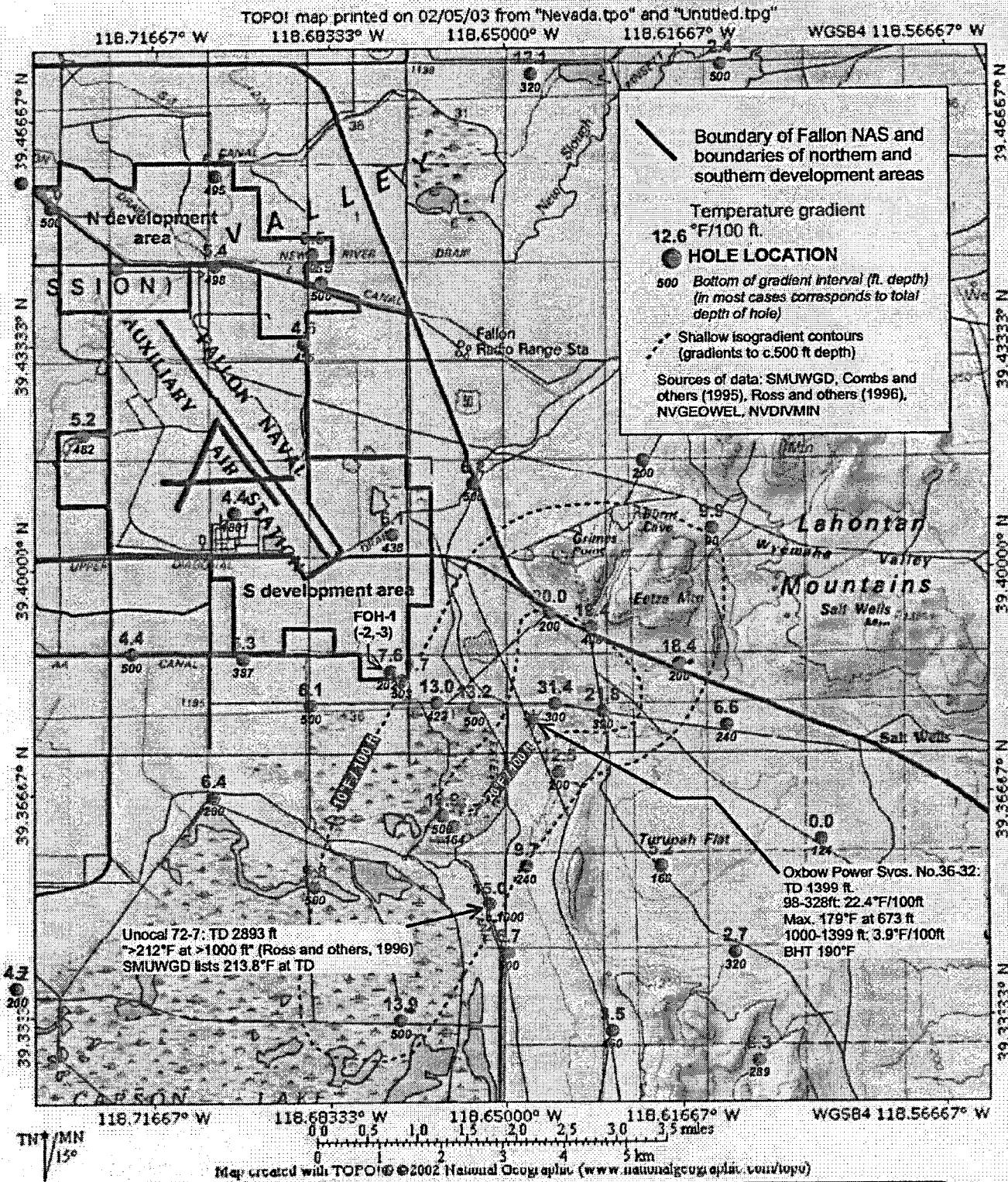
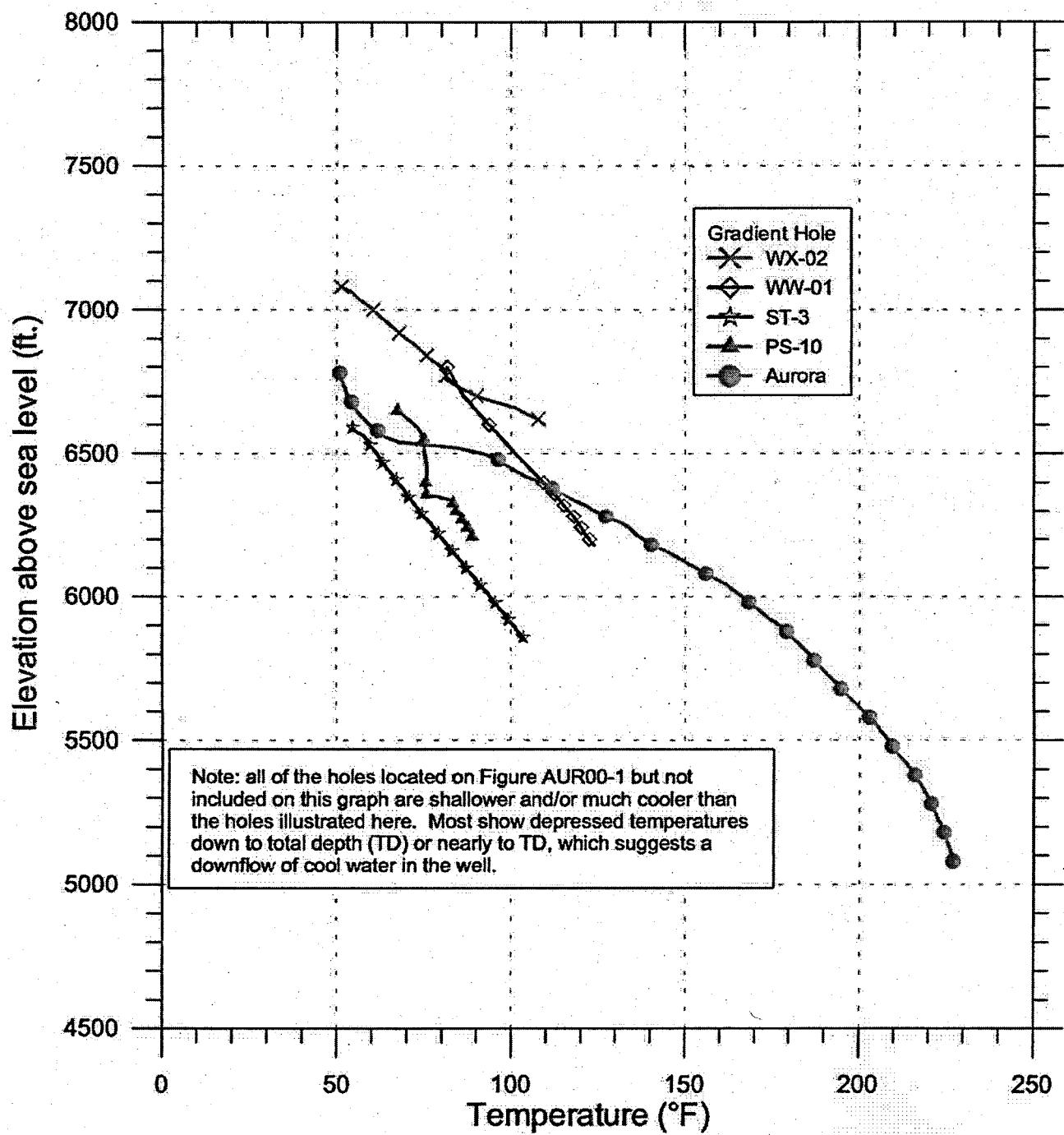


Figure 5: Local site area map (example)



Source of data: USGSOF99-425

Figure 6: Local site downhole temperature graph (example)

SUMMARY OF INPUT PARAMETERS

Variable Parameters

	Minimum	Most Likely	Maximum
Reservoir Area (sq. mi.)	1.7	3.4	5.1
Reservoir Thickness (ft)	2500	3500	4500
Rock Porosity	0.03		0.07
Reservoir Temperature (°F)	340		380
Recovery Factor	0.05		0.20

Fixed Parameters

Rock Volumetric Heat Capacity	39.0	BTU/cu. ft°F
Rejection Temperature	50	°F
Utilization Factor	0.45	
Plant Capacity Factor	0.90	
Power Plant Life	30	years

RESULTS

	Statistics		
	MW	MW/sq. mi.	Recovery Efficiency
Mean	62.40	18.39	1.23%
Std. Deviation	26.82	6.84	0.43%
Minimum (90% prob.)	30.14	9.43	0.64%
Most-likely (Modal)	46.95	12.90	0.83%

Figure FIS00-2:
Probabilistic Calculation of Geothermal Energy Reserves
FISH LAKE VALLEY, NEVADA

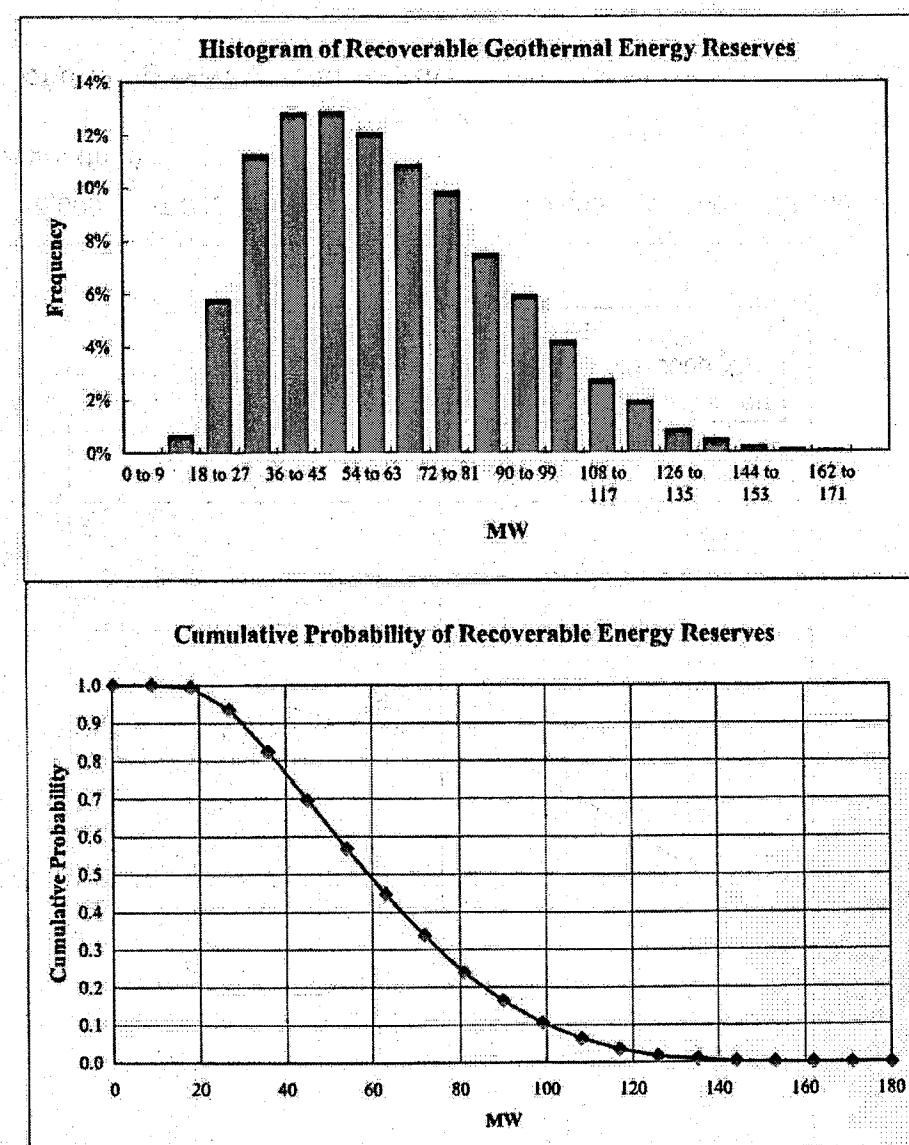


Figure 7: Probabilistic calculation of geothermal energy reserves (example)

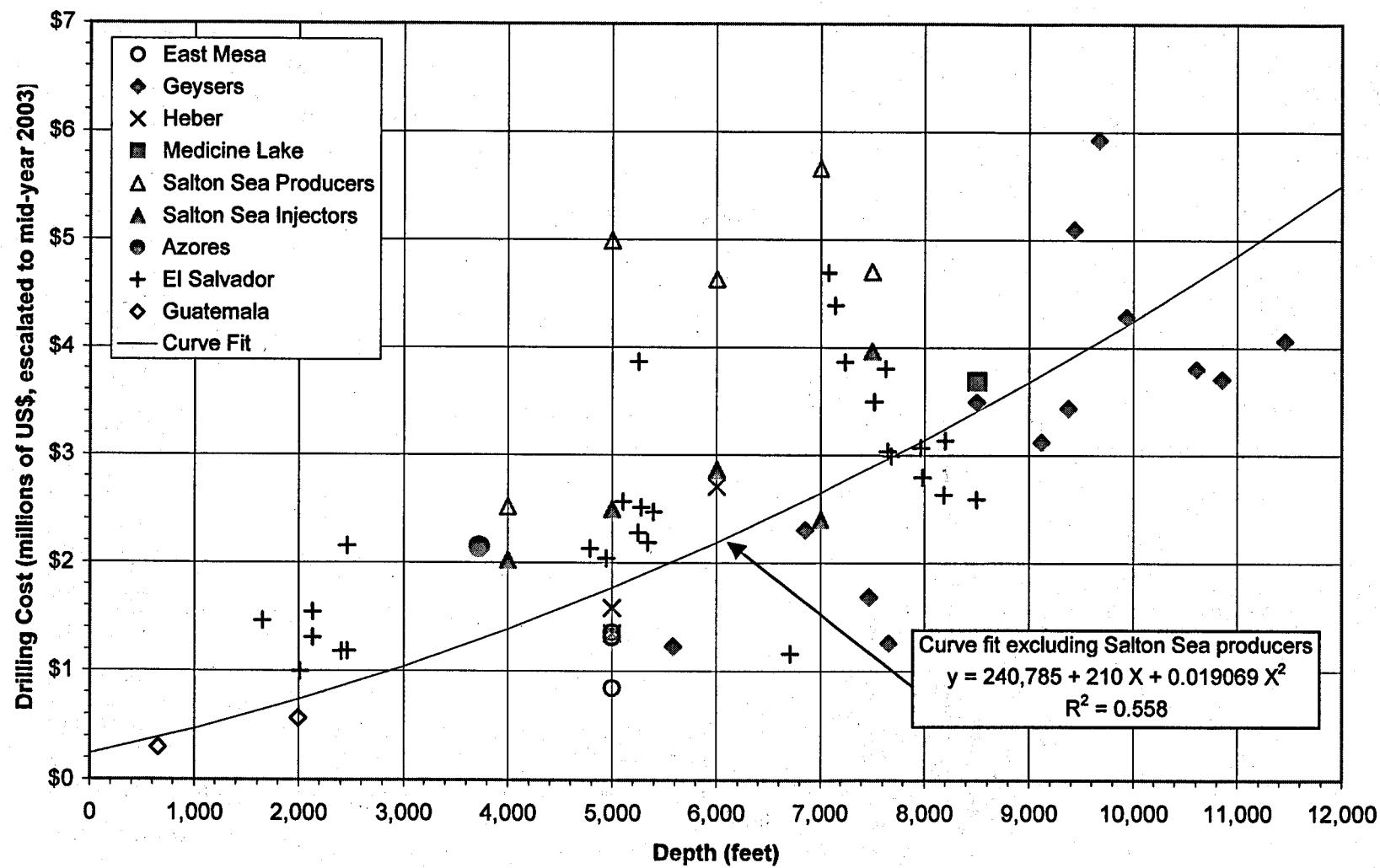


Figure 8. Correlation of drilling cost vs. well depth

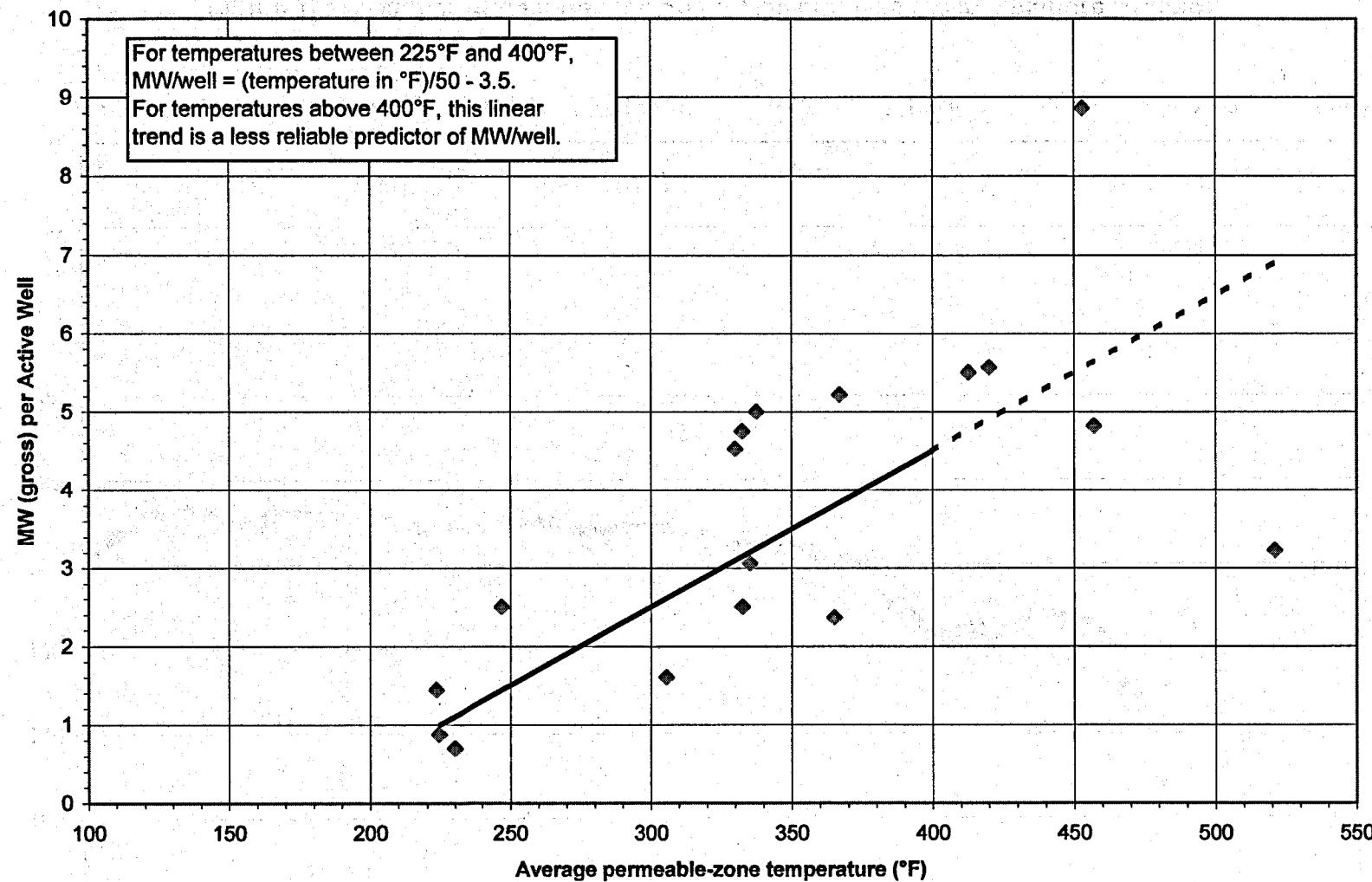


Figure 9: Correlation of well productivity vs. production-zone temperature

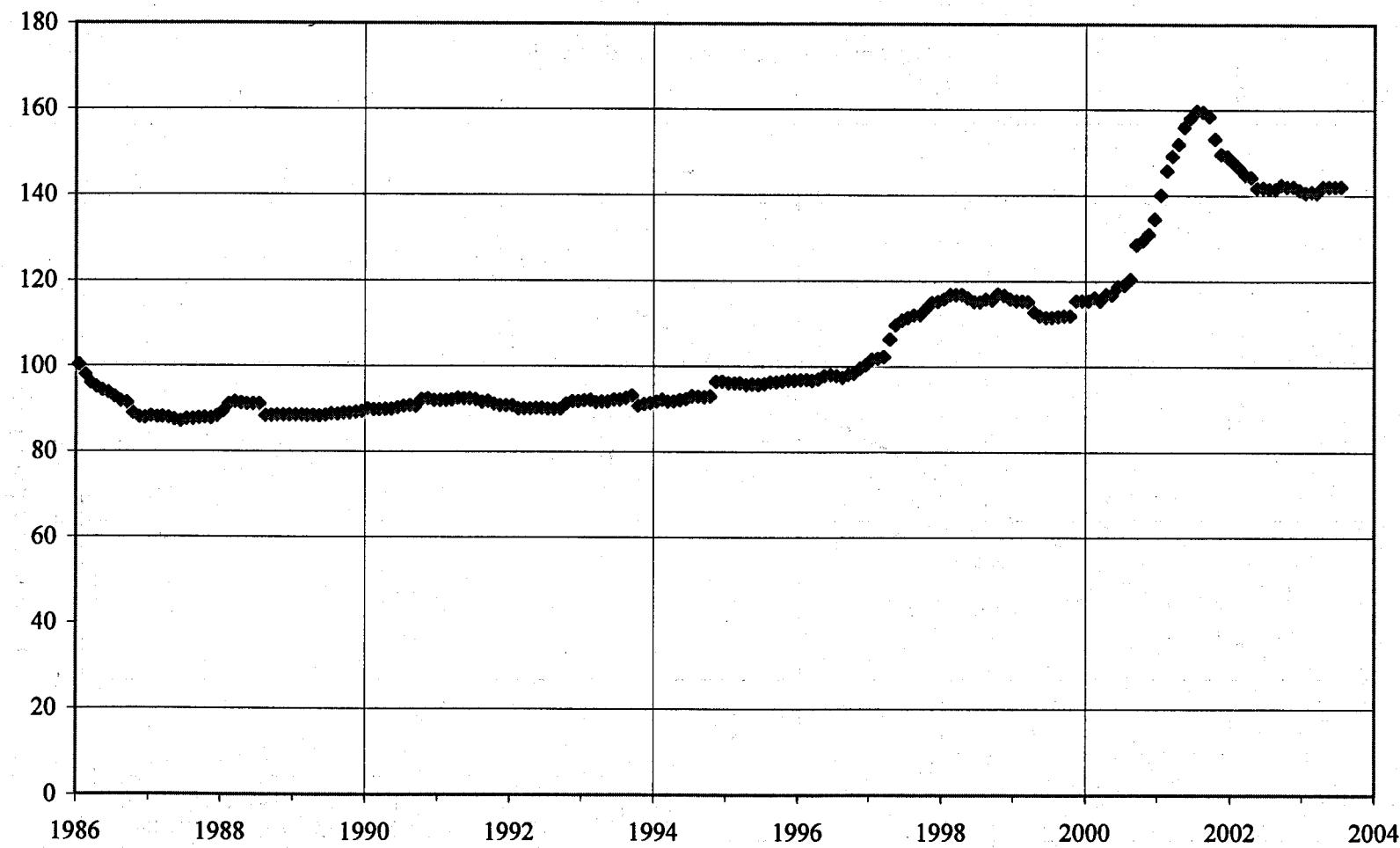


Figure 10: Producer Price Index for Drilling Oil and Gas Wells (Onshore Drilling)

Tables

Hetch Hetchy/SFPUC Programmatic Renewable Energy Project
Project: 1.3 New Geothermal Site Identification and Qualification
Project Team: GeothermEx, Inc.
Task: 1.3.10 Final Project Report
Subject: D.1.3.10.3 Final Report

Table 1: Projects List

PROJID	Name: Field/District	Name: Area/Power Plant	KGRA	Area⁽¹⁾	State	County	Lat	Long	Expl-Dev. Cat.⁽²⁾	Gen.Cap. Estimated
ADO00	Adobe Valley	(Granite Springs V. - N. End)		1	NV	Pershing	40.22	118.92	D	N
ANT00	Antelope Valley			3	NV	Churchill	39.83	117.50	D	N
AUR00	Aurora			2	NV	Mineral	38.35	118.82	C	Y
BAL00	Baltazor	Baltazor		3	NV	Humboldt	41.92	118.72	C	Y
BAT00	Battle Mountain			1	NV	Humboldt	40.77	117.21	D	N
BEO00	Beowawe	Beowawe		1	NV	Eureka-Lander	40.55	113.62	A	Y
BIG00	Big Smokey Valley	N.End - Spencer Hot Springs		3	NV	Lander	39.33	116.83	D	N
BLA00	Black Rock Desert			1	NV	Humboldt				N
BLU00	Blue Mountain			1	NV	Humboldt	41.00	118.13	C	Y
BOD00	Bodie	Bodie		4	CA	Mono	38.16	119.11	D	N
BRA00	Brady's Hot Springs	Brady-Hazen		1	NV	Churchill	39.80	119.00	A	Y
BRW00	Brawley	Area-wide summary	Brawley	4	CA	Imperial	32.99	115.52	B	N
BRW01	Brawley	Brawley (North Brawley)	Brawley	4	CA	Imperial	33.00	115.53	B	Y
BRW02	Brawley	East Brawley		4	CA	Imperial	32.99	115.35	B	Y
BRW03	Brawley	South Brawley (Mesquite field)		4	CA	Imperial	32.96	115.54	B	Y
CAL00	Calistoga	Geysers-Calistoga		4	CA	Napa	38.58	122.58	C	Y
CAR00	Carson Sink			1	NV	Churchill			D	N
COL00	Colado	Colado		1	NV	Pershing	40.23	118.37	C	Y
COS00	Coso	Field-wide Summary	Coso Hot Springs	4	CA	Inyo	36.03	117.80	A	Y

PROJID	Name: Field/District	Name: Area/Power Plant	KGRA	Expl-Dev. Gen.Cap.						
				Area ⁽¹⁾	State	County	Lat	Long	Cat. ⁽²⁾	Estimated
COS01	Coso	Navy I	Coso Hot Springs	4	CA	Inyo	36.03	117.80	A	N
COS02	Coso	Navy II	Coso Hot Springs	4	CA	Inyo	36.03	117.80	A	N
COS03	Coso	BLM	Coso Hot Springs	4	CA	Inyo	36.03	117.80	A	N
COS04	Coso	Northeast frontier	Coso Hot Springs	4	CA	Inyo	36.03	117.80	D	N
DAR00	Darrough Hot Springs	(Big Smokey Valley - S.End)	Darrough Hot Springs	3	NV	Nye	38.82	117.18	C	N
DES00	Desert Peak		Brady-Hazen	1	NV	Churchill	39.76	118.92	A	Y
DIX00	Dixie Valley	Caithness Dixie Valley	Dixie Valley	2	NV	Churchill	39.99	117.85	A	Y
DIX01	Dixie Valley	Dixie Valley Power Partners (DVPP)		2	NV	Churchill	39.99	117.85	C	Y
DOU00	Double - Black Rk Hot Springs		Double Hot Springs	3	NV	Humboldt	41.05	119.03	D	Y
DRY00	Dry Lake			1	NV	Pershing	39.37	116.83	D	N
DUN00	Dunes		Dunes	4	CA	Imperial	32.80	115.01	C	Y
DYK00	Dyke Hot Springs			3	NV	Humboldt	41.57	118.57	D	N
EAS00	East Mesa	Field-wide summary	East Mesa	4	CA	Imperial	32.78	115.25	A	Y
EAS01	East Mesa	Ormesa 1	East Mesa	4	CA	Imperial	32.78	115.25	A	N
EAS02	East Mesa	Ormesa 1E	East Mesa	4	CA	Imperial	32.78	115.25	A	N
EAS03	East Mesa	Ormesa 1H		4	CA	Imperial	32.78	115.25	A	N
EAS04	East Mesa	Ormesa 2 (or II)	East Mesa	4	CA	Imperial	32.78	115.25	A	N
EAS05	East Mesa	Geo East Mesa (GEM) I	East Mesa	4	CA	Imperial	32.78	115.25	A	N
EAS06	East Mesa	Geo East Mesa (GEM) 2-3	East Mesa	4	CA	Imperial	32.78	115.25	A	N
ELE00	Eleven Mile Canyon			2	NV	Churchill	39.42	118.24		N
EMI00	Emigrant (Fish Lake V.)			2	NV	Esmeralda	37.86	117.87	C	Y
EMP00	Empire (San Emidio)	Field-wide summary	San Emidio Desert	1	NV	Washoe	40.38	119.40	A	Y
EMP01	Empire (San Emidio)	Empire Energy	San Emidio Desert	1	NV	Washoe	40.38	119.40	A	N
EMP02	Empire (San Emidio)	Empire Foods	San Emidio Desert	1	NV	Washoe	40.38	119.40	B	N
EXC00	Excelsior			2	NV	Mineral	38.31	118.56		N
FAL00	Fallon / Carson Lake	Carson Lake anomaly		1	NV	Churchill	39.38	118.65	C	Y

PROJID	Name: Field/District	Name: Area/Power Plant	KGRA	Area ⁽¹⁾	State	County	Lat	Long	Expl-Dev. Gen. Cap.	
									Cat. ⁽²⁾	Estimated
FAL01	Fallon / Carson Lake	Fallon Naval Air Station		1	NV	Churchill	39.38	118.65	C	N
FIR00	Fireball Ridge			1	NV	Churchill	39.92	119.07	D	N
FIS00	Fish Lake (Valley)			2	NV	Esmeralda	37.86	118.05	B	Y
FLY00	Fly Ranch/Granite Ranch	Ward's (Fly/Hualapi Flat) H.S.	Fly Ranch	1	NV	Washoe-Pershing	40.86	119.32	C	Y
FLY01	Fly Ranch/Granite Ranch	Granite Ranch		1	NV	Washoe-Pershing	40.86	119.32	C	Y
FOX00	Fox Mountain			3	NV	Washoe	41.02	119.56	C	N
GER00	Gerlach	(Great Boiling Spring)	Gerlach	1	NV	Washoe	40.66	119.37	C	Y
GEY00	Geysers	Field-wide Summary	Geysers-Calistoga	4	CA	Lake-Sonoma	38.8	122.75	A	Y
GEY01	Geysers	McCabe (Units 5 & 6)	Geysers-Calistoga	4	CA	Sonoma			A	N
GEY02	Geysers	Ridgeline (Units 7 & 8)	Geysers-Calistoga	4	CA	Sonoma			A	N
GEY03	Geysers	Fumarole (Units 9 & 10)	Geysers-Calistoga	4	CA	Sonoma			A	N
GEY04	Geysers	Eagle Rock (Unit 11)	Geysers-Calistoga	4	CA	Sonoma and Lake			A	N
GEY05	Geysers	Cobb Creek (Unit 12)	Geysers-Calistoga	4	CA	Sonoma			A	N
GEY06	Geysers	Big Geysers (Unit 13)	Geysers-Calistoga	4	CA	Sonoma and Lake			A	N
GEY07	Geysers	Sulphur Springs (Unit 14)	Geysers-Calistoga	4	CA	Sonoma			A	N
GEY08	Geysers	Lake View (Unit 17)	Geysers-Calistoga	4	CA	Sonoma and Lake			A	N
GEY09	Geysers	NCPA 1 & 2	Geysers-Calistoga	4	CA	Sonoma and Lake			A	N
GEY10	Geysers	Socrates (Unit 18)	Geysers-Calistoga	4	CA	Sonoma and Lake			A	N
GEY11	Geysers	Sonoma (SMUDGEPO)	Geysers-Calistoga	4	CA	Sonoma and Lake			A	N
GEY12	Geysers	Calistoga	Geysers-Calistoga	4	CA	Sonoma and Lake			A	N
GEY13	Geysers	Quicksilver (Unit 16)	Geysers-Calistoga	4	CA	Lake			A	N

PROJID	Name: Field/District	Name: Area/Power Plant	KGRA	Area ⁽¹⁾	State	County	Lat	Long	Expl-Dev. Gen.Cap.	
									Cat. ⁽²⁾	Estimated
GEY14	Geysers	Grant (Unit 20)	Geysers-Calistoga	4	CA	Sonoma			A	N
GEY15	Geysers	NCPA 3 & 4	Geysers-Calistoga	4	CA	Sonoma and Lake			A	N
GEY16	Geysers	Bear Canyon	Geysers-Calistoga	4	CA	Lake			A	N
GEY17	Geysers	West Ford Flat	Geysers-Calistoga	4	CA	Lake			A	N
GEY18	Geysers	Aidlin	Geysers-Calistoga	4	CA	Sonoma			A	N
GEY19	Geysers	Unit 15	Geysers-Calistoga	4		Sonoma			B	N
GLA00	Glamis		Glamis	4	CA	Imperial	32.97	115.04	D	Y
GRA00	Grass Valley	(Little Hot Springs)		3	NV	Lander	39.89	116.65		N
HAW00	Hawthorne			2	NV	Mineral	38.53	118.65	C	Y
HAZ00	Hazen (Black Butte)	(Patua Hot Springs)	Brady-Hazen (S end of)	1	NV	Lyon	39.6	119.11	C	Y
HEB00	Heber	Field-wide Summary	Heber	4	CA	Imperial	32.72	115.53	A	Y
HEB01	Heber	Heber (HGC)	Heber	4	CA	Imperial	32.72	115.53	A	N
HEB02	Heber	Second Imperial Geoth. (SIGC)	Heber	4	CA	Imperial	32.72	115.53	A	N
HON00	Honey Lake	Area-wide Summary	Wendel-Amedee	1	CA	Lassen	40.33	120.20	A	Y
HON01	Honey Lake	Amedee	Wendel-Amedee	1	CA	Lassen	40.30	120.20	A	N
HON02	Honey Lake	Wendel/Wineagle	Wendel-Amedee	1	CA	Lassen	40.35	120.25	A	N
HON03	Honey Lake	Wendel/Honey Lake Power	Wendel-Amedee	1	CA	Lassen	40.37	120.25	A	N
HSS00	Hot Sulphur Springs	(Independence V./Tuscarora)		3	NV	Elko	41.47	116.15	C	N
HYD00	Hyder Hot Springs		Dixie Valley	2	NV	Pershing	39.99	117.71	D	Y
KYL00	Kyle Hot Springs (Granite Mtn.)	(Buena Vista Valley)		1	NV	Pershing	40.41	117.89	C	Y
LAK00	Lake City / Surprise Valley	Lake City	Lake City-Surprise Valley	4	CA	Modoc	41.67	120.22	B	Y
LEA00	Leach Hot Springs	Grass Valley	Leach Hot Springs	1	NV	Pershing	40.60	117.65	C	Y
LEE00	Lee Hot Springs			1	NV	Churchill	39.21	118.72	C	Y
LOC00	Lockwood			1	NV	Washoe	39.51	119.65		N
LVC00	Long Valley - Casa Diablo	MP Field Summary	Mono-Long Valley	4	CA	Mono	37.65	118.90	A	N
LVC01	Long Valley - Casa Diablo	Mammoth-Pacific G1(MP-1)	Mono-Long Valley	4	CA	Mono	37.65	118.90	A	N

PROJID	Name: Field/District	Name: Area/Power Plant	KGRA	Area ⁽¹⁾	State	County	Lat	Long	Expl-Dev. Gen. Cap.	
									Cat. ⁽²⁾	Estimated
LVC02	Long Valley - Casa Diablo	Mammoth-Pacific G2(MP-2)	Mono-Long Valley	4	CA	Mono	37.65	118.90	A	N
LVC03	Long Valley - Casa Diablo	Mammoth-Pacific G3(PLES-1)	Mono-Long Valley	4	CA	Mono	37.65	118.90	A	N
LVM00	Long Valley - M-P Leases	M-P Lease Summary	Mono-Long Valley	4	CA	Mono	37.65	118.90	A	Y
LVM01	Long Valley - M-P Leases	Basalt Canyon Expl. Project	Mono-Long Valley	4	CA	Mono	37.65	118.90	C	N
LVM02	Long Valley - M-P Leases	Upper Basalt Canyon Expl. Project	Mono-Long Valley	4	CA	Mono	37.65	118.90	C	N
LVM03	Long Valley - M-P Leases	Rhyolite Plateau Exploration Area	Mono-Long Valley	4	CA	Mono	37.65	118.90	C	N
MCF00	McFarlanes Hot Spring (Black Rock Desert)			1	NV	Humboldt	41.08	118.69	D	N
MCG00	McGee Mountain (Painted Hills)			3	NV	Humboldt	41.80	118.87	C	Y
MED00	Medicine Lake Field-wide Summary		Glass Mountain	4	CA	Siskiyou	41.58	121.6	B	N
MED01	Medicine Lake Fourmile Hill		Glass Mountain	4	CA	Siskiyou	41.63	121.63	B	Y
MED02	Medicine Lake Telephone Flat		Glass Mountain	4	CA	Siskiyou	41.57	121.57	B	Y
MED03	Medicine Lake Pumice Mine Prospect		Glass Mountain	4	CA	Siskiyou			D	N
MOS00	Mount Signal			4	CA	Imperial	32.65	115.71	C	Y
NEW00	New York Canyon			1	NV	Pershing	40.05	118.00	C	Y
NIL00	Niland			4	CA	Imperial	33.22	115.54	B	Y
NOR00	North Valley			1	NV	Churchill-Washoe	39.90	119.22	C	Y
PIN00	Pinto Hot Springs		Pinto Hot Springs	3	NV	Humboldt	41.36	118.80	D	Y
PIR00	Priouette Mountain	(S.Dixie Valley)		2	NV	Churchill	39.51	118.16	D	Y
PUM00	Pumpernickel Valley	Tipton Ranch/Hot Springs Ranch		1	NV	Humboldt	40.76	117.49	C	Y
PYR00	Pyramid Lake Indian Reserv.	(Needle Rocks Hot Springs)		1	NV	Washoe	40.15	119.68	C	Y
RAN00	Randsburg		Randsburg	4	CA	San Bernardino	35.38	117.53	C	Y
ROS00	Rose Creek			1	NV	Pershing(?)	40.84	117.95	D	N
RYE00	Rye Patch-Humboldt House District	Field-wide summary	Rye Patch	1	NV	Pershing	40.53	118.27	B	N

PROJID	Name: Field/District	Name: Area/Power Plant	KGRA	Area ⁽¹⁾	State	County	Lat	Long	Expl-Dev. Gen. Cap.	
									Cat. ⁽²⁾	Estimated
RYE01	Rye Patch-Humboldt House District	Rye Patch	Rye Patch	1	NV	Pershing	40.53	118.27	B	Y
RYE02	Rye Patch-Humboldt House District	Humboldt House	Rye Patch	1	NV	Pershing	40.53	118.27	C	Y
SAI00	Saline Valley		Saline Valley	4	CA	Inyo	36.79	117.76	D	N
SAL00	Salton Sea	Field-wide summary	Salton Sea	4	CA	Imperial	33.17	115.62	A	Y
SAL01	Salton Sea	Unit 1	Salton Sea	4	CA	Imperial	33.17	115.62	A	N
SAL02	Salton Sea	Unit 2	Salton Sea	4	CA	Imperial	33.17	115.62	A	N
SAL03	Salton Sea	Unit 3	Salton Sea	4	CA	Imperial	33.17	115.62	A	N
SAL04	Salton Sea	Unit 4	Salton Sea	4	CA	Imperial	33.17	115.62	A	N
SAL05	Salton Sea	Unit 5	Salton Sea	4	CA	Imperial	33.17	115.62	A	N
SAL06	Salton Sea	Unit 6	Salton Sea	4	CA	Imperial	33.17	115.62	B	N
SAL07	Salton Sea	Vulcan	Salton Sea	4	CA	Imperial	33.17	115.62	A	N
SAL08	Salton Sea	Del Ranch (Hoch)	Salton Sea	4	CA	Imperial	33.17	115.62	A	N
SAL09	Salton Sea	Elmore	Salton Sea	4	CA	Imperial	33.17	115.62	A	N
SAL10	Salton Sea	Leathers	Salton Sea	4	CA	Imperial	33.17	115.62	A	N
SAL11	Salton Sea	Vulcan/Hoch Turboexpander	Salton Sea	4	CA	Imperial	33.17	115.62	A	N
SAW00	Salt Wells	Eight Mile Flat		1	NV	Churchill	39.31	118.57	C	Y
SES00	Sespe Hot Springs		Sespe Hot Springs	4	CA	Ventura	34.60	119.00	D	Y
SHO00	Shoshone-Reese River			3	NV	Lander	39.89	117.14	D	Y
SIL00	Silver Peak	(Alum prospect)		2	NV	Esmeralda	37.91	117.67	C	Y
SOD00	Soda Lake	Soda Lake No.1/No.2	Stillwater-Soda Lake	1	NV	Churchill	39.55	118.87	A	Y
SOH00	Sou Hot Springs	(Seven Devils/Gilbert's H.S.)	Dixie Valley	2	NV	Pershing	40.08	117.72	D	Y
SOU00	Southern Pacific			1	NV	Churchill(?)	40.06	118.89	D	N
STE00	Steamboat Hot Sprs	Field-wide Summary	Steamboat Springs	1	NV	Washoe	39.38	117.76	A	Y
STE01	Steamboat Hot Sprs	Lower SB: Steamboat I-1A	Steamboat Springs	1	NV	Washoe	39.38	117.76	A	N
STE02	Steamboat Hot Sprs	Lower SB: Steamboat II-III	Steamboat Springs	1	NV	Washoe	39.38	117.76	A	N
STE03	Steamboat Hot Sprs	Lower SB: Steamboat IV	Steamboat Springs	1	NV	Washoe	39.38	117.76	B	N

PROJID	Name: Field/District	Name: Area/Power Plant	KGRA	Area ⁽¹⁾	State	County	Lat	Long	Expl-Dev. Gen.Cap.	
									Cat. ⁽²⁾	Estimated
STE04	Steamboat Hot Sprs	Lower SB: UNV Redfield Utility	Steamboat Springs	1	NV	Washoe	39.38	117.76	D	N
STE05	Steamboat Hot Sprs	Upper SB: Yankee-Caithness	Steamboat Springs	1	NV	Washoe	39.38	117.76	A	N
STI00	Stillwater	Stillwater Geothermal 1	Stillwater-Soda Lake	1	NV	Churchill	39.55	118.55	A	Y
STI01	Stillwater	Stillwater N Expansion	Stillwater-Soda Lake	1	NV	Churchill	39.55	118.55	B	Y
SUL00	Sulphur Bank	Clear Lake	Geysers/Calistoga	4	CA	Lake	39.00	122.66	B	Y
SUP00	Superstition Mountain			4	CA	Imperial	32.95	115.80	D	Y
TRA00	Tracy			1	NV	Washoe	39.57	119.53	D	N
TRI00	Trinity Mountains District	Telephone Well area		1	NV	Church.-Persh.-Wash.	40.00	118.99	D	Y
TRU00	Truckhaven			4	CA	Imperial	33.26	116.00	C	N
TRU01	Truckhaven			4	CA	Imperial	33.26	116.00	C	N
VIR00	Virginia Range			1	NV	Washoe	39.42	119.66		N
WAB00	Wabuska			1	NV	Lyon	39.16	118.18	A	Y
WES00	Westmorland		Westmorland - Salton Sea	4	CA	Imperial	33.08	115.65	C	N
WIL00	Wilson Hot Springs		Wilson Hot Springs	3	NV	Lyon	38.77	119.18	D	Y

(1) Geographic Areas:

Area 1 – Greater Reno, Nevada (includes California locations)

Area 2 – Nevada sites with direct access to the California grid, excluding Greater Reno

Area 3 – Other Nevada locations

Area 4 – All other California

(2) Exploration-Development Categories:

A – Existing power plant operating

B – One or more wells tested at ≥ 1 MW (no power plant in operation)

C – Minimum 212°F logged downhole (no well tests at ≥ 1 MW)

D – Other exploration data and information available ($\geq 212^{\circ}\text{F}$ not proven)

No category assigned – area does not meet the minimum criteria (see Final Report section 2.2)

Hetch Hetchy/SFPUC Programmatic Renewable Energy Project
Project: 1.3 New Geothermal Site Identification and Qualification
Project Team: GeothermEx, Inc.
Task: 1.3.10 Final Project Report
Subject: D.1.3.10.3 Final Report

Table 2: Projects by Area

PROJID	Name: Field/District	Name: Area/Power Plant	KGRA	Area⁽¹⁾	State	County	Lat	Long	Expl-Dev. Cat.⁽²⁾	Gen.Cap. Estimated
Area: 1 - Greater Reno (NV and CA)										
ADO00	Adobe Valley	(Granite Springs V. - N. End)		1	NV	Pershing	40.22	118.92	D	N
BAT00	Battle Mountain			1	NV	Humboldt	40.77	117.21	D	N
BEO00	Beowawe		Beowawe	1	NV	Eureka-Lander	40.55	113.62	A	Y
BLA00	Black Rock Desert			1	NV	Humboldt				N
BLU00	Blue Mountain			1	NV	Humboldt	41.00	118.13	C	Y
BRA00	Brady's Hot Springs		Brady-Hazen	1	NV	Churchill	39.80	119.00	A	Y
CAR00	Carson Sink			1	NV	Churchill			D	N
COL00	Colado		Colado	1	NV	Pershing	40.23	118.37	C	Y
DES00	Desert Peak		Brady-Hazen	1	NV	Churchill	39.76	118.92	A	Y
DRY00	Dry Lake			1	NV	Pershing	39.37	116.83	D	N
EMP00	Empire (San Emidio)	Field-wide summary	San Emidio Desert	1	NV	Washoe	40.38	119.40	A	Y
EMP01	Empire (San Emidio)	Empire Energy	San Emidio Desert	1	NV	Washoe	40.38	119.40	A	N
EMP02	Empire (San Emidio)	Empire Foods	San Emidio Desert	1	NV	Washoe	40.38	119.40	B	N
FAL00	Fallon / Carson Lake	Carson Lake anomaly		1	NV	Churchill	39.38	118.65	C	Y
FAL01	Fallon / Carson Lake	Fallon Naval Air Station		1	NV	Churchill	39.38	118.65	C	N
FIR00	Fireball Ridge			1	NV	Churchill	39.92	119.07	D	N
FLY00	Fly Ranch/Granite Ranch	Ward's (Fly/Hualapi Flat) H.S.	Fly Ranch	1	NV	Washoe-Pershing	40.86	119.32	C	Y

PROJID	Name: Field/District	Name: Area/Power Plant	KGRA	Area ⁽¹⁾	State	County	Lat	Long	Expl-Dev. Gen.Cap.	
									Cat. ⁽²⁾	Estimated
FLY01	Fly Ranch/Granite Ranch	Granite Ranch		1	NV	Washoe-Pershing	40.86	119.32	C	Y
GER00	Gerlach	(Great Boiling Spring)	Gerlach	1	NV	Washoe	40.66	119.37	C	Y
HAZ00	Hazen (Black Butte)	(Patua Hot Springs)	Brady-Hazen (S end of)	1	NV	Lyon	39.6	119.11	C	Y
HON00	Honey Lake	Area-wide Summary	Wendel-Amedee	1	CA	Lassen	40.33	120.20	A	Y
HON01	Honey Lake	Amedee	Wendel-Amedee	1	CA	Lassen	40.30	120.20	A	N
HON02	Honey Lake	Wendel/Wineagle	Wendel-Amedee	1	CA	Lassen	40.35	120.25	A	N
HON03	Honey Lake	Wendel/Honey Lake Power	Wendel-Amedee	1	CA	Lassen	40.37	120.25	A	N
KYL00	Kyle Hot Springs (Granite Mtn.)	(Buena Vista Valley)		1	NV	Pershing	40.41	117.89	C	Y
LEA00	Leach Hot Springs	Grass Valley	Leach Hot Springs	1	NV	Pershing	40.60	117.65	C	Y
LEE00	Lee Hot Springs			1	NV	Churchill	39.21	118.72	C	Y
LOC00	Lockwood			1	NV	Washoe	39.51	119.65		N
MCF00	McFarlanes Hot Spring	(Black Rock Desert)		1	NV	Humboldt	41.08	118.69	D	N
NEW00	New York Canyon			1	NV	Pershing	40.05	118.00	C	Y
NOR00	North Valley			1	NV	Churchill-Washoe	39.90	119.22	C	Y
PUM00	Pumperrick Valley	Tipton Ranch/Hot Springs Ranch		1	NV	Humboldt	40.76	117.49	C	Y
PYR00	Pyramid Lake Indian Reserv.	(Needle Rocks Hot Springs)		1	NV	Washoe	40.15	119.68	C	Y
ROS00	Rose Creek			1	NV	Pershing(?)	40.84	117.95	D	N
RYE00	Rye Patch-Humboldt House District	Field-wide summary	Rye Patch	1	NV	Pershing	40.53	118.27	B	N
RYE01	Rye Patch-Humboldt House District	Rye Patch	Rye Patch	1	NV	Pershing	40.53	118.27	B	Y
RYE02	Rye Patch-Humboldt House District	Humboldt House	Rye Patch	1	NV	Pershing	40.53	118.27	C	Y
SAW00	Salt Wells	Eight Mile Flat		1	NV	Churchill	39.31	118.57	C	Y
SOD00	Soda Lake	Soda Lake No.1/No.2	Stillwater-Soda Lake	1	NV	Churchill	39.55	118.87	A	Y
SOU00	Southern Pacific			1	NV	Churchill(?)	40.06	118.89	D	N

PROJID	Field/District	Name: Area/Power Plant	KGRA	Area ⁽¹⁾	State	County	Lat	Long	Expl-Dev. Gen.Cap.	
									Cat. ⁽²⁾	Estimated
STE00	Steamboat Hot Sprs	Field-wide Summary	Steamboat Springs	1	NV	Washoe	39.38	117.76	A	Y
STE01	Steamboat Hot Sprs	Lower SB: Steamboat I-1A	Steamboat Springs	1	NV	Washoe	39.38	117.76	A	N
STE02	Steamboat Hot Sprs	Lower SB: Steamboat II-III	Steamboat Springs	1	NV	Washoe	39.38	117.76	A	N
STE03	Steamboat Hot Sprs	Lower SB: Steamboat IV	Steamboat Springs	1	NV	Washoe	39.38	117.76	B	N
STE04	Steamboat Hot Sprs	Lower SB: UNV Redfield Utility	Steamboat Springs	1	NV	Washoe	39.38	117.76	D	N
STE05	Steamboat Hot Sprs	Upper SB: Yankee-Caithness	Steamboat Springs	1	NV	Washoe	39.38	117.76	A	N
STI00	Stillwater	Stillwater Geothermal 1	Stillwater-Soda Lake	1	NV	Churchill	39.55	118.55	A	Y
STI01	Stillwater	Stillwater N Expansion	Stillwater-Soda Lake	1	NV	Churchill	39.55	118.55	B	Y
TRA00	Tracy			1	NV	Washoe	39.57	119.53	D	N
TRI00	Trinity Mountains District	Telephone Well area		1	NV	Church.-Persh.-Wash.	40.00	118.99	D	Y
VIR00	Virginia Range			1	NV	Washoe	39.42	119.66		N
WAB00	Wabuska			1	NV	Lyon	39.16	118.18	A	Y
Area: 2 - NV with direct access to CA										
AUR00	Aurora			2	NV	Mineral	38.35	118.82	C	Y
DIX00	Dixie Valley	Caithness Dixie Valley	Dixie Valley	2	NV	Churchill	39.99	117.85	A	Y
DIX01	Dixie Valley	Dixie Valley Power Partners (DVPP)		2	NV	Churchill	39.99	117.85	C	Y
ELE00	Eleven Mile Canyon			2	NV	Churchill	39.42	118.24		N
EMI00	Emigrant (Fish Lake V.)			2	NV	Esmeralda	37.86	117.87	C	Y
EXC00	Excelsior			2	NV	Mineral	38.31	118.56		N
FIS00	Fish Lake (Valley)			2	NV	Esmeralda	37.86	118.05	B	Y
HAW00	Hawthorne			2	NV	Mineral	38.53	118.65	C	Y
HYD00	Hyder Hot Springs		Dixie Valley	2	NV	Pershing	39.99	117.71	D	Y
PIR00	Piroquette Mountain	(S.Dixie Valley)		2	NV	Churchill	39.51	118.16	D	Y
SIL00	Silver Peak	(Alum prospect)		2	NV	Esmeralda	37.91	117.67	C	Y

PROJID	Name: Field/District	Name: Area/Power Plant	KGRA	Area ⁽¹⁾	State	County	Lat	Long	Expl-Dev.	Gen.Cap.
									Cat. ⁽²⁾	Estimated
SOH00	Sou Hot Springs	(Seven Devils/Gilbert's H.S.)	Dixie Valley	2	NV	Pershing	40.08	117.72	D	Y
Area: 3 - Other NV										
ANT00	Antelope Valley			3	NV	Churchill	39.83	117.50	D	N
BAL00	Baltazar		Baltazar	3	NV	Humboldt	41.92	118.72	C	Y
BIG00	Big Smokey Valley	N.End - Spencer Hot Springs		3	NV	Lander	39.33	116.83	D	N
DAR00	Darrough Hot Springs	(Big Smokey Valley - S.End)	Darrough Hot Springs	3	NV	Nye	38.82	117.18	C	N
DOU00	Double - Black Rk Hot Springs		Double Hot Springs	3	NV	Humboldt	41.05	119.03	D	Y
DYK00	Dyke Hot Springs			3	NV	Humboldt	41.57	118.57	D	N
FOX00	Fox Mountain			3	NV	Washoe	41.02	119.56	C	N
GRA00	Grass Valley	(Little Hot Springs)		3	NV	Lander	39.89	116.65		N
HSS00	Hot Sulphur Springs	(Independence V./Tuscarora)		3	NV	Elko	41.47	116.15	C	N
MCG00	McGee Mountain	(Painted Hills)		3	NV	Humboldt	41.80	118.87	C	Y
PIN00	Pinto Hot Springs		Pinto Hot Springs	3	NV	Humboldt	41.36	118.80	D	Y
SHO00	Shoshone-Reese River			3	NV	Lander	39.89	117.14	D	Y
WIL00	Wilson Hot Springs		Wilson Hot Springs	3	NV	Lyon	38.77	119.18	D	Y
Area: 4 - All other CA										
BOD00	Bodie		Bodie	4	CA	Mono	38.16	119.11	D	N
BRW00	Brawley	Area-wide summary	Brawley	4	CA	Imperial	32.99	115.52	B	N
BRW01	Brawley	Brawley (North Brawley)	Brawley	4	CA	Imperial	33.00	115.53	B	Y
BRW02	Brawley	East Brawley		4	CA	Imperial	32.99	115.35	B	Y
BRW03	Brawley	South Brawley (Mesquite field)		4	CA	Imperial	32.96	115.54	B	Y
CAL00	Calistoga		Geysers-Callistoga	4	CA	Napa	38.58	122.58	C	Y
COS00	Coso	Field-wide Summary	Coso Hot Springs	4	CA	Inyo	36.03	117.80	A	Y
COS01	Coso	Navy I	Coso Hot Springs	4	CA	Inyo	36.03	117.80	A	N
COS02	Coso	Navy II	Coso Hot Springs	4	CA	Inyo	36.03	117.80	A	N

PROJID	Name: Field/District	Name: Area/Power Plant	KGRA	Expl-Dev. Gen.Cap.						
				Area ⁽¹⁾	State	County	Lat	Long	Cat. ⁽²⁾	Estimated
COS03	Coso	BLM	Coso Hot Springs	4	CA	Inyo	36.03	117.80	A	N
COS04	Coso	Northeast frontier	Coso Hot Springs	4	CA	Inyo	36.03	117.80	D	N
DUN00	Dunes		Dunes	4	CA	Imperial	32.80	115.01	C	Y
EAS00	East Mesa	Field-wide summary	East Mesa	4	CA	Imperial	32.78	115.25	A	Y
EAS01	East Mesa	Ormesa 1	East Mesa	4	CA	Imperial	32.78	115.25	A	N
EAS02	East Mesa	Ormesa 1E	East Mesa	4	CA	Imperial	32.78	115.25	A	N
EAS03	East Mesa	Ormesa 1H		4	CA	Imperial	32.78	115.25	A	N
EAS04	East Mesa	Ormesa 2 (or II)	East Mesa	4	CA	Imperial	32.78	115.25	A	N
EAS05	East Mesa	Geo East Mesa (GEM) I	East Mesa	4	CA	Imperial	32.78	115.25	A	N
EAS06	East Mesa	Geo East Mesa (GEM) 2-3	East Mesa	4	CA	Imperial	32.78	115.25	A	N
GEY00	Geysers	Field-wide Summary	Geysers/Calistoga	4	CA	Lake-Sonoma	38.8	122.75	A	Y
GEY01	Geysers	McCabe (Units 5 & 6)	Geysers-Calistoga	4	CA	Sonoma			A	N
GEY02	Geysers	Ridgeline (Units 7 & 8)	Geysers-Calistoga	4	CA	Sonoma			A	N
GEY03	Geysers	Fumarole (Units 9 & 10)	Geysers-Calistoga	4	CA	Sonoma			A	N
GEY04	Geysers	Eagle Rock (Unit 11)	Geysers-Calistoga	4	CA	Sonoma and Lake			A	N
GEY05	Geysers	Cobb Creek (Unit 12)	Geysers-Calistoga	4	CA	Sonoma			A	N
GEY06	Geysers	Big Geysers (Unit 13)	Geysers-Calistoga	4	CA	Sonoma and Lake			A	N
GEY07	Geysers	Sulphur Springs (Unit 14)	Geysers-Calistoga	4	CA	Sonoma			A	N
GEY08	Geysers	Lake View (Unit 17)	Geysers-Calistoga	4	CA	Sonoma and Lake			A	N
GEY09	Geysers	NCPA 1 & 2	Geysers-Calistoga	4	CA	Sonoma and Lake			A	N
GEY10	Geysers	Socrates (Unit 18)	Geysers-Calistoga	4	CA	Sonoma and Lake			A	N
GEY11	Geysers	Sonoma (SMUDGEPO)	Geysers-Calistoga	4	CA	Sonoma and Lake			A	N

PROJID	Name: Field/District	Name: Area/Power Plant	KGRA	Area ⁽¹⁾	State	County	Lat	Long	Expl-Dev. Gen.Cap.	
									Cat. ⁽²⁾	Estimated
GEY12	Geysers	Calistoga	Geysers-Calistoga	4	CA	Sonoma and Lake			A	N
GEY13	Geysers	Quicksilver (Unit 16)	Geysers-Calistoga	4	CA	Lake			A	N
GEY14	Geysers	Grant (Unit 20)	Geysers-Calistoga	4	CA	Sonoma			A	N
GEY15	Geysers	NCPA 3 & 4	Geysers-Calistoga	4	CA	Sonoma and Lake			A	N
GEY16	Geysers	Bear Canyon	Geysers-Calistoga	4	CA	Lake			A	N
GEY17	Geysers	West Ford Flat	Geysers-Calistoga	4	CA	Lake			A	N
GEY18	Geysers	Aldlin	Geysers-Calistoga	4	CA	Sonoma			A	N
GEY19	Geysers	Unit 15	Geysers-Calistoga	4		Sonoma			B	N
GLA00	Glamis		Glamis	4	CA	Imperial	32.97	115.04	D	Y
HEB00	Heber	Field-wide Summary	Heber	4	CA	Imperial	32.72	115.53	A	Y
HEB01	Heber	Heber (HGC)	Heber	4	CA	Imperial	32.72	115.53	A	N
HEB02	Heber	Second Imperial Geoth. (SIGC)	Heber	4	CA	Imperial	32.72	115.53	A	N
LAK00	Lake City / Surprise Valley	Lake City	Lake City-Surprise Valley	4	CA	Modoc	41.67	120.22	B	Y
LVC00	Long Valley - Casa Diablo	MP Field Summary	Mono-Long Valley	4	CA	Mono	37.65	118.90	A	N
LVC01	Long Valley - Casa Diablo	Mammoth-Pacific G1(MP-1)	Mono-Long Valley	4	CA	Mono	37.65	118.90	A	N
LVC02	Long Valley - Casa Diablo	Mammoth-Pacific G2(MP-2)	Mono-Long Valley	4	CA	Mono	37.65	118.90	A	N
LVC03	Long Valley - Casa Diablo	Mammoth-Pacific G3(PLES-1)	Mono-Long Valley	4	CA	Mono	37.65	118.90	A	N
LVM00	Long Valley - M-P Leases	M-P Lease Summary	Mono-Long Valley	4	CA	Mono	37.65	118.90	A	Y
LVM01	Long Valley - M-P Leases	Basalt Canyon Expl. Project	Mono-Long Valley	4	CA	Mono	37.65	118.90	C	N
LVM02	Long Valley - M-P Leases	Upper Basalt Canyon Expl. Project	Mono-Long Valley	4	CA	Mono	37.65	118.90	C	N
LVM03	Long Valley - M-P Leases	Rhyolite Plateau Exploration Area	Mono-Long Valley	4	CA	Mono	37.65	118.90	C	N
MED00	Medicine Lake	Field-wide Summary	Glass Mountain	4	CA	Siskiyou	41.58	121.6	B	N
MED01	Medicine Lake	Fourmile Hill	Glass Mountain	4	CA	Siskiyou	41.63	121.63	B	Y

PROJID	Name: Field/District	Name: Area/Power Plant	KGRA	Area ⁽¹⁾	State	County	Lat	Long	Expl-Dev.	Gen. Cap.
									Cat. ⁽²⁾	Estimated
MED02	Medicine Lake	Telephone Flat	Glass Mountain	4	CA	Siskiyou	41.57	121.57	B	Y
MED03	Medicine Lake	Pumice Mine Prospect	Glass Mountain	4	CA	Siskiyou			D	N
MOS00	Mount Signal			4	CA	Imperial	32.65	115.71	C	Y
NIL00	Niland			4	CA	Imperial	33.22	115.54	B	Y
RAN00	Randsburg		Randsburg	4	CA	San Bernardino	35.38	117.53	C	Y
SAI00	Saline Valley		Saline Valley	4	CA	Inyo	36.79	117.76	D	N
SAL00	Salton Sea	Field-wide summary	Salton Sea	4	CA	Imperial	33.17	115.62	A	Y
SAL01	Salton Sea	Unit 1	Salton Sea	4	CA	Imperial	33.17	115.62	A	N
SAL02	Salton Sea	Unit 2	Salton Sea	4	CA	Imperial	33.17	115.62	A	N
SAL03	Salton Sea	Unit 3	Salton Sea	4	CA	Imperial	33.17	115.62	A	N
SAL04	Salton Sea	Unit 4	Salton Sea	4	CA	Imperial	33.17	115.62	A	N
SAL05	Salton Sea	Unit 5	Salton Sea	4	CA	Imperial	33.17	115.62	A	N
SAL06	Salton Sea	Unit 6	Salton Sea	4	CA	Imperial	33.17	115.62	B	N
SAL07	Salton Sea	Vulcan	Salton Sea	4	CA	Imperial	33.17	115.62	A	N
SAL08	Salton Sea	Del Ranch (Hoch)	Salton Sea	4	CA	Imperial	33.17	115.62	A	N
SAL09	Salton Sea	Elmore	Salton Sea	4	CA	Imperial	33.17	115.62	A	N
SAL10	Salton Sea	Leathers	Salton Sea	4	CA	Imperial	33.17	115.62	A	N
SAL11	Salton Sea	Vulcan/Hoch Turboexpander	Salton Sea	4	CA	Imperial	33.17	115.62	A	N
SES00	Sespe Hot Springs		Sespe Hot Springs	4	CA	Ventura	34.60	119.00	D	Y
SUL00	Sulphur Bank	Clear Lake	Geysers/Calistoga	4	CA	Lake	39.00	122.66	B	Y
SUP00	Superstition Mountain			4	CA	Imperial	32.95	115.80	D	Y
TRU00	Truckhaven			4	CA	Imperial	33.26	116.00	C	N
TRU01	Truckhaven			4	CA	Imperial	33.26	116.00	C	N
WES00	Westmorland		Westmorland - Salton Sea	4	CA	Imperial	33.08	115.65	C	N

PROJID	Name: Field/District	Name: Area/Power Plant	KGRA	Area⁽¹⁾	State	County	Lat	Long	Expl-Dev. Cat.⁽²⁾	Gen.Cap. Estimated
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(1) Geographic Areas:

- Area 1 – Greater Reno, Nevada (includes California locations)
- Area 2 – Nevada sites with direct access to the California grid, excluding Greater Reno
- Area 3 – Other Nevada locations
- Area 4 – All other California

(2) Exploration-Development Categories:

- A – Existing power plant operating
- B – One or more wells tested at ≥ 1 MW (no power plant in operation)
- C – Minimum 212°F logged downhole (no well tests at ≥ 1 MW)
- D – Other exploration data and information available ($\geq 212^{\circ}\text{F}$ not proven)

No category assigned – area does not meet the minimum criteria (see Final Report section 2.2)

Hetch Hetchy/SFPUC Programmatic Renewable Energy Project
Project: 1.3 New Geothermal Site Identification and Qualification
Project Team: GeothermEx, Inc.
Task: 1.3.10 Final Project Report
Subject: D.1.3.10.3 Final Report

Table 3: Estimated Generation Capacities

PROJ ID	Field or District	Area or Power Plant	State	County	Temperature (°F)			Volume (mi ³)	Installed Capacity (MW) Gross - Net	Wellhd. MW in use ⁴	Explor- Devel. Cat. ⁵	Generation Capacity (MW-30yrs) ⁶				
					Min	Mlk	Max					Min	Mlk	Mean	Std. Dev.	
Area: 1 - Greater Reno (NV and CA)																
BEO00	Beowawe		NV	Eureka- Lander	400°	410°	420°	1.70	16.7	16	15	A	30	41	58	21
BLU00	Blue Mountain		NV	Humboldt	291°	345°	440°	1.33	0	-	0	C	16	30	38	19
BRA00	Brady's Hot Springs		NV	Churchill	340°	360°	380°	0.76	26	20	15	A	11	18	22	8.3
COL00	Colado		NV	Pershing	215°	270°	330°	0.80	0	-	0	C	3.7	6.2	8.3	4.1
DES00	Desert Peak		NV	Churchill	370°	385°	400°	2.27	11	9.9	10	A	33	45	79	40
EMP00	Empire (San Emidio)	Field-wide summary	NV	Washoe	285°	305°	330°	0.62	4.8	4.6	4.8	A	4.3	6.6	11	6.7
FAL00	Fallon / Carson Lake	Carson Lake anomaly	NV	Churchill	360°	370°	380°	2.61	0	-	0	C	34	55	74	34
FLY00	Fly Ranch/Granite Ranch	Ward's (Fly/Hualapi Flat) H.S.	NV	Washoe- Pershing	200°	220°	210°	2.40	0	-	0	C	6.0	8.7	13	5.7
FLY01	Fly Ranch/Granite Ranch	Granite Ranch	NV	Washoe- Pershing	221°	345°	440°	0.53	0	-	0	C	5.4	8.1	13	7.1
GER00	Gerlach	(Great Boiling Spring)	NV	Washoe	290°	340°	385°	2.50	0	-	0	C	17	25	36	16
HAZ00	Hazen (Black Butte)	(Patua Hot Springs)	NV	Lyon	280°	330°	430°	1.25	0	-	0	C	6.3	8.5	14	6.9
HON00	Honey Lake	Area-wide Summary	CA	Lassen	230°	240°	250°	1.09	6.4	3.4	1.2	A	5.7	8.3	13	6.9
KYL00	Kyle Hot Springs (Granite Mtn.)	(Buena Vista Valley)	NV	Pershing	280°	375°	412°	0.99	0	-	0	C	16	22	36	19
LEA00	Leach Hot Springs	Grass Valley	NV	Pershing	220°	265°	343°	1.79	0	-	0	C	13	18	29	15

PROJ ID	Field or District	Area or Power Plant	State County	Temperature (°F)			Volume ² (mi ³)	Installed Capacity (MW) ³ Gross - Net	Wellhd. MW in use ⁴	Explor-Devel. Cat. ⁵	Generation Capacity (MW-30yrs) ⁶				
				Min	Mlk	Max					Min	Mlk	Mean	Std. Dev.	
LEE00	Lee Hot Springs		NV Churchill	303°	324°	0.53	0	-	0	C	5.4	9.4	11	5.1	
NEW00	New York Canyon		NV Pershing	245°	345°	440°	1.72	0	-	0	C	20	26	46	23
NOR00	North Valley		NV Churchill-Washoe	255°	345°	440°	3.18	0	-	0	C	37	49	84	43
PUM00	Pumpernickel Valley	Tipton Ranch/Hot Springs Ranch	NV Humboldt	235°	295°	356°	1.19	0	-	0	C	10	13	22	11
PYR00	Pyramid Lake Indian Reserv.	(Needle Rocks Hot Springs)	NV Washoe	240°	345°	417°	0.93	0	-	0	C	9.9	14	23	12
RYE01	Rye Patch-Humboldt House District	Rye Patch	NV Pershing	335°	345°	405°	1.13	12.5	8.75	0	B	16	20	34	15
RYE02	Rye Patch-Humboldt House District	Humboldt House	NV Pershing	290°	345°	440°	2.12	0	-	0	C	27	34	60	30
SAW00	Salt Wells	Eight Mile Flat	NV Churchill	330°	400°	430°	3.98	0	-	0	C	63	96	136	63
SOD00	Soda Lake	Soda Lake No.1/No.2	NV Churchill	340°	360°	370°	2.12	26.1	16.6	15.7	A	29	42	62	28
STE00	Steamboat Hot Sprs	Field-wide Summary	NV Washoe	350°	370°	390°	2.33	59.84	48.1	53	A	56	62	78	17
STI00	Stillwater	Stillwater Geothermal 1	NV Churchill	290°	310°	330°	1.09	19	10	14.3	A	11	18	21	8.0
STI01	Stillwater	Stillwater N Expansion	NV Churchill	310°	330°	350°	1.36	0	-	0	B	16	24	31	11
TRI00	Trinity Mountains District	Telephone Well area	NV Church.-Persh.-Wash.	225°	345°	440°	3.98	0	-	0	D	42	66	100	53
WAB00	Wabuska		NV Lyon	225°	245°	290°	1.33	1.45	1.2	1.4	A	8.1	13	17	8.0

Totals for Area: 184 139 130 552 787 1169 129⁷

Area: 2 - NV with direct access to CA

AUR00	Aurora		NV Mineral	250°	345°	440°	2.65	0	-	0	C	31	51	70	35
DIX00	Dixie Valley	Caithness Dixie Valley	NV Churchill	420°	440°	460°	3.17	66	56	66	A	71	107	142	56
DIX01	Dixie Valley	Dixie Valley Power	NV Churchill	445°	460°	475°	4.69	0	-	0	C	107	151	210	83

PROJ ID	Field or District	Area or Power Plant	State County	Temperature (°F)			Installed Capacity (MW) Gross - Net	Wellhd. MW in use ⁴	Explor- Devel. Cat. ⁵	Generation Capacity (MW-30yrs) ⁶						
				Min	Mlk	Max				Min	Mlk	Mean	Std. Dev.			
Partners (DVPP)																
EMI00	Emigrant (Fish Lake V.)		NV Esmeralda	230°	340°	450°	6.77	0	-	0	C	49	85	118	63	
FIS00	Fish Lake (Valley)		NV Esmeralda	340°		380°	2.25	0	-	0	B	30	47	62	27	
HAW00	Hawthorne		NV Mineral	200°	285°	440°	1.06	0	-	0	C	8.7	14	22	13	
HYD00	Hyder Hot Springs		NV Pershing	180°		310°	1.67	0	-	0	D	5.5	9.6	15	8.4	
PIR00	Pirouette Mountain	(S.Dixie Valley)	NV Churchill	190°	345°	440°	1.52	0	-	0	D	16	23	40	22	
SIL00	Silver Peak	(Alum prospect)	NV Esmeralda	310°	345°	440°	2.85	0	-	0	C	41	78	91	43	
SOH00	Sou Hot Springs	(Seven Devils/Gilbert's H.S.)	NV Pershing	180°		370°	0.53	0	-	0	D	3.3	6.1	9.5	6.1	
<i>Totals for Area:</i>										66	56	66	363	572	780	136
<i>⁷</i>																
<i>Area: 3 - Other NV</i>																
BAL00	Baltazor		NV Humboldt	288°	306°	316°	1.19	0	-	0	C	11	16	24	11	
DOU00	Double - Black Rk Hot Springs		NV Humboldt	240°	255°	275°	2.12	0	-	0	D	20	33	53	31	
MCG00	McGee Mountain	(Painted Hills)	NV Humboldt	225°	345°	440°	1.86	0	-	0	C	19	28	47	26	
PIN00	Pinto Hot Springs		NV Humboldt	285°	366°	440°	1.33	0	-	0	D	18	29	39	19	
SHO00	Shoshone-Reese River		NV Lander	225°	345°	440°	1.19	0	-	0	D	13	18	30	16	
WIL00	Wilson Hot Springs		NV Lyon	200°	345°	440°	1.13	0	-	0	D	10	17	27	15	
<i>Totals for Area:</i>										0	0	91	141	220	51	
<i>⁷</i>																
<i>Area: 4 - All other CA</i>																
BRW01	Brawley	Brawley (North Brawley)	CA Imperial	490°	510°	530°	2.45	0	-	0	B	88	135	144	45	
BRW02	Brawley	East Brawley	CA Imperial	480°	520°	560°	2.21	0	-	0	B	85	129	138	44	
BRW03	Brawley	South Brawley (Mesquite field)	CA Imperial	480°	500°	520°	1.19	0	-	0	B	45	62	70	21	

PROJ ID	Field or District	Area or Power Plant	State County	Temperature (°F) ¹			Volume ² (mi ³)	Installed Capacity (MW) ³ Gross - Net	Wellhd. MW in use ⁴	Explor-Devel. Cat. ⁵	Generation Capacity (MW-30yrs) ⁶				
				Min	Mlk	Max					Min	Mlk	Mean	Std. Dev.	
CAL00	Calistoga		CA Napa	275°	320°	1.86	0	-	0	C	17	25	35	16	
COS00	Coso	Field-wide Summary	CA Inyo	475°	550°	575°	8.52	300	270	280	A	246	355	490	189
DUN00	Dunes		CA Imperial	250°	400°	0.86	0	-	0	C	7.4	11	18	10	
EAS00	East Mesa	Field-wide summary	CA Imperial	300°	310°	320°	8.54	73.2	56	62	A	119	148	167	38
GEY00	Geysers	Field-wide Summary	CA Lake-Sonoma	464°	468°	482°	37.88	1000	900	850	A	1200	1400	1400	N1
GLA00	Glamis		CA Imperial	250°	400°	0.83	0	-	0	D	4.3	6.4	11	6.0	
HEB00	Heber	Field-wide Summary	CA Imperial	330°	340°	360°	6.73	100	79	100	A	109	142	158	40
LAK00	Lake City / Surprise Valley	Lake City	CA Modoc	320°	335°	350°	2.18	0	-	0	B	23	37	49	21
LVM00	Long Valley - M-P Leases	M-P Lease Summary	CA Mono	342°	362°	382°	8.18	40	30.1	40	A	70	111	148	65
MED01	Medicine Lake	Fourmile Hill	CA Siskiyou	388°	428°	455°	2.05	0	-	0	B	25	36	70	42
MED02	Medicine Lake	Telephone Flat	CA Siskiyou	440°	480°	490°	5.05	0	-	0	B	110	175	256	128
MOS00	Mount Signal		CA Imperial	250°	345°	440°	1.19	0	-	0	C	12	19	29	15
NIL00	Niland		CA Imperial	500°	540°	550°	1.39	0	-	0	B	59	76	92	27
RAN00	Randsburg		CA San Bernardino	240°	345°	440°	3.31	0	-	0	C	32	48	82	46
SAL00	Salton Sea	Field-wide summary	CA Imperial	550°	575°	600°	25.71	350	326	350	A	1350	1750	1880	400
SES00	Sespe Hot Springs		CA Ventura	230°	265°	300°	0.53	0	-	0	D	3.6	5.3	7.8	3.6
SUL00	Sulphur Bank	Clear Lake	CA Lake	400°	450°	1.66	0	-	0	B	27	43	61	30	
SUP00	Superstition Mountain		CA Imperial	225°	345°	440°	0.66	0	-	0	D	5.9	9.5	15	8.0
Totals for Area:				1863	1661	1682						3638	4723	5321	480 ⁷

PROJ ID	Field or District	Area or Power Plant	State County	Temperature (°F)			Installed Capacity (MW) Gross - Net	Wellhd. MW in use ⁴	Explor- ation- Development Category ⁵	Generation Capacity (MW-30yrs) ⁶							
				Min	Mlk	Max				Min	Mlk	Mean	Std. Dev.				
										Grand Totals:	2113	1856	1878	4644	6223	7490	518 ⁷

1. Reservoir temperature values used for Monte-Carlo estimation of generation capacity.

Min = minimum average; Mlk = most-likely average; Max = Maximum average.

2. The listed reservoir volume is the product: (most-likely average reservoir thickness) x (most-likely reservoir area), where the most-likely values are those used for Monte-Carlo estimation of generation capacity.

3. Installed generation capacity, gross and net MW. Applies only to Exploration-Development Category A.

4. MW in use is based on the most recent record of actual generation. Gross generation is listed if available, but available information is often not specific about gross vs. net.

5. Exploration-Development Category

A = existing power plant operating

B = one or more wells tested at ≥ 1 MW

C = a temperature $\geq 212^{\circ}\text{F}$ has been logged downhole (or boiling temperature for local elevation)

D = other exploration data (such as spring chemistry and/or shallow temperature gradient measurements)

6. Min = Minimum = generation capacity value with Monte Carlo simulation cumulative probability of more than 90%

Mlk = Most-likely = Monte Carlo simulation modal generation capacity value

Mean = Monte Carlo simulation mean value

Std.Dev. = Standard Deviation of the Mean value

7. The standard deviation of the sum of mean values is the square root of the sum of the squares of individual standard deviations.

Hetch Hetchy/SFPUC Programmatic Renewable Energy Project
Project: 1.3 New Geothermal Site Identification and Qualification
Project Team: GeothermEx, Inc.
Task: 1.3.10 Final Project Report
Subject: D.1.3.10.3 Final Report

Table 4: Comments to Estimated Generation Capacities

PROJ ID	Field or District	Area or Power Plant	Comments/Notes
Area: 1 - Greater Reno (NV and CA)			
BEO00	Beowawe		Figure BEO00-3. Based on relatively good and complete data. Estimate does not include heat reserves in the discharge (upflow) zone to the hot springs area (above a depth of about 6,500 ft), but the temperature model (Figure BEO00-2) suggests that the volume of this zone is quite small relative to deeper reserves. The histogram of estimated values has a broad maximum, which makes the most-likely value relatively non-unique.
BLU00	Blue Mountain		Figure BLU00-5. Area of reservoir may be under-estimated (insufficient data), causing under-estimation of capacity. The capacity estimate is optimistic if deeper temperatures do not prove higher than the confirmed 291°F, and deeper permeability is not found.
BRA00	Brady's Hot Springs		Figure BRA00-3. The histogram of estimated values has a broad maximum, which makes the most-likely value relatively non-unique. The major uncertain parameter is the reservoir volume, which is hard to estimate due to irregular shape. On the basis of available information, it would be difficult to justify a volume significantly (say, 2x) greater than that represented for the capacity estimate. There is evidence of a laterally extensive volume of hot rock (>=390-410°F) at depth below the commercial reservoir, mostly in the footwall (east side) of the Bradys fault, and mostly below the depths represented by this capacity estimate. Available evidence indicates that the permeability in this hot rock is localized to the area near the Bradys fault; deep wells drilled into this rock from locations further to the east have so-far been dry holes. The more permeable part of this rock, near the Bradys fault, is considered to be included in the capacity estimate. Greater heat reserves would be calculated by including a larger volume of this deep hot rock, but boundary conditions (depth to bottom and area) would still have to be assumed.
COL00	Colado		Figure COL00-2. The capacity may be under-estimated. The estimate is constrained by apparent low temperature and a limitation of the reservoir area to the default values assumed for a point source. The reservoir area may be under-estimated. The temperature estimates used for calculating capacity are based on geothermometers applied to samples from warm wells (max, 155°F) in the area of Colado junction, which is assumed to be about 1.5 miles from the area of upwelling. Therefore, it is likely that even the highest geothermometers have re-equilibrated and may be under-estimating true conditions at depth. The Na-Cl composition of the water (Cl about 2,500 mg/l) encourages the possibility of a higher-temperature geothermal system at depth, but could instead be a function of flow through meta-sedimentary rocks at lower temperatures. Hot water samples from the assumed area of upwelling, just S of Woolsey, would be useful. Reservoir permeability could be limited if confined to fine-grained metasedimentary rocks.

PROJ ID	Field or District	Area or Power Plant	Comments/Notes
DES00	Desert Peak		Figure DES00-4. The capacity estimate represents both the existing hydrothermal project area and the EGS (Enhanced Geothermal Systems) area of hot rock but apparent lesser permeability to the NNE (see Figures). Input parameters are relatively well-constrained by drilling and production data.
EMP00	Empire (San Emidio)	Field-wide summary	Figure EMP00-2. Most of the drilling at Empire has been confined to a narrow, N-S zone that coincides with hydrothermal alteration and hot springs, with significant (and unsuccessful) step-out drilling only to the W. Successful exploration to the E would produce results that increase the capacity estimate, by increasing the estimated minimum reservoir area. Depths of greater than 2,000 ft below the central zone have also not been explored.
FAL00	Fallon / Carson Lake	Carson Lake anomaly	Figure FAL00-6. One deep and productive well (a slim hole) has been drilled so-far, at the western edge of the anomaly. The top of the reservoir is at c.5,850 ft depth. Large anomaly is promising.
FLY00	Fly Ranch/Granite Ranch	Ward's (Fly/Hualapi Flat) H.S.	Figure FLY00-3. A chemical geothermometer esimtate of 308°F has not been used for the capacity estimate, because drilling to 5,000 ft encountered a maximum of only 210°F. Thus, the capacity estimate represents a low-temperature system (200°-220°F) over an area of 1.2 to 3.4 square miles (indicated by temperature gradient holes, and very approximate). Deep drilling has not established commercial levels of permeability.
FLY01	Fly Ranch/Granite Ranch	Granite Ranch	Figure FLY01-1. Granite Ranch area, 5 miles to the S of Fly Ranch (See Figure FLY00-1). Shallow drilling has encountered 221°F at 130 ft, with a reversal below. No fluids samples. Estimate is based on default values for a point source, except for a minimum average 221°F.
GER00	Gerlach	(Great Boiling Spring)	Figure GER00-1. A hole to 5,870 ft found c.200°F and was dry, but the chemical geothermometers of all three hot springs in the area have a good probability of being accurate at 290°-380°F. Results of drilling to c.3,000 ft in the early-mid 1990s are not available. The capacity estimate depends stongly on assumed reservoir thickness, and on areal extent based only on the hot spring distribution, with support from the distribution of temperatures at 30 m depth.
HAZ00	Hazen (Black Butte)	(Patua Hot Springs)	Figure HAZ00-1. This estimate uses the chemical geothermometers of the hot springs and default values for other input parameters. The area used is a point source, and depth is the Nevada default. It thus calculates the amount of heat present in a thickness that would require drilling to at least several thousand feet. Prior drilling has established that there is productivity of water at c.280°F from less than 800 ft., and a developer might seek to exploit this shallow source. In such a case, the estimated generation capacity would be several MW at most, but for a point source. It is reasonably likely that the system area is at least somewhat greater.
HON00	Honey Lake	Area-wide Summary	Figure HON00-4. Assumes a relatively thin reservoir, which may not be correct, but drilling costs could prohibit exploiting deeper zones unless higher temperatures are discovered. A higher temperature source is suggested by a fluids mixing model for Wendel H.S. and Amedee H.S. Existing production of about 5 MW gr is very localized in three areas (projects HON01-03) that together cover only a small fraction of the total apparent area of the heat anomaly, and this does suggest that the thickness of the reservoir has been under-estimated.

PROJ ID	Field or District	Area or Power Plant	Comments/Notes
KYL00	Kyle Hot Springs (Granite Mtn)		(Buena Vista Valley) Figure KYL00-2. May be an under-estimate. The definite possibility that Kyle H.S. is a mixed water means that the Min average resource temperature may be higher than the 280°F value which has been used. Further chemical studies and results from near-by petroleum exploration wells (not presently in the public domain) need to be considered.
LEA00	Leach Hot Springs	Grass Valley	Figure LEA00-5. Fairly uncertain. The only deep well was dry (257°F at 8,565 ft.)
LEE00	Lee Hot Springs		Figure LEE00-1. Dependent on default input parameter values except for chemical geothermometers of the hot spring water.
NEW00	New York Canyon		Figure NEW00-2. Very uncertain. Area is not well-defined and could be larger. Other parameters are default values. The maximum measured temperature is 166°F at 1,180 ft but with a high BH gradient (c.9°F/100 ft). Steam has been reported from a separate 140 ft-deep hole. A kaolinite deposit indicates former hot spring activity and fairly high temperatures, at least in the past. This area is assigned to Exploration-Development Category C on the basis of reported shallow steam, not actual measured temperature.
NOR00	North Valley		Figure NOR00-2. Relatively abundant shallow and ID Slim hole data define a large anomaly in an area where there may be relatively abundant fracturing and fault offsets. 265°F has been measured at 1,811 ft.
PUM00	Pumpernickel Valley	Tipton Ranch/Hot Springs Ranch	Figure PUM00-2. The maximum measured temperature is 219°F at 3,071 ft (flowing well). This and the hot spring chalcedony temperature of 257°F establish likely minimum condition at depth. Very low Cl in the hot spring water tempers any possibility of temperatures above about 350°F. The Area value used is poorly constrained; it could be larger, and default values of thickness are used. If the resource is assumed to have a fixed temperature of 219°F, and all other parameters are unchanged, then the Min. is 5.2 MW, the Mlk is 7.3 MW, the Mean is 11.0 MW, and the Std.Dev is 4.9 MW.
PYR00	Pyramid Lake Indian Reserv.		(Needle Rocks Hot Springs) Figure PYR00-2. Temperatures higher than 240°F (known production at roughly 4,000 and/or 5,800 ft) are suggested by chemical geothermometers but not yet confirmed. Higher temperatures could be much deeper. Area is not constrained and could be significantly larger. Represents only the Needles H.S. area and does not include any estimates for Pyramid Island or Anaho Island (Figure PYR00-1). If temperature is fixed at 240°F and all other input parameters remain unchanged, then Min is 5.2 MW, Mlk is 7.8 MW, Mean is 11 MW and Std.Dev is 4.8 MW.
RYE01	Rye Patch-Humboldt House District	Rye Patch	Figure RYE01-1. The estimate assumes a minimum average temperature that is the average of shallow production at c.260°F and deeper production at 405°F. Higher capacity may be possible if enough deeper hot zones can be successfully drilled, so higher default temperatures have been used for the most-likely and maximum values.
RYE02	Rye Patch-Humboldt House District	Humboldt House	Figure RYE02-1. Largely dependent upon default values. Area is given by shallow and deep drilling results, but the distribution of permeability is uncertain (both deep holes were apparently dry or sub-commercial). Capacity could be less if permeability is restricted to the N half of the anomaly, where the most extensive part of the outflow zone is defined by shallow temperatures and hydrothermal silica deposits.

Table 4 - Page 3 of 11

PROJ ID	Field or District	Area or Power Plant	Comments/Notes
SAW00	Salt Wells	Eight Mile Flat	Figure SAW00-2. The relatively high estimated capacity is mostly due to the large area of the shallow thermal anomaly, which may over-represent the deep anomaly. Shallow temperatures that reach 264°F at 400 ft and (very limited) chemical information encourage the possibility of high temperatures ($\geq 400^{\circ}\text{F}$) at depth. Deep permeability (and reservoir thickness) has to be assumed. The only deep hole, drilled within the area of the shallow thermal anomaly, encountered sub-commercial permeability and a maximum 358°F (at 8,500 ft). More deep exploration is needed.
SOD00	Soda Lake	Soda Lake No.1/No.2	Figure SOD00-4. System temperatures and geometry are reasonably well-established. A large number of wells have been drilled in the area, and the number in production is a relatively small fraction of the total. This suggests that it has been difficult to find adequate permeability at depth.
STE00	Steamboat Hot Sprs	Field-wide Summary	Figure STE00-4. Based on relatively good and complete data. The minimum recovery factor has been adjusted upwards from the normal value used for reservoirs in fractured rocks, because permeability and rate of thermal recharge appear to be very large. Recovery could still be under-estimated. The histogram of estimation frequency has a very broad maximum, which makes the most-likely (modal) estimate relatively non-unique.
STI00	Stillwater	Stillwater Geothermal 1	Figure STI00-2. Good temperature data. The reservoir Area requires some rough estimation, but a large error is unlikely. Since this is a heat-in-place estimate, it does not factor in the natural thermal recharge to the area, which probably comes from the N. The histogram of frequency of estimates has a very broad maximum, which makes the most-likely (modal) estimate relatively non-unique. See separate estimate for Stillwater N expansion (STI01).
STI01	Stillwater	Stillwater N Expansion	Figure STI01-1. This area is hotter and apparently closer to upflow than is the Stillwater Geothermal I area (STI00). The histogram of frequency of estimates has a very broad maximum, which makes the most-likely (modal) estimate from a single (set of) calculation(s) very non-unique. The most-likely value tabulated here (24 MW) is the average mode of 10 calculations, instead of the 33 MW value on Figure STI01-1 (which represents a single calculation).
TRI00	Trinity Mountains District	Telephone Well area	Figure TRI00-3. Based on default values except the area of a poorly bounded shallow temperature gradient anomaly defined by values of 5.3° to $8.9^{\circ}\text{F}/100 \text{ ft}$. Therefore, very highly uncertain.
WAB00	Wabuska		Figure WAB00-1. The major uncertainty is reservoir thickness and whether permeability exists at depths below 2,200 ft. The existence of somewhat higher temperatures than being produced is indicated with reasonable confidence by chemical geothermometers
Area: 2 - NV with direct access to CA			
AUR00	Aurora		Figure AUR00-3. Capacity may be considerably less if the area and/or most-likely and maximum average temperatures have been over-estimated. The estimated area is based on widely separated holes that may not represent a single continuous hydrothermal system. The only confirmed temperature is c.250°F, at 1,500 ft depth.

PROJ ID	Field or District	Area or Power Plant	Comments/Notes
DIX00	Dixie Valley	Caithness Dixie Valley	Figure DIX00-6. This capacity estimate is based on relatively good and complete data. It has been restricted to represent the zone of deep, hot permeability occupied by the existing production/injection wellfield, at temperatures $\geq 400^{\circ}\text{F}$. An outer volume of (deep) rock to the SE at temperatures $< 400^{\circ}\text{F}$ is effectively not included, and significant additional deep heat reserves can be expected to exist to the NW, in the footwall (W side) of the Dixie Valley fault, where temperatures $> 400^{\circ}\text{F}$ probably are present (no deep drilling done). Therefore, this capacity estimate is conservative relative to a total heat-in-place estimate. This estimate represents reserves to the NE of a line drawn from NW to SE through the middles of Sections 11, 13 and 19 (Figure DIX00-1). The histogram of estimated values has a broad maximum, which makes the most-likely value relatively non-unique. A separate capacity estimate for the Dixie Valley Power Partners area to the SW is listed under DIX01.
DIX01	Dixie Valley	Dixie Valley Power Partners (DVPP)	Figure DIX01-1. The histogram of estimated values has a broad maximum, which makes the most-likely value relatively non-unique. This estimate represents reserves to the SE of a line drawn from NW to SE through the middles of Sections 11, 13 and 19 (Figure DIX00-1). A separate capacity estimate for the Caithness Dixie Valley Project area to the NE is listed under DIX00. Even though somewhat adjusted for the possibility of permeable conditions along the front of the Stillwater Range in the central part of the area (see discussion of Area used for input to estimate calculation), this estimate may far exceed developable reserves if distributed commercial levels of permeability are not established or EGS development cannot access the total hot rock volume in the capacity estimate model. Otherwise, this estimate is based on relatively good data concerning temperature and system geometry.
EMI00	Emigrant (Fish Lake V.)		Figure EMI00-3. High gradients and bottom hole temperatures in holes 100 ft to 2,400 ft deep extend over a large area. The most-likely average temperature that has been used for the estimate (340°F) appears to be reasonable and may be a little low, considering the temperatures in deep wells of the near-by Fish Lake Valley project (FIS00).
FIS00	Fish Lake (Valley)		Figure FIS00-2. Productive wells have been drilled and successfully tested (test data is not in the public domain). The resource appears to be relatively deep and the area of the reservoir is fairly uncertain.
HAW00	Hawthorne		Figure HAW00-4. Based on limited data and relatively uncertain, but evidence of a large, high-temperature system is thus-far lacking.
HYD00	Hyder Hot Springs		Figure HYD00-2. This estimate is largely dependent upon default values for the input parameters, except for temperature. The minimum estimated average deep temperature is less than 200°F , and the presence of significantly higher temperature is relatively uncertain.
PIR00	Pirouette Mountain	(S.Dixie Valley)	Figure PIR00-2. Relatively uncertain. The maximum temperature measured is 189°F at 2,000 ft., but there are elevated temperature gradients at depths as great as 2,000 ft over a large area. Seven holes already drilled to c.2,000 ft.
SIL00	Silver Peak	(Alum prospect)	Figure SIL00-3. Highly uncertain. Shallow permeability and temperatures to 245°F have been established. It is assumed that a single water sample correctly indicates that a higher temperature system lies at depth. Area is estimated from moderate temperature gradients to 2,000 ft at only a few points, that do not provide very good or convincing definition of the extent of the anomaly. Reservoir thickness has been assumed using default average Nevada values.

PROJ ID	Field or District	Area or Power Plant	Comments/Notes
SOH00	Sou Hot Springs	(Seven Devils/ Gilbert's H.S.)	Figure SOH00-2. Spring chemistry makes it doubtful that high temperatures are present. Otherwise, based on default values.
Area: 3 - Other NV			
BAL00	Baltazor		Figure BAL00-4. The size of the resource is not well-constrained by available drilling data. If the top of the reservoir (except for the discharge zone to the hot springs) is indeed at about 5,000 ft, drilling costs may be high relative to the modest resource temperature.
DOU00	Double - Black Rk Hot Springs		Figure DOU00-2. The capacity is the sum of 4 separate (but possibly connected) hot spring areas that are distributed N-S along 13 miles of a tectonic lineament. Development of more than about 5 - 10 MW at any one area may not be feasible. Note that the most-likely temperature is only 255°F.
MCG00	McGee Mountain	(Painted Hills)	Figure MCG00-2. Estimate depends upon default values except for area, which is not well-constrained to the SW. The maximum temperature measured downhole is 208°F at 279 ft.. The deepest known hole has 200°F at 1,680 ft, with a bottom hole gradient of 5.2°F/100 ft. Minor fumarolic activity. Assigned to Exploration-Development Category C because 208°F exceeds boiling temperature at local elevation.
PIN00	Pinto Hot Springs		Figure PIN00-2. Spring chemistry offers some promise of temperatures around 350°F, but high spring flow rates at temperatures just below boiling and bicarbonate in excess of Cl add some caution to the estimate. The Area value used is based only on hot spring distribution, and could be significantly less than the true resource area. TG drilling has been done only close to the hot springs, and is no guide.
SHO00	Shoshone-Reese River		Figure SOH00-2. There is a large area of anomalous temperature gradients to a maximum depth of 500 ft, but the resource area has been estimated conservatively, because much of the anomaly could be an outflow zone. Otherwise, the capacity estimate is based almost entirely on default input parameters. The highest measured temperature is 155°F at 450 ft. A blind anomaly.
WIL00	Wilson Hot Springs		Figure WIL00-1. Very dependent upon default values except for area. No spring chemistry. Highest measured temperature is 196°F. An ID Slim hole has isothermal conditions at 193°-190°F from 1,200 to 2,000 ft.
Area: 4 - All other CA			
BRW01	Brawley	Brawley (North Brawley)	Figure BRW01-2. Based on relatively good data from commercially productive wells, but these are confined to a small area and there is considerable uncertainty about the horizontal extent of the resource. The estimate defines the area that has been drilled and found to have enough permeability to flow, but it includes hot wells with sub-commercial flow rates (not dry holes). A much larger and more extensive heat resource undoubtedly exists, to the sides, above and (especially) below. The (North) Brawley resource is at depths intermediate between the shallower Salton Sea resource and the deeper resources at East Brawley and South Brawley. The brine TDS is hypersaline, as at the Salton Sea and South Brawley, but includes decidedly lower salinities (down to c.50,000 ppm, probably at the shallower production zones).

PROJ ID	Field or District	Area or Power Plant	Comments/Notes
BRW02	Brawley	East Brawley	Figure BRW02-3. Very uncertain. There are public data records of two apparently very productive wells about 3.5 miles apart, but it is unknown whether the area in-between is a continuous, potentially productive system. Even if so, there is no particular constraint (among available data) on the horizontal extent of the reservoir. The estimated power density of the area is about 40 MW/sq mile (most-likely value; see Figure BRW02-3). Heat-in-place at depths of less than c.8,500 ft is not included in the estimate, because shallower permeability is apparently limited. If it is possible to inject at shallower levels, additional heat may be available. The reservoir may be somewhat less hypersaline than at the Salton Sea (project SAL00), with TDS about 160,000 ppm, but possibly with higher dissolved CO ₂ (c.1.5 to 2%). It also is deeper (>8,500 ft to c.14,000 ft).
BRW03	Brawley	South Brawley (Mesquite field)	Figure BRW03-3. May be a significant under-estimate. The calculated capacity that is listed here corresponds only to the area drilled and tested by MCR during 1979-82 (about 1.8 sq miles), because there is no information that establishes the horizontal limit of the reservoir. The reservoir area could be much larger. If, for example, it occupies much of the seismically active region of the South Brawley KGRA between the Imperial and Brawley faults (Figure BRW03-2), then the area could be as large as c.30 sq miles, which would increase the estimated modal generation capacity to over 800 MW. The estimated power density of the area is about 28 MW/sq mile (most-likely value; see Figure BRW03-3). Heat-in-place at depths of less than c.11,000 ft is not included in the estimate, because shallower permeability is apparently limited. If it is possible to inject at shallower levels, additional heat may be available. The reservoir is hypersaline as at the Salton Sea (project SAL00), but much deeper (>11,000 ft; Figure BRW00-2) and with much higher dissolved CO ₂ and heavy metals. The result may be a combination of higher scaling and corrosion tendency and higher development and operations costs.
CAL00	Calistoga		Figure CAL00-4. Relatively uncertain, in spite of abundant shallow well data. The maximum depth drilled has been about 2,000 ft and there are very few holes deeper than about 600 ft. Upflow into the shallow aquifer is believed to occur along an axis (probably a fault or fracture zone) that coincides with the geographic center of the NW-SE trending Napa Valley. Locations of relatively high temperatures (>250°F) in the shallow system occur near the NW and SE ends of this axis, at a separation of about 1.8 miles. The generation estimate assumes that there is a reservoir at depths greater than 2,000 ft, and average temperatures as high as 320°F, that connects and surrounds these two locations and feeds the shallow aquifer. The 320°F estimate is given by the Na-K-Ca thermometer without an Mg correction. Default values have been used for estimated reservoir thickness. Deep exploration and electrification development would seem unlikely, due to extensive use of the shallow aquifer and intense development (commercial, agricultural and residential) in the Calistoga area.
COS00	Coso	Field-wide Summary	Figure COS00-2. Based on a relatively good understanding and definition of the resource. The histogram of estimated values has a broad maximum, which makes the most-likely value relatively non-unique. Figure COS00-3 shows that the Coso field has generally maintained power output in the range of 260 to 300 MW gross since the ninth turbogenerator unit went on-line in 1990.
DUN00	Dunes		Figure DUN00-4. Shallow gradient drilling appears to limit the size of the temperature anomaly but a lack of deep information makes the estimate relatively uncertain. For example, although Figure DUN00-3 shows a model of the system that places the deep reservoir beneath the shallow anomaly, this anomaly could instead be the outflow of a deeper and hotter
EAS00	East Mesa	Field-wide summary	Figure EAS00-5. Based on relatively complete and reliable data, but operators apparently have had difficulty maintaining production at the installed capacity of 73 MW. The principal uncertainty is reservoir thickness.

PROJ ID	Field or District	Area or Power Plant	Comments/Notes
GEY00	Geysers	Field-wide Summary	<p>This Estimated Generation Capacity for The Geysers does NOT represent application of the heat-in-place method and Monte Carlo simulation. Instead, the estimate is based on the following:</p> <p>A) As of 2002, the installed power capacity at The Geysers was approximately 1,000 MW gross, and the annual decline rate of generation was on the order of 5%. It is assumed that this amount of decline can be mitigated by working over existing wells, drilling new wells and undertaking modifications to the power plant and gathering systems. Once the injection of effluent from the City of Santa Rosa commences, this decline trend is expected to be somewhat reduced. Therefore, maintaining the present installed capacity of about 1,000 MW gross at The Geysers for the next two decades should be relatively inexpensive and straightforward.</p> <p>B) The total proven reservoir area at The Geysers is nearly 40 square miles, as determined by the extensive shallow and deep well drilling in the region. Of this area, there is a portion of approximately 10 square miles, which has never been developed for continuous steam supply. This 10 square miles, lying between the Aidlin project area to the northwest and the areas of Units 5-6, 7-8 and 11 to the southeast, comprises about 25% of the 40 square mile total proven area. Given that an installed capacity of 1,000 MW gross is being supported at a steady state by some 30 square miles of the field area, a reasonable estimate of average installed capacity is 33 MW per square mile. Therefore, the un-utilized 10 square miles should be able to support 333 MW gross of additional capacity.</p> <p>C) In addition, about 2 square miles in the northeastern part of the field (within the proven reservoir area) remain untapped, at the former Bottlerock project and a contiguous area to the southeast. Using the factor of 33 MW gross per square mile, this area would support another 66 MW gross of additional capacity.</p> <p>D) Therefore, the maximum possible capacity of The Geysers is estimated to be approximately (1,000+333+66) or about 1,400 MW gross (which includes existing power plants). This is listed herein as both the Most-likely value and the Mean value.</p> <p>E) A minimum value for the incremental power available would be about half of the estimate based on 33 MW per square mile, or 200 MW above current generation levels. Therefore, the minimum installed capacity at The Geysers over the next two decades is about (1,000+200) or 1,200 MW gross: this is listed herein as the Minimum value.</p> <p>F) If energy prices increase, operators of existing plants would have an incentive to invest in further facility optimization, which could yield an additional 10% of capacity at existing plants, or 100 MW. Thus, the total capacity of the Geysers could easily reach 1500 MW gross under the right economic conditions.</p> <p>N1) Since the MW estimates are not based on a Monte-Carlo heat-in-place calculation, there is no corresponding standard deviation value.</p> <p>Figure GLA00-1. Based on no significant data other than a single hot (132°F) gradient hole. Only a few shallow holes have been drilled in the area. Data from a 2,000 ft hole were not found. This estimate is therefore very uncertain.</p>
GLA00	Glamis		

PROJ ID	Field or District	Area or Power Plant	Comments/Notes
HEB00	Heber	Field-wide Summary	Figure HEB00-3. Based on relatively good and complete data. Reservoir thickness has been largely confined to the thickness being exploited and known to be sufficiently permeable for production. A larger amount of heat-in-place (and higher capacity) would be calculated by adding the hot rock (below about 6,500 ft depth) which underlies production wells in the SIGC area, outside of the central hot core of the system; however, the deep rock in this (SIGC) area may have relatively low permeability.
LAK00	Lake City / Surprise Valley	Lake City	Figure LAK00-4. In spite of one successful well (2-3 MW production), the thickness and extent of the reservoir remain very uncertain.
LVM00	Long Valley - M-P Leases	M-P Lease Summary	Figure LVM00-6. The geothermal resource at Casa Diablo has a very high permeability and a high natural recharge rate. This is not explicitly reflected in the heat-in-place method, which neglects the addition of heat to the exploited reservoir volume in the time frame of commercial development. The assumed 5% default minimum recovery factor is therefore likely to be conservative, and the generation capacity of the area may be greater than the minimum (90% probable) estimate.
MED01	Medicine Lake	Fourmile Hill	<p>1) This estimate (Figure MED01-2) is based on relatively limited information. There is just one deep exploration well (TD 8,503 ft) and no publicly available samples of the geothermal fluid. There is one ID slim hole (TD 4,416 ft.), with a maximum temperature of 455°F and a temperature profile that suggests permeable, convective conditions below about 3,000 ft depth. The deep exploration hole shows some permeability at c.6,000 ft and a temperature reversal below c.4,000 ft (T.Box, pers.comm. 25 July 03).</p> <p>2) The generation capacity estimate herein does not use a most-likely (Mlk) estimate of reservoir area, only a minimum and a maximum. It is felt that inadequate information is available to estimate the Mlk area.</p>
MED02	Medicine Lake	Telephone Flat	<p>1) This estimate (Figure MED02-1) is based on relatively good information, as there are three deep, full-diameter wells that have been drilled and tested. The most-uncertain parameter is reservoir area. A reasonable minimum area is provided by the distribution of the three wells. A much larger maximum possible area is given by the location of the shallow, 38°C/100°F isotherm at 1500 m elevation (Figure MED00-1). However, the correlation of this isotherm with the boundary of the deep reservoir is not established with confidence. For the purposes of reserves associated with Telephone Flat, a 9 sq mi area in the vicinity of the proposed power plant is being used.</p> <p>2) A reservoir volume number is not provided, because reservoir volume is calculated from most-likely area and most-likely thickness, but the generation capacity estimate herein does not use a most-likely (Mlk) estimate of reservoir area, only a minimum and a maximum. It is felt that inadequate information is available to estimate the Mlk area.</p> <p>3) BLM99a, p.ES37 states that "The Supplemental Environmental Assessment (EA) for geothermal leasing in the Glass Mountain KGRA provided an estimation of the electric-generation potential of the Glass Mountain KGRA to be about 550 MW for a 30-year period. However, this estimation was based on indirect information with very limited geothermal resource data obtained from only a few deep temperature gradient holes in the area. More recent information suggests that the actual commercial development potential of the Glass Mountain KGRA is far less than earlier projected." The factual basis for this comment is not given.</p>

Table 4 - Page 9 of 11

PROJ ID	Field or District	Area or Power Plant	Comments/Notes
MOS00	Mount Signal		Figure MOS00-3. Based on relatively good data from temperature gradient holes and one ID Slim hole (to 1826 ft, BHT 259°F). No fluids samples (apparently a blind anomaly). Represents only the part of the anomaly that is within the U.S.
NIL00	Niland		Figure NIL00-1. This capacity estimate is confined to the area that was drilled and (it has been reported) successfully tested in the early 1980s. Evidence suggests that the Niland resource is the eastern-most edge of the Salton Sea system, although the Niland wells are located about 1 mile east of the shallow heat flow anomaly shown on Figures SAL00-1 and -2, and permeability at Niland is deeper than in the Salton Sea reservoir (see Figure BRW00-2). Deep, hot rock at temperatures similar to those encountered at Niland probably extends across a much larger area, at a power density of about 32 MW/sq mile (minimum estimate).
RAN00	Randsburg		Figure RAN00-2. Highly uncertain. The shallow temperature anomaly is well-defined, but the actual temperature, thickness and area of the resource are largely assigned default values. There are no chemical data. The highest measured temperature reported is 239°F at 772 ft. Results of drilling by Phillips in 1981 are not in the public domain.
SAL00	Salton Sea	Field-wide summary	<p>Figure SAL00-3. This estimate, which is based on relatively good and complete data, represents an area of 18.1 sq miles within the shallow gradient anomaly (Figures SAL00-1 and -2) that is on-shore or can reasonably be reached by directional drilling from on-shore at this time. The total shallow gradient anomaly is some 28 sq miles, and if scaled to that value, the Min (90% probable) value of generation capacity would become 2090 MW. The histogram which is the frequency of generation estimates (on Figure SAL00-3) has a relatively broad maximum, which means that the most-likely (modal) estimate is relatively non-unique.</p> <p>For comparison, a recent published estimate of the generation capacity of the geothermal field can be summarized as follows:</p> <p>A) Hulen and others (2002) (Hul02a) have estimated the area of the Salton Sea resource based on the 11°F/100ft (200°C/km) shallow temperature gradient contour, which has been defined by more than 100 shallow boreholes and deep geothermal wells (Figure SAL00-1). The area inside this contour is estimated by Hul02a to be 72.4 square km, or 28 square miles (sqmi).</p> <p>B) The estimation method used by Hul02a is to divide the existing developed production capacity (335 MWe) by the land area that has been extensively drilled to support this capacity (4.0 sq mi), to obtain a MWe/sqmi value, and then scale this value up to 28 sqmi. Accordingly, $(335/4.0) = 83.7$ MWe/sqmi, and $28 \text{ sqmi} * 83.7 \text{ MWe/sqmi} = 2330 \text{ MWe}$ (see Figure SAL00-2). Hul02a estimates the onshore resource of the Salton Sea as having a potential of 900 MWe, which is within the range of the minimum and most-likely estimates presented in this database.</p> <p>Figure SES00-1. Based on default values for a non-volcanic system, except for temperatures from hot spring chemistry (3 samples, all very similar).</p>
SES00	Sespe Hot Springs		

PROJ ID	Field or District	Area or Power Plant	Comments/Notes
SUL00	Sulphur Bank	Clear Lake	<p>Figure SUL00-5. Deep drilling data indicate widespread temperatures $\geq 425^{\circ}\text{F}$ at depths of 4,000 to 7,000 ft., that are associated with a volcanic heat source. The distribution of deep permeability is uncertain. A commercially productive well former Sulphur Bank mercury mine. This well found production of water at about 425°F from a depth of 1,625 ft. Relatively shallow permeability may be confined to SW-NE and/or E-W-trending fault/fracture zones that have been the locus of the mercury and sulfur deposit that was exploited by the mine. However, the amounts of historic hot spring activity at the site, and the size of the mercury deposit, suggest hydrologic communication with a much larger volume of rock than would be contained by these fault/fracture zones alone.</p>
SUP00	Superstition Mountain		<p>Figure SUP00-3. Except for area, this calculation is based on deafult values for Nevada Basin and Range resources, and the applicability of these defaults to this setting is uncertain. Area is based on isotherms at 200 ft depth (maximum 110°F), and is also relatively uncertain.</p>

Hetch Hetchy/SFPUC Programmatic Renewable Energy Project
Project: 1.3 New Geothermal Site Identification and Qualification
Project Team: GeothermEx, Inc.
Task: 1.3.10 Final Project Report
Subject: D.1.3.10.3 Final Report

Table 5: Estimated Generation Capacities - by Exploration-Development Category

PROJ ID	Field or District	Area or Power Plant	State County	Temperature (°F) ¹			Volume ² (mi ³)	Installed Capacity (MW) ³ Gross - Net	Explor- Devel. Cat. ⁴	Generation Capacity (MW-30yrs) ⁵				
				Min	Mlk	Max				Min	Mlk	Mean	Std. Dev.	
Category: A - Existing power plant operating.														
BEO00	Beowawe		NV Eureka-Lander	400°	410°	420°	1.70	16.7	16	A	30	41	58	21
BRA00	Brady's Hot Springs		NV Churchill	340°	360°	380°	0.76	26	20	A	11	18	22	8.3
COS00	Coso	Field-wide Summary	CA Inyo	475°	550°	575°	8.52	300	270	A	246	355	490	189
DES00	Desert Peak		NV Churchill	370°	385°	400°	2.27	11	9.9	A	33	45	79	40
DIX00	Dixie Valley	Caithness Dixie Valley	NV Churchill	420°	440°	460°	3.17	66	56	A	71	107	142	56
EAS00	East Mesa	Field-wide summary	CA Imperial	300°	310°	320°	8.54	73.2	56	A	119	148	167	38
EMP00	Empire (San Emidio)	Field-wide summary	NV Washoe	285°	305°	330°	0.62	4.8	4.6	A	4.3	6.6	11	6.7
GEY00	Geysers	Field-wide Summary	CA Lake-Sonoma	464°	468°	482°	37.88	1000	900	A	1200	1400	1400	N1
HEB00	Heber	Field-wide Summary	CA Imperial	330°	340°	360°	6.73	100	79	A	109	142	158	40
HON00	Honey Lake	Area-wide Summary	CA Lassen	230°	240°	250°	1.09	6.4	3.4	A	5.7	8.3	13	6.9
LVM00	Long Valley - M-P Leases	M-P Lease Summary	CA Mono	342°	362°	382°	8.18	40	30.1	A	70	111	148	65
SAL00	Salton Sea	Field-wide summary	CA Imperial	550°	575°	600°	25.71	350	326	A	1350	1750	1880	400
SOD00	Soda Lake	Soda Lake No.1/No.2	NV Churchill	340°	360°	370°	2.12	26.1	16.6	A	29	42	62	28
STE00	Steamboat Hot Sprs	Field-wide Summary	NV Washoe	350°	370°	390°	2.33	59.84	48.1	A	56	62	78	17

PROJ ID	Field or District	Area or Power Plant	State County	Temperature (°F)			Volume (mi ³)	Installed Capacity (MW)	Explor-Devel. Cat.	Generation Capacity (MW-30yrs)				
				Min	Mlk	Max				Min	Mlk	Mean	Std. Dev.	
STI00	Stillwater	Stillwater Geothermal 1	NV Churchill	290°	310°	330°	1.09	19	10	A	11	18	21	8.0
WAB00	Wabuska		NV Lyon	225°	245°	290°	1.33	1.45	1.2	A	8.1	13	17	8.0
Totals for Category:													3353	
3267													4746	
458													6	
Category: B - One or more wells tested at >=1 MW.														
BRW01	Brawley	Brawley (North Brawley)	CA Imperial	490°	510°	530°	2.45	0	-	B	88	135	144	45
BRW02	Brawley	East Brawley	CA Imperial	480°	520°	560°	2.21	0	-	B	85	129	138	44
BRW03	Brawley	South Brawley (Mesquite field)	CA Imperial	480°	500°	520°	1.19	0	-	B	45	62	70	21
FIS00	Fish Lake (Valley)		NV Esmeralda	340°	380°		2.25	0	-	B	30	47	62	27
LAK00	Lake City / Surprise Valley	Lake City	CA Modoc	320°	335°	350°	2.18	0	-	B	23	37	49	21
MED01	Medicine Lake	Fourmile Hill	CA Siskiyou	388°	428°	455°	2.05	0	-	B	25	36	70	42
MED02	Medicine Lake	Telephone Flat	CA Siskiyou	440°	480°	490°	5.05	0	-	B	110	175	256	128
NIL00	Niland		CA Imperial	500°	540°	550°	1.39	0	-	B	59	76	92	27
RYE01	Rye Patch-Humboldt House District	Rye Patch	NV Pershing	335°	345°	405°	1.13	12.5	8.75	B	16	20	34	15
STI01	Stillwater	Stillwater N Expansion	NV Churchill	310°	330°	350°	1.36	0	-	B	16	24	31	11
SUL00	Sulphur Bank	Clear Lake	CA Lake	400°	450°		1.66	0	-	B	27	43	61	30
Totals for Category:													524	
784													1007	
160													6	
Category: C - Minimum 212°F logged downhole.														
AUR00	Aurora		NV Mineral	250°	345°	440°	2.65	0	-	C	31	51	70	35
BAL00	Baltazor		NV Humboldt	288°	306°	316°	1.19	0	-	C	11	16	24	11
BLU00	Blue Mountain		NV Humboldt	291°	345°	440°	1.33	0	-	C	16	30	38	19
CAL00	Calistoga		CA Napa	275°	320°		1.86	0	-	C	17	25	35	16

PROJ ID	Field or District	Area or Power Plant	State County	Temperature (°F)			Volume (mi ³) ²	Installed Capacity (MW) ³ Gross - Net	Explor-Devel. Cat. ⁴	Generation Capacity (MW-30yrs) ⁵				
				Min	Mlk	Max				Min	Mlk	Mean	Std. Dev.	
COL00	Colado		NV Pershing	215°	270°	330°	0.80	0	-	C	3.7	6.2	8.3	4.1
DIX01	Dixie Valley	Dixie Valley Power Partners (DVPP)	NV Churchill	445°	460°	475°	4.69	0	-	C	107	151	210	83
DUN00	Dunes		CA Imperial	250°	400°		0.86	0	-	C	7.4	11	18	10
EMI00	Emigrant (Fish Lake V.)		NV Esmeralda	230°	340°	450°	6.77	0	-	C	49	85	118	63
FAL00	Fallon / Carson Lake	Carson Lake anomaly	NV Churchill	360°	370°	380°	2.61	0	-	C	34	55	74	34
FLY00	Fly Ranch/Granite Ranch	Ward's (Fly/Hualapi Flat) H.S.	NV Washoe-Pershing	200°	220°	210°	2.40	0	-	C	6.0	8.7	13	5.7
FLY01	Fly Ranch/Granite Ranch	Granite Ranch	NV Washoe-Pershing	221°	345°	440°	0.53	0	-	C	5.4	8.1	13	7.1
GER00	Gerlach	(Great Boiling Spring)	NV Washoe	290°	340°	385°	2.50	0	-	C	17	25	36	16
HAW00	Hawthorne		NV Mineral	200°	285°	440°	1.06	0	-	C	8.7	14	22	13
HAZ00	Hazen (Black Butte)	(Patua Hot Springs)	NV Lyon	280°	330°	430°	1.25	0	-	C	6.3	8.5	14	6.9
KYL00	Kyle Hot Springs (Granite Mtn.)	(Buena Vista Valley)	NV Pershing	280°	375°	412°	0.99	0	-	C	16	22	36	19
LEA00	Leach Hot Springs	Grass Valley	NV Pershing	220°	265°	343°	1.79	0	-	C	13	18	29	15
LEE00	Lee Hot Springs		NV Churchill	303°		324°	0.53	0	-	C	5.4	9.4	11	5.1
MCG00	McGee Mountain	(Painted Hills)	NV Humboldt	225°	345°	440°	1.86	0	-	C	19	28	47	26
MOS00	Mount Signal		CA Imperial	250°	345°	440°	1.19	0	-	C	12	19	29	15
NEW00	New York Canyon		NV Pershing	245°	345°	440°	1.72	0	-	C	20	26	46	23
NOR00	North Valley		NV Churchill-Washoe	255°	345°	440°	3.18	0	-	C	37	49	84	43
PUM00	Pumpernickel Valley	Tipton Ranch/Hot Springs Ranch	NV Humboldt	235°	295°	356°	1.19	0	-	C	10	13	22	11
PYR00	Pyramid Lake Indian Reserv.	(Needle Rocks Hot Springs)	NV Washoe	240°	345°	417°	0.93	0	-	C	9.9	14	23	12

PROJ ID	Field or District	Area or Power Plant	State County	Temperature (°F)			Volume (mi ³)	Installed Capacity (MW) Gross - Net	Explor-Devel. Cat. ⁴	Generation Capacity (MW-30yrs) ⁵				
				Min	Mlk	Max				Min	Mlk	Mean	Std. Dev.	
RAN00	Randsburg		CA San Bernardino	240°	345°	440°	3.31	0	-	C	32	48	82	46
RYE02	Rye Patch-Humboldt House District	Humboldt House	NV Pershing	290°	345°	440°	2.12	0	-	C	27	34	60	30
SAW00	Salt Wells	Eight Mile Flat	NV Churchill	330°	400°	430°	3.98	0	-	C	63	96	136	63
SIL00	Silver Peak	(Alum prospect)	NV Esmeralda	310°	345°	440°	2.85	0	-	C	41	78	91	43
<i>Totals for Category:</i>								0			625	949	1389	166 ⁶
<i>Category: D - Other exploration data/information.</i>														
DOU00	Double - Black Rk Hot Springs		NV Humboldt	240°	255°	275°	2.12	0	-	D	20	33	53	31
GLA00	Glamis		CA Imperial	250°		400°	0.83	0	-	D	4.3	6.4	11	6.0
HYD00	Hyder Hot Springs		NV Pershing	180°		310°	1.67	0	-	D	5.5	9.6	15	8.4
PIN00	Pinto Hot Springs		NV Humboldt	285°	366°	440°	1.33	0	-	D	18	29	39	19
PIR00	Pirouette Mountain	(S.Dixie Valley)	NV Churchill	190°	345°	440°	1.52	0	-	D	16	23	40	22
SES00	Sespe Hot Springs		CA Ventura	230°	265°	300°	0.53	0	-	D	3.6	5.3	7.8	3.6
SHO00	Shoshone-Reese River		NV Lander	225°	345°	440°	1.19	0	-	D	13	18	30	16
SOH00	Sou Hot Springs	(Seven Devils/Gilbert's H.S.)	NV Pershing	180°		370°	0.53	0	-	D	3.3	6.1	9.5	6.1
SUP00	Superstition Mountain		CA Imperial	225°	345°	440°	0.66	0	-	D	5.9	9.5	15	8.0
TRI00	Trinity Mountains District	Telephone Well area	NV Church.-Persh.-Wash.	225°	345°	440°	3.98	0	-	D	42	66	100	53
WIL00	Wilson Hot Springs		NV Lyon	200°	345°	440°	1.13	0	-	D	10	17	27	15
<i>Totals for Category:</i>								0			142	223	347	73 ⁶

PROJ ID	Field or District	Area or Power Plant	State County	Temperature (°F) 1	Volume 2	Installed Capacity (MW) 3	Explor- Devel. Cat. 4	Generation Capacity (MW-30yrs) 5						
				Min	Mlk	Max	(mi ³)	Gross	- Net	Min	Mlk			
								Grand Totals:	2113	1856	4644	6223	7490	518 ⁶

1. Reservoir temperature values used for Monte-Carlo estimation of generation capacity.

Min = minimum average; Mlk = most-likely average; Max = Maximum average.

2. The listed reservoir volume is the product: (most-likely average reservoir thickness) x (most-likely reservoir area), where the most-likely values are those used for Monte Carlo estimation of generation capacity.

3. Installed generation capacity, gross and net MW. Applies only to Exploration-Development Category A.

4. Exploration-Development Category

A = existing power plant operating

B = one or more wells tested at ≥ 1 MW

C = a temperature $\geq 212^{\circ}\text{F}$ has been logged downhole (or boiling temperature for local elevation)

D = other exploration data (such as spring chemistry and/or shallow temperature gradient measurements)

5. Min = Minimum = generation capacity value with Monte Carlo simulation cumulative probability of more than 90%

Mlk = Most-likely = Monte Carlo simulation modal generation capacity value

Mean = Monte Carlo simulation mean value

Std.Dev. = Standard Deviation of the Mean value

6. The standard deviation of the sum of mean values is the square root of the sum of squares of individual standard deviations.

Hetch Hetchy/SFPUC Programmatic Renewable Energy Project

Project: 1.3 New Geothermal Site Identification and Qualification

Project Team: GeothermEx, Inc.

Task: 1.3.10 Final Project Report

Subject: D.1.3.10.3 Final Report

Table 6a: Data for Statistical Correlation of Drilling Costs vs. Depth

Well	Completion <i>Date (estimated dates in italics)</i>	Total Depth <i>(feet)</i>	Unescalated Total Cost <i>(US\$)</i>	Producer Price <i>Index (PPI)</i>	Escalation Factor to <i>July 2003 (PPI=142.0)</i>	Total Cost Escalated to 2003 <i>(US\$)</i>	Escalated Cost Per Foot <i>(US\$)</i>	Comments
Geysers 1	1-Jul-94	11,452	\$2,660,000	93.0	1.527	\$4,061,505	\$355	Cost is for first leg only. Full well cost was \$3,282,000 including 2,193-ft fork (8,900' to 11,093'). Includes mob of rig to site. Stacked out rig at end of job.
Geysers 2	1-Jul-92	9,378	\$2,184,000	90.3	1.573	\$3,434,419	\$366	Cost includes \$47,000 mob, but no de-mob (skidded to another well).
Geysers 3	1-Jul-95	9,932	\$2,920,000	96.7	1.468	\$4,287,901	\$432	Includes full mob and de-mob of rig.
Geysers 4	1-Jul-92	9,670	\$3,764,150	90.3	1.573	\$5,919,261	\$612	Well has 3 legs. Depth is for deepest leg. Cost is for all legs, so cost per foot is high.
Geysers 5	1-Jul-92	8,496	\$2,220,265	90.3	1.573	\$3,491,447	\$411	
Geysers 6	1-Jul-92	10,850	\$2,352,530	90.3	1.573	\$3,699,438	\$341	
Geysers 7	1-Jul-92	9,429	\$3,239,895	90.3	1.573	\$5,094,851	\$540	Well has 3 legs.
Geysers 8	1-Jul-86	7,658	\$822,185	93.0	1.527	\$1,255,379	\$164	
Geysers 9	1-Jul-85	7,471	\$1,186,334	100.0	1.420	\$1,684,594	\$225	
Geysers 10	1-Jul-86	10,606	\$2,487,327	93.0	1.527	\$3,797,854	\$358	
Geysers 11	1-Jul-86	5,588	\$803,584	93.0	1.527	\$1,226,978	\$220	
Geysers 12	1-Jul-88	9,120	\$1,970,296	89.7	1.583	\$3,119,086	\$342	
Geysers 13	1-Jul-87	6,849	\$1,418,780	87.6	1.621	\$2,299,849	\$336	
Medicine Lake 1	7-Oct-02	8,503	\$3,789,388	146.1	0.972	\$3,683,047	\$433	Completion date is at end of remedial work. Not clear how much idle rig time.
SSU3 1	1-Jul-88	7,000	\$3,575,000	89.7	1.583	\$5,659,420	\$808	From GCS ¹ submitted to CEC by Unocal on 7 September 1993. Average of 2 producers.

Hetch Hetchy/SFPUC Programmatic Renewable Energy Project

Project: 1.3 New Geothermal Site Identification and Qualification
Project Team: GeothermEx, Inc.
Task: 1.3.10 Final Project Report
Subject: D.1.3.10.3 Final Report

Table 6a: Data for Statistical Correlation of Drilling Costs vs. Depth

Well	Completion		Unescalated Total Cost (US\$)	Producer Price Index (PPI)	Escalation Factor to July 2003 (PPI=142.0)	Total Cost Escalated to 2003 (US\$)	Escalated Cost Per Foot (US\$)	Comments
	Date (estimated dates in italics)	Total Depth (feet)						
Vulcan 1	1-Jul-85	4,000	\$1,772,486	100.0	1.420	\$2,516,930	\$629	From GCS ¹ submitted to CEC by Magma on 2 September 1993. Average of 7 producers.
Hoch 1	1-Jul-87	5,000	\$3,078,000	87.6	1.621	\$4,989,452	\$998	From GCS ¹ submitted to CEC by Magma on 2 September 1993. Average of 7 producers.
Elmore 1	1-Jul-87	6,000	\$2,858,556	87.6	1.621	\$4,633,732	\$772	From GCS ¹ submitted to CEC by Magma on 2 September 1993. Average of 8 producers.
Leathers 1	1-Jul-88	7,500	\$2,970,302	89.7	1.583	\$4,702,150	\$627	From GCS ¹ submitted to CEC by Magma on 2 September 1993. Average of 8 producers.
SSU3 2	1-Jul-88	7,000	\$1,516,667	89.7	1.583	\$2,400,967	\$343	From GCS ¹ submitted to CEC by Unocal on 7 September 1993. Average of 3 injectors. Depth assumed to be same as production wells.
Vulcan 2	1-Jul-85	4,000	\$1,423,800	100.0	1.420	\$2,021,796	\$505	From GCS ¹ submitted to CEC by Magma on 2 September 1993. Average of 5 injectors. Depth assumed to be same as production wells.
Hoch 2	1-Jul-87	5,000	\$1,539,000	87.6	1.621	\$2,494,726	\$499	From GCS ¹ submitted to CEC by Magma on 2 September 1993. Average of 4 injectors. Depth assumed to be same as production wells.
Elmore 2	1-Jul-87	6,000	\$1,767,108	87.6	1.621	\$2,864,490	\$477	From GCS ¹ submitted to CEC by Magma on 2 September 1993. Average of 4 injectors. Depth assumed to be same as production wells.

Hetch Hetchy/SFPUC Programmatic Renewable Energy Project

Project: 1.3 New Geothermal Site Identification and Qualification

Project Team: GeothermEx, Inc.

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Table 6a: Data for Statistical Correlation of Drilling Costs vs. Depth

Well	Completion		Unescalated Total Cost (US\$)	Producer Price Index (PPI)	Escalation Factor to July 2003 (PPI=142.0)	Total Cost Escalated to 2003 (US\$)	Escalated Cost Per Foot (US\$)	Comments
	Date (estimated dates in <i>italics</i>)	Total Depth (feet)						
Leathers 2	1-Jul-88	7,500	\$2,506,193	89.7	1.583	\$3,967,440	\$529	From GCS ¹ submitted to CEC by Magma on 2 September 1993. Average of 4 injectors. Depth assumed to be same as production wells.
HFC 1	1-Jul-84	6,000	\$1,904,762	100.0	1.420	\$2,704,762	\$451	From GCS ¹ submitted to CEC by HGC on 26 August 1993. Average of 11 producers and 10 injectors. Calculated as total field cost (including gathering system) divided by 21 wells.
SIGC 1	1-Jul-93	5,000	\$1,018,182	91.4	1.554	\$1,581,858	\$316	From GCS ¹ submitted to CEC by Ormat (Fall 1993). Average of 11 producers.
SIGC 2	1-Jul-93	5,000	\$868,000	91.4	1.554	\$1,348,534	\$270	From GCS ¹ submitted to CEC by Ormat (Fall 1993). Average of 10 injectors. Depth assumed to be same as production wells.
Ormesa I-1	1-Jul-86	5,000	\$852,632	93.0	1.527	\$1,301,868	\$260	From GCS ¹ submitted to CEC by Ormat (Fall 1993). Average of 19 producers.
Ormesa I-2	1-Jul-86	5,000	\$553,846	93.0	1.527	\$845,657	\$169	From GCS ¹ submitted to CEC by Ormat (Fall 1993). Average of 13 injectors. Depth assumed to be same as production wells.
Ormesa II-1	1-Jul-87	5,000	\$835,714	87.6	1.621	\$1,354,696	\$271	From GCS ¹ submitted to CEC by Ormat (Fall 1993). Average of 7 producers.
Ormesa II-2	1-Jul-87	5,000	\$812,500	87.6	1.621	\$1,317,066	\$263	From GCS ¹ submitted to CEC by Ormat (Fall 1993). Average of 4 injectors. Depth assumed to be same as production wells.

Hetch Hetchy/SFPUC Programmatic Renewable Energy Project

Project: 1.3 New Geothermal Site Identification and Qualification
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Task: 1.3.10 Final Project Report
Subject: D.1.3.10.3 Final Report

Table 6a: Data for Statistical Correlation of Drilling Costs vs. Depth

Well	Completion		Unescalated Total Cost (US\$)	Producer Price Index (PPI)	Escalation Factor to July 2003 (PPI=142.0)	Total Cost Escalated to 2003 (US\$)	Escalated Cost Per Foot (US\$)	Comments
	Date (estimated dates in italics)	Total Depth (feet)						
El Salvador 1	18-Mar-98	4,788	\$1,800,477	120.2	1.181	\$2,127,019	\$444	Directional well
El Salvador 2	25-Aug-97	5,276	\$2,020,711	114.2	1.243	\$2,512,618	\$476	Directional well
El Salvador 3	30-Sep-97	5,250	\$1,833,972	114.4	1.241	\$2,276,434	\$434	Directional well
El Salvador 4	22-Sep-97	5,341	\$1,762,148	114.4	1.241	\$2,187,282	\$409	Vertical well
El Salvador 5	14-Dec-97	5,399	\$2,054,171	118.2	1.201	\$2,467,786	\$457	Directional well
El Salvador 6	15-Jun-98	4,944	\$1,694,198	118.2	1.201	\$2,035,331	\$412	Directional well
El Salvador 7	6-Sep-98	5,104	\$2,141,611	118.6	1.197	\$2,564,155	\$502	Directional well
El Salvador 8	3-Jul-97	5,253	\$3,088,393	113.5	1.251	\$3,863,893	\$736	Directional well
El Salvador 9	1-Jun-99	2,461	\$1,730,924	114.3	1.242	\$2,150,404	\$874	Vertical well
El Salvador 10	30-May-97	2,133	\$1,209,395	111.4	1.275	\$1,541,599	\$723	Vertical well
El Salvador 11	27-Feb-98	7,648	\$2,567,631	120.2	1.181	\$3,033,308	\$397	Directional well
El Salvador 12	1-Aug-98	7,979	\$2,344,005	119.0	1.193	\$2,797,048	\$351	Directional well
El Salvador 13	1-Jan-99	8,186	\$2,208,848	119.2	1.191	\$2,631,346	\$321	Directional well
El Salvador 14	4-Dec-97	7,077	\$3,905,537	118.2	1.201	\$4,691,931	\$663	Directional well
El Salvador 15	30-Mar-98	7,520	\$2,958,289	120.2	1.181	\$3,494,817	\$465	Directional well
El Salvador 16	24-Aug-98	7,149	\$3,680,947	119.0	1.193	\$4,392,391	\$614	Directional well
El Salvador 17	29-Aug-98	7,630	\$3,186,211	119.0	1.193	\$3,802,033	\$498	Directional well
El Salvador 18	1-Jul-98	7,244	\$3,212,397	118.0	1.203	\$3,865,766	\$534	Directional well
El Salvador 19	30-Mar-98	7,684	\$2,530,845	120.2	1.181	\$2,989,850	\$389	Directional well
El Salvador 20	1-Jul-98	2,461	\$984,492	118.0	1.203	\$1,184,728	\$481	Vertical well
El Salvador 21	1-Jul-98	8,498	\$2,151,796	118.0	1.203	\$2,589,450	\$305	Directional well
El Salvador 22	16-Oct-97	8,203	\$2,563,282	116.1	1.223	\$3,135,108	\$382	Vertical well
El Salvador 23	14-Jan-98	1,653	\$1,226,493	119.0	1.193	\$1,463,547	\$885	Directional well

Hetch Hetchy/SFPUC Programmatic Renewable Energy Project**Project: 1.3 New Geothermal Site Identification and Qualification****Project Team: GeothermEx, Inc.****Task: 1.3.10 Final Project Report****Subject: D.1.3.10.3 Final Report****Table 6a: Data for Statistical Correlation of Drilling Costs vs. Depth**

Well	Completion		Unescalated Total Cost (US\$)	Producer Price Index (PPI)	Escalation Factor to July 2003 (PPI=142.0)	Total Cost Escalated to 2003 (US\$)	Escalated Cost Per Foot (US\$)	Comments
	Date (estimated dates in italics)	Total Depth (feet)						
El Salvador 24	11-Feb-98	2,015	\$844,752	120.2	1.181	\$997,960	\$495	Directional well
El Salvador 25	29-Mar-98	2,133	\$1,108,839	120.2	1.181	\$1,309,943	\$614	Directional well
El Salvador 26	27-Nov-97	6,709	\$962,439	117.8	1.205	\$1,160,155	\$173	Vertical well
El Salvador 27	4-Dec-98	2,406	\$996,157	119.7	1.186	\$1,181,740	\$491	Vertical well
El Salvador 28	1-Jan-99	7,966	\$2,574,545	119.2	1.191	\$3,066,991	\$385	Directional well
Azores 1	1-Jul-00	3,724	\$1,890,000	125.2	1.134	\$2,143,610	\$576	
Guatemala 1	3-Aug-99	655	\$239,911	114.5	1.240	\$297,532	\$454	Includes mobilization (\$17,500) but no de-mob.
Guatemala 2	7-Jul-99	1,996	\$454,222	114.3	1.242	\$564,300	\$283	Includes mobilization (\$17,500) but no de-mob.

1. GCS = Geothermal Cost Survey conducted in 1993.

Hetch Hetchy/SFPUC Programmatic Renewable Energy Project

Project: 1.3 New Geothermal Site Identification and Qualification
Project Team: GeothermEx, Inc.
Task: 1.3.10 Final Project Report
Subject: D.1.3.10.3 Final Report

Table 6b. Data for Statistical Correlation of Well Productivity vs. Temperature

Project ID	Field	Project	Plant Capacity (MW gross)	Plant Technology	Well Type ¹	Number of Active Producers	MW gross per Active Well	Permeable Zone Average Temperature ² (°F)
BEO00	Beowawe		16.7	Dual Flash	P	3	5.6	420
BRA00	Brady's Hot Springs		26		S, P	11	2.4	365
COS00	Coso	Field-wide Summary	300	Dual Flash	S	93	3.2	521
DES00	Desert Peak		11	Dual Flash	S	2	5.5	412.5
DIX00	Dixie Valley	Caithness Dixie Valley	62	Single Flash	S	7	8.9	453
EMP00	Empire (San Emidio)	Field-wide summary	4.8	Binary	P	3	1.6	305.5
HON01	Honey Lake	Amedee	1.75	Binary-Water Cooled	P	2	0.9	224.5
HON02	Honey Lake	Wendel/Wineagle	0.7	Binary-Water Cooled	P	1	0.7	230
HON03	Honey Lake	Wendel/Honey Lake Power	2.5	Hybrid	P	1	2.5	247
LAK00	Lake City / Surprise Valley	Lake City	2.5		S	1	2.5	332.5
LVC00	Long Valley - Casa Diablo	MP Field Summary	40	Binary	P	8	5.0	337.5
SOD00	Soda Lake	Soda Lake No.1/No.2	26.1	Binary-Air Cooled	P	5	5.2	367
STE01	Steamboat Hot Sprs	Lower SB: Steamboat I-1A	9.2	Binary-Air Cooled	P	3	3.1	335
STE02	Steamboat Hot Sprs	Lower SB: Steamboat II-III	36.2	Binary-Air Cooled	P	8	4.5	330
STE05	Steamboat Hot Sprs	Upper SB: Yankee-Caithness	14.44	Dual Flash	S	3	4.8	457
STI00	Stillwater	Stillwater Geothermal 1	19	Binary-Air Cooled	S, P	4	4.8	332.5
WAB00	Wabuska		1.45	Binary	P	1	1.5	223.5

Notes:

(1) S = self-flowing, P = pumped.

(2) The permeable zone average temperature is the average of the Min and Max values specifically for the permeable zone, as listed in the Data Summary Sheet for each field. This is typically higher than the most-likely value of the average reservoir temperature used in the Monte-Carlo heat-in-place calculation.

Hetch Hetchy/SFPUC Programmatic Renewable Energy Project
Project: 1.3 New Geothermal Site Identification and Qualification
Project Team: GeothermEx, Inc.
Task: 1.3.10 Final Project Report
Subject: D.1.3.10.3 Final Report

(1)

Table 7: Details of Exploration Programs

Project: AUR00 Aurora

Method

	Unit	# Units	Cost / unit	Cost Adj.Fact.	Comment	Cost
Drilling: ID slim hole(s)	foot	4000	\$140.00	1.0	Two holes to 2000 ft each	\$560,000
Drilling: ID Slim hole(s): roads and pads	well	2	\$50,000.00	0.5		\$50,000
Drilling: ID Slim hole(s): temperature logs	well	2	\$5,000.00	1.0		\$10,000
Drilling: TG hole(s)	foot	2500	\$15.00	1.0	Five holes to 500 ft each, to better define the heat anomaly between the Aurora hole and the hot area at Borealis mine.	\$37,500
Geology: field mapping	project	1	\$20,000.00	1.0	May be less if Phillips data can be obtained.	\$20,000
Geophysical survey: gravity	project	1	\$25,000.00	1.0	May be less if Phillips did survey and data can be obtained.	\$25,000
Geophysical survey: ground magnetics	project	1	\$12,500.00	1.0	May be less if Phillips did survey and data can be obtained.	\$12,500
Reporting - Documentation and Administration (20% of subtotal)						\$143,000
Total for Project						\$858,000

Project: BAL00 Baltazar

Method

	Unit	# Units	Cost / unit	Cost Adj.Fact.	Comment	Cost
					Considerable information appears to exist in the public domain. Additional exploration probably not warranted.	

Reporting - Documentation and Administration (20% of subtotal)

Total for Project

Project: BEO00 Beowawe

Method

	Unit	# Units	Cost / unit	Cost Adj.Fact.	Comment	Cost
					A well-known area. Significant additional exploration probably not needed.	

Reporting - Documentation and Administration (20% of subtotal)

Total for Project

Project: BLU00 Blue Mountain**Method**

Geochemistry surveys

Geophysical survey: gravity

	Unit	# Units	Cost / unit	Cost Adj.Fact.	Comment	Cost
	project	1	\$30,000.00	0.5		\$15,000
	project	1	\$25,000.00	1.0	Extensive exploration has already been done, although the documentation obtained does not mention detailed gravimetry or detailed fluids chemistry surveys (water samples from boreholes), and does not describe the chemical data that may have been obtained from hole Deep Blue No.1. Accordingly, these two kinds of survey are listed here.	\$25,000

Reporting - Documentation and Administration (20% of subtotal)

Total for Project

\$8,000

\$48,000**Project: BRA00 Brady's Hot Springs****Method**

	Unit	# Units	Cost / unit	Cost Adj.Fact.	Comment	Cost
					It is assumed that any additional exploration of the Brady's area will consist of the integration of existing data, and deep drilling that is estimated under confirmation costs.	

Reporting - Documentation and Administration (20% of subtotal)

Total for Project**Project: BRW01 Brawley - Brawley (North Brawley)****Method**

	Unit	# Units	Cost / unit	Cost Adj.Fact.	Comment	Cost
				1.0	It is assumed that no further exploration is needed	

Reporting - Documentation and Administration (20% of subtotal)

Total for Project

\$8,000

\$90,000**Project: BRW02 Brawley - East Brawley****Method**

Drilling: TG hole(s)

	Unit	# Units	Cost / unit	Cost Adj.Fact.	Comment	Cost
	foot	5000	\$15.00	1.0	Drill 10 holes to 500 ft each (or a larger number to shallower depth), to better define the temperature anomaly.	\$75,000

\$15,000

\$90,000

Reporting - Documentation and Administration (20% of subtotal)

Total for Project**Project: BRW03 Brawley - South Brawley (Mesquite field)****Method**

Drilling: TG hole(s)

	Unit	# Units	Cost / unit	Cost Adj.Fact.	Comment	Cost
	foot	5000	\$15.00	1.0	Drill 10 holes to 500 ft, to better define the temperature anomaly.	\$75,000

HHWP-042, D1.3.10.3, 31 December 2003

Friday, March 05, 2004

Table 7 - Page 2 of 18**500-01-042**

Reporting - Documentation and Administration (20% of subtotal)		\$15,000
Total for Project		\$90,000

Project: CAL00 Calistoga

Method	Unit	# Units	Cost / unit	Cost Adj.Fact.	Comment	Cost
					It is assumed that sufficient exploration has been done to enable a deep, full-diameter hole to be sited.	

Reporting - Documentation and Administration (20% of subtotal)

Total for Project

Project: COL00 Colado

Method	Unit	# Units	Cost / unit	Cost Adj.Fact.	Comment	Cost
Drilling: ID slim hole(s)	foot	4000	\$140.00	1.0	Two holes, each to c.2000 ft, to test the area S of Woolsey.	\$560,000
Drilling: ID Slim hole(s): roads and pads	well	2	\$50,000.00	1.0		\$100,000
Drilling: ID Slim hole(s): temperature logs	well	1	\$5,000.00	1.0		\$5,000
Geophysical survey: gravity	project	1	\$25,000.00	1.0	The Getty hole was probably too far to the south. An exploration program that targets the area of hot wells S of Woolsey is envisioned.	\$25,000
Well Test: ID slim hole, 3-10 days	well	2	\$40,000.00	1.0		\$80,000
Reporting - Documentation and Administration (20% of subtotal)						\$154,000
Total for Project						\$924,000

Project: COS00 Coso - Field-wide Summary

Method	Unit	# Units	Cost / unit	Cost Adj.Fact.	Comment	Cost
					It is assumed that any "exploration" costs for expansion to the Mlk (Modal) Estimated Capacity would be a small fraction of confirmation costs. However, if the expansion includes a significant step-out (e.g. to the Northeast Frontier, project COS04), then part of this "confirmation" expense may be considered to be "exploration"	

Reporting - Documentation and Administration (20% of subtotal)

Total for Project

Project: DES00 Desert Peak

Method	Unit	# Units	Cost / unit	Cost Adj.Fact.	Comment	Cost
					The area has been extensively explored already. No new activity foreseen, other than deep drilling and testing.	

Reporting - Documentation and Administration (20% of subtotal)

Total for Project

Project: DIX00 Dixie Valley - Caithness Dixie Valley

Method	Unit	# Units	Cost / unit	Cost Adj.Fact.	Comment	Cost
Method						

The area has already been extensively explored. No new activities foreseen other than deep drilling.

Reporting - Documentation and Administration (20% of subtotal)

Total for Project

Project: DIX01 Dixie Valley - Dixie Valley Power Partners (DVPP)

Method	Unit	# Units	Cost / unit	Cost Adj.Fact.	Comment	Cost
Method						
Other	project	1	\$10,000.00	5.0	Review of existing data and information to assist the siting of deep holes drilled for confirmation.	\$50,000
						\$10,000
						\$60,000

Reporting - Documentation and Administration (20% of subtotal)

Total for Project

Project: DOU00 Double - Black Rk Hot Springs

Method	Unit	# Units	Cost / unit	Cost Adj.Fact.	Comment	Cost
Method						
Drilling: ID slim hole(s)	foot	16000	\$140.00	1.0	Two holes to 2000 ft each, at each of 4 hot spring areas along the lineament.	\$2,240,000
Drilling: ID Slim hole(s): roads and pads	well	8	\$50,000.00	1.0		\$400,000
Drilling: ID Slim hole(s): temperature logs	well	8	\$5,000.00	1.0		\$40,000
Drilling: TG hole(s)	foot	20000	\$15.00	1.0	Ten holes to 500 ft each, at each of 4 hot spring areas along the lineament.	\$300,000
Geophysical survey: gravity	project	4	\$25,000.00	0.8	Gravity surveys around and between each of 4 hot spring areas.	\$80,000
Geophysical survey: ground magnetics	project	4	\$12,500.00	0.8	Surveys around and between each of 4 hot spring areas.	\$40,000
Geophysical survey: MT or DC resistivity	project	2	\$200,000.00	1.0	Surveys in two areas.	\$400,000
Well Test: ID slim hole, 3-10 days	well	4	\$40,000.00	1.0		\$160,000
Reporting - Documentation and Administration (20% of subtotal)						\$732,000
Total for Project						\$4,392,000

Project: DUN00 Dunes

Method	Unit	# Units	Cost / unit	Cost Adj.Fact.	Comment	Cost
Method						

HHWP-042, D1.3.10.3, 31 December 2003

Friday, March 05, 2004

Table 7 - Page 4 of 18

500-01-042

Drilling: ID slim hole(s)	foot	4000	\$140.00	1.0	Two holes each to 2000 ft. One would be sited at location of hole UCR 115 (Figure DUN00-2), the second to the west, probably between there and hole DWR No.1.	\$560,000
Drilling: ID Slim hole(s): roads and pads	well	2	\$50,000.00	1.0		\$100,000
Drilling: ID Slim hole(s): temperature logs	well	2	\$5,000.00	1.0		\$10,000
Geophysical survey: gravity	project	1	\$25,000.00	1.0		\$25,000
Reporting - Documentation and Administration (20% of subtotal)						\$139,000
Total for Project						\$834,000

Project: EAS00 East Mesa - Field-wide summary

Method	Unit	# Units	Cost / unit	Cost Adj.Fact.	Comment	Cost
Reporting - Documentation and Administration (20% of subtotal)						
Total for Project						

Project: EMI00 Emigrant (Fish Lake V.)

Method	Unit	# Units	Cost / unit	Cost Adj.Fact.	Comment	Cost
Other	project	1	\$10,000.00	4.0	Cost of compiling and interpreting existing exploration data (much of it in private hands) to enable siting a deep hole.	\$40,000
Reporting - Documentation and Administration (20% of subtotal)						\$8,000
Total for Project						\$48,000

Project: EMP00 Empire (San Emidio) - Field-wide summary

Method	Unit	# Units	Cost / unit	Cost Adj.Fact.	Comment	Cost
Reporting - Documentation and Administration (20% of subtotal)						
Total for Project						

Project: FAL00 Fallon / Carson Lake - Carson Lake anomaly

Method	Unit	# Units	Cost / unit	Cost Adj.Fact.	Comment	Cost
Other	project	1	\$10,000.00	4.0	Integration of existing data to allow siting the first deep hole. It is assumed that the most important data and information is in the public domain, or can be obtained from private parties at a reasonable cost.	\$40,000
Reporting - Documentation and Administration (20% of subtotal)						\$8,000
Total for Project						\$48,000

Project: FIS00 Fish Lake (Valley)

Method	Unit	# Units	Cost / unit	Cost Adj.Fact.	Comment	Cost
Other	project	1	\$10,000.00	6.0	Cost of integrating the large body of existing data to site further deep drilling.	\$60,000
Reporting - Documentation and Administration (20% of subtotal)						\$12,000
Total for Project						\$72,000

Project: FLY00 Fly Ranch/Granite Ranch - Ward's (Fly/Hualapi Flat) H.S.

Method	Unit	# Units	Cost / unit	Cost Adj.Fact.	Comment	Cost
No exploration program is estimated, because deep drilling has discovered a temperature of only 211°F at 5,000 ft depth. Further exploration and deep drilling are relatively unlikely to attract commercial interest.						

Reporting - Documentation and Administration (20% of subtotal)

Total for Project**Project: FLY01 Fly Ranch/Granite Ranch - Granite Ranch**

Method	Unit	# Units	Cost / unit	Cost Adj.Fact.	Comment	Cost
Drilling: ID slim hole(s)	foot	400	\$140.00	0.5	Drilled at the ranch location to intercept the 220°F permeable zone previously encountered and obtain fluids samples for chemical	\$28,000
Drilling: ID slim hole(s)	foot	2000	\$140.00	1.0	Two holes to 1000 ft each, sited and drilled after all other exploration studies.	\$280,000
Drilling: ID Slim hole(s): roads and pads	well	2	\$50,000.00	1.0		\$100,000
Drilling: ID Slim hole(s): temperature logs	well	2	\$5,000.00	1.0		\$10,000
Drilling: TG hole(s)	foot	3000	\$15.00	1.0	Six holes to 500 ft each, to define the anomaly.	\$45,000
Geophysical survey: gravity	project	1	\$25,000.00	1.0		\$25,000
Geophysical survey: ground magnetics	project	1	\$12,500.00	1.0		\$12,500
Reporting - Documentation and Administration (20% of subtotal)						\$100,100
Total for Project						\$600,600

Project: GER00 Gerlach - (Great Boiling Spring)

Method	Unit	# Units	Cost / unit	Cost Adj.Fact.	Comment	Cost
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Other	project 1	\$10,000.00	3.0	This area has already been extensively explored. The results of several holes drilled to c.3,000 ft during the early-mid 1990s are not available. It is assumed that these data can be obtained, and deep confirmation wells sited on the basis of the information obtained from them, once this has been integrated into all other information from the area. The cost listed represents studies to perform this data integration and well siting.	\$30,000
Reporting - Documentation and Administration (20% of subtotal)					\$6,000
Total for Project					\$36,000

Reporting - Documentation and Administration (20% of subtotal)

Total for Project

Project: GEY00 Geysers - Field-wide Summary

Method **Unit** **# Units**

Reporting - Documentation and Administration (20% of subtotal)

Total for Project

Project: GLA00 Glamis

Method

Drilling: ID slim hole(s)

Drilling: ID Slim hole(s): roads and

Drilling: ID Slim hole(s): temperature log

Drilling: TG hole(s)

Geophysical survey: gravity

Reporting - Documentation and Administration (20% of subtotal)

Total for Project

Project: HAWOO Hawthorne

Method

Other

Reporting - Documentation and Administration (20% of subtotal)

Total for Project

Project: HAZ00 Hazen (Black Butte) - (Patua Hot Springs)

Method

HHWP-042-D1.3.10.3.31 December 2003

THIRI 312, B.I.B.H.O.5,
Friday, March 05, 2004

Table 7 - Page 7 of 18

500-01-042

Drilling: ID slim hole(s)	foot	4000	\$140.00	0.8	Two holes to 2000 ft each. Cost factor is adjusted for the possibility of relatively easy drilling in sedimentary rocks (the Magma/Dow hole drilled to nearly 4000 ft at a location 1.5 miles to the SW encountered only sediments). It is assumed that these holes will not reach reservoir depth, so a testing cost is not listed.	\$448,000
Drilling: ID Slim hole(s): roads and pads	well	2	\$50,000.00	0.8	For two holes, cost factor adjusted for flat terrain, possibility of relatively easy access.	\$80,000
Drilling: ID Slim hole(s): temperature logs	well	2	\$5,000.00	1.0		\$10,000
Drilling: TG hole(s)	foot	4000	\$15.00	1.0	To define the anomaly. Assumes 8 holes to 500 ft each.	\$60,000
Geophysical survey: gravity	project	1	\$25,000.00	1.0		\$25,000
Geophysical survey: ground magnetics	project	1	\$12,500.00	1.0		\$12,500
Geophysical survey: MT or DC resistivity	project	1	\$200,000.00	1.0		\$200,000
Reporting - Documentation and Administration (20% of subtotal)						\$167,100
Total for Project						\$1,002,600

Project: HEB00 Heber - Field-wide Summary

Method	Unit	# Units	Cost / unit	Cost Adj.Fact.	Comment	Cost
Reporting - Documentation and Administration (20% of subtotal)					Additional exploration is assumed to be unnecessary.	
Total for Project						Cost

Project: HON00 Honey Lake - Area-wide Summary

Method	Unit	# Units	Cost / unit	Cost Adj.Fact.	Comment	Cost
Reporting - Documentation and Administration (20% of subtotal)					The area has been extensively explored. It is relatively unlikely that additional exploration will assist in the finding of deep permeability. Drilling is required.	
Total for Project						Cost

Project: HYD00 Hyder Hot Springs

Method	Unit	# Units	Cost / unit	Cost Adj.Fact.	Comment	Cost
Drilling: ID slim hole(s)	foot	4000	\$140.00	1.0	Two holes to 2000 ft each.	\$560,000
Drilling: ID Slim hole(s): roads and pads	well	1	\$50,000.00	0.8	Relatively flat terrain, easy access possible.	\$40,000
Drilling: ID Slim hole(s): temperature logs	well	1	\$5,000.00	1.0		\$5,000
Drilling: TG hole(s)	foot	4000	\$15.00	1.0	Eight holes to 500 ft., to better define the anomaly.	\$60,000
Geophysical survey: gravity	project	1	\$25,000.00	1.0		\$25,000
Geophysical survey: ground magnetics	project	1	\$12,500.00	1.0		\$12,500

HHWP-042, D1.3.10.3, 31 December 2003

Friday, March 05, 2004

Table 7 - Page 8 of 18

500-01-042

Reporting - Documentation and Administration (20% of subtotal) \$140,500
Total for Project \$843,000

Project: KYL00 Kyle Hot Springs (Granite Mtn.) - (Buena Vista Valley)

Method	Unit	# Units	Cost / unit	Cost Adj.Fact.	Comment	Cost
Drilling: ID slim hole(s)	foot	4000	\$140.00	1.0	Two holes to 2000 ft each. May be reduced to one hole if data are available from the oil and gas wells (Figure KYL00-1)	\$560,000
Drilling: ID Slim hole(s): roads and pads	well	1	\$50,000.00	0.8		\$40,000
Drilling: ID Slim hole(s): temperature logs	well	5	\$5,000.00	1.0	Allows logging of oil and gas wells (availability not confirmed)	\$25,000
Drilling: TG hole(s)	foot	4000	\$15.00	1.0	Eight holes each to 500 ft, to define the anomaly in the area of the hot springs.	\$60,000

Reporting - Documentation and Administration (20% of subtotal) \$137,000
Total for Project \$822,000

Project: LAK00 Lake City / Surprise Valley - Lake City

Method	Unit	# Units	Cost / unit	Cost Adj.Fact.	Comment	Cost
					Since there is already one (apparently) successful confirmation hole, no additional exploration is envisioned. However, some additional studies may be warranted if not already done. These include gravimetry and a complete integration of the existing data.	

Reporting - Documentation and Administration (20% of subtotal) \$137,000
Total for Project \$822,000

Project: LEA00 Leach Hot Springs - Grass Valley

Method	Unit	# Units	Cost / unit	Cost Adj.Fact.	Comment	Cost
Drilling: ID slim hole(s)	foot	2000	\$140.00	1.0	The area has been very extensively explored, with much information in the public domain, but there is relatively little information from the area E of the hot springs. A small amount of drilling in the E area suggests elevated temperatures, and the possibility of an anomaly in the foot wall of the W-dipping fault (system) that probably feeds the hot springs. This cost represents drilling a hole to 2000 ft at a location about 0.5-0.7 miles E of the hot springs, in the middle of	\$280,000
Drilling: ID Slim hole(s): roads and pads	well	1	\$50,000.00	1.0		\$50,000
Drilling: ID Slim hole(s): temperature logs	well	1	\$5,000.00	1.0		\$5,000

Reporting - Documentation and Administration (20% of subtotal) \$67,000
Total for Project \$402,000

Project: LEE00 Lee Hot Springs

Method	Unit	# Units	Cost / unit	Cost Adj.Fact.	Comment	Cost
Drilling: ID slim hole(s)	foot	4000	\$140.00	1.0	Two holes to 2000 ft each. A decision to drill would be partly contingent on the results of the 3000 ft Oxy hole, if available.	\$560,000
Drilling: ID Slim hole(s): roads and pads	well	2	\$50,000.00	1.0		\$100,000
Drilling: ID Slim hole(s): temperature logs	well	2	\$5,000.00	1.0		\$10,000
Drilling: TG hole(s)	foot	4000	\$15.00	1.0	Eight holes each to 500 ft.	\$60,000
Geology: field mapping	project	1	\$20,000.00	1.0		\$20,000
Geophysical survey: gravity	project	1	\$25,000.00	1.0		\$25,000
Geophysical survey: ground magnetics	project	1	\$12,500.00	1.0		\$12,500
Reporting - Documentation and Administration (20% of subtotal)						\$157,500
Total for Project						\$945,000

Project: LVM00 Long Valley - M-P Leases - M-P Lease Summary

Method	Unit	# Units	Cost / unit	Cost Adj.Fact.	Comment	Cost
Drilling: ID slim hole(s)	foot	12000	\$140.00	1.0	Four holes each to 3,000 ft at widely spaced locations, to confirm the temperature model of the resource, and to confirm permeability.	\$1,680,000
Drilling: ID Slim hole(s): roads and pads	well	4	\$50,000.00	1.0		\$200,000
Drilling: ID Slim hole(s): temperature logs	well	4	\$5,000.00	1.0		\$20,000
Well Test: ID slim hole, 3-10 days	well	4	\$40,000.00	1.0	The proposed hole depths are relatively likely to encounter	\$160,000
Reporting - Documentation and Administration (20% of subtotal)						\$412,000
Total for Project						\$2,472,000

Project: MCG00 McGee Mountain - (Painted Hills)

Method	Unit	# Units	Cost / unit	Cost Adj.Fact.	Comment	Cost
Drilling: ID slim hole(s)	foot	4000	\$140.00	1.0	Two holes each to 2000 ft.	\$560,000
Drilling: ID Slim hole(s): roads and pads	well	2	\$50,000.00	1.0		\$100,000
Drilling: ID Slim hole(s): temperature logs	well	2	\$5,000.00	1.0		\$10,000
Drilling: TG hole(s)	foot	4000	\$15.00	1.0	Eight holes to 500 ft each. Locally rugged topography may make access difficult.	\$60,000
Geology: field mapping	project	1	\$20,000.00	1.0	Probably already done (data in private hands)	\$20,000
Geophysical survey: gravity	project	1	\$25,000.00	1.0		\$25,000
Geophysical survey: ground magnetics	project	1	\$12,500.00	1.0		\$12,500
Reporting - Documentation and Administration (20% of subtotal)						\$157,500
Total for Project						\$945,000

Project: MED01 Medicine Lake - Fourmile Hill

Method	Unit	# Units	Cost/unit	Cost Adj.Fact.	Comment	Cost
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Reporting - Documentation and Administration (20% of subtotal)

Total for Project

Project: MED02 Medicine Lake - Telephone Flat

Method	Unit	# Units	Cost/unit	Cost Adj.Fact.	Comment	Cost
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Reporting - Documentation and Administration (20% of subtotal)

Total for Project

Project: MOS00 Mount Signal

Method	Unit	# Units	Cost/unit	Cost Adj.Fact.	Comment	Cost
Drilling: ID slim hole(s)	foot	2000	\$140.00	1.0	Drill a second 2000 ft hole, at a location to the E of the existing hole.	\$280,000
Drilling: ID Slim hole(s): roads and pads	well	1	\$50,000.00	1.0		\$50,000
Drilling: ID Slim hole(s): temperature logs	well	1	\$5,000.00	1.0		\$5,000
Geology: field mapping	project	1	\$20,000.00	1.0		\$20,000
Geophysical survey: ground magnetics	project	1	\$12,500.00	1.0		\$12,500
Reporting - Documentation and Administration (20% of subtotal)						\$73,500
Total for Project						\$441,000

Project: NEW00 New York Canyon

Method	Unit	# Units	Cost/unit	Cost Adj.Fact.	Comment	Cost
Drilling: ID slim hole(s)	foot	4000	\$140.00	1.0	Two holes to 2000 ft each	\$560,000
Drilling: ID Slim hole(s): roads and pads	well	2	\$50,000.00	1.0		\$100,000
Drilling: ID Slim hole(s): temperature logs	well	2	\$5,000.00	1.0		\$10,000
Drilling: TG hole(s)	foot	4000	\$15.00	1.0	Eight holes to 500 ft each	\$60,000
Geology: field mapping	project	1	\$20,000.00	1.0		\$20,000
Geophysical survey: gravity	project	1	\$25,000.00	1.0		\$25,000
Geophysical survey: ground magnetics	project	1	\$12,500.00	1.0		\$12,500
Geophysical survey: MT or DC resistivity	project	1	\$200,000.00	1.0	This expense may be warranted by the high TG at TD in hole BV	\$200,000
Reporting - Documentation and Administration (20% of subtotal)						\$197,500
Total for Project						\$1,185,000

HHWP-042, D1.3.10.3, 31 December 2003

Friday, March 05, 2004

Table 7 - Page 11 of 18

500-01-042

Project: NIL00 Niland

Method	Unit	# Units	Cost / unit	Cost Adj.Fact.	Comment	Cost
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Reporting - Documentation and Administration (20% of subtotal)

Total for Project**Project: NOR00 North Valley**

Method	Unit	# Units	Cost / unit	Cost Adj.Fact.	Comment	Cost
Geology: field mapping	project	1	\$20,000.00	1.0		\$20,000
Geophysical survey: ground magnetics	project	1	\$12,500.00	1.0		\$12,500
Geophysical survey: MT or DC resistivity	project	1	\$200,000.00	1.0	May help define depth and areal extent of deep permeability (high-risk expense).	\$200,000

Reporting - Documentation and Administration (20% of subtotal)

Total for Project**Project: PIN00 Pinto Hot Springs**

Method	Unit	# Units	Cost / unit	Cost Adj.Fact.	Comment	Cost
Drilling: ID slim hole(s)	foot	4000	\$140.00	1.0	Two holes to 2000 ft each.	\$560,000
Drilling: ID Slim hole(s): roads and pads	well	2	\$50,000.00	1.0		\$100,000
Drilling: ID Slim hole(s): temperature logs	well	2	\$5,000.00	1.0		\$10,000
Drilling: TG hole(s)	foot	8000	\$15.00	1.0	Six holes to 500 ft on each of the E and W sides, plus four holes in the area between the two hot springs	\$120,000
Geology: field mapping	project	1	\$20,000.00	1.0		\$20,000
Geophysical survey: gravity	project	1	\$25,000.00	1.0		\$25,000
Geophysical survey: ground magnetics	project	1	\$12,500.00	1.0		\$12,500

Reporting - Documentation and Administration (20% of subtotal)

Total for Project**Project: PIR00 Pirouette Mountain - (S.Dixie Valley)**

Method	Unit	# Units	Cost / unit	Cost Adj.Fact.	Comment	Cost
Drilling: ID slim hole(s)	foot	6000	\$140.00	1.0	A deep ID Slim hole to test for permeability and temperature. A developer might choose to proceed directly to full-diameter drilling (calculated as confirmation cost).	\$840,000
Drilling: ID Slim hole(s): roads and pads	well	1	\$50,000.00	1.0		\$50,000
Drilling: ID Slim hole(s): temperature logs	well	1	\$5,000.00	1.0		\$5,000
Geophysical survey: gravity	project	1	\$25,000.00	1.0		\$25,000

HHWP-042, D1.3.10.3, 31 December 2003

Friday, March 05, 2004

Table 7 - Page 12 of 18

500-01-042

Geophysical survey: gravity	project	1	\$25,000.00	1.0		\$25,000
Well Test: ID slim hole, 3-10 days	well	1	\$40,000.00	1.0		\$40,000
Reporting - Documentation and Administration (20% of subtotal)						\$197,000
Total for Project						\$1,182,000

Project: PUM00 Pumpernickel Valley - Tipton Ranch/Hot Springs Ranch

Method	Unit	# Units	Cost / unit	Cost Adj.Fact.	Comment	Cost
Drilling: TG hole(s)	foot	4000	\$15.00	1.0	Eight holes each to 500 ft.	\$60,000
Geology: field mapping	project	1	\$20,000.00	1.0		\$20,000
Geophysical survey: gravity	project	1	\$25,000.00	1.0		\$25,000
Geophysical survey: ground magnetics	project	1	\$12,500.00	1.0		\$12,500
Reporting - Documentation and Administration (20% of subtotal)						\$23,500
Total for Project						\$141,000

Project: PYR00 Pyramid Lake Indian Reserv. - (Needle Rocks Hot Springs)

Method	Unit	# Units	Cost / unit	Cost Adj.Fact.	Comment	Cost
Drilling: TG hole(s)	foot	4000	\$15.00	1.0	Eight holes to 500 ft each	\$60,000
Geology: field mapping	project	1	\$20,000.00	1.0		\$20,000
Geophysical survey: gravity	project	1	\$25,000.00	1.0		\$25,000
Geophysical survey: ground magnetics	project	1	\$12,500.00	1.0		\$12,500
Reporting - Documentation and Administration (20% of subtotal)						\$23,500
Total for Project						\$141,000

Project: RAN00 Randsburg

Method	Unit	# Units	Cost / unit	Cost Adj.Fact.	Comment	Cost
Drilling: ID slim hole(s)	foot	2000	\$140.00	1.0	To duplicate the Phillips ID Slim Hole, if data from that hole cannot be obtained.	\$280,000
Drilling: ID Slim hole(s): roads and pads	well	1	\$50,000.00	1.0		\$50,000
Drilling: ID Slim hole(s): temperature logs	well	1	\$5,000.00	1.0		\$5,000
Well Test: ID slim hole, 3-10 days	well	1	\$40,000.00	1.0		\$40,000
Reporting - Documentation and Administration (20% of subtotal)						\$75,000
Total for Project						\$450,000

Project: RYE01 Rye Patch-Humboldt House District - Rye Patch

Method	Unit	# Units	Cost / unit	Cost Adj.Fact.	Comment	Cost
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HHWP-042, D1.3.10.3, 31 December 2003

Friday, March 05, 2004

Table 7 - Page 13 of 18

500-01-042

Reporting - Documentation and Administration (20% of subtotal)

Total for Project

Project: RYE02 Rye Patch-Humboldt House District - Humboldt House

Method	Unit	# Units	Cost/unit	Cost Adj.Fact.	Comment	Cost
					It is assumed that abundant exploration data are already in private hands and that no more exploration should be needed to site the first deep confirmation hole. However, if this is not the case, then additional exploration will be warranted. Methods of primary interest may include gravimetry and ID Slim hole drilling.	

Reporting - Documentation and Administration (20% of subtotal)

Total for Project

Project: SAL00 Salton Sea - Field-wide summary

Method	Unit	# Units	Cost/unit	Cost Adj.Fact.	Comment	Cost
					No additional exploration should be needed.	

Reporting - Documentation and Administration (20% of subtotal)

Total for Project

Project: SAW00 Salt Wells - Eight Mile Flat

Method	Unit	# Units	Cost/unit	Cost Adj.Fact.	Comment	Cost
Drilling: ID slim hole(s)	foot	4000	\$140.00	1.0	Additional ID Slim hole drilling is regarded as necessary to site another deep confirmation well. Four holes each to 1000 ft are	\$560,000
Drilling: ID Slim hole(s): roads and pads	well	4	\$50,000.00	1.0		\$200,000
Drilling: ID Slim hole(s): temperature logs	well	4	\$5,000.00	1.0		\$20,000
Geophysical survey: gravity	project	1	\$25,000.00	1.0	Assumed not yet done	\$25,000
Geophysical survey: ground magnetics	project	1	\$12,500.00	1.0	Assumed not yet done	\$12,500
Reporting - Documentation and Administration (20% of subtotal)						\$163,500
Total for Project						\$981,000

Project: SES00 Sespe Hot Springs

Method	Unit	# Units	Cost/unit	Cost Adj.Fact.	Comment	Cost
Drilling: ID slim hole(s)	foot	4000	\$140.00	1.0	Two holes each to 2000 ft.	\$560,000

HHWP-042, D1.3.10.3, 31 December 2003

Friday, March 05, 2004

Table 7 - Page 14 of 18

500-01-042

Drilling: ID Slim hole(s): roads and pads	well	2	\$50,000.00	1.0		\$100,000
Drilling: ID Slim hole(s): temperature logs	well	2	\$5,000.00	1.0		\$10,000
Drilling: TG hole(s)	foot	4000	\$15.00	1.0	Eight holes each to 500 ft	\$60,000
Geology: field mapping	project	1	\$20,000.00	1.0		\$20,000
Geophysical survey: gravity	project	1	\$25,000.00	1.0		\$25,000
Geophysical survey: ground magnetics	project	1	\$12,500.00	1.0		\$12,500
Reporting - Documentation and Administration (20% of subtotal)						\$157,500
Total for Project						\$845,000

Project: SH000 Shoshone-Reese River

Method	Unit	# Units	Cost / unit	Cost Adj.Fact.	Comment	Cost
Drilling: ID slim hole(s)	foot	4000	\$140.00	1.0	Two holes each to 2000 ft	\$560,000
Drilling: ID Slim hole(s): roads and pads	well	2	\$50,000.00	1.0		\$100,000
Drilling: ID Slim hole(s): temperature logs	well	2	\$5,000.00	1.0		\$10,000
Geology: field mapping	project	1	\$20,000.00	1.0		\$20,000
Geophysical survey: gravity	project	1	\$25,000.00	1.0		\$25,000
Geophysical survey: ground magnetics	project	1	\$12,500.00	1.0		\$12,500
Reporting - Documentation and Administration (20% of subtotal)						\$145,500
Total for Project						\$873,000

Project: SIL00 Silver Peak - (Alum prospect)

Method	Unit	# Units	Cost / unit	Cost Adj.Fact.	Comment	Cost
Other	project	1	\$10,000.00	3.0		
Reporting - Documentation and Administration (20% of subtotal)						\$6,000
Total for Project						\$36,000

Project: SOD00 Soda Lake - Soda Lake No.1/No.2

Method	Unit	# Units	Cost / unit	Cost Adj.Fact.	Comment	Cost
Other	project	1	\$10,000.00	5.0	Cost for a thorough study of existing data to enable siting additional wells.	\$50,000
Reporting - Documentation and Administration (20% of subtotal)						\$10,000
Total for Project						\$60,000

Project: SOH00 Sou Hot Springs - (Seven Devils/Gilbert's H.S.)

Method	Unit	# Units	Cost / unit	Cost Adj.Fact.	Comment	Cost
Drilling: ID slim hole(s)	foot	4000	\$140.00	1.0	Two holes to 2000 ft each.	\$560,000
Drilling: ID Slim hole(s): roads and pads	well	2	\$50,000.00	1.0		\$100,000
Drilling: ID Slim hole(s): temperature logs	well	2	\$5,000.00	1.0		\$10,000
Drilling: TG hole(s)	foot	4000	\$15.00	1.0	Eight holes to 500 ft each.	\$60,000
Geophysical survey: gravity	project	1	\$25,000.00	1.0		\$25,000
Geophysical survey: ground magnetics	project	1	\$12,500.00	1.0		\$12,500
Reporting - Documentation and Administration (20% of subtotal)						\$153,500
Total for Project						\$921,000

Project: STE00 Steamboat Hot Sprs - Field-wide Summary

Method	Unit	# Units	Cost / unit	Cost Adj.Fact.	Comment	Cost
Reporting - Documentation and Administration (20% of subtotal)					Already very extensively explored.	
Total for Project						

Project: STI00 Stillwater - Stillwater Geothermal 1

Method	Unit	# Units	Cost / unit	Cost Adj.Fact.	Comment	Cost
Reporting - Documentation and Administration (20% of subtotal)					It is assumed that no additional exploration is needed.	
Total for Project						

Project: STI01 Stillwater - Stillwater N Expansion

Method	Unit	# Units	Cost / unit	Cost Adj.Fact.	Comment	Cost
Reporting - Documentation and Administration (20% of subtotal)					It is assumed that no additional exploration is needed.	
Total for Project						

Project: SUL00 Sulphur Bank - Clear Lake

Method	Unit	# Units	Cost / unit	Cost Adj.Fact.	Comment	Cost
Reporting - Documentation and Administration (20% of subtotal)					It appears that additional exploration is not needed.	
Total for Project						

HHWP-042, D1.3.10.3, 31 December 2003

Friday, March 05, 2004

Table 7 - Page 16 of 18

500-01-042

Project: SUP00 Superstition Mountain**Method**

	Unit	# Units	Cost/unit	Cost Adj.Fact.	Comment	Cost
Drilling: ID slim hole(s)	foot	4000	\$140.00	1.0	Two holes each to 2000 ft.	\$560,000
Drilling: ID Slim hole(s): roads and pads	well	2	\$50,000.00	1.0		\$100,000
Drilling: ID Slim hole(s): temperature logs	well	2	\$5,000.00	1.0		\$10,000
Geophysical survey: gravity	project	1	\$25,000.00	1.0		\$25,000
Geophysical survey: ground magnetics	project	1	\$12,500.00	1.0		\$12,500
Reporting - Documentation and Administration (20% of subtotal)						\$141,500
Total for Project						\$849,000

Project: TRI00 Trinity Mountains District - Telephone Well area**Method**

	Unit	# Units	Cost/unit	Cost Adj.Fact.	Comment	Cost
Drilling: ID slim hole(s)	foot	4000	\$140.00	1.0	Two holes each to 2000 ft, in the area of Telephone Well.	\$560,000
Drilling: ID Slim hole(s): roads and pads	well	2	\$50,000.00	1.0		\$100,000
Drilling: ID Slim hole(s): temperature logs	well	2	\$5,000.00	1.0		\$10,000
Drilling: TG hole(s)	foot	4000	\$15.00	1.0	Eight holes, each to 500 ft, in the general area of Telephone Well.	\$60,000
Geology: field mapping	project	1	\$20,000.00	1.0		\$20,000
Geophysical survey: gravity	project	1	\$25,000.00	1.0		\$25,000
Geophysical survey: ground magnetics	project	1	\$12,500.00	1.0		\$12,500
Reporting - Documentation and Administration (20% of subtotal)						\$157,500
Total for Project						\$945,000

Project: WAB00 Wabuska**Method**

	Unit	# Units	Cost/unit	Cost Adj.Fact.	Comment	Cost
Drilling: ID Slim hole(s): temperature logs	well	5	\$5,000.00	1.0	Re-logging of existing holes (assumed available)	\$25,000
Geophysical survey: gravity	project	1	\$25,000.00	1.0		\$25,000
Geophysical survey: ground magnetics	project	1	\$12,500.00	1.0		\$12,500
Other	project	1	\$10,000.00	4.0	Intgration of existing data to establish a conceptual model of the resource and assist further well siting.	\$40,000
Reporting - Documentation and Administration (20% of subtotal)						\$20,500
Total for Project						\$123,000

Project: WIL00 Wilson Hot Springs**Method**

	Unit	# Units	Cost/unit	Cost Adj.Fact.	Comment	Cost
Drilling: ID slim hole(s)	foot	4000	\$140.00	1.0	One hole to 4,000 ft., or two to 2,000 ft each.	\$560,000

HHWP-042, D1.3.10.3, 31 December 2003

Friday, March 05, 2004

Table 7 - Page 17 of 18

500-01-042

Geology: field mapping	project 1	\$20,000.00	1.0	\$20,000
Geophysical survey: gravity	project 1	\$25,000.00	1.0	\$25,000
Geophysical survey: ground magnetics	project 1	\$12,500.00	1.0	\$12,500
Reporting - Documentation and Administration (20% of subtotal)				\$123,500
Total for Project				\$741,000
Grand Total all Projects				\$27,784,200

Hetch Hetchy/SFPUC Programmatic Renewable Energy Project
Project: 1.3 New Geothermal Site Identification and Qualification
Project Team: GeothermEx, Inc.
Task: 1.3.10 Final Project Report
Subject: D.1.3.10.3 Final Report

Table 8: Exploration, Confirmation and Site Development Cost Estimates – Summary with Cost Totals ⁽¹⁾

PROJ ID	Field or Area	Area or Power Plant	(2) Explor- Devel. Cat.	(3) Existing Wellhd MW	Estimated Costs in thousands ⁽⁴⁾										
					Minimum Estimated Generation Capacity				Most-likely Estimated Generation Capacity						
					MW (C)	Confirm (SD)	Develop Site (SD)	E+C SD	MW (C)	Confirm (SD)	Develop Site (SD)	E+C SD			
Area: 1 - Greater Reno (NV and CA)															
BEO00	Beowawe		A	15/0	30	\$4,930	\$48,048	\$4,930	\$52,978	41	\$9,675	\$84,618	\$9,675	\$94,293	
BLU00	Blue Mountain		C	0/0	\$48	16	\$3,110	\$36,376	\$3,158	\$39,534	30	\$6,112	\$67,277	\$6,160	\$73,437
BRA00	Brady's Hot Springs		A	15/0	11	\$0	\$0	\$0	\$0	18	\$2,927	\$7,233	\$2,927	\$10,160	
COL00	Colado		C	0/0	\$924	3.7	\$2,086	\$13,600	\$3,010	\$16,610	6.2	\$2,086	\$22,180	\$3,010	\$25,190
DES00	Desert Peak		A	10/0	33	\$4,848	\$54,703	\$4,848	\$59,551	45	\$7,257	\$82,568	\$7,257	\$89,825	
EMP00	Empire (San Emidio)	Field-wide summary	A	4.8/0	4.3	\$0	\$0	\$0	\$0	6.6	\$1,593	\$6,276	\$1,593	\$7,869	
FAL00	Fallon / Carson Lake	Carson Lake anomaly	C	0/0	\$48	34	\$11,808	\$94,956	\$11,856	\$106,812	55	\$17,735	\$145,992	\$17,783	\$163,775
FLY00	Fly Ranch/Granite Ranch	Ward's (Fly/Hualapi Flat) H.S.	C	0/0	6	\$15,981	\$59,832	\$15,981	\$75,813	8.7	\$19,986	\$83,100	\$19,986	\$103,086	
FLY01	Fly Ranch/Granite Ranch	Granite Ranch	C	0/0	\$601	5.4	\$2,615	\$14,271	\$3,216	\$17,487	8.1	\$2,615	\$22,435	\$3,216	\$25,651
GER00	Gerlach	(Great Boiling Spring)	C	0/0	\$36	17	\$7,250	\$55,380	\$7,286	\$62,666	25	\$10,858	\$82,320	\$10,894	\$93,214
HAZ00	Hazen (Black Butte)	(Patua Hot Springs)	C	0/0	\$1,003	6.3	\$3,010	\$21,402	\$4,013	\$25,415	8.5	\$3,010	\$24,702	\$4,013	\$28,715
HON00	Honey Lake	Area-wide Summary	A	1.2/0	5.7	\$1,716	\$10,368	\$1,716	\$12,084	8.3	\$3,249	\$15,810	\$3,249	\$19,059	
KYL00	Kyle Hot Springs (Granite Mtn.)	(Buena Vista Valley)	C	0/0	\$822	16	\$7,250	\$47,904	\$8,072	\$55,976	22	\$7,250	\$62,880	\$8,072	\$70,952
LEA00	Leach Hot Springs	Grass Valley	C	0/0	\$402	13	\$12,334	\$70,560	\$12,736	\$83,296	18	\$16,435	\$95,080	\$16,837	\$111,917
LEE00	Lee Hot Springs		C	0/0	\$945	5.4	\$2,615	\$18,385	\$3,560	\$21,945	9.4	\$2,615	\$30,556	\$3,560	\$34,116
NEW00	New York Canyon		C	0/0	\$1,185	20	\$5,048	\$56,741	\$6,233	\$62,974	26	\$7,556	\$69,855	\$8,741	\$78,596

Estimated Costs in thousands⁽⁴⁾

PROJ ID	Field or Area	Area or Power Plant	(2) Explor- Devel. Cat.	(3) Existing Wellhd MW	Explor- ation (E)	Minimum Estimated Generation Capacity				Most-likely Estimated Generation Capacity					
						MW	Confirm (C)	Develop Site (SD)	E+C SD	MW	Confirm (C)	Develop Site (SD)	E+C SD		
NOR00	North Valley		C	0 / 0	\$279	37	\$10,668	\$95,704	\$10,947	\$106,651	49	\$12,810	\$124,192	\$13,089	\$137,281
PUM00	Pumpernickel Valley	Tipton Ranch/Hot Springs Ranch	C	0 / 0.9	\$141	10	\$2,768	\$32,496	\$2,909	\$35,405	13	\$5,356	\$41,370	\$5,497	\$46,867
PYR00	Pyramid Lake Indian Reserv.	(Needle Rocks Hot Springs)	C	0 / 0	\$141	9.9	\$3,310	\$28,075	\$3,451	\$31,526	14	\$6,437	\$42,160	\$6,578	\$48,738
RYE01	Rye Patch-Humboldt House District	Rye Patch	B	0 / 10		16	\$0	\$25,911	\$0	\$25,911	20	\$0	\$37,554	\$0	\$37,554
RYE02	Rye Patch-Humboldt House District	Humboldt House	C	0 / 0		27	\$7,556	\$71,355	\$7,556	\$78,911	34	\$10,062	\$92,140	\$10,062	\$102,202
SAW00	Salt Wells	Eight Mile Flat	C	0 / 0	\$981	63	\$15,003	\$143,868	\$15,984	\$159,852	96	\$22,376	\$222,166	\$23,357	\$245,523
SOD00	Soda Lake	Soda Lake No.1/No.2	A	16 / 0	\$60	29	\$2,202	\$22,796	\$2,262	\$25,058	42	\$7,558	\$58,693	\$7,618	\$66,311
STE00	Steamboat Hot Sprs	Field-wide Summary	A	53 / 0		56	\$0	\$1,462	\$0	\$1,462	62	\$1,048	\$7,627	\$1,048	\$8,675
STI00	Stillwater	Stillwater Geothermal 1A	A	14 / 0		11	\$0	\$0	\$0	\$0	18	\$0	\$0	\$0	\$0
STI01	Stillwater	Stillwater N Expansion B	A	0 / 5		16	\$0	\$23,603	\$0	\$23,603	24	\$1,167	\$39,761	\$1,167	\$40,928
TRI00	Trinity Mountains District	Telephone Well area	D	0 / 0	\$945	42	\$12,247	\$113,375	\$13,192	\$126,567	66	\$19,546	\$177,585	\$20,491	\$198,076
WAB00	Wabuska		A	1.4 / 0	\$123	8.1	\$3,900	\$35,127	\$4,023	\$39,150	13	\$5,835	\$61,341	\$5,958	\$67,299
<i>Area Totals :</i>				130	\$8,684		\$142,255	\$1,196,299		\$1,347,238		\$213,154	\$1,807,471		\$2,029,309
					16		552			\$150,939		787			\$221,838

Area: 2 - NV with direct access to CA

AUR00	Aurora		C	0 / 0	\$858	31	\$10,602	\$85,866	\$11,460	\$97,326	51	\$15,925	\$139,923	\$16,783	\$156,706
DIX00	Dixie Valley	Caithness Dixie Valley A	A	66 / 0		71	\$4,862	\$14,623	\$4,862	\$19,485	107	\$7,202	\$116,107	\$7,202	\$123,309
DIX01	Dixie Valley	Dixie Valley Power Partners (DVPP)	C	0 / 0	\$60	107	\$40,669	\$300,684	\$40,729	\$341,413	151	\$55,889	\$421,908	\$55,949	\$477,857
EMI00	Emigrant (Fish Lake V.)		C	0 / 0	\$48	49	\$21,608	\$160,152	\$21,656	\$181,808	85	\$39,425	\$279,888	\$39,473	\$319,361
FIS00	Fish Lake (Valley)		B	0 / 7	\$72	30	\$4,862	\$104,355	\$4,934	\$109,289	47	\$9,542	\$169,425	\$9,614	\$179,039
HAW00	Hawthorne		C	0 / 0	\$36	8.7	\$5,885	\$32,338	\$5,921	\$38,259	14	\$8,812	\$52,343	\$8,848	\$61,191
HYD00	Hyder Hot Springs		D	0 / 0	\$843	5.5	\$7,250	\$32,154	\$8,093	\$40,247	9.6	\$10,858	\$53,244	\$11,701	\$64,945

Estimated Costs in thousands⁽⁴⁾

PROJ ID	Field or Area	Area or Power Plant	(2) Explor- Devel. Cat.	(3) Existing Wellhd MW	Minimum Estimated Generation Capacity						Most-likely Estimated Generation Capacity						
					Explor- ation (E)	MW	Confirm (C)	Develop Site (SD)	E+C	E+C+ SD	MW	Confirm (C)	Develop Site (SD)	E+C	E+C+ SD		
PIR00	Pirouette Mountain	(S.Dixie Valley)	D	0 / 0	\$1,182	16	\$5,048	\$44,570	\$6,230	\$50,800	23	\$7,556	\$61,241	\$8,738	\$69,979		
SIL00	Silver Peak	(Alum prospect)	C	0 / 0	\$36	41	\$12,495	\$112,925	\$12,531	\$125,456	78	\$24,882	\$207,508	\$24,918	\$232,426		
SOH00	Sou Hot Springs	(Seven Devils/Gilbert's H.S.)	D	0 / 0	\$921	3.3	\$2,615	\$11,121	\$3,536	\$14,657	6.1	\$2,615	\$19,435	\$3,536	\$22,971		
<i>Area Totals:</i>				66	\$4,056		\$115,896	\$898,788		\$1,018,740		\$182,706	\$1,521,022		\$1,707,784		
						7		363					\$119,952		572		
<i>Area Totals:</i>				0	\$7,968		\$37,499	\$279,389		\$324,856		\$58,253	\$442,601		\$508,822		
						0		91					\$45,467		141		
<i>Area: 3 - Other NV</i>																	
BAL00	Baltazor		C	0 / 0		11	\$7,611	\$41,628	\$7,611	\$49,239	16	\$11,400	\$64,833	\$11,400	\$76,233		
DOU00	Double - Black Rk Hot Springs		D	0 / 0	\$4,392	20	\$12,495	\$81,425	\$16,887	\$98,312	33	\$22,376	\$133,837	\$26,768	\$160,605		
MCG00	McGee Mountain	(Painted Hills)	C	0 / 0	\$945	19	\$5,048	\$49,070	\$5,993	\$55,063	28	\$7,556	\$79,026	\$8,501	\$87,527		
PIN00	Pinto Hot Springs		D	0 / 0	\$1,017	18	\$5,048	\$47,570	\$6,065	\$53,635	29	\$7,556	\$74,355	\$8,573	\$82,928		
SHO00	Shoshone-Reese River		D	0 / 0	\$873	13	\$5,048	\$35,956	\$5,921	\$41,877	18	\$5,048	\$47,570	\$5,921	\$53,491		
WIL00	Wilson Hot Springs		D	0 / 0	\$741	10	\$2,249	\$23,740	\$2,990	\$26,730	17	\$4,317	\$42,980	\$5,058	\$48,038		
<i>Area Totals:</i>				0	\$7,968		\$37,499	\$279,389		\$324,856		\$58,253	\$442,601		\$508,822		
						0		91					\$45,467		141		
<i>Area: 4 - All other CA</i>																	
BRW01	Brawley	Brawley (North Brawley)	B	0 / 20		88	\$0	\$228,968	\$0	\$228,968	135	\$14,434	\$341,740	\$14,434	\$356,174		
BRW02	Brawley	East Brawley	B	0 / 0	\$90	85	\$47,773	\$312,340	\$47,863	\$360,203	129	\$76,925	\$464,100	\$77,015	\$541,115		
BRW03	Brawley	South Brawley (Mesquite field)	B	0 / 0	\$90	45	\$30,175	\$179,352	\$30,265	\$209,617	62	\$41,043	\$244,442	\$41,133	\$285,575		
CAL00	Calistoga		C	0 / 0		17	\$7,033	\$54,150	\$7,033	\$61,183	25	\$9,368	\$75,700	\$9,368	\$85,068		
COS00	Coso	Field-wide Summary	A	280 / 0		246	\$0	\$0	\$0	\$0	355	\$40,606	\$214,800	\$40,606	\$255,406		
DUN00	Dunes		C	0 / 0	\$834	7.4	\$3,310	\$24,325	\$4,144	\$28,469	11	\$6,437	\$37,660	\$7,271	\$44,931		
EAS00	East Mesa	Field-wide summary	A	62 / 0		119	\$43,663	\$250,644	\$43,663	\$294,307	148	\$63,105	\$379,051	\$63,105	\$442,156		

Estimated Costs in thousands⁽⁴⁾

PROJ ID	Field or Area	Area or Power Plant	(2) Explor- Devel. Cat.	(3) Existing Wellhd MW	Explor- ation (E)	Minimum Estimated Generation Capacity			Most-likely Estimated Generation Capacity		
						MW (C)	Confirm (SD)	Develop Site	E+C SD	MW (C)	Confirm (SD)
GEY00	Geysers	Field-wide Summary	A	850 / 0		1200	\$269,615	\$991,684	\$269,615 \$1,261,299	1400	\$420,585
GLA00	Glamis		D	0 / 0	\$906	4.3	\$4,201	\$16,645	\$5,107	6.4	\$4,201
HEB00	Heber	Field-wide Summary	A	100 / 0		109	\$1,971	\$28,809	\$1,971	\$30,780	142
LAK00	Lake City / Surprise Valley	Lake City	B	0 / 3		23	\$5,356	\$67,305	\$5,356	\$72,661	37
LVM00	Long Valley - M-P Lease	M-P Lease Summary	A	40 / 0	\$2,472	70	\$3,366	\$11,557	\$5,838	\$17,395	111
MED01	Medicine Lake	Fourmile Hill	B	0 / 0		25	\$7,013	\$60,604	\$7,013	\$67,617	36
MED02	Medicine Lake	Telephone Flat	B	0 / 15		110	\$9,222	\$230,702	\$9,222	\$239,924	175
MOS00	Mount Signal		C	0 / 0	\$441	12	\$2,387	\$32,909	\$2,828	\$35,737	19
NIL00	Niland		B	0 / 0		59	\$21,262	\$165,178	\$21,262	\$186,440	76
RAN00	Randsburg		C	0 / 0	\$450	32	\$7,783	\$79,820	\$8,233	\$88,053	48
SAL00	Salton Sea	Field-wide summary	A	350 / 0		1350	\$136,065	\$2,125,089	\$136,065 \$2,261,154	1750	\$182,281
SES00	Sespe Hot Springs		D	0 / 0	\$945	3.6	\$2,615	\$15,685	\$3,560	\$19,245	5.3
SUL00	Sulphur Bank	Clear Lake	B	0 / 0		27	\$4,517	\$56,997	\$4,517	\$61,514	43
SUP00	Superstition Mountain		D	0 / 0	\$849	5.9	\$2,615	\$15,021	\$3,464	\$18,485	9.5
<i>Area Totals :</i>				1682		\$7,077	\$609,942	\$4,947,784	\$5,564,803		\$984,765
						38	3,638		\$617,019	4,723	
											\$991,842
<i>Grand Totals :</i>				1878		\$27,785	\$905,592	\$7,322,259	\$8,255,636		\$1,438,878
						61	4,644		\$933,377	6,223	
											\$1,466,663

Estimated Costs in thousands⁽⁴⁾

PROJ ID	Field or Area	Area or Power Plant	(2)	(3)	Explor- ation (E)	Minimum Estimated Generation Capacity			Most-likely Estimated Generation Capacity		
			Explor- Existing Devel. Cat.	Existing Wellhd MW		MW Confirm (C)	Develop Site (SD)	E+C SD	MW Confirm (C)	Develop Site (SD)	E+C SD

1. The methodologies used for cost estimation are described in Appendices IV, V and VI

2. **Exploration-Development Category**

A = existing power plant operating

B = one or more wells tested at ≥ 1 MW

C = a temperature $\geq 212^{\circ}\text{F}$ has been logged downhole (or boiling temperature for local elevation)

D = other exploration data (such as spring chemistry and/or shallow temperature gradient measurements)

3. The number to the left is actual generation and the number to the right is MW proven at the wellhead but not in use. Details are given in Table 9 (Comments to the Cost Estimates). Actual generation values are often uncertain by at least a few percent, because published records differ in detail, and often do not specify gross or net MW. Gross MW is represented whenever available.

4. Estimates represent the costs to bring each resource to the total Estimated Generation Capacity from existing (year 2003) levels of actual generation and/or MW proven but unused at the wellhead. Site Development represents the wellfield and power plant, but not the transmission line.

Hetch Hetchy/SFPUC Programmatic Renewable Energy Project
Project: 1.3 New Geothermal Site Identification and Qualification
Project Team: GeothermEx, Inc.
Task: 1.3.10 Final Project Report
Subject: D.1.3.10.3 Final Report

Table 9. Comments on Confirmation Cost Estimates

PROJID	Comment for Minimum Generation Estimate	Comment for Mlk (Modal) Generation Estimate
Area: 1 - Greater Reno (NV and CA)		
BEO00		
BLU00	<p>The generation capacity estimate assumes a default value for reservoir thickness that results in an estimated average TD/well (5000 ft) that is more than twice the depth of ID Slim hole Deep Blue No.1. Since that well has encountered some possibility of commercial production from about 2000-2500 ft. (being tested during 2003), the expected cost/well that is listed here may be too large by a factor of about 2. Conversely, the temperature at Deep Blue No.1 (BHT 291°F) is less than the Mlk average temperature used for the generation capacity estimate, and the expected capacity/well at 291°F would be 2.4 MW, not 3.4 MW. At 2.4MW/well, the expected number of wells needed to be drilled for confirmation remains 2, but it becomes increasingly likely that that a lending institution would require 2 successful full-diameter wells at adequate spacing for long-term production, plus one injector (which could possibly be Deep Blue No.1), even if the first full-diameter hole is successful. In such a case, it may be necessary to drill 3 full-diameter holes (with one dry). Given these considerations (lesser depth but lower temperature), the cost factor for drilling is here adjusted to 0.7.</p>	<p>See comments concerning the confirmation estimate for Min Estimated Generation Capacity.</p>
BRA00	<p>MW currently being produced exceeds this estimate. No further confirmation applies.</p>	<p>This estimate represents confirmation to bring generation from the level actually produced in yr 2000 up to the modal estimated capacity, which is less than actual installed gross generating capacity. Current average production is about 2.1 MWgr/well (7 wells producing 15 MWgr), which means that 2 wells could be needed to confirm 1.0 MW if the first well is not successful.</p>

PROJID	Comment for Minimum Generation Estimate	Comment for Mlk (Modal) Generation Estimate
COL00	The testing of a successful deep hole would require injection capacity that might be provided by the ID Slim holes drilled during exploration. Otherwise, a second full-diameter hole may be needed.	The operator may be investigating or undertaking plant modifications designed to increase efficiency and restore generation without (some of) this additional drilling. No new field-wide testing is likely to be needed, since the normal operations of the field would provide the data collection needed to evaluate the effects of the new well(s) on the reservoir.
DES00		The testing of a successful deep hole would require injection capacity that might be provided by the ID Slim holes drilled during exploration. Otherwise, a second full-diameter hole may be needed.
EMP00	Existing generation exceeds the Min Estimated Capacity.	Would require drilling deeper in the central zone than previously done, or stepping out to the east. Existing wellhead productivity is about 1.6 MW/well (4.8 MW/3 production wells). No compensation for the higher Expect/well (2.6 MW) is made, because somewhat deeper and more productive wells are assumed. (In addition, at 1.6 MW/well, Expect-to-drill remains 1 well at success rate 0.6.)
FAL00		
FLY00	Deep drilling has discovered a temperature of only 211°F at 5,000 ft depth and chemical evidence of possibly higher temperatures is ambiguous. Therefore, further exploration and deep drilling may not easily attract commercial interest.	Deep drilling has discovered a temperature of only 211°F at 5,000 ft depth and chemical evidence of possibly higher temperatures is ambiguous. Therefore, further exploration and deep drilling may not easily attract commercial interest.
FLY01		
GER00		
HAZ00	Assumes drilling for a resource deeper and hotter than the confirmed production of 275°F(?) water from about 800 ft. See comments at generation capacity estimates.	See comments at confirmation costs for Min capacity estimate.
	A financial institution may require a second well as additional confirmation and/or as injection capacity.	
	Drilling cost factor is adjusted for the possibility of relatively rapid penetration through sediments in the upper several thousand feet, based on the section at the Magma/Dow hole (TD 3668 ft) 1.5 miles to the SW. However, basement may be shallower at the confirmation	

PROJID	Comment for Minimum Generation Estimate	Comment for Mlk (Modal) Generation Estimate
HON00	hole locations (which will depend upon the results of exploration.).	
KYL00		
LEA00	Risk of a relatively high cost per MW.	
LEE00	A lending institution may require a second confirmation hole, or the use of an ID Slim hole for injection.	
NEW00		
NOR00		
PUM00	MW unused represents production at 219°F from the Tipton No.1 well, although flow rate is unknown. A developer would probably need to pump the well, but it is unknown whether the existing well completion would permit this.	Risk of a relatively high cost per MW.
	A lending institution may require a second confirmation well for injection and/or backup capacity, which would double the confirmation cost. The Tipton No.1 well might be available for this use.	A lending institution may require a second confirmation hole, or the use of an ID Slim hole for injection.
PYR00	The capacity estimation (and this confirmation estimate) assumes that permeability can be found beneath the 219°F zone at c.3,000 ft that was found by Tipton No.1, and at a higher temperature.	See Comments under Confirmation Costs - Min.
	The target of confirmation and development could be instead the zone at c.3,000 ft/219°F. In such a case: a) estimated resource capacity decreases, as described under Comments to Generation Capacity; b) per-well expected capacity becomes c.0.9 MW; c) drilling cost per well is lowered by about 1/2, and; d) expect-to-drill increases to 2 wells. Therefore, estimated confirmation cost remains about the same.	
	The development target is a deeper and hotter resource than found by the Western Geothermal holes, the presence of which is suggested by geothermometry.	
	It is assumed that the Western Geothermal holes are not suitable or no longer available for commercial use.	
	If the confirmation/development target is instead the known	

PROJID	Comment for Minimum Generation Estimate	Comment for Mlk (Modal) Generation Estimate
RYE01	<p>permeability in the Western Geothermal holes (c.4,000 - 5,800 ft, 240°F), then Expect/well becomes 1.3 MW, drilling costs drop somewhat, but Expect-to-drill increases to 2 wells.</p>	<p>MW unused is uncertain: it is reported that there are 6 wells that are definitely commercial to marginally commercial (see Well Summaries), and it is assumed that 3 of these produce 3.4 MW each.</p> <p>Confirmation for a 16 MW development is therefore regarded as achieved. However, there is good evidence that historic confirmation drilling at Rye Patch has found it difficult to find commercial permeability, except for moderate-temperature (c.260-340°F) water from relatively shallow zones, and in spite of the success of one deep well in finding a commercial flow of 405°F water. Given this fact, additional confirmation drilling may be demanded for development beyond 10 MW.</p>
RYE02		<p>There is good evidence that historic confirmation drilling at Rye Patch has found it difficult to find commercial permeability, except for moderate-temperature (c.260-340°F) water from relatively shallow zones, and in spite of the success of one deep well in finding a commercial flow of 405°F water.</p>
SAW00		<p>Given this difficulty, it seems unlikely that the current developer will seek to develop the Modal Estimated Capacity, without first successfully developing and producing (close to) the Min Estimated Capacity, even though confirmation for development of the modal estimated capacity has otherwise already been obtained.</p>
SOD00	<p>MW in use is approximate, calculated as the ratio of gross MW installed to net MW installed, times net MW produced during 2000 $((26.1/16.6)*10 = 15.7)$.</p>	<p>See comments at Confirmation Costs - MIn.</p> <p>Historic productivity per well appears to be closer to 3.1MW than 3.7 MW (see data under Well Summaries), but Expect-to-drill remains unchanged.</p>
STE00	<p>An increase to Min. Estimated Capacity from actual production would probably require only one new production well at an expected high success rate. Therefore, the cost is assigned only to Development, and Confirmation is assumed to be 0.</p>	<p>Drilling and well test cost factors have been adjusted to 1.2 because the historic productivity per well appears to be closer to 3.1 than 3.7 (see data under Well Summaries), which changes Expect to drill to 5 wells.</p> <p>It is apparent that developer/operators of this field have found it difficult to achieve and maintain production equal to installed capacity. Therefore, it is unlikely that an attempt to increase production to the Modal Estimated Capacity would be made, until and unless sustained production at the Min Estimated Capacity level can be demonstrated.</p>
		<p>Very high permeability has made it possible to produce from relatively shallow wells, about 1,000 ft deep in the northern part of the field (Lower Steamboat) and 3,100 ft deep in the southern part of the field (Upper Steamboat), so the Expected TD/well (which is calculated from estimated average depth to top of reservoir and average reservoir thickness) is unrealistically high. Drilling cost</p>

PROJID **Comment for Minimum Generation Estimate**

STI00	MW in use is approximate, calculated as the ratio of gross MW installed to net MW installed, times net MW produced during 2000 ((19/10)*7.5 = 14.3). This total exceeds Min Estimated Capacity, so a confirmation estimate does not apply.
STI01	MW unused is an approximate value, estimated from the reported results of 3 full-diameter holes (see Well Summaries); it indicates that confirmation has been achieved.
TRI00	
WAB00	Assumes drilling to greater depth than currently being produced (c.2,200 ft), in search of the higher temperatures indicated by chemical geothermometers. It is unknown whether quantitative studies have been done to determine whether long-term production from c.2,200 ft could be expanded (and it is also unknown whether such studies could be conducted without additional testing and data gathering). Possibly high cost for the expected MW/well.

Area: 2 - NV with direct access to CA

AUR00	
DIX00	

Comment for Mlk (Modal) Generation Estimate

factor has been adjusted to reflect an average depth of 2,000 ft.

MW in use is approximate, calculated as the ratio of gross MW installed to net MW installed, times net MW produced during 2000 ((19/10)*7.5 = 14.3).

Existing production does not match installed capacity, and the 4.7 MW shortfall suggests that the developer/operator has found it difficult to achieve or maintain the installed production level (which is equal to the Modal Estimated Capacity) using wells in the immediate lease area. The owner/developer of Stillwater Geothermal 1 also owns/controls the Stillwater North Expansion project (project STI01), and it is considered probable that the additional 4.7 MW will be sought in the Stillwater North Expansion area (project STI01). Therefore, confirmation for additional MW production in Stillwater Geothermal 1 is set to 0.

MW unused is an approximate value, estimated from the reported results of 3 full-diameter holes (see Well Summaries). Drilling cost factor is adjusted to reflect evidence that successful production is achieved with wells that are about 2,500 ft deep.

See comments at Confirmation Costs - Min. Possibly high cost for the expected MW/well.

It is very doubtful that the operator will attempt to increase power generation by this amount, unless significant new step-out opportunities were to be discovered.

Drilling and testing cost factor are adjusted for the historic average of 9.4 MW/well, which reduces Expect-to-drill to 2.57 wells.

PROJID	Comment for Minimum Generation Estimate	Comment for Mlk (Modal) Generation Estimate
DIX01	Existing evidence points to a large volume of very hot rock, but commercial levels of permeability have yet to be established.	Existing evidence points to a large volume of very hot rock, but commercial levels of permeability have yet to be established.
EMI00		
FIS00	It is assumed that the two existing holes that are said to be commercial producers have a gross capacity each of 3.7 MW.	It is assumed that the two existing holes that are said to be commercial producers have a gross capacity each of 3.7 MW.
HAW00		
HYD00	Risk of high cost per MW.	Risk of high cost per MW.
PIR00		
SIL00		
SOH00	High cost relative to expected MW/well.	
Area: 3 - Other NV		
BAL00	Injection capacity would have to be proven and used for testing. If the deep hole or ID Slim holes previously drilled have been plugged and abandoned, a second hole, for injection, may be needed.	
DOU00	Expected capacity/well is low, due to a most-likely temperature of only c.250°F. Expected TD/well is a default value due to lack of data. Confirmation expenses will probably not be warrented unless further exploration increases the likelihood of a higher resource temperature, or relatively shallow permeability is encountered.	See comment at cost of confirming Min Capacity Estimate.
MCG00		
PIN00		
SHO00		
WIL00	It is unlikely that a financial institution would except confirmation without a second well. An ID Slim hole (included in Exploration Cost Estimate) might be acceptable, particularly if usable for injection.	
Area: 4 - All other CA		
BRW01	Confirmation already achieved (see comments at Confirmation	A 10-MW power plant operated from 1980-85. It is reasonably likely

PROJID	Comment for Minimum Generation Estimate	Comment for Mlk (Modal) Generation Estimate
Costs - Mlk)		
BRW02	Available information (e.g. data on Figure BRW02-2) indicates that exploration wells Emanuelli 1 and Borchard A-1 had a combined capacity of about 220 klb/hr steam at commercial WHP, which would have confirmed about 11 MW. However, without evidence from longer-term tests, it is considered unlikely that a lending institution would accept these wells (probably since abandoned) as confirmation of the resource.	It is therefore assumed that 20 MW have been confirmed, and the cost estimate here represents drilling to confirm an expansion to the full minimum estimated capacity. However, the apparently successful older wells may no longer be available or suitable for a new development, and may have to be re-drilled (whether they have been plugged and abandoned has not been researched). It is reported that the 10-MW power plant operated using 2 production wells. If so, the average production was 5 MW/well, which would change Expect-to-drill to $1.67 = 2$ wells at the success ratio of 0.6. It is assumed that there is enough information about the resource available in private hands that the success ratio will be higher, and it will be necessary to drill only one new well.
BRW03	Data tabulated in Figure BRW03-1 indicate that tests of Mercer 1-28	Other Cost represents the approximate cost of corrosion-resistant titanium casing in two wells at \$2.5 million each. See comments under Min Capacity Estimate. Other Cost represents the use of corrosion-resistant titanium casing in 5 wells at \$2.5million/well.

PROJID	Comment for Minimum Generation Estimate	Comment for Mlk (Modal) Generation Estimate
	<p>and 2-28 and Lacy 1A-28 and 2-28 produced a total steam flow at commercial WHP of about 275 klb/hr. This would yield about 14 MW, which is enough for confirmation.</p> <p>Mercer 1-28 and Lacy 2-28 contributed only about 2.5 MW of the 14 MW total. These two wells would be considered non-commercial and suitable only for injection, considering the well depth and completion cost for a hyper-saline brine resource.</p> <p>It is assumed that a commercial lender would require at least one new well to be successfully drilled and tested before committing to development, so the MW already confirmed (MW unused) is set to zero instead of 14. If the existing wells are no longer available, then it could be necessary to drill two successful new wells, to provide one for injection, before confirmation can be confirmed. Therefore, Expect-to-drill = 3 wells is considered reasonable.</p> <p>Other Cost represents the use of corrosion-resistant titanium casing in two wells.</p>	<p>the use of corrosion-resistant titanium casing in 3 wells.</p>
CAL00	Confirmation expenses may not be warranted, due to environmental sensitivity and existing development of the area.	Confirmation expenses may not be warranted, due to environmental sensitivity and existing development of the area.
COS00	Min Estimated Capacity is less than actual production. No confirmation estimate is required.	<p>The operator is unlikely to attempt expansion of the Coso field to this extent, unless there is a discovery of significant new productive territory outside of the presently confirmed area of the reservoir as shown by the 350°F contour on Figure COS00-1. The "Northeast Frontier" (project COS04) may be such an area, but apparently not yet confirmed by drilling.</p> <p>Drilling and well test cost factors are adjusted to reflect a historic average productivity of 3.3 MW/well.</p>
DUN00	A lending institution would probably require a second well, drilled either as a producer available for injection, or solely for injection.	
EAS00	MW in use is the 49.7 MW produced at the Ormesa plants, plus an assumed 12 MW produced at the GEM plants for pumping the Ormesa wells (If all 35 production wells require about 1/3 MW each, then the power requirement is about 12 MW).	MW in use is the 49.7 MW produced at the Ormesa plants, plus an assumed 12 MW produced at the GEM plants for pumping the Ormesa wells (If all 35 production wells require about 1/3 MW each, then the power requirement is about 12 MW).
	Existing production of about 62 MW from 35 wells amounts to 1.9	Existing production of about 62 MW from 35 wells amounts to 1.9

PROJID	Comment for Minimum Generation Estimate	Comment for Mlk (Modal) Generation Estimate
	MWgr/well. The Drilling and Well Test Cost Factors are adjusted to compensate for the inaccurate 2.7 MWgr/well value that is based on temperature alone.	MWgr/well. The Drilling and Well Test Cost Factors are adjusted to compensate for the inaccurate 2.7 MWgr/well value that is based on temperature alone.
GEY00	Given historic production at less than installed capacity, it is unlikely that the Operator/Developer will attempt an expansion of this field to the full Min (90% probable) Estimated Capacity value.	Given historic production at less than installed capacity, it is unlikely that the Operator/Developer will attempt an expansion of this field to the Mlk (Modal) Estimated Capacity value.
	Due to a wide range of depths to top of reservoir in this field, the expected TD/well 9500 ft. is regarded as too large. Drilling cost factor is adjusted to compensate, assuming an average depth of 7,500 ft. Drilling factor is also adjusted to compensate for a real historic average of 2 MW/well.	See comments at Min Capacity Estimate.
	Since this is a producing steam field, well test costs are small, and a field test is regarded as unnecessary.	
	Until about 2001 or 2002, there was some unused wellhead capacity in the abandoned CCPA project area at the northeast end of the steamfield. It is understood that all of these wells have been abandoned, but this has not been confirmed. A small amount of unused wellhead capacity may still exist in the abandoned Bottle Rock project area, along the eastern edge of the field south of the CCPA area, but all of these wells may also have been abandoned.	
GLA00	The reported depth to top of reservoir (basis unknown) results in an estimated depth/well which is considered unrealistic. Drilling cost factor is reduced to reflect a depth of 8,000 ft.	See comment at confirmation costs for Min.Generation Estimate.
HEB00	Relationships between installed capacity and number of production wells suggest that the average/well is about 4.3 MWgr. Drilling and well test cost factors are adjusted to compensate.	Relationships between installed capacity and number of production wells suggest that the average/well is about 4.3 MWgr. Drilling and well test cost factors are adjusted to compensate.
	MW total installed gross capacity is assumed to be MW in use.	MW total installed gross capacity is assumed to be MW in use.
LAK00	MW unused represents Phipps 2, which is assumed to be available. If not, Expect-to-drill increases to 3 wells.	MW unused represents Phipps 2, which is assumed to be available. If not, Expect-to-drill increases to 5 wells.
LVM00	Well depth is likely to increase from E to W. The expected average depth listed here (calculated from estimated depth to top of reservoir and estimated thickness) is regarded as somewhat high, and expected	Well depth is likely to increase from E to W. The expected average depth listed here (calculated from estimated depth to top of reservoir and estimated thickness) is regarded as somewhat high, and expected

PROJID	Comment for Minimum Generation Estimate	Comment for Mlk (Modal) Generation Estimate
	MW/well is somewhat low (production wells in the Casa Diablo field average 5 MW each), so drilling and well test cost factors are adjusted to compensate.	MW/well is somewhat low (production wells in the Casa Diablo field average 5 MW each), so drilling and well test cost factors are adjusted to compensate.
MED01	Some MW capacity at the wellhead may have already been confirmed, but data are not available.	Some MW capacity at the wellhead may have already been confirmed, but data are not available.
MED02	MW confirmed represents the three commercially successful wells that already have been drilled. The developer is apparently planning on about 10 production wells (Figure MED02-1) for a 49.5 MW plant, which would be 5 MW/well. MW unused represents the three commercially successful wells that already have been drilled.	See Comments at Confirmation Cost - Min.
MOS00	The nominal expected TD/well (4,450 ft) is less than the 5,230 ft depth at which the 2.5°F/100 ft gradient in the 1,826 ft Phillips hole projects to the Mlk average temperature of 345°F. An estimated depth of 5,230 ft is regarded as more realistic than 4,450 ft, so drilling cost factor is adjusted to 1.2 to compensate.	See comments at confirmation for Min Generation Capacity Estimate
	A lending institution is likely to require a second well, at least to enable injection during testing. It is assumed that a second ID Slim hole drilled in the exploration program will serve for that purpose and satisfy the lender, but this is not certain.	
NIL00	Drilling cost factor is adjusted to 0.8 to compensate for probable over-estimation of TD/well. Other Cost represents \$2,500,000/well for titanium casing in 2 wells.	See comment at confirmation estimate for Min Estimated generation capacity.
	Three wells are reported to have been successfully tested. Details are not available but this suggests that there may exist some unused wellhead capacity.	
RAN00		
SAL00	MW in use is based on current production, but some excess well capacity may already exist and be available for an expansion of generation.	See comments at confirmation cost for Min Generation Estimate.
	Drilling and well test cost factors are adjusted for the historic average 11 MWgr/well (350 MW/31 wells) and for an expected very	

PROJID	Comment for Minimum Generation Estimate	Comment for Mlk (Modal) Generation Estimate
	low dry- hole fraction (10%). It is also assumed that depth/well has been over-estimated.	
	Other cost represents titanium casing in 10 wells at \$2,500,000/well.	
SES00	A lending institution may require a second well, to confirm temperature and permeability and allow testing with injection. An ID Slim hole drilled during exploration might be acceptable for this purpose. The remote location and apparent environmental sensitivity of this are make confirmation and development uncertain.	See comments at Confirmation Costs - Min.
SUL00		
SUP00	A lender is likely to require a second well. A permeable ID Slim hole drilled during exploration may serve for this.	Drilling cost factor is 2 on the assumption that a lender will require a second deep well.

Hetch Hetchy/SFPUC Programmatic Renewable Energy Project
Project: 1.3 New Geothermal Site Identification and Qualification
Project Team: GeothermEx, Inc.
Task: 1.3.10 Final Project Report
Subject: D.1.3.10.3 Final Report

Table 10. Comments on Site Development Cost Estimates

PROJID	Comment for Minimum Generation Estimate	Comment for Mlk (Modal) Generation Estimate
Area: 1 - Greater Reno (NV and CA)		
BEO00	I/P and P+I success rate are adjusted to estimated historic Beowawe levels.	I/P and P+I success rate are adjusted to estimated historic Beowawe levels.
BLU00	Cost Factor for development drilling is adjusted to reflect a well depth of 2,500 ft and wellhead capacity 2.4 MW/well (see comments at confirmation cost estimate).	Cost Factor for development drilling is adjusted to reflect a well depth of 2,500 ft and wellhead capacity 2.4 MW/well (see comments at confirmation cost estimate).
BRA00	MW currently being produced exceeds this estimate. No development applies.	At 2.1 MWgr/well current average wellhead productivity, 2 production wells would be needed for the wellhead development plan, instead of the 1 well calculated at 3.7MW/well. It is assumed that a previously drilled successful confirmation well will combine with the 1 development well to provide the total 4 MW needed.
COL00		
DES00	I/P and P+I success rate are adjusted to historic values.	I/P and P+I success rate are adjusted to historic values.
EMP00	Existing generation exceeds the Min Estimated Capacity, no development applies.	I/P and P+I success rate are adjusted to estimated historic values. Existing wellhead productivity is about 1.6 MW/well (4.8 MW/3 production wells). No compensation of the Cost Factor for development drilling is made, because somewhat deeper, more productive wells are assumed.
FAL00		
FLY00	Deep drilling has discovered a temperature of only 211°F at 5,000 ft depth and chemical evidence of possibly higher temperatures is ambiguous. Therefore, further exploration and deep drilling may not easily attract commercial interest.	Deep drilling has discovered a temperature of only 211°F at 5,000 ft depth and chemical evidence of possibly higher temperatures is ambiguous. Therefore, further exploration and deep drilling may not easily attract commercial interest.

PROJID	Comment for Minimum Generation Estimate	Comment for Mlk (Modal) Generation Estimate
FLY01		
GER00		
HAZ00	Drilling cost factor is adjusted for the possibility of relatively rapid penetration through sediments in the upper several thousand feet, based on the section at the Magma/Dow hole (TD 3668 ft) 1.5 miles to the SW.	Drilling cost factor is adjusted for the possibility of relatively rapid penetration through sediments in the upper several thousand feet, based on the section at the Magma/Dow hole (TD 3668 ft) 1.5 miles to the SW.
HON00		
KYL00		
LEA00	Risk of a relatively high cost per MW.	Risk of a relatively high cost per MW.
LEE00		
NEW00		
NOR00		
PUM00	See comments at Confirmation costs - MIn	See comments at Confirmation costs - MIn
PYR00	See Comments at Confirmation Costs - Min.	See Comments at Confirmation Costs - Min.
RYE01	MW unused-at-wellhead is uncertain: it is reported that there are 6 wells that are definitely commercial to marginally commercial (see Well Summaries), and it is assumed that 3 of these produce 3.4 MW each. Information listed under Well Summaries suggests that the successful hole ratio for Rye Patch has been (and may remain) lower than the default value of 0.8, so a value of 0.7 is applied. It is assumed that the 12.5 MW binary plant constructed 1991-93 is still on-site, unused and available. Other Dev. Cost represents the assumption that this plant will be purchased by a new developer, at a 50% discount.	See comments at Development Costs - Min.
RYE02		
SAW00		
SOD00	MW in use is approximate, calculated as the ratio of gross MW installed to net MW installed, times net MW produced during 2000	See comments at Development Costs - Min.

PROJID	Comment for Minimum Generation Estimate	Comment for Mlk (Modal) Generation Estimate
	((26.1/16.6)*10 = 15.7).	
	I/P and P+I success rate are adjusted to historic values.	
	Drilling cost factor has been adjusted to 1.2 because the historic productivity per well appears to be closer to 3.1 than 3.7 (see data under Well Summaries).	
STE00	P/I and P+I success rate are adjusted to historic values. Drilling cost factor is adjusted for an average depth/well of about 2,000 ft. (See comments at Confirmation Costs - Mlk).	P/I and P+I success rate are adjusted to historic values. Drilling cost factor is adjusted for an average depth/well of about 2,000 ft. (See comments at Confirmation Costs - Mlk).
STI00	MW in use is approximate, calculated as the ratio of gross MW installed to net MW installed, times net MW produced during 2000 ((19/10)*7.5 = 14.3). This total exceeds Min Estimated Capacity, so a development estimate does not apply.	MW in use is approximate, calculated as the ratio of gross MW installed to net MW installed, times net MW produced during 2000 ((19/10)*7.5 = 14.3).
		Existing production (MW in use) does not match installed plant capacity, and the 4.7 MW shortfall suggests that the developer/operator has found it difficult to achieve or maintain the installed production level (which is equal to the Modal Estimated Capacity) using wells in the immediate lease area. The owner/developer of Stillwater Geothermal 1 also owns/controls the Stillwater North Expansion project (project STI01), and it is considered probable that the additional 4.7 MW will be sought in the Stillwater North Expansion area (project STI01). Therefore, development for additional MW production in Stillwater Geothermal 1 is set to 0.
STI01	MW unused is an approximate value, estimated from the reported results of 3 full diameter holes (see Well Summaries).	See comments at Development Costs - Min.
	P/I and P+I success rate are adjusted to historic values at STI00.	
	Drilling cost factor is adjusted to reflect evidence that successful production has been achieved with wells that are about 2,500 ft deep.	
	Although Existing plant capacity is 0, it is assumed that 4.7 MW of the new wellhead production developed in Stillwater North will be shipped south to Stillwater Geothermal 1 (STI00), to bring that plant up to full generation capacity, and a smaller plant will be constructed for the North Expansion. The negative other-development cost value (which represents 4.7 MW) compensates, effectively providing an assumption that the new plant will be 14 - 4.7 = 9.3 MW.	
TRI00		

PROJID	Comment for Minimum Generation Estimate	Comment for Mlk (Modal) Generation Estimate
WAB00	Assumes drilling to greater depth than currently being produced (c.2,200 ft), in search of the higher temperatures indicated by chemical geothermometers. It is unknown whether quantitative studies have been done to determine whether long-term production from c.2,200 ft could be expanded (and it is also unknown whether such studies could be conducted without additional testing and data gathering). Possibly high cost for the expected MW/well. P+I success rate reflects historic average.	See comments at Development Costs - Min.
Area: 2 - NV with direct access to CA		
AUR00		
DIX00	Cost factor for drilling is adjusted for the historic average of 9.4 MW/well. I/P and P+I success rate are adjusted to historic values.	It is very doubtful that the operator will attempt to increase power generation by this amount, unless significant new step-out opportunities were to be discovered. Cost factor for drilling is adjusted for the historic average of 9.4 MW/well. I/P and P+I success rate are adjusted to historic values.
DIX01	Existing evidence points to a large volume of very hot rock, but commercial levels of permeability have yet to be established.	Existing evidence points to a large volume of very hot rock, but commercial levels of permeability have yet to be established.
EMI00		Transmission line costs might be lowered by combining project with development of the near-by Fish Lake project (FIS00).
FIS00	It is assumed that the two existing holes that are said to be commercial producers have a gross capacity each of 3.7 MW.	It is assumed that the two existing holes that are said to be commercial producers have a gross capacity each of 3.7 MW.
HAW00		
HYD00	Risk of high cost per MW.	Risk of high cost per MW.
PIR00		
SIL00		
SOH00		High cost relative to expected MW/well.
Area: 3 - Other NV		
BAL00		
DOU00	Expected capacity/well is low, due to a most-likely temperature of	Expected capacity/well is low, due to a most-likely temperature of

PROJID **Comment for Minimum Generation Estimate**

only c.250°F. Expected TD/well is a default value due to lack of data. Development is unlikely unless further exploration increases the likelihood of a higher resource temperature, or relatively shallow permeability is encountered.

MCG00

PIN00

SHO00

WIL00

Area: 4 - All other CA

BRW01 MW unused at wellhead may be inaccurate. See comments at Confirmation Costs - Mlk. I/P during power plant operation in 1983 was 2, but historic I/P at the similar (but shallower) Salton Sea resource (SAL00) has been about 0.85. It is assumed that the higher Brawley I/P was due to availability of wells and that a lower I/P would be possible, so a value of 1 is being applied. Other cost represents the approximate cost of titanium casing in 11 wells at \$2.5 million each.

BRW02 Salton Sea historic I/P assumed. Other cost is titanium casing in production wells at \$2.5 million each.

BRW03 Development cost may be over-estimated. Unused at wellhead may be as high as 11.5, if wells drilled and tested in 1980s are available, and confirmation may have added 6.5 MW more (see comments at Confirmation Cost - Min). In such a case, the production need may be only 1 or 2 wells. Injection need may be reduced if wells drilled in 1980s can serve for injection even if no longer in condition for production. I/P of Salton Sea project (SAL00) assumed. Other cost is titanium casing in 6 production wells at \$2.5 million each.

CAL00 Development is relatively unlikely, due to environmental sensitivity and existing development of the area.

COS00 Min Estimated Capacity is less than actual production. No development estimate is required.

Comment for Mlk (Modal) Generation Estimate

only c.250°F. Expected TD/well is a default value due to lack of data. Development will probably not be warranted unless further exploration increases the likelihood of a higher resource temperature, or relatively shallow permeability is encountered.

See comments at Development Costs - Min.

Other Cost represents titanium casing in the production wells at \$2.5million/well.

Salton Sea I/P assumed. Other cost is titanium casing in production wells at \$2.5 million each.

See Comments at Development Costs for Min Estimated Generation Capacity.

Development is relatively unlikely, due to environmental sensitivity and existing development of the area.

I/P and P+I success rate are adjusted to estimated historic values. Cost factor for development drilling is adjusted to reflect a historic

PROJID	Comment for Minimum Generation Estimate	Comment for Mlk (Modal) Generation Estimate
DUN00		average productivity of 3.3 MW/well.
EAS00	I/P and (P+I) success rate are based on historic values. Existing production of about 62 MW from 35 wells amounts to 1.9 MWgr/well. The Drilling Cost Factor is adjusted to compensate for the inaccurate 2.7 MWgr/well value that is based on temperature alone. Existing plant reflects only the Ormesa plants and does not include GEM2-3.	I/P and (P+I) success rate are based on historic values. Existing production of about 62 MW from 35 wells amounts to 1.9 MWgr/well. The Drilling Cost Factor is adjusted to compensate for the inaccurate 2.7 MWgr/well value that is based on temperature alone. Existing plant reflects only the Ormesa plants and does not include GEM2-3.
GEY00	Given historic production at less than installed capacity, it is unlikely that the Operator/Developer will attempt an expansion of this field to the full Min (90% probable) Estimated Capacity value.	Given historic production at less than installed capacity, it is unlikely that the Operator/Developer will attempt an expansion of this field to the Mlk (Modal) Estimated Capacity value.
GLA00	I/P is the historic value. The overall success rate of Geysers wells is very high, but many wells require re-drills and some are completed with multiple open legs.	See comments at Development Costs - Mlk
HEB00	Drilling cost factor is adjusted to assume an average depth of 7,500 ft and a real historic average of 2 MW/well. Existing plant is set to current generation, but there has been a considerable amount of under-utilized plant capacity due to productivity declines at existing wells. Some plant capacity has been decommissioned, but some is probably available for (re-)expansion beyond 900 MW. Therefore, Total On-site Capital Cost may be grossly over-estimated.	
LAK00	The reported depth to top of reservoir (basis unknown) results in an estimated depth/well which is considered unrealistic. Drilling cost factor is reduced to reflect a depth of 8,000 ft.	The reported depth to top of reservoir (basis unknown) results in an estimated depth/well which is considered unrealistic. Drilling cost factor is reduced to reflect a depth of 8,000 ft.
LVM00	P+I success rate is the historic value. Relationships between installed capacity and number of production wells suggest that the average/well is about 4.3 MWgr. Drilling cost factors is adjusted to compensate.	P+I success rate is the historic value. Relationships between installed capacity and number of production wells suggest that the average/well is about 4.3 MWgr. Drilling cost factors is adjusted to compensate.
	I/P and P+I success rate are adjusted to historic values at the Casa Diablo wellfield, but the ratios at other Long Valley M-P lease	I/P and P+I success rate are adjusted to historic values at the Casa Diablo wellfield, but the ratios at other Long Valley M-P lease

PROJID	Comment for Minimum Generation Estimate	Comment for Mlk (Modal) Generation Estimate
	locations could be quite different. See comments at Mlk confirmation cost estimate with respect to the cost factor for drilling.	locations could be quite different. See comments at Mlk confirmation cost estimate with respect to the cost factor for drilling.
MED01	I/P and P+I success rate are based on Telephone Flat data (MED02)	I/P and P+I success rate are based on Telephone Flat data (MED02)
MED02	The development plan wellfield (Figure MED02-1) shows 10 P wells, 4 I wells, and 3 wells that are I/P (assumed to be I or P depending upon drilling outcomes). If the I/P wells are split, then 11.5 P and 5.5 I yields I/P ratio = 0.5. Drilling to date has had a success rate of about 0.75, and it is assumed that this will improve to the default value of 0.8	See comments at Development Costs for Min Estimated Generation Capacity.
MOS00	see comments at Confirmation Costs - Min	see comments at Confirmation Costs - Min
NIL00	I/P is the historic Salton Sea project value.	see comments at Development Costs - Min
	Drilling cost factor is adjusted to 0.8 to compensate for probable over-estimation of TD/well. Other Cost represents \$2,500,000/production well for titanium casing.	
	Three wells are reported to have been successfully tested. Details are not available but this suggests that there may exist some unused wellhead capacity.	
RAN00		
SAL00	I/P and P+I success rate are historic values. Drilling cost factor is adjusted for the historic average 11 MWgr/well (350 MW/31 wells) and for an expected very low dry hole fraction (10%). It is also assumed that depth/well has been over-estimated. Other cost is titanium casing at \$2,500,000/production well.	See comments at Development Costs - Min.
SES00		
SUL00		
SUP00		

Hetch Hetchy/SFPUC Programmatic Renewable Energy Project
 Project: 1.3 New Geothermal Site Identification and Qualification
 Project Team: GeothermEx, Inc.
 Task: 1.3.10 Final Project Report
 Subject: D.1.3.10.3 Final Report

Table 11. Confirmation and Site Development Cost Estimates - Drilling Details⁽¹⁾

PROJ ID	Area or Power Plant	Estimated Generation		(4)	(5)	(6) Expect	Confirmation ⁽⁷⁾			Development ⁽⁸⁾							
		(2) Capacity (MW)	(3) Existing Wellhd				TD /well	Plan (MW)	Plan (wells)	Cost-Fact.	Total Drilling (\$1000)	Plan (MW)	I/P (P+I)/T	Plan (wells)	Cost-Fact.	Total Drilling (\$1000)	
Area: 1 - Greater Reno (NV and CA)																	
BEO00	Beowawe	A	30	15/0	4.7	9,600	3.8	1	1.00	\$4,014	12.75	0.33	0.60	7	1.0	\$28,098	
BEO00	Beowawe	A	41	15/0	4.7	9,600	6.5	2	1.00	\$8,028	21.55	0.33	0.60	12	1.0	\$48,168	
BLU00	Blue Mountain	C	16	0/0	3.4	5,000	4.0	2	0.70	\$2,475	12.8	0.95	0.80	10	0.7	\$12,376	
BLU00	Blue Mountain	C	30	0/0	3.4	5,000	7.5	4	0.70	\$4,950	24	0.95	0.80	18	0.7	\$22,277	
BRA00	Brady's Hot Springs	A	11	15/0	3.7	6,500	0.0	0	0.00	\$0	-3.45	0.95	0.80	0	0.0	\$0	
BRA00	Brady's Hot Springs	A	18	15/0	3.7	6,500	0.8	1	1.00	\$2,411	3.15	1.30	0.80	3	1.0	\$7,233	
COL00	Colado	C	3.7	0/0	1.9	4,600	0.9	1	1.00	\$1,610	2.96	0.95	0.80	5	1.0	\$8,050	
COL00	Colado	C	6.2	0/0	1.9	4,600	1.6	1	1.00	\$1,610	4.96	0.95	0.80	8	1.0	\$12,880	
DES00	Desert Peak	A	33	10/0	4.2	5,500	5.8	2	1.00	\$3,946	18.9	0.50	0.70	11	1.0	\$21,703	
DES00	Desert Peak	A	45	10/0	4.2	5,500	8.8	3	1.00	\$5,919	28.5	0.50	0.70	16	1.0	\$31,568	
EMP00	Empire (San Emidio)	Field-wide summary	A	4.3	4.8/0	2.6	3,450	0.0	0	0.00	\$0	-0.29	0.95	0.80	0	0.0	\$0
EMP00	Empire (San Emidio)	Field-wide summary	A	6.6	4.8/0	2.6	3,450	0.5	1	1.00	\$1,192	1.68	1.00	0.70	3	1.0	\$3,576
FAL00	Fallon / Carson Lake	Carson Lake anomaly	C	34	0/0	3.9	6,567	8.5	4	1.00	\$9,768	27.2	0.95	0.80	18	1.0	\$43,956
FAL00	Fallon / Carson Lake	Carson Lake anomaly	C	55	0/0	3.9	6,567	13.8	6	1.00	\$14,652	44	0.95	0.80	26	1.0	\$63,492

PROJ ID	Field or Area	Area or Power Plant	Estimated Generation				(6) Expect	Confirmation ⁽⁷⁾				Development ⁽⁸⁾				Total Drilling (\$1000)	
			(2) Explor.-Cat.	(3) Devel.	(4) Upper = Min Wellhd	(5) Existing MW		(6) Est. MW /well	(7) TD /well (ft)	Plan (MW)	Plan (wells)	Cost-Fact.	Total Drilling (\$1000)	Plan (MW)	I/P /T	(P+I)	Plan (wells)
FLY00	Fly Ranch/Granite Ranch	Ward's (Fly/Hualapi Flat) H.S.	C	6	0/0	0.7	8,350	1.5	4	1.00	\$13,296	4.8	0.95	0.80	18	1.0	\$59,832
FLY00	Fly Ranch/Granite Ranch	Ward's (Fly/Hualapi Flat) H.S.	C	8.7	0/0	0.7	8,350	2.2	5	1.00	\$16,620	6.96	0.95	0.80	25	1.0	\$83,100
FLY01	Fly Ranch/Granite Ranch	Granite Ranch	C	5.4	0/0	3.4	5,700	1.4	1	1.00	\$2,057	4.32	0.95	0.80	3	1.0	\$6,171
FLY01	Fly Ranch/Granite Ranch	Granite Ranch	C	8.1	0/0	3.4	5,700	2.0	1	1.00	\$2,057	6.48	0.95	0.80	5	1.0	\$10,285
GER00	Gerlach	(Great Boiling Spring)	C	17	0/0	3.3	7,700	4.3	2	1.00	\$5,976	13.6	0.95	0.80	10	1.0	\$29,880
GER00	Gerlach	(Great Boiling Spring)	C	25	0/0	3.3	7,700	6.3	3	1.00	\$8,964	20	0.95	0.80	15	1.0	\$44,820
HAZ00	Hazen (Black Butte)	(Patua Hot Springs)	C	6.3	0/0	3.1	7,700	1.6	1	0.80	\$2,390	5.04	0.95	0.80	5	0.8	\$11,952
HAZ00	Hazen (Black Butte)	(Patua Hot Springs)	C	8.5	0/0	3.1	7,700	2.1	1	0.80	\$2,390	6.8	0.95	0.80	5	0.8	\$11,952
HON00	Honey Lake	Area-wide Summary	A	5.7	1.2/0	1.3	3,750	1.1	1	1.00	\$1,296	3.66	0.95	0.80	8	1.0	\$10,368
HON00	Honey Lake	Area-wide Summary	A	8.3	1.2/0	1.3	3,750	1.8	2	1.00	\$2,592	5.74	0.95	0.80	10	1.0	\$12,960
KYL00	Kyle Hot Springs (Granite Mtn.)	(Buena Vista Valley)	C	16	0/0	4.0	7,700	4.0	2	1.00	\$5,976	12.8	0.95	0.80	8	1.0	\$23,904
KYL00	Kyle Hot Springs (Granite Mtn.)	(Buena Vista Valley)	C	22	0/0	4.0	7,700	5.5	2	1.00	\$5,976	17.6	0.95	0.80	10	1.0	\$29,880
LEA00	Leach Hot Springs	Grass Valley	C	13	0/0	1.8	8,500	3.3	3	1.00	\$10,212	10.4	0.95	0.80	15	1.0	\$51,060
LEA00	Leach Hot Springs	Grass Valley	C	18	0/0	1.8	8,500	4.5	4	1.00	\$13,616	14.4	0.95	0.80	20	1.0	\$68,080
LEE00	Lee Hot Springs		C	5.4	0/0	2.8	5,700	1.4	1	1.00	\$2,057	4.32	0.95	0.80	5	1.0	\$10,285
LEE00	Lee Hot Springs		C	9.4	0/0	2.8	5,700	2.4	1	1.00	\$2,057	7.52	0.95	0.80	8	1.0	\$16,456
NEW00	New York Canyon		C	20	0/0	3.4	5,700	5.0	2	1.00	\$4,114	16	0.95	0.80	13	1.0	\$26,741
NEW00	New York Canyon		C	26	0/0	3.4	5,700	6.5	3	1.00	\$6,171	20.8	0.95	0.80	15	1.0	\$30,855

PROJ ID	Field or Area	Area or Power Plant	Estimated Generation				(6) Expect	Confirmation ⁽⁷⁾			Development ⁽⁸⁾				Total Drilling (\$1000)		
			(2) Capacity (MW)		(3) Existing	(4) Est. TD		Total			Plan (MW)	Plan (wells)	Cost-Fact.	Plan (MW)	I/P (P+I) /T		
			Explor.-	Devel. Cat.	Upper = Min Wellhd	Lower = Mlk MW	MW /well	TD (ft)	Drilling (\$1000)	Cost-Fact.	Drilling (\$1000)	Cost-Fact.	Drilling (\$1000)	Cost-Fact.			
NOR00	North Valley		C	37	0/0	3.4	4,950	9.3	5	1.00	\$8,740	29.6	0.95	0.80	23	1.0	\$40,204
NOR00	North Valley		C	49	0/0	3.4	4,950	12.3	6	1.00	\$10,488	39.2	0.95	0.80	29	1.0	\$50,692
PUM00	Pumpernickel Valley	Tipton Ranch/Hot Springs Ranch	C	10	0/0.9	2.4	6,000	1.6	1	1.00	\$2,187	8	0.95	0.80	8	1.0	\$17,496
PUM00	Pumpernickel Valley	Tipton Ranch/Hot Springs Ranch	C	13	0/0.9	2.4	6,000	2.4	2	1.00	\$4,374	10.4	0.95	0.80	10	1.0	\$21,870
PYR00	Pyramid Lake Indian Reserv.	(Needle Rocks Hot Springs)	C	9.9	0/0	3.4	7,000	2.5	1	1.00	\$2,645	7.92	0.95	0.80	5	1.0	\$13,225
PYR00	Pyramid Lake Indian Reserv.	(Needle Rocks Hot Springs)	C	14	0/0	3.4	7,000	3.5	2	1.00	\$5,290	11.2	0.95	0.80	8	1.0	\$21,160
RYE01	Rye Patch-Humboldt House District	Rye Patch	B	16	0/10	3.4	5,280	0.0	0	0.00	\$0	6.8	0.95	0.70	6	1.0	\$11,286
RYE01	Rye Patch-Humboldt House District	Rye Patch	B	20	0/10	3.4	5,280	0.0	0	0.00	\$0	11	0.95	0.70	9	1.0	\$16,929
RYE02	Rye Patch-Humboldt House District	Humboldt House	C	27	0/0	3.4	5,700	6.8	3	1.00	\$6,171	21.6	0.95	0.80	15	1.0	\$30,855
RYE02	Rye Patch-Humboldt House District	Humboldt House	C	34	0/0	3.4	5,700	8.5	4	1.00	\$8,228	27.2	0.95	0.80	20	1.0	\$41,140
SAW00	Salt Wells	Eight Mile Flat	C	63	0/0	4.5	5,700	15.8	6	1.00	\$12,342	50.4	0.75	0.80	24	1.0	\$49,368
SAW00	Salt Wells	Eight Mile Flat	C	96	0/0	4.5	5,700	24.0	9	1.00	\$18,513	76.8	0.75	0.80	38	1.0	\$78,166
SOD00	Soda Lake	Soda Lake No.1/No.2	A	29	16/0	3.7	4,850	3.3	1	1.00	\$1,708	11.43	1.00	0.70	9	1.2	\$18,446
SOD00	Soda Lake	Soda Lake No.1/No.2	A	42	16/0	3.7	4,850	6.6	3	1.20	\$6,149	21.83	1.00	0.70	17	1.2	\$34,843
STE00	Steamboat Hot Sprs	Field-wide Summary A		56	53/0	3.9	5,150	0.8	1	0.00	\$0	5.05	0.50	0.90	2	0.4	\$1,462
STE00	Steamboat Hot Sprs	Field-wide Summary A		62	53/0	3.9	5,150	2.3	1	0.40	\$731	9.85	0.50	0.90	6	0.4	\$4,387

PROJ ID	Field or Area	Area or Power Plant	Estimated Generation				(6) Expect	Confirmation ⁽⁷⁾			Development ⁽⁸⁾						
			(2) Explor.- Devel. Cat.	(3) Existing Upper = Min Lower = Mlk	(4) Est. Wellhd MW	(5) Est. MW /well		TD well (#)	Plan (MW)	Plan (wells)	Cost- Fact.	Total Drilling (\$1000)	Plan (MW)	I/P (P+I) /T	Plan (wells)	Cost- Fact.	Total Drilling (\$1000)
STI00	Stillwater	Stillwater Geothermal 1	A	11	14/0	2.7	2,300	0.0	0	0.00	\$0	-2.75	0.95	0.80	0	0.0	\$0
STI00	Stillwater	Stillwater Geothermal 1	A	18	14/0	2.7	2,300	0.9	1	0.00	\$0	3.675	0.75	0.86	2	0.0	\$0
STI01	Stillwater	Stillwater N Expansion	B	16	0/5	3.1	4,000	0.0	0	0.00	\$0	11.8	0.75	0.86	8	0.6	\$6,653
STI01	Stillwater	Stillwater N Expansion	B	24	0/5	3.1	4,000	1.0	1	0.60	\$832	19.2	0.75	0.86	13	0.6	\$10,811
TRI00	Trinity Mountains District	Telephone Well area D		42	0/0	3.4	5,600	10.5	5	1.00	\$10,075	33.6	0.95	0.80	25	1.0	\$50,375
TRI00	Trinity Mountains District	Telephone Well area D		66	0/0	3.4	5,600	16.5	8	1.00	\$16,120	52.8	0.95	0.80	39	1.0	\$78,585
WAB00	Wabuska		A	8.1	1.4/0	1.4	4,500	1.7	2	1.00	\$3,144	5.43	0.95	0.50	16	1.0	\$25,152
WAB00	Wabuska		A	13	1.4/0	1.4	4,500	2.9	3	1.00	\$4,716	9.35	0.95	0.50	28	1.0	\$44,016
Area: 2 - NV with direct access to CA																	
AUR00	Aurora		C	31	0/0	3.4	6,000	7.8	4	1.00	\$8,748	24.8	0.95	0.80	18	1.0	\$39,366
AUR00	Aurora		C	51	0/0	3.4	6,000	12.8	6	1.00	\$13,122	40.8	0.95	0.80	29	1.0	\$63,423
DIX00	Dixie Valley	Caithness Dixie Valley	A	71	66/0	5.3	9,500	1.3	1	1.00	\$3,957	7.3	1.40	0.75	3	0.6	\$7,123
DIX00	Dixie Valley	Caithness Dixie Valley	A	107	66/0	5.3	9,500	10.3	3	0.50	\$5,936	36.1	1.40	0.75	23	0.6	\$54,607
DIX01	Dixie Valley	Dixie Valley Power Partners (DVPP)	C	107	0/0	5.7	10,000	26.8	8	1.00	\$33,984	85.6	0.75	0.80	33	1.0	\$140,184
DIX01	Dixie Valley	Dixie Valley Power Partners (DVPP)	C	151	0/0	5.7	10,000	37.8	11	1.00	\$46,728	120.8	0.75	0.80	46	1.0	\$195,408
EMI00	Emigrant (Fish Lake V.)		C	49	0/0	3.3	7,700	12.3	6	1.00	\$17,928	39.2	0.95	0.80	29	1.0	\$86,652

PROJ ID	Field or Area	Area or Power Plant	Estimated Generation				(6) Expect	Confirmation			Development				Total Drilling (\$1000)	
			Explor.-	Devel.-	Upper = Min	Lower = Mlk		(3) Existing Wellhd	(4) Est. MW	(5) TD /well	Plan (MW)	Plan (wells)	Cost-Fact.	Total Drilling (\$1000)		
EMI00	Emigrant (Fish Lake V.)		C	85	0/0		3.3	7,700	21.3	11	1.00	\$32,868	68	0.95	0.80	51 1.0 \$152,388
FIS00	Fish Lake (Valley)		B	30	0/7.4		3.7	9,500	0.1	1	1.00	\$3,957	24	0.95	0.80	15 1.0 \$59,355
FIS00	Fish Lake (Valley)		B	47	0/7.4		3.7	9,500	4.4	2	1.00	\$7,914	37.6	0.95	0.80	25 1.0 \$98,925
HAW00	Hawthorne		C	8.7	0/0		2.2	6,500	2.2	2	1.00	\$4,822	6.96	0.95	0.80	8 1.0 \$19,288
HAW00	Hawthorne		C	14	0/0		2.2	6,500	3.5	3	1.00	\$7,233	11.2	0.95	0.80	13 1.0 \$31,343
HYD00	Hyder Hot Springs		D	5.5	0/0		1.4	7,700	1.4	2	1.00	\$5,976	4.4	0.95	0.80	8 1.0 \$23,904
HYD00	Hyder Hot Springs		D	9.6	0/0		1.4	7,700	2.4	3	1.00	\$8,964	7.68	0.95	0.80	13 1.0 \$38,844
PIR00	Pirouette Mountain (S.Dixie Valley)		D	16	0/0		3.4	5,700	4.0	2	1.00	\$4,114	12.8	0.95	0.80	10 1.0 \$20,570
PIR00	Pirouette Mountain (S.Dixie Valley)		D	23	0/0		3.4	5,700	5.8	3	1.00	\$6,171	18.4	0.95	0.80	13 1.0 \$26,741
SIL00	Silver Peak (Alum prospect)		C	41	0/0		3.4	5,700	10.3	5	1.00	\$10,285	32.8	0.95	0.80	25 1.0 \$51,425
SIL00	Silver Peak (Alum prospect)		C	78	0/0		3.4	5,700	19.5	10	1.00	\$20,570	62.4	0.95	0.80	44 1.0 \$90,508
SOH00	Sou Hot Springs (Seven Devils/Gilbert's H.S.)		D	3.3	0/0		2.0	5,700	0.8	1	1.00	\$2,057	2.64	0.95	0.80	3 1.0 \$6,171
SOH00	Sou Hot Springs (Seven Devils/Gilbert's H.S.)		D	6.1	0/0		2.0	5,700	1.5	1	1.00	\$2,057	4.88	0.95	0.80	5 1.0 \$10,285
Area: 3 - Other NV																
BAL00	Baltazor		C	11	0/0		2.6	8,000	2.8	2	1.00	\$6,282	8.8	0.95	0.80	8 1.0 \$25,128
BAL00	Baltazor		C	16	0/0		2.6	8,000	4.0	3	1.00	\$9,423	12.8	0.95	0.80	13 1.0 \$40,833
DOU00	Double - Black Rk Hot Springs		D	20	0/0		1.6	5,700	5.0	5	1.00	\$10,285	16	0.95	0.80	25 1.0 \$51,425
DOU00	Double - Black Rk Hot Springs		D	33	0/0		1.6	5,700	8.3	9	1.00	\$18,513	26.4	0.95	0.80	41 1.0 \$84,337

PRO ID	Field or Area	Area or Power Plant	Estimated Generation				(6) Expect	Confirmation ⁽⁷⁾			Development ⁽⁸⁾				Total Drilling (\$1000)		
			(2) Explor.- Devel. Cat.	(3) Upper = Min Wellhd MW	(4) Existing MW	(5) Est. MW /well		TD /well (#)	Plan (MW)	Plan (wells)	Cost- Fact.	Total Drilling (\$1000)	Plan (MW)	I/P /T	(P+I) /T	Plan (wells)	Cost- Fact.
MCG00	McGee Mountain	(Painted Hills)	C	19	0/0	3.4	5,700	4.8	2	1.00	\$4,114	15.2	0.95	0.80	10	1.0	\$20,570
MCG00	McGee Mountain	(Painted Hills)	C	28	0/0	3.4	5,700	7.0	3	1.00	\$6,171	22.4	0.95	0.80	18	1.0	\$37,026
PIN00	Pinto Hot Springs		D	18	0/0	3.8	5,700	4.5	2	1.00	\$4,114	14.4	0.95	0.80	10	1.0	\$20,570
PIN00	Pinto Hot Springs		D	29	0/0	3.8	5,700	7.3	3	1.00	\$6,171	23.2	0.95	0.80	15	1.0	\$30,855
SHO00	Shoshone-Reese River		D	13	0/0	3.4	5,700	3.3	2	1.00	\$4,114	10.4	0.95	0.80	8	1.0	\$16,456
SHO00	Shoshone-Reese River		D	18	0/0	3.4	5,700	4.5	2	1.00	\$4,114	14.4	0.95	0.80	10	1.0	\$20,570
WIL00	Wilson Hot Springs		D	10	0/0	3.4	4,950	2.5	1	1.00	\$1,748	8	0.95	0.80	5	1.0	\$8,740
WIL00	Wilson Hot Springs		D	17	0/0	3.4	4,950	4.3	2	1.00	\$3,496	13.6	0.95	0.80	10	1.0	\$17,480
<i>Area: 4 - All other CA</i>																	
BRW01	Brawley	Brawley (North Brawley)	B	88	0/20	6.7	6,650	2.0	1	0.00	\$0	70.4	1.00	0.80	28	1.0	\$69,468
BRW01	Brawley	Brawley (North Brawley)	B	135	0/20	6.7	6,650	13.8	3	1.00	\$7,443	108	1.00	0.80	40	1.0	\$99,240
BRW02	Brawley	East Brawley	B	85	0/0	6.9	13,650	21.3	5	1.00	\$33,300	68	0.85	0.80	24	1.0	\$159,840
BRW02	Brawley	East Brawley	B	129	0/0	6.9	13,650	32.3	8	1.00	\$53,280	103.2	0.85	0.80	35	1.0	\$233,100
BRW03	Brawley	South Brawley (Mesquite field)	B	45	0/0	6.5	14,000	11.3	3	1.00	\$20,754	36	0.85	0.80	14	1.0	\$96,852
BRW03	Brawley	South Brawley (Mesquite field)	B	62	0/0	6.5	14,000	15.5	4	1.00	\$27,672	49.6	0.85	0.80	19	1.0	\$131,442
CAL00	Calistoga		C	17	0/0	2.5	5,350	4.3	3	1.00	\$5,730	13.6	0.95	0.80	15	1.0	\$28,650
CAL00	Calistoga		C	25	0/0	2.5	5,350	6.3	4	1.00	\$7,640	20	0.95	0.80	20	1.0	\$38,200
COS00	Coso	Field-wide Summary A	246	280/0	7.5	9,000	0.0	0	0.00	\$0	-21.7	0.75	0.80	0	0.0	\$0	
COS00	Coso	Field-wide Summary A	355	280/0	7.5	9,000	18.8	4	2.30	\$33,810	74	0.40	0.95	15	2.4	\$132,300	
DUN00	Dunes		C	7.4	0/0	3.0	7,000	1.9	1	1.00	\$2,645	5.92	0.95	0.80	5	1.0	\$13,225
DUN00	Dunes		C	11	0/0	3.0	7,000	2.8	2	1.00	\$5,290	8.8	0.95	0.80	8	1.0	\$21,160

PROJ ID	Field or Area	Area or Power Plant	Explor.- Devel. Cat.	Estimated Generation			(6) Expect	Confirmation			Development						
				(2) Capacity(MW)	(3) Existing	(4) Est. MW /well		Plan (MW)	Plan (wells)	Cost-Fact.	Total Drilling (\$1000)	Plan (MW)	I/P /T	(P+I)	Plan (wells)	Cost-Fact.	Total Drilling (\$1000)
				Upper = Min	Wellhd MW	Lower = Mlk MW											
EAS00	East Mesa	Field-wide summary	A	119	62/0	2.7	7,500	14.3	9	1.40	\$36,389	48.7	1.25	0.92	45	1.4	\$181,944
EAS00	East Mesa	Field-wide summary	A	148	62/0	2.7	7,500	21.5	13	1.40	\$52,562	71.9	1.25	0.92	66	1.4	\$266,851
GEY00	Geysers	Field-wide Summary	A	1200	850/0	5.9	9,500	87.5	25	2.30	\$227,528	322.5	0.10	0.80	76	2.3	\$691,684
GEY00	Geysers	Field-wide Summary	A	1400	850/0	5.9	9,500	137.5	39	2.30	\$354,943	482.5	0.10	0.80	113	2.3	\$1,028,424
GLA00	Glamis		D	4.3	0/0	3.0	10,000	1.1	1	0.80	\$3,398	3.44	0.95	0.80	3	0.8	\$10,195
GLA00	Glamis		D	6.4	0/0	3.0	10,000	1.6	1	0.80	\$3,398	5.12	0.95	0.80	5	0.8	\$16,992
HEB00	Heber	Field-wide Summary	A	109	100/0	3.3	6,000	2.3	1	0.70	\$1,531	12.2	0.95	0.84	10	0.7	\$15,309
HEB00	Heber	Field-wide Summary	A	142	100/0	3.3	6,000	10.5	5	0.70	\$7,654	38.6	0.95	0.84	27	0.7	\$41,334
LAK00	Lake City / Surprise Valley	Lake City	B	23	0/2.5	3.2	6,000	3.3	2	1.00	\$4,374	18.4	0.95	0.80	15	1.0	\$32,805
LAK00	Lake City / Surprise Valley	Lake City	B	37	0/2.5	3.2	6,000	6.8	4	1.00	\$8,748	29.6	0.95	0.80	23	1.0	\$50,301
LVM00	Long Valley - M-P Leases	M-P Lease Summary	A	70	40/0	3.7	3,675	7.5	3	0.70	\$2,667	26	0.63	0.86	13	0.7	\$11,557
LVM00	Long Valley - M-P Leases	M-P Lease Summary	A	111	40/0	3.7	3,675	17.8	8	0.70	\$7,112	58.8	0.63	0.86	30	0.7	\$26,670
MED01	Medicine Lake	Fourmile Hill	B	25	0/0	5.1	7,500	6.3	2	1.00	\$5,776	20	0.50	0.80	8	1.0	\$23,104
MED01	Medicine Lake	Fourmile Hill	B	36	0/0	5.1	7,500	9.0	3	1.00	\$8,664	28.8	0.50	0.80	11	1.0	\$31,768
MED02	Medicine Lake	Telephone Flat	B	110	0/15	6.1	6,750	12.5	3	1.00	\$7,581	88	0.50	0.80	26	1.0	\$65,702
MED02	Medicine Lake	Telephone Flat	B	175	0/15	6.1	6,750	28.8	8	1.00	\$20,216	140	0.50	0.80	44	1.0	\$111,188
MOS00	Mount Signal		C	12	0/0	3.4	4,450	3.0	1	1.20	\$1,864	9.6	0.95	0.80	8	1.2	\$14,909
MOS00	Mount Signal		C	19	0/0	3.4	4,450	4.8	2	1.20	\$3,727	15.2	0.95	0.80	10	1.2	\$18,636
NIL00	Niland		B	59	0/0	7.3	12,000	14.8	3	0.80	\$13,217	47.2	0.85	0.80	14	0.8	\$61,678
NIL00	Niland		B	76	0/0	7.3	12,000	19.0	4	0.80	\$17,622	60.8	0.85	0.80	19	0.8	\$83,706
RAN00	Randsburg		C	32	0/0	3.4	4,550	8.0	4	1.00	\$6,364	25.6	0.95	0.80	20	1.0	\$31,820

PROJ ID	Field or Area	Area or Power Plant	Estimated Generation				(6) Expect	Confirmation			Development				Total Drilling (\$1000)		
			(2) Explor.- Devel. Cat.		(3) Existing Wellhd	(4) Est. MW		(5) TD /well (ft)	Plan (MW)	Plan (wells)	Cost-Fact.	Total Drilling (\$1000)	Plan (MW)	I/P /T	(P+I)		
			Upper = Min	Lower = Mlk	MW	/well		(ft)	(MW)	(wells)			(MW)				
RAN00	Randsburg		C	48	0/0	3.4	4,550	12.0	6	1.00	\$9,546	38.4	0.95	0.80	26	1.0	\$41,366
SAL00	Salton Sea	Field-wide summary	A	1350	350/0	8.0	10,250	250.0	52	0.40	\$91,458	817.5	0.84	0.90	209	0.4	\$367,589
SAL00	Salton Sea	Field-wide summary	A	1750	350/0	8.0	10,250	350.0	73	0.40	\$128,392	1138	0.84	0.90	290	0.4	\$510,052
SES00	Sespe Hot Springs		D	3.6	0/0	1.8	5,700	0.9	1	1.00	\$2,057	2.88	0.95	0.80	5	1.0	\$10,285
SES00	Sespe Hot Springs		D	5.3	0/0	1.8	5,700	1.3	1	1.00	\$2,057	4.24	0.95	0.80	5	1.0	\$10,285
SUL00	Sulphur Bank	Clear Lake	B	27	0/0	5.0	5,163	6.8	2	1.00	\$3,666	21.6	0.75	0.80	9	1.0	\$16,497
SUL00	Sulphur Bank	Clear Lake	B	43	0/0	5.0	5,163	10.8	4	1.00	\$7,332	34.4	0.75	0.80	15	1.0	\$27,495
SUP00	Superstition Mountain		D	5.9	0/0	3.4	5,700	1.5	1	1.00	\$2,057	4.72	0.95	0.80	3	1.0	\$6,171
SUP00	Superstition Mountain		D	9.5	0/0	3.4	5,700	2.4	1	2.00	\$4,114	7.6	0.95	0.80	5	1.0	\$10,285

1. Methods of cost estimation are described in Appendices IV, V and VI. Background information concerning the data in this table is listed at the database command buttons for Confirmation and Development Costs, summarized in the project-specific reports entitled "Exploration - Confirmation - Development Programs and Costs" (of which Appendix V is an example), as well as in Tables 8, 9 and 10.

2. Exploration-Development Category:

A = existing power plant operating

B = one or more wells tested at ≥ 1 MW

C = a temperature $\geq 212^{\circ}\text{F}$ has been logged downhole (or boiling temperature for local elevation)

D = other exploration data (such as spring chemistry and/or shallow temperature gradient measurements)

3. Min = Minimum = estimated generation capacity with Monte Carlo simulation cumulative probability of more than 90% (MW for 30 years)

Min = Most-likely = Monte Carlo simulation modal generation capacity (MW for 30 years)

4. The number to the left is actual gross generation (Exploration-Development Category A, most recent year available (assumed sustainable for 30 years)). The number to the right is MW proven at the wellhead but not in use at a power plant.

5. Estimated MW per production well. This is the initial, nominal estimate based on resource temperature; drilling cost factors not equal to 1 may compensate if there is information that suggests a different value. See the comments to confirmation and development costs for each project in Tables 9 and 10.

6. Expected total depth of each well. This is the initial, nominal estimate based on average depth of the resource; drilling cost factors not equal to 1 may compensate if there is information that suggests a different value. See the comments to confirmation and development costs for each project in Tables 9 and 10.

7. Confirmation drilling plan:

Plan (MW) = wellhead MW to confirm

Plan (wells) = total number of wells to plan to drill if success rate is 60%. (The initial, nominal estimate; a drilling cost factor not equal to 1 may compensate if there is information that suggests a different value. See the comments to confirmation costs for each project in Table 9.)

Cost Factor = drilling cost factor

Total Drilling (\$1000) = estimated total drilling expense. For projects in the Imperial Valley, California, Total Drilling Cost does NOT include corrosion-resistant titanium casing, which is estimated as a separate part of total confirmation cost.

8. Development drilling plan:

Plan (MW) = wellhead MW to develop for 105% of capacity.

I/P = expected ratio of injectors to producers that will be needed.

(P+I)/T = expected overall drilling success rate = sum of producers plus injectors divided by total number of wells drilled.

Plan (wells) = total number of wells to plan to drill, given I/P and (P+I)/T. (The initial, nominal estimate; a drilling cost factor not equal to 1 may compensate if there is information that suggests a different value. See the comments to development costs for each project in Table 10.)

Cost Factor = drilling cost factor

Total Drilling (\$1000) = estimated total drilling expense. (For projects in the Imperial Valley, California, Total Drilling Cost does NOT include corrosion-resistant titanium casing, which is estimated as a separate part of total development cost.)

Hetch Hetchy/SFPUC Programmatic Renewable Energy Project
Project: 1.3 New Geothermal Site Identification and Qualification
Project Team: GeothermEx, Inc.
Task: 1.3.10 Final Project Report
Subject: D.1.3.10.3 Final Report

Table 12. Exploration, Confirmation and Site Development Cost Estimates - per kW

PROJ ID	Field or Area	Area or Power Plant	Explor.-Devel. Cat.	Min Estimated Development (Gross MW) ⁽¹⁾						Cost/kW ⁽²⁾				Max Estimated Development (Gross MW) ⁽¹⁾						Cost/kW ⁽²⁾			
				Wells	Plant New	Explore	Confirm	Expl + Conf.	E+C+	Site Dev.	Wells	Plant New	Explore	Confirm	Expl + Conf.	E+C+	Site Dev.	Wells	Plant New	Explore	Confirm	Expl + Conf.	E+C+
Area: 1 - Greater Reno (NV and CA)																							
BEO00	Beowawe		A	15	13.3	15		\$329	\$329	\$3,532	26	24.3	26		\$372	\$372	\$3,627						
BLU00	Blue Mountain		C	16	16	16	\$3	\$194	\$197	\$2,471	30	30	30	\$2	\$204	\$205	\$2,448						
BRA00	Brady's Hot Springs		A	0	0	0					3	0	3		\$976	\$976	\$3,387						
COL00	Colado		C	3.7	3.7	3.7	\$250	\$564	\$814	\$4,489	6.2	6.2	6.2	\$149	\$336	\$485	\$4,063						
DES00	Desert Peak		A	23	22	23		\$211	\$211	\$2,589	35	34	35		\$207	\$207	\$2,566						
EMP00	Empire (San Emidio)	Field-wide summary	A	0	0	0					1.8	1.8	1.8		\$885	\$885	\$4,372						
FAL00	Fallon / Carson Lake	Carson Lake anomaly	C	34	34	34	\$1	\$347	\$349	\$3,142	55	55	55	\$1	\$322	\$323	\$2,978						
FLY00	Fly Ranch/Granite Ranch	Ward's (Fly/Hualapi Flat) H.S.	C	6	6	6		\$2,664	\$2,664	\$12,636	8.7	8.7	8.7		\$2,297	\$2,297	\$11,849						
FLY01	Fly Ranch/Granite Ranch	Granite Ranch	C	5.4	5.4	5.4	\$111	\$484	\$596	\$3,238	8.1	8.1	8.1	\$74	\$323	\$397	\$3,167						
GER00	Gerlach	(Great Boiling Spring)	C	17	17	17	\$2	\$426	\$429	\$3,686	25	25	25	\$1	\$434	\$436	\$3,729						
HAZ00	Hazen (Black Butte)	(Patua Hot Springs)	C	6.3	6.3	6.3	\$159	\$478	\$637	\$4,034	8.5	8.5	8.5	\$118	\$354	\$472	\$3,378						
HON00	Honey Lake	Area-wide Summary	A	4.5	0	4.5		\$381	\$381	\$2,685	7.1	1.9	7.1		\$458	\$458	\$2,684						
KYL00	Kyle Hot Springs (Granite Mtn.)	(Buena Vista Valley)	C	16	16	16	\$51	\$453	\$505	\$3,499	22	22	22	\$37	\$330	\$367	\$3,225						
LEA00	Leach Hot Springs	Grass Valley	C	13	13	13	\$31	\$949	\$980	\$6,407	18	18	18	\$22	\$913	\$935	\$6,218						
LEE00	Lee Hot Springs		C	5.4	5.4	5.4	\$175	\$484	\$659	\$4,064	9.4	9.4	9.4	\$101	\$278	\$379	\$3,629						
NEW00	New York Canyon		C	20	20	20	\$59	\$252	\$312	\$3,149	26	26	26	\$46	\$291	\$336	\$3,023						
NOR00	North Valley		C	37	37	37	\$8	\$288	\$296	\$2,882	49	49	49	\$6	\$261	\$267	\$2,802						
PUM00	Pumpernickel Valley	Tipton Ranch/Hot Springs Ranch	C	9.1	10	10	\$14	\$277	\$291	\$3,541	12.1	13	13	\$11	\$412	\$423	\$3,605						
PYR00	Pyramid Lake Indian Reserv.	(Needle Rocks Hot Springs)	C	9.9	9.9	9.9	\$14	\$334	\$349	\$3,184	14	14	14	\$10	\$460	\$470	\$3,481						

PROJ ID	Field or Area	Area or Power Plant	Explor.-Devel. Cat.	Min Estimated Development (Gross MW) ⁽¹⁾							Mlk Estimated Development (Gross MW) ⁽¹⁾							
				Wells	Plant	New	Explore	Cost/kW ⁽²⁾	Confirm	Expl + Conf.	E+C+ Site Dev.	Wells	Plant	New	Explore	Cost/kW ⁽²⁾	Confirm	Expl + Conf.
RYE01	Rye Patch-Humboldt House District	Rye Patch	B	6	3.5	6		\$	\$	\$4,319	10	7.5	10		\$	\$	\$	\$3,755
RYE02	Rye Patch-Humboldt House District	Humboldt House	C	27	27	27		\$280	\$280	\$2,923	34	34	34		\$296	\$296	\$296	\$3,006
SAW00	Salt Wells	Eight Mile Flat	C	63	63	63	\$16	\$238	\$254	\$2,537	96	96	96	\$10	\$233	\$243	\$243	\$2,558
SOD00	Soda Lake	Soda Lake No.1/No.2	A	13.3	2.9	13.3	\$5	\$166	\$170	\$1,884	26.3	15.9	26.3	\$2	\$287	\$290	\$290	\$2,521
STE00	Steamboat Hot Sprs	Field-wide Summary	A	3	0	3		\$	\$	\$487	9	2.16	9		\$116	\$116	\$116	\$964
STI00	Stillwater	Stillwater Geothermal 1	A	0	0	0					0	0	0					
STI01	Stillwater	Stillwater N Expansion	B	11	16	16		\$	\$	\$1,475	19	24	24		\$49	\$49	\$49	\$1,705
TRI00	Trinity Mountains District	Telephone Well area	D	42	42	42	\$23	\$292	\$314	\$3,014	66	66	66	\$14	\$296	\$310	\$310	\$3,001
WAB00	Wabuska		A	6.7	6.65	6.7	\$18	\$582	\$600	\$5,843	11.6	11.55	11.6	\$11	\$503	\$514	\$514	\$5,802
				<i>Area Totals :</i>				413	396	419				637	612	643		
				<i>Area Averages (weighted) :</i>					\$21	\$339	\$360	\$3,214			\$14	\$332	\$345	\$3,157
<i>Area: 2 - NV with direct access to CA</i>																		
AUR00	Aurora		C	31	31	31	\$28	\$342	\$370	\$3,140	51	51	51	\$17	\$312	\$329	\$3,073	
DIX00	Dixie Valley	Caithness Dixie Valley	A	5	5	5		\$972	\$972	\$3,897	41	41	41		\$176	\$176	\$176	\$3,008
DIX01	Dixie Valley	Dixie Valley Power Partners (DVPP)	C	107	107	107	\$1	\$380	\$381	\$3,191	151	151	151	\$	\$370	\$371	\$371	\$3,165
EMI00	Emigrant (Fish Lake V.)		C	49	49	49	\$1	\$441	\$442	\$3,710	85	85	85	\$1	\$464	\$464	\$464	\$3,757
FIS00	Fish Lake (Valley)		B	22.6	30	30	\$2	\$162	\$164	\$3,643	39.6	47	47	\$2	\$203	\$205	\$205	\$3,809
HAW00	Hawthorne		C	8.7	8.7	8.7	\$4	\$676	\$681	\$4,398	14	14	14	\$3	\$629	\$632	\$632	\$4,371
HYD00	Hyder Hot Springs		D	5.5	5.5	5.5	\$153	\$1,318	\$1,471	\$7,318	9.6	9.6	9.6	\$88	\$1,131	\$1,219	\$1,219	\$6,765
PIR00	Pirouette Mountain	(S.Dixie Valley)	D	16	16	16	\$74	\$316	\$389	\$3,175	23	23	23	\$51	\$329	\$380	\$380	\$3,043
SIL00	Silver Peak	(Alum prospect)	C	41	41	41	\$1	\$305	\$306	\$3,060	78	78	78	\$	\$319	\$319	\$319	\$2,980
SOH00	Sou Hot Springs	(Seven Devils/Gilbert's H.S.)	D	3.3	3.3	3.3	\$279	\$792	\$1,072	\$4,442	6.1	6.1	6.1	\$151	\$429	\$580	\$580	\$3,766
				<i>Area Totals :</i>				289	297	297				498	506	506		
				<i>Area Averages (weighted) :</i>					\$14	\$391	\$405	\$3,436			\$8	\$361	\$369	\$3,377

PROJ ID	Field or Area	Area or Power Plant	Explor.-Devel. Cat.	Min Estimated Development (Gross MW) ⁽¹⁾						Mlk Estimated Development (Gross MW) ⁽¹⁾								
				Wells	Plant	New	Explore	Confirm	Expl + Conf.	E+C+ Site Dev.	Wells	Plant	New	Explore	Confirm	Expl + Conf.		
Area: 3 - Other NV																		
BAL00	Baltazar		C	11	11	11		\$692	\$692	\$4,476	16	16	16	\$713	\$713	\$4,765		
DOU00	Double - Black Rk Hot Springs		D	20	20	20	\$220	\$625	\$844	\$4,916	33	33	33	\$133	\$678	\$811	\$4,867	
MCG00	McGee Mountain	(Painted Hills)	C	19	19	19	\$50	\$266	\$315	\$2,898	28	28	28	\$34	\$270	\$304	\$3,126	
PIN00	Pinto Hot Springs		D	18	18	18	\$57	\$280	\$337	\$2,980	29	29	29	\$35	\$261	\$296	\$2,860	
SHO00	Shoshone-Reese River		D	13	13	13	\$67	\$388	\$455	\$3,221	18	18	18	\$49	\$280	\$329	\$2,972	
WIL00	Wilson Hot Springs		D	10	10	10	\$74	\$225	\$299	\$2,673	17	17	17	\$44	\$254	\$298	\$2,826	
				Area Totals :			91	91	91			141	141	141				
				Area Averages (weighted) :				\$88	\$412	\$500	\$3,570				\$57	\$413	\$470	\$3,609
Area: 4 - All other CA																		
BRW01	Brawley	Brawley (North Brawley)	B	68	88	88		\$	\$	\$2,602	115	135	135	\$107	\$107	\$2,638		
BRW02	Brawley	East Brawley	B	85	85	85	\$1	\$562	\$563	\$4,238	129	129	129	\$1	\$596	\$597	\$4,195	
BRW03	Brawley	South Brawley (Mesquite field)	B	45	45	45	\$2	\$671	\$673	\$4,658	62	62	62	\$1	\$662	\$663	\$4,606	
CAL00	Calistoga		C	17	17	17		\$414	\$414	\$3,599	25	25	25		\$375	\$375	\$3,403	
COS00	Coso	Field-wide Summary	A	0	0	0					75	55	75		\$541	\$541	\$3,405	
DUN00	Dunes		C	7.4	7.4	7.4	\$113	\$447	\$560	\$3,847	11	11	11	\$76	\$585	\$661	\$4,085	
EAS00	East Mesa	Field-wide summary	A	57	45.8	57		\$766	\$766	\$5,163	86	74.8	86		\$734	\$734	\$5,141	
GEY00	Geysers	Field-wide Summary	A	350	200	350		\$770	\$770	\$3,604	550	400	550		\$765	\$765	\$3,725	
GLA00	Glamis		D	4.3	4.3	4.3	\$211	\$977	\$1,188	\$5,059	6.4	6.4	6.4	\$142	\$656	\$798	\$4,953	
HEB00	Heber	Field-wide Summary	A	9	9	9		\$219	\$219	\$3,420	42	42	42		\$222	\$222	\$2,706	
LAK00	Lake City / Surprise Valley	Lake City	B	20.5	23	23		\$233	\$233	\$3,159	34.5	37	37		\$287	\$287	\$3,146	
LVM00	Long Valley - M-P Leases	M-P Lease Summary	A	30	30	30	\$82	\$112	\$195	\$580	71	71	71	\$35	\$124	\$159	\$2,034	
MED01	Medicine Lake	Fourmile Hill	B	25	25	25		\$281	\$281	\$2,705	36	36	36		\$292	\$292	\$2,674	
MED02	Medicine Lake	Telephone Flat	B	95	110	110		\$84	\$84	\$2,181	160	175	175		\$139	\$139	\$2,275	
MOS00	Mount Signal		C	12	12	12	\$37	\$199	\$236	\$2,978	19	19	19	\$23	\$242	\$265	\$2,746	
NIL00	Niland		B	59	59	59		\$360	\$360	\$3,160	76	76	76		\$385	\$385	\$3,249	

PROJ ID	Field or Area	Area or Power Plant	Explor.-Devel. Cat.	Min Estimated Development (Gross MW) ⁽¹⁾						Cost/kW ⁽²⁾				Mlk Estimated Development (Gross MW) ⁽¹⁾						Cost/kW ⁽²⁾			
				Wells	Plant	New	Explore	Confirm	Expl + Conf.	E+C+ Site Dev.	Wells	Plant	New	Explore	Confirm	Expl + Conf.	E+C+ Site Dev.						
RAN00	Randsburg		C	32	32	32	\$14	\$243	\$257	\$2,752	48	48	48	\$9	\$244	\$253	\$253	\$2,615					
SAL00	Salton Sea	Field-wide summary	A	1000	1000	1000		\$136	\$136	\$2,261	1400	1400	1400		\$130	\$130	\$130	\$2,250					
SES00	Sespe Hot Springs		D	3.6	3.6	3.6	\$263	\$726	\$989	\$5,346	5.3	5.3	5.3	\$178	\$493	\$672	\$672	\$4,112					
SUL00	Sulphur Bank	Clear Lake	B	27	27	27		\$167	\$167	\$2,278	43	43	43		\$208	\$208	\$208	\$2,347					
SUP00	Superstition Mountain		D	5.9	5.9	5.9	\$144	\$443	\$587	\$3,133	9.5	9.5	9.5	\$89	\$539	\$629	\$629	\$3,211					
<i>Area Totals :</i>				1953	1829	1990					3004	2860	3041										
<i>Area Averages (weighted) :</i>								\$4	\$306	\$310	\$2,796									\$2	\$324	\$326	\$2,857
<i>Grand Totals :</i>				2746	2613	2797					4280	4119	4331										
<i>Grand Averages (weighted) :</i>								\$10	\$324	\$334	\$2,952									\$6	\$332	\$339	\$2,987

Notes:

(1) Gross MW of new wellhead production capacity and of new plant capacity needed to bring total electricity generation to the Minimum (Min) or Most-likely (Modal or Mlk) estimated generation capacity of the resource. The well and plant figures differ if there is existing unused (but proven) wellhead production capacity, or existing under-utilized plant capacity. A value of 0 indicates that the existing wellfield production capacity or plant capacity is very close to or exceeds the corresponding generation capacity estimate, so that no confirmation or development is planned and costed. These cases are explained in the notes to individual projects found in Tables 9 and 10. "New" is the larger of wellhead MW or plant MW and represents the total increment of electricity production (gross MW) to be expected. Development costs are actually calculated on the basis of drilling and proving 105% of needed gross MW, so that a reserve capacity is available.

(2) Costs/kW are calculated with respect to new gross MW.

Site Development does not include estimated transmission line costs.

Hetch Hetchy/SFPUC Programmatic Renewable Energy Project
Project: 1.3 New Geothermal Site Identification and Qualification
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Task: 1.3.10 Final Project Report
Subject: D.1.3.10.3 Final Report

Table 13. Transmission Line Cost Estimates

PROJID	Cost	Cost	Total	Comment
		Factor	Cost	
<i>Area: 1 - Greater Reno (NV and CA)</i>				
BEO00	\$0	0.0	\$0	It is assumed that existing transmission can handle expansion.
BLU00	\$14,510,000	1.0	\$14,510,000	Estimate based on data in Woo03a, for the Blue Mtn MW fraction of a collection system that connects to the PDCI (Woo03a Stage 4 project; see Appendix VI).
BRA00	\$0	0.0	\$0	Existing transmission to handle upgrade
COL00	\$3,650,000	1.0	\$3,650,000	Estimate based on data in Woo03a, for the Colado MW fraction of a collection system that connects to the PDCI (Woo03a Stage 4 project; see Appendix VI).
DES00	\$0	0.0	\$0	Existing transmission capacity is assumed capable of handling the expansion.
EMP00	\$0	0.0	\$0	It is assumed that the existing transmission line can handle the expansion.
FAL00	\$12,410,000	1.0	\$12,410,000	Estimate based on data in Woo03a for the Fallon/Carson MW fraction of a collection system from Lee H.S. to a 345 kV connection at Tracy (Woo03a Stage 3 project; see Appendix VI).
FLY00	\$7,320,000	0.5	\$3,660,000	Estimate based on data in Woo03a for a line from Fly Ranch to Gerlach, plus a MW proportion of combined transmission from there to PDCI (see Appendix VI). Cost Factor = 0.5 represents assuming that one half of the Fly Ranch transmission cost is assigned to this project, and one-half to FLY00.
FLY01	\$7,320,000	0.5	\$3,660,000	Estimate based on data in Woo03a for a line from Fly Ranch to Gerlach, plus a MW proportion of combined transmission from there to PDCI (see Appendix VI). Cost Factor = 0.5 represents assuming that one half of the Fly Ranch transmission cost is assigned to this project, and one-half to FLY00.
GER00	\$7,280,000	1.0	\$7,280,000	Estimate based on data in Woo03a for transmission from Gerlach to the PDCI, adjusted for carrying power also from Fly Ranch (see Appendix VI).
HAZ00	\$5,730,000	1.0	\$5,730,000	Estimate based on data in Woo03a, for transmission from Hazen to existing grid at Eagle (see Appendix VI).

PROJID	Cost	Cost Factor	Total Cost	Comment
HON00	\$0	0.0	\$0	It is assumed that existing transmission capacity can handle the expansion.
KYL00	\$10,630,000	1.0	\$10,630,000	Estimate based on data in Woo03a, for the Kyle H.S. MW fraction of a collection system that connects to the PDCI (Woo03a Stage 4 project; see Appendix VI).
LEA00	\$9,160,000	1.0	\$9,160,000	Estimate based on data in Woo03a, for the Leach H.S. MW fraction of a collection system that connects to the PDCI (Woo03a Stage 4 project; see Appendix VI).
LEE00	\$5,960,000	1.0	\$5,960,000	Estimate based on data in Woo03a for a line from Lee H.S. to Salt Wells (project SAW00), plus the Lee H.S. MW fraction of a collection system from Salt Wells to 345 kV connection at Tracy (Woo03a Stage 3 project; see Appendix VI).
NEW00	\$12,800,000	1.0	\$12,800,000	Estimate based on data in Woo03a, for the New York Canyon MW fraction of a collection system that connects to the PDCI (Woo03a Stage 4 project; see Appendix VI).
NOR00	\$7,020,000	1.0	\$7,020,000	Estimate based on data in Woo03a for the North Valley MW fraction of a collection system to a 345 kV connection at Tracy (Woo03a Stage 3 project; see Appendix VI).
PUM00	\$8,500,000	1.0	\$8,500,000	Estimate based on data in Woo03a, for the Pumpernickel Valley MW fraction of a collection system that connects to the PDCI (Woo03a Stage 4 project; see Appendix VI).
PYR00	\$268,000	21.0	\$5,628,000	Cost Factor = c.21 miles NE to connect to a new 345 kV line between Honey Lake and the PDCI tap SW of Gerlach, that is part of the new developments in Woo03a
RYE01	\$9,200,000	1.0	\$9,200,000	Estimate based on data in Woo03a, for the RYE01 MW fraction of a collection system that connects to the PDCI (Woo03a Stage 4 project; see Appendix VI).
RYE02	\$16,940,000	1.0	\$16,940,000	Estimate based on data in Woo03a, for the RYE02 MW fraction of a collection system that connects to the PDCI (Woo03a Stage 4 project; see Appendix VI).
SAW00	\$31,640,000	1.0	\$31,640,000	Estimate based on data in Woo03a for the Salt Wells MW fraction of a collection system from Lee H.S. through Salt Wells and other projects to a 345 kV connection at Tracy (Woo03a Stage 3 project; see Appendix VI).
SOD00	\$0	0.0	\$0	It is assumed that existing transmission capacity can handle the expansion.
STE00	\$0	0.0	\$0	It is assumed that existing transmission capacity can handle the expansion.
STI00	\$0	0.0	\$0	

PROJID	Cost	Cost Factor	Total Cost	Comment
STI01	\$0	0.0	\$0	It is assumed that existing transmission capacity can handle the expansion
TRI00	\$11,460,000	1.0	\$11,460,000	Estimate based on data in Woo03a, for the Trinity MW fraction of a collection system that connects to the PDCI (Woo03a Stage 4 project; see Appendix VI).
WAB00	\$0	0.0	\$0	It is assumed that existing transmission capacity can handle the expansion.
<i>Area: 2 - NV with direct access to CA</i>				
AUR00	\$268,000	2.0	\$536,000	Cost Factor = about 2 miles to an existing 55-69 kV transmission line.
DIX00	\$0	0.0	\$0	Existing transmission capacity is assumed capable of handling an expansion.
DIX01	\$268,000	1.0	\$268,000	Cost Factor = 1 mile distance (approximate) to existing Dixie Valley 230 kV line.
EMI00	\$268,000	16.0	\$4,288,000	Cost Factor = c.17 miles SW to an existing transmission line terminus at N. Dyer, or c.15 miles E to an existing transmission line N of Silver Peak (both lines 55 kV). Transmission line costs would be greatly lowered by combining this project with development of the near-by Fish Lake project (FIS00).
FIS00	\$268,000	13.0	\$3,484,000	Cost Factor = c.13 miles S to an an existing 55 kV terminus at N. Dyer. Transmission costs could be greatly reduced by simultaneous development of the near-by Emigrant anomaly (EMI00)
HAW00	\$268,000	1.0	\$268,000	Cost Factor = assumed distance of 1 mile to existing transmission capacity that passes through
HYD00	\$286,000	6.0	\$1,716,000	Cost Factor = c.6 miles to tie-in at the Dixie Valley development (DIX00)
PIR00	\$0	0.0	\$0	Assumed to be negligible (site is along the Dixie Valley transmission line)
SIL00	\$268,500	2.5	\$671,250	Cost Factor = 2.5 miles E to an existing 55 kV transmission line
SOH00	\$268,500	10.0	\$2,685,000	Cost Factor = c.10 miles to connect to transmission at the existing Dixie Valley project
<i>Area: 3 - Other NV</i>				
BAL00	\$268,000	26.0	\$6,968,000	Cost Factor = c.26 miles to Quinn River termination of existing 120 kV line. Another possibility is connection at Fields, Oregon (similar distance). Simultaneous development of and cost-sharing with near-by McGee Mtn. (MCG00) would reduce the cost by about 1/2.
DOU00	\$268,000	16.0	\$4,288,000	Cost Factor = c.15 miles from the middle of the anomaly to existing 60 kV transmission to the S
MCG00	\$268,000	28.0	\$7,504,000	Cost Factor = c.12 miles from McGee Mtn to Baltazar HS (BAL00) plus c.26 miles from there to the Quinn River termination of an existing 120 kV line. Another possibility from Baltazar is connection at Fields, Oregon (similar distance). Simultaneous development of and cost-sharing with Baltazar would

PROJID	Cost	Cost Factor	Total Cost	Comment
				reduce the overall McGee cost by about 1/2. Without development of Baltazor, a line from McGee might go a shorter distance directly E to Quinn River, but over high mountains at higher cost/mile.
PIN00	\$268,500	25.0	\$6,712,500	Cost Factor = c.25 miles NE to the terminus of an existing 120 kV line at Quinn River.
SHO00	\$268,500	15.0	\$4,027,500	Cost Factor = c.15 miles N to an existing 55-69 kV transmission terminus at Antelope Valley. A 230 kV line is about 25 miles to the S.
WIL00	\$268,500	17.0	\$4,564,500	Cost Factor = c.17 miles N to existing 55 kV transmission capacity near Yerington
<i>Area: 4 - All other CA</i>				
BRW01	\$20,900,000	1.0	\$20,900,000	The MW fraction of total cost to connect to the PDCI from SAL00 (Woo03a), plus a 16 mile transmission from BRW01 to SAL00. See Appendix VI.
BRW02	\$21,900,000	1.0	\$21,900,000	The MW fraction of total cost to connect to the PDCI from SAL00 (Woo03a), plus a 16 mile transmission from BRW01 to SAL00. See Appendix VI.
BRW03	\$12,900,000	1.0	\$12,900,000	The MW fraction of total cost to connect to the PDCI from SAL00 (Woo03a), plus a 16 mile transmission from BRW01 to SAL00. See Appendix VI.
CAL00	\$268,000	1.0	\$268,000	Assume that existing transmission is within one mile.
COS00	\$0	0.0	\$0	Existing transmission capacity is assumed capable of handling expansion.
DUN00	\$180,000	14.0	\$2,520,000	Cost Factor = c.14 miles W to connection at East Mesa (EAS00)
EAS00	\$0	0.0	\$0	It is assumed that existing transmission can handle any project expansion.
GEY00	\$0	0.0	\$0	It is assumed that existing transmission lines can handle capacity expansion
GLA00	\$180,000	18.0	\$3,240,000	Cost Factor = c.18 miles to existing transmission at East Mesa (EAS00)
HEB00	\$0	0.0	\$0	It is assumed that existing transmission capacity can handle the expansion.
LAK00	\$268,000	25.0	\$6,700,000	Cost Factor = assumed 25 mile line to the vicinity of Alturas (very uncertain)
LVM00	\$0	0.0	\$0	It is assumed that existing transmission lines can handle the expansion.
MED01	\$268,000	22.0	\$5,896,000	Cost Factor = c. 22 miles ENE to existing BPA Malin-Warner transmission line. Cost would be shared by additional or eventual development of the Telephone Flat project (MED02)

PROJID	Cost	Cost Factor	Total Cost	Comment
MED02	\$268,000	22.0	\$5,896,000	Cost Factor = c. 22 miles ENE to existing BPA Malin-Warner transmission line. Cost would be shared by additional or eventual development of the Fourmile Hill project (MED01)
MOS00	\$180,000	5.0	\$900,000	Cost Factor = c.5 miles N to an existing 500 kV(?) transmission line
NIL00	\$10,900,000	1.0	\$10,900,000	The MW fraction of total cost to connect to the PDCI from SAL00 (Woo03a), plus a 16 mile transmission from BRW01 to SAL00. See Appendix VI.
RAN00	\$268,000	20.0	\$5,360,000	Cost Factor = c.20 miles W to existing transmission corridor
SAL00	\$184,500,000	1.0	\$184,500,00	The MW fraction of total cost to connect new Imperial Valley development to the PDCI (Woo03a). See Appendix VI.
SES00	\$268,500	15.0	\$4,027,500	Cost Factor = assumed 15 mile distance to an existing transmission corridor (very uncertain)
SUL00	\$268,500	2.0	\$537,000	Cost Factor = approximate distance to an existing transmission line
SUP00	\$268,500	6.0	\$1,611,000	Cost Factor = c.6 miles NE to an existing transmission line.

Hetch Hetchy/SFPUC Programmatic Renewable Energy Project
 Project: 1.3 New Geothermal Site Identification and Qualification
 Project Team: GeothermEx, Inc.
 Task: 1.3.10 Final Project Report
 Subject: D.1.3.10.3 Final Report

Table 14. Site Development, Transmission Line and Total Cost Estimates - Totals and per kW

PROJ ID	Field or Area	Area or Power Plant	Explor.- Devel. Cat.	Min Estimated Development (Gross MW) (1)				Cost (thousands) (2)				Mkt Estimated Development (Gross MW) (1)				Cost (thousands) (2)			
				Wells	Plant	New	Site Dev.	Tran.Ln.	E+C+SD+TL Tot.	\$/kW	Wells	Plant	New	Site Dev.	Tran.Ln.	E+C+SD+TL Tot.	\$/kW		
Area: 1 - Greater Reno (NV and CA)																			
BEO00	Beowawe		A	15	13.3	15	\$48,048	\$	\$52,978	\$3,532	26	24.3	26	\$84,618	\$	\$94,293	\$3,627		
BLU00	Blue Mountain		C	16	16	16	\$36,376	\$14,510	\$54,044	\$3,378	30	30	30	\$67,277	\$14,510	\$87,947	\$2,932		
BRA00	Brady's Hot Springs		A	0	0	0	\$	\$	\$	\$	3	0	3	\$7,233	\$	\$10,160	\$3,387		
COL00	Colado		C	3.7	3.7	3.7	\$13,600	\$3,650	\$20,260	\$5,476	6.2	6.2	6.2	\$22,180	\$3,650	\$28,840	\$4,652		
DES00	Desert Peak		A	23	22	23	\$54,703	\$	\$59,551	\$2,589	35	34	35	\$82,568	\$	\$89,825	\$2,566		
EMP00	Empire (San Emidio)	Field-wide summary	A	0	0	0	\$	\$	\$	\$	1.8	1.8	1.8	\$6,276	\$	\$7,869	\$4,372		
FAL00	Fallon / Carson Lake	Carson Lake anomaly	C	34	34	34	\$94,956	\$12,410	\$119,222	\$3,507	55	55	55	145,992	\$12,410	\$176,185	\$3,203		
FLY00	Fly Ranch/Granite Ranch	Ward's (Fly/Hualapi Flat) H.S.	C	6	6	6	\$59,832	\$3,660	\$79,473	\$13,246	8.7	8.7	8.7	\$83,100	\$3,660	\$106,746	\$12,270		
FLY01	Fly Ranch/Granite Ranch	Granite Ranch	C	5.4	5.4	5.4	\$14,271	\$3,660	\$21,147	\$3,916	8.1	8.1	8.1	\$22,435	\$3,660	\$29,311	\$3,619		
GER00	Gerlach	(Great Boiling Spring)	C	17	17	17	\$55,380	\$7,280	\$69,946	\$4,114	25	25	25	\$82,320	\$7,280	\$100,494	\$4,020		
HAZ00	Hazen (Black Butte)	(Patua Hot Springs)	C	6.3	6.3	6.3	\$21,402	\$5,730	\$31,145	\$4,944	8.5	8.5	8.5	\$24,702	\$5,730	\$34,445	\$4,052		
HON00	Honey Lake	Area-wide Summary	A	4.5	0	4.5	\$10,368	\$	\$12,084	\$2,685	7.1	1.9	7.1	\$15,810	\$	\$19,059	\$2,684		
KYL00	Kyle Hot Springs (Granite Mtn.)	(Buena Vista Valley)	C	16	16	16	\$47,904	\$10,630	\$66,606	\$4,163	22	22	22	\$62,880	\$10,630	\$81,582	\$3,708		
LEA00	Leach Hot Springs	Grass Valley	C	13	13	13	\$70,560	\$9,160	\$92,456	\$7,112	18	18	18	\$95,080	\$9,160	\$121,077	\$6,727		
LEE00	Lee Hot Springs		C	5.4	5.4	5.4	\$18,385	\$5,960	\$27,905	\$5,168	9.4	9.4	9.4	\$30,556	\$5,960	\$40,076	\$4,263		
NEW00	New York Canyon		C	20	20	20	\$56,741	\$12,800	\$75,774	\$3,789	26	26	26	\$69,855	\$12,800	\$91,396	\$3,515		
NOR00	North Valley		C	37	37	37	\$95,704	\$7,020	\$113,671	\$3,072	49	49	49	124,192	\$7,020	\$144,301	\$2,945		
PUM00	Pumpernickel Valley	Tipton Ranch/Hot Springs Ranch	C	9.1	10	10	\$32,496	\$8,500	\$43,905	\$4,391	12.1	13	13	\$41,370	\$8,500	\$55,367	\$4,259		
PYR00	Pyramid Lake Indian Reserv.	(Needle Rocks Hot Springs)	C	9.9	9.9	9.9	\$28,075	\$5,628	\$37,154	\$3,753	14	14	14	\$42,160	\$5,628	\$54,366	\$3,883		

PROJ ID	Field or Area	Area or Power Plant	Explor.-Devel. Cat.	Min Estimated Development (Gross MW) (1)								Mid Estimated Development (Gross MW) (1)							
				Wells	Plant	New	Cost (thousands) (2)				Site Dev.	E+C+SD+TL	Wells	Plant	New	Cost (thousands) (2)			
									Tran.Ln.	Tot.	\$/kW						Tran.Ln.	Tot.	\$/kW
RYE01	Rye Patch-Humboldt House District	Rye Patch	B	6	3.5	6	\$25,911	\$9,200	\$35,111	\$5,852	10	7.5	10	\$37,554	\$9,200	\$46,754	\$4,675		
RYE02	Rye Patch-Humboldt House District	Humboldt House	C	27	27	27	\$71,355	\$16,940	\$95,851	\$3,550	34	34	34	\$92,140	\$16,940	\$119,142	\$3,504		
SAW00	Salt Wells	Eight Mile Flat	C	63	63	63	\$143,868	\$31,640	\$191,492	\$3,040	96	96	96	222,166	\$31,640	\$277,163	\$2,887		
SOD00	Soda Lake	Soda Lake No.1/No.2	A	13.3	2.9	13.3	\$22,796	\$	\$25,058	\$1,884	26.3	15.9	26.3	\$58,693	\$	\$66,311	\$2,521		
STE00	Steamboat Hot Sprs	Field-wide Summary	A	3	0	3	\$1,462	\$	\$1,462	\$487	9	2.16	9	\$7,627	\$	\$8,675	\$964		
STI00	Stillwater	Stillwater Geothermal 1	A	0	0	0	\$	\$	\$	\$	0	0	0	\$	\$	\$	\$		
STI01	Stillwater	Stillwater N Expansion	B	11	16	16	\$23,603	\$	\$23,603	\$1,475	19	24	24	\$39,761	\$	\$40,928	\$1,705		
TRI00	Trinity Mountains District	Telephone Well area	D	42	42	42	\$113,375	\$11,460	\$138,027	\$3,286	66	66	66	177,585	\$11,460	\$209,536	\$3,175		
WAB00	Wabuska		A	6.7	6.65	6.7	\$35,127	\$	\$39,150	\$5,843	11.6	11.55	11.6	\$61,341	\$	\$67,299	\$5,802		
<i>Area Totals and Averages (weighted):</i>				413	396	419	\$180,000				637	612	643	\$180,000					
							\$1,196,000							\$1,527,000					
							\$3,643							\$1,807,000					
							\$2,209,000							\$3,437					

Area: 2 - NV with direct access to CA

AUR00	Aurora		C	31	31	31	\$85,866	\$536	\$97,862	\$3,157	51	51	51	139,923	\$536	\$157,242	\$3,083	
DIX00	Dixie Valley	Caithness Dixie Valley	A	5	5	5	\$14,623	\$	\$19,485	\$3,897	41	41	41	116,107	\$	\$123,309	\$3,008	
DIX01	Dixie Valley	Dixie Valley Power Partners (DVPP)	C	107	107	107	\$300,684	\$268	\$341,681	\$3,193	151	151	151	421,908	\$268	\$478,125	\$3,166	
EMI00	Emigrant (Fish Lake V.)		C	49	49	49	\$160,152	\$4,288	\$186,096	\$3,798	85	85	85	279,888	\$4,288	\$323,649	\$3,808	
FIS00	Fish Lake (Valley)		B	22.6	30	30	\$104,355	\$3,484	\$112,773	\$3,759	39.6	47	47	169,425	\$3,484	\$182,523	\$3,883	
HAW00	Hawthorne		C	8.7	8.7	8.7	\$32,338	\$268	\$38,527	\$4,428	14	14	14	\$52,343	\$268	\$61,459	\$4,390	
HYD00	Hyder Hot Springs		D	5.5	5.5	5.5	\$32,154	\$1,716	\$41,963	\$7,630	9.6	9.6	9.6	\$53,244	\$1,716	\$66,661	\$6,944	
PIR00	Pirouette Mountain	(S.Dixie Valley)	D	16	16	16	\$44,570	\$	\$50,800	\$3,175	23	23	23	\$61,241	\$	\$69,979	\$3,043	
SIL00	Silver Peak	(Alum prospect)	C	41	41	41	\$112,925	\$671	\$126,127	\$3,076	78	78	78	207,508	\$671	\$233,097	\$2,988	
SOH00	Sou Hot Springs	(Seven Devils/Gilbert's H.S.)	D	3.3	3.3	3.3	\$11,121	\$2,685	\$17,342	\$5,255	6.1	6.1	6.1	\$19,435	\$2,685	\$25,656	\$4,206	
<i>Area Totals and Averages (weighted):</i>				289	297	297		\$14,000				498	506	506		\$14,000		
								\$899,000		\$1,033,000	\$3,483				\$1,521,000		\$1,722,000	\$3,405

PROJ ID	Field or Area	Area or Power Plant	Explor.- Devel. Cat.	Min Estimated Development (Gross MW) (1)							Mkt Estimated Development (Gross MW) (1)						
				Wells	Plant	New	Cost (thousands) (2)				Wells	Plant	New	Cost (thousands) (2)			
Area Totals and Averages (weighted):																	
BAL00	Baltazar		C	11	11	11	\$41,628	\$6,968	\$56,207	\$5,110	16	16	16	\$64,833	\$6,968	\$83,201	\$5,200
DOU00	Double - Black Rk Hot Springs		D	20	20	20	\$81,425	\$4,288	\$102,600	\$5,130	33	33	33	133,837	\$4,288	\$164,893	\$4,997
MCG00	McGee Mountain	(Painted Hills)	C	19	19	19	\$49,070	\$7,504	\$62,567	\$3,293	28	28	28	\$79,026	\$7,504	\$95,031	\$3,394
PIN00	Pinto Hot Springs		D	18	18	18	\$47,570	\$6,713	\$60,348	\$3,353	29	29	29	\$74,355	\$6,713	\$89,641	\$3,091
SHO00	Shoshone-Reese River		D	13	13	13	\$35,956	\$4,028	\$45,905	\$3,531	18	18	18	\$47,570	\$4,028	\$57,519	\$3,195
WIL00	Wilson Hot Springs		D	10	10	10	\$23,740	\$4,565	\$31,295	\$3,129	17	17	17	\$42,980	\$4,565	\$52,603	\$3,094
Area Totals and Averages (weighted):														\$34,000			
				91	91	91					141	141	141				
							\$34,000							\$34,000			
							\$279,000							\$443,000			
								\$359,000							\$543,000		
									\$3,944							\$3,850	
Area: 4 - All other CA																	
BRW01	Brawley	Brawley (North Brawley)	B	68	88	88	\$228,968	\$20,900	\$249,868	\$2,839	115	135	135	341,740	\$20,900	\$377,074	\$2,793
BRW02	Brawley	East Brawley	B	85	85	85	\$312,340	\$21,900	\$382,103	\$4,495	129	129	129	464,100	\$21,900	\$563,015	\$4,364
BRW03	Brawley	South Brawley (Mesquite field)	B	45	45	45	\$179,352	\$12,900	\$222,517	\$4,945	62	62	62	244,442	\$12,900	\$298,475	\$4,814
CAL00	Calistoga		C	17	17	17	\$54,150	\$268	\$61,451	\$3,615	25	25	25	\$75,700	\$268	\$85,336	\$3,413
COS00	Coso	Field-wide Summary	A	0	0	0	\$	\$	\$	\$	75	55	75	214,800	\$	\$255,406	\$3,405
DUN00	Dunes		C	7.4	7.4	7.4	\$24,325	\$2,520	\$30,989	\$4,188	11	11	11	\$37,660	\$2,520	\$47,451	\$4,314
EAS00	East Mesa	Field-wide summary	A	57	45.8	57	\$250,644	\$	\$294,307	\$5,163	86	74.8	86	379,051	\$	\$442,156	\$5,141
GEY00	Geysers	Field-wide Summary	A	350	200	350	\$991,684	\$1,261,299	\$3,604	550	400	550	628,424	\$2,049,009	\$3,725		
GLA00	Glamis		D	4.3	4.3	4.3	\$16,645	\$3,240	\$24,992	\$5,812	6.4	6.4	6.4	\$26,592	\$3,240	\$34,939	\$5,459
HEB00	Heber	Field-wide Summary	A	9	9	9	\$28,809	\$	\$30,780	\$3,420	42	42	42	104,334	\$	\$113,651	\$2,706
LAK00	Lake City / Surprise Valley	Lake City	B	20.5	23	23	\$67,305	\$6,700	\$79,361	\$3,450	34.5	37	37	105,801	\$6,700	\$123,103	\$3,327
LVM00	Long Valley - M-P Leases	M-P Lease Summary	A	30	30	30	\$11,557	\$	\$17,395	\$580	71	71	71	133,170	\$	\$144,424	\$2,034
MED01	Medicine Lake	Fourmile Hill	B	25	25	25	\$60,604	\$5,896	\$73,513	\$2,941	36	36	36	\$85,768	\$5,896	\$102,167	\$2,838
MED02	Medicine Lake	Telephone Flat	B	95	110	110	\$230,702	\$5,896	\$245,820	\$2,235	160	175	175	373,688	\$5,896	\$403,974	\$2,308
MOS00	Mount Signal		C	12	12	12	\$32,909	\$900	\$36,637	\$3,053	19	19	19	\$47,136	\$900	\$53,066	\$2,793
NIL00	Niland		B	59	59	59	\$165,178	\$10,900	\$197,340	\$3,345	76	76	76	217,706	\$10,900	\$257,840	\$3,393

PROJ ID	Field or Area	Area or Power Plant	Explor.-Devel. Cat.	Min Estimated Development (Gross MW) (1)							Mlk Estimated Development (Gross MW) (1)							Cost (thousands) (2)							
				Wells	Plant	New	Cost (thousands) (2)			Site Dev.	E+C+SD+TL	Tran.Ln.	Tot.	\$/kW	Wells	Plant	New	Cost (thousands) (2)			Site Dev.	E+C+SD+TL	Tran.Ln.	Tot.	\$/kW
RAN00	Randsburg		C	32	32	32	\$79,820	\$5,360	\$93,413	\$2,919					48	48	48	113,366	\$5,360	\$130,872	\$2,727				
SAL00	Salton Sea	Field-wide summary	A	1000	1000	1000	2,125,089	\$184,500	2,445,654	\$2,446					1400	1400	1400	967,552	\$184,500	3,334,333	\$2,382				
SES00	Sespe Hot Springs		D	3.6	3.6	3.6	\$15,685	\$4,028	\$23,273	\$6,465					5.3	5.3	5.3	\$18,235	\$4,028	\$25,823	\$4,872				
SUL00	Sulphur Bank	Clear Lake	B	27	27	27	\$56,997	\$537	\$62,051	\$2,298					43	43	43	\$91,995	\$537	\$101,461	\$2,360				
SUP00	Superstition Mountain		D	5.9	5.9	5.9	\$15,021	\$1,611	\$20,096	\$3,406					9.5	9.5	9.5	\$24,535	\$1,611	\$32,118	\$3,381				
				Area Totals and Averages (weighted):	1953	1829	1990	\$288,000							3004	2860	3041	\$288,000							
								\$4,948,000									\$5,853,000	\$2,941				\$7,696,000			
				Grand Totals :	2746	2613	2797								4280	4119	4331								
				Grand Totals and Averages (weighted):				\$7,322,000			\$8,772,000							\$11,467,000			\$13,449,000				
								\$516,000			\$3,136							\$516,000			\$3,106				

Notes:

(1) Gross MW of new wellhead production capacity and of new plant capacity needed to bring total electricity generation to the Minimum (Min) or Most-likely (Modal or Mlk) estimated generation capacity of the resource. The well and plant figures differ if there is existing unused (but proven) wellhead production capacity, or existing under-utilized plant capacity. A value of 0 indicates that the existing wellfield production capacity or plant capacity is very close to or exceeds the corresponding generation capacity estimate, so that no confirmation or development is planned and costed. "New" is the larger of wellhead MW or plant MW and represents the total increment of electricity production to be expected. Development costs are actually calculated on the basis of drilling and proving 105% of needed gross MW, so that a reserve capacity is available.

(2) E+C+SD+TL = Exploration + Confirmation + Site Development + Transmission Line. Costs/kW are calculated with respect to new gross MW.

Hetch Hetchy/SFPUC Programmatic Renewable Energy Project

Project: 1.3 New Geothermal Site Identification and Qualification
Project Team: GeothermEx, Inc.
Task: 1.3.10 Final Project Report
Subject: D.1.3.10.3 Final Report

Table 15. Total and Incremental Generation Capacities for Selected Areas¹

Area	Minimum Total Generation Capacity (Gross MW)	Most-likely Total Generation Capacity (Gross MW)	Minimum Incremental Generation Capacity (Gross MW)	Most-likely Incremental Generation Capacity (Gross MW)	Percentage of State Total	Percentage of Grand Total
California						
Imperial Valley	1,900	2,500	1,350	1,950	65%	45%
The Geysers	1,200	1,400	350	550	18%	13%
Medicine Lake	150	200	150	200	7%	5%
Other	<u>450</u>	<u>600</u>	<u>150</u>	<u>300</u>	<u>10%</u>	<u>7%</u>
California Total	3,700	4,700	2,000	3,000	100%	70%
Nevada						
Greater Reno	550	800	400	650	50%	15%
Dixie Corridor	350	550	300	500	38%	12%
Other	<u>100</u>	<u>150</u>	<u>100</u>	<u>150</u>	<u>12%</u>	<u>3%</u>
Nevada Total	1,000	1,500	800	1,300	100%	30%
Grand Total	<u>4,700</u>	<u>6,200</u>	<u>2,800</u>	<u>4,300</u>	-	<u>100%</u>

Note: (1) The data in this table are derived from the Area totals in Tables 3 and 12, rounded to the nearest increment of 50 MW.

Appendix I

Database Figure List by Project

Hetch Hetchy/SFPUC Programmatic Renewable Energy Project
Project: 1.3 New Geothermal Site Identification and Qualification
Project Team: GeothermEx, Inc.
Task: 1.3.10 Final Project Report
Subject: D.1.3.10.3 Final Report

Appendix I. Database Figure List by Project

Proj	Figure
ADO00	Adobe Valley (Granite Springs V. - N. End)
	ADO00-1 Map showing hole locations and temperature data, Adobe Valley (Granite Springs Valley) area, Nevada
AUR00	Aurora
	AUR00-1 Locations of temperature gradient holes in the Aurora prospect area
	AUR00-2 Downhole temperature logs from the Aurora prospect area
	AUR00-3 Probabilistic calculation of geothermal energy reserves, Aurora prospect, Nevada
BAL00	Baltazor
	BAL00-1 Downhole temperatures near Baltazor Hot Spring
	BAL00-2 Geologic map of the Baltazor Hot Springs area
	BAL00-3 Downhole lithology, temperature and geologic section in the Baltazor Hot Springs area
	BAL00-4 Probabilistic calculation of geothermal energy reserves, Baltazor Hot Springs, Nevada
BEO00	Beowawe
	BEO00-1 Well location map, Beowawe geothermal field
	BEO00-2 Beowawe initial-state temperatures within Malpais fault zone
	BEO00-3 Probabilistic calculation of geothermal energy reserves, Beowawe, Nevada
BLU00	Blue Mountain
	BLU00-1 Map showing location of Blue Mountain geothermal leases
	BLU00-2 Map showing bore hole locations
	BLU00-3 Geologic map and gradient hole information
	BLU00-4 Downhole temperatures at the Blue Mountain geothermal area
	BLU00-5 Probabilistic calculation of geothermal energy reserves, Blue Mountain, Nevada
BRA00	Brady's Hot Springs
	BRA00-1 Well locations and surface temperature anomaly, Brady's Hot Springs, Nevada
	BRA00-2 Approximate elevation of 350°F isotherm, Brady's Hot Springs, Nevada
	BRA00-3 Probabilistic calculation of geothermal energy reserves, Brady's Hot Springs, Nevada
BRW00	Brawley
	Area-wide summary

Proj	Figure
	BRW00-1 Locations of the geothermal anomalies of the Imperial Valley, California
	BRW00-2 Total depths and bottomhole temperatures of deep holes in the Salton Sea, Brawley and Westmorland areas of the Imperial Valley, California
BRW01 Brawley	Brawley (North Brawley)
	BRW00-1 Locations of geothermal areas of the Imperial Valley, California
	BRW00-2 Total depths and bottomhole temperatures of deep holes in the Salton Sea, Brawley and Westmorland areas of the Imperial Valley, California
	BRW01-1 Deep well data: (North) Brawley area, Imperial Valley, California
	BRW01-2 Probabilistic calculation of geothermal energy reserves, (North) Brawley geothermal area, California
BRW02 Brawley	East Brawley
	BRW00-1 Locations of geothermal areas of the Imperial Valley, California
	BRW00-2 Total depths and bottomhole temperatures of deep holes in the Salton Sea, Brawley and Westmorland areas of the Imperial Valley, California
	BRW02-1 Heat flow map and well data, East Brawley geothermal area, California
	BRW02-2 Deep well data: East Brawley area, Imperial Valley, California
	BRW02-3 Probabilistic calculation of geothermal energy reserves, East Brawley geothermal area, California
BRW03 Brawley	South Brawley (Mesquite field)
	BRW00-1 Locations of geothermal areas of the Imperial Valley, California
	BRW00-2 Total depths and bottomhole temperatures of deep holes in the Salton Sea, Brawley and Westmorland areas of the Imperial Valley, California
	BRW03-1 Deep well data: South Brawley area, Imperial Valley, California
	BRW03-2 Geologic map of the southern Imperial Valley, California
	BRW03-3 Probabilistic calculation of geothermal energy reserves, South Brawley geothermal area, California
CAL00 Calistoga	
	CAL00-1 Map showing the general location of the Calistoga geothermal field in the upper Napa Valley, California
	CAL00-2 Map of the Calistoga area showing chemical and temperature anomalies
	CAL00-3 Downhole well temperatures and diagrammatic cross-section of the Calistoga geothermal field, Napa Valley, California
	CAL00-4 Probabilistic calculation of geothermal energy reserves, Calistoga area, Napa County, California
COL00 Colado	
	COL00-1 Map showing hole locations and temperature data, Colado area, Nevada
	COL00-2 Probabilistic calculation of geothermal energy reserves, Colado area, Nevada
COS00 Coso	Field-wide Summary

Proj	Figure	
COS00	Coso lease areas and outline of 350°F temperature contour at sea level	
COS00	Probabilistic calculation of geothermal energy reserves, Coso, California	
COS00	Historical power output of Coso field	
DES00	Desert Peak	
DES00	Well and fault location map, showing project areas, Desert Peak, Nevada	
DES00	Geologic and temperature cross section, Desert Peak, Nevada	
DES00	Map showing possible reservoir boundaries, Desert Peak, Nevada	
DES00	Probabilistic calculation of geothermal energy reserves, Desert Peak, Nevada	
DIX00	Dixie Valley	Caithness Dixie Valley
DIX00	Well location map, Dixie Valley geothermal field	
DIX00	Observed temperature distribution at -4,000 ft (msl), Dixie Valley	
DIX00	Observed temperature distribution at -5,000 ft (msl), Dixie Valley	
DIX00	Observed temperature distribution at -6,000 ft (msl), Dixie Valley	
DIX00	Map showing shallow-to-intermediate depth hole locations and temperature data, Dixie Valley, Nevada	
DIX00	Probabilistic calculation of geothermal energy reserves, Dixie Valley (Caithness project area), Nevada	
DIX01	Dixie Valley	Dixie Valley Power Partners (DVPP)
DIX01	Shallow thermal gradient contours and temperature cross-section of the Dixie Valley Power Partners area	
DIX01	Probabilistic calculation of geothermal energy reserves, Dixie Valley (Dixie Valley Power Partners project area), Nevada	
DOU00	Double - Black Rk Hot Springs	
DOU00	Map showing hole locations and temperature data, Double - Black Rock Hot Springs area, Nevada	
DOU00	Probabilistic calculation of geothermal energy reserves, Double - Black Rock Hot Springs, Nevada	
DUN00	Dunes	
BRW00	Locations of geothermal areas of the Imperial Valley, California	
DUN00	Hole locations and downhole temperature logs, Dunes geothermal anomaly, Imperial County, California	
DUN00	Temperature and lithologic cross-sections, Dunes geothermal anomaly, Imperial County, California	
DUN00	Temperature profile of hole DWR No.1 and schematic diagram of the hydrothermal system, Dunes geothermal anomaly, Imperial County, California	
DUN00	Probabilistic calculation of geothermal energy reserves, Dunes anomaly, California	
EAS00	East Mesa	Field-wide summary

Proj	Figure
	BRW00-1 Locations of geothermal areas of the Imperial Valley, California
	EAS00-1 Temperature contours in the East Mesa geothermal field, California
	EAS00-2 Downhole temperature logs of wells 6-1, 6-2 and 5-1, East Mesa geothermal field, California
	EAS00-3 Downhole temperature logs of wells 8-1 and 31-1, East Mesa geothermal field, California
	EAS00-4 S-N vertical temperature section, East Mesa geothermal field, California
	EAS00-5 Probabilistic calculation of geothermal energy reserves, East Mesa geothermal field, California
EMI00	Emigrant (Fish Lake V.)
	EMI00-1 Map showing hole locations and temperature data, Emigrant prospect, Fish Lake Valley, Nevada - SMU data set
	EMI00-2 Map showing hole locations and temperature data, Emigrant prospect, Fish Lake Valley, Nevada - FLGPC data set
	EMI00-3 Probabilistic calculation of geothermal energy reserves, Emigrant (Fish Lake Valley) area, Nevada
EMP00	Empire (San Emidio) Field-wide summary
	EMP00-1 Well locations and thermal anomaly, Empire geothermal area, Nevada
	EMP00-2 Probabilistic calculation of geothermal energy reserves, Empire (San Emidio) area, Nevada
FAL00	Fallon / Carson Lake Carson Lake anomaly
	FAL00-1 Temperatures to 7,000 ft at SE corner of Naval Air Station
	FAL00-2 Shallow temperature anomaly at Fallon / Carson Lake
	FAL00-3 Map showing hole locations, temperature data and boundaries of Fallon NAS
	FAL00-4 Map showing reflection seismic lines and inferred fault zones, Fallon NAS area,
	FAL00-5 Map showing land use in Fallon NAS area, Nevada
	FAL00-6 Probabilistic calculation of geothermal energy reserves, Fallon (Carson Lake) anomaly, Nevada
FIS00	Fish Lake (Valley)
	FIS00-1 Map showing hole locations and temperature data, Fish Lake Valley, Nevada
	FIS00-2 Probabilistic calculation of geothermal energy reserves, Fish Lake Valley, Nevada
FLY00	Fly Ranch/Granite Ranch Ward's (Fly/Hualapi Flat) H.S.
	FLY00-1 Map showing hole locations and temperature data, Fly Ranch area, Nevada
	FLY00-2 Downhole temperatures in Holland Ranch 1-2-FR and Cordero Fly No.3
	FLY00-3 Probabilistic calculation of geothermal energy reserves, Fly Ranch (Ward's H.S.) area, Nevada
FLY01	Fly Ranch/Granite Ranch Granite Ranch

Proj	Figure
FLY00	FLY00-1 Map showing hole locations and temperature data, Fly Ranch area, Nevada FLY00-2 Downhole temperatures in Holland Ranch 1-2-FR and Cordero Fly No.3 FLY01-1 Probabilistic calculation of geothermal energy reserves, Fly Ranch / Granite Ranch area, Nevada
GER00	Gerlach (Great Boiling Spring) GER00-1 Map showing hole locations and temperature data, Gerlach (Great Boiling Springs) area, Nevada GER00-2 Probabilistic calculation of geothermal energy reserves, Gerlach Area, Nevada
GEY00	Geysers Field-wide Summary GEY00-1 Location of power plants and Unit Areas at The Geysers GEY00-2 Location map showing the position of The Geysers steam field and "felsite" pluton relative to regional structure GEY00-3 Maps showing top of felsite and top of steam reservoir at The Geysers steam field GEY00-4 Vertical sections through Units 13, 16 and Bear Canyon, showing wellbore traces and steam entry elevations GEY00-5 Non-condensable gas concentration in early steam production from the Northwest Geysers GEY00-6 Calpine Unit areas steam production and injection history GEY00-7 Field-wide Geysers steam production and injection history GEY00-8 Geysers fieldwide monthly injection fraction
GLA00	Glamis BRW00-1 Locations of geothermal areas of the Imperial Valley, California GLA00-1 Probabilistic calculation of geothermal energy reserves, Glamis geothermal anomaly, California
HAW0	Hawthorne HAW00-1 Map showing hole locations and temperature data, Hawthorne area, Nevada (SMU data) HAW00-2 Map showing hole locations and temperature data, Hawthorne area, Nevada (GPO data) HAW00-3 Temperature logs and cross-section, Hawthorne area, Nevada (GPO) HAW00-4 Probabilistic calculation of geothermal energy reserves, Hawthorne area, Nevada
HAZ00	Hazen (Black Butte) (Patua Hot Springs) HAZ00-1 Probabilistic calculation of geothermal energy reserves, Hazen (Black Butte / Patua H.S.) area, Nevada
HEB00	Heber Field-wide Summary BRW00-1 Locations of geothermal areas of the Imperial Valley, California HEB00-1 Temperature and permeability models of the Heber geothermal field, California

Proj	Figure
HEB00-2	Temperature cross-sections through the Heber geothermal field
HEB00-3	Probabilistic calculation of geothermal energy reserves, Heber field, California
HON00 Honey Lake	Area-wide Summary
HON00-1	Map showing hole locations and temperature data, Honey Lake (Wendel-Amedee H.S.) area, California
HON00-2	NW-SE cross section through the Wendel-Amedee geothermal area, California
HON00-3	Downhole temperature data, Honey Lake (Wendel-Amedee H.S.) area, California
HON00-4	Probabilistic calculation of geothermal energy reserves, Honey Lake (Wendel - Amedee H.S.) area, California
HYD00 Hyder Hot Springs	
HYD00-1	Map showing hole locations, temperature and lease information, Hyder Hot Springs, Dixie Valley, Nevada
HYD00-2	Probabilistic calculation of geothermal energy reserves, Hyder Hot Springs, Nevada
KYL00 Kyle Hot Springs (Granite Mtn.)	(Buena Vista Valley)
KYL00-1	Location map with lease position and downhole temperature information, Kyle Hot Springs, Nevada
KYL00-2	Probabilistic calculation of geothermal energy reserves, Kyle Hot Springs, Nevada
LAK00 Lake City / Surprise Valley	Lake City
LAK00-1	Map showing hole locations and temperature data, Lake City (Surprise Valley) area, California
LAK00-2	Cross section showing temperature, Lake City (Surprise Valley) area, California
LAK00-3	Regional tectonic features, Lake City (Surprise Valley) area, California
LAK00-4	Probabilistic calculation of geothermal energy reserves, Lake City / Surprise Valley, California
LEA00 Leach Hot Springs	Grass Valley
LEA00-1	Summaries of exploration data at Leach Hot Springs (Sorey and Olmsted, 1994)
LEA00-2	Map showing hole locations, depth and lease position, Leach Hot Springs, Grass Valley, Nevada
LEA00-3	Map showing bottom hole temperatures, Leach Hot Springs, Grass Valley, Pershing County, Nevada
LEA00-4	Map showing temperature gradients , Leach Hot Springs, Grass Valley, Pershing County, Nevada
LEA00-5	Probabilistic calculation of geothermal energy reserves, Leach Hot Springs, Nevada
LEE00 Lee Hot Springs	
LEE00-1	Probabilistic calculation of geothermal energy reserves, Lee Hot Springs, Nevada
LVM00 Long Valley - M-P Leases	M-P Lease Summary
LVM00-1	Location of Mammoth-Pacific leases in the western half of Long Valley

Proj	Figure
LVM00-2	Examples of published temperature logs from the western half of the Long Valley caldera
LVM00-3	Approximate temperature distribution at +6,500 ft msl, in the western half of Long Valley
LVM00-4	Approximate temperature distribution at +5,500 ft msl, in the western half of Long Valley
LVM00-5	Approximate temperature distribution at +5,000 ft msl, in the western half of Long Valley
LVM00-6	Probabilistic calculation of geothermal energy reserves in the western half of Long Valley
LVM01	Long Valley - M-P Leases
	Basalt Canyon Expl. Project
LVM01-1	Drill sites of proposed Basalt Canyon Exploration Project
LVM02	Long Valley - M-P Leases
	Upper Basalt Canyon Expl. Project
LVM02-1	Drill sites of proposed Upper Basalt Canyon Exploration Project
MCF00	McFarlanes Hot Spring
	(Black Rock Desert)
MCF00-1	Map showing hole locations and temperature data, McFarlanes (McFarlans) area, Nevada
MCG0	McGee Mountain
	(Painted Hills)
MCG00-1	Map showing hole locations and temperature data, McGee Mountain (Painted Hills) area, Nevada
MCG00-2	Probabilistic calculation of geothermal energy reserves, McGee Mountain (Painted Hills) area, Nevada
MED00	Medicine Lake
	Field-wide Summary
MED00-1	Map showing hole locations, project areas and temperature contours, Medicine Lake area, California
MED00-2	Probabilistic calculation of geothermal energy reserves, Medicine Lake Caldera, California
MED01	Medicine Lake
	Fourmile Hill
MED01-1	Temperature data from hole 88-28, Fourmile Hill project area
MED01-2	Probabilistic calculation of geothermal energy reserves, Fourmile Hill Area, Medicine Lake, California
MED02	Medicine Lake
	Telephone Flat
MED02-1	Locations of existing and proposed drill holes in the Telephone Flat project area, Medicine Lake volcano, California
MED02-2	Downhole temperature data from the Telephone Flat project area, Medicine Lake volcano, California
MED02-3	Probabilistic calculation of geothermal energy reserves, Telephone Flat Area, Medicine Lake, California
MOS00	Mount Signal

Proj	Figure
MOS00	Geology and isogradient contours, Mt. Signal geothermal area
MOS00	Lease map with isogradient contours, Mt. Signal geothermal area
MOS00	Temperature profile, Mt. Signal Strat. No.1
MOS00	Probabilistic calculation of geothermal energy reserves, Mt. Signal, Imperial County, California
NEW00	New York Canyon
NEW00	Map showing property boundaries, temperature hole locations and data, New York Canyon, Nevada
NEW00	Probabilistic calculation of geothermal energy reserves, New York Canyon area, Nevada
NIL00	Niland
BRW00	Locations of geothermal areas of the Imperial Valley, California
BRW00	Total depths and bottomhole temperatures of deep holes in the Salton Sea, Brawley and Westmorland areas of the Imperial Valley, California
NIL00	Probabilistic calculation of geothermal energy reserves, Niland geothermal area, California
SAL00	Hole locations and shallow gradient maps of the Salton Sea geothermal field, California (showing also the locations of Niland project wells)
NOR00	North Valley
NOR00	Map showing hole locations and temperature data, North Valley area, Nevada
NOR00	Probabilistic calculation of geothermal energy reserves, North Valley area, Nevada
PIN00	Pinto Hot Springs
PIN00	Map showing hole locations and temperature data, Pinto Hot Springs area (Black Rock Desert), Nevada
PIN00	Probabilistic calculation of geothermal energy reserves, Pinto Hot Springs (Black Rock Desert), Nevada
PIR00	Pirouette Mountain (S.Dixie Valley)
PIR00	Map showing hole locations and temperature data, Pirouette Mountain area, southern Dixie Valley, Nevada
PIR00	Probabilistic calculation of geothermal energy reserves, Pirouette Mountain area (southern Dixie Valley), Nevada
PUM00	Pumpernickel Valley Tipton Ranch/Hot Springs Ranch
PUM00	Map showing hole locations and temperature data, Pumpernickel Valley (Tipton Ranch) area, Nevada
PUM00	Probabilistic calculation of geothermal energy reserves, Pumpernickel Valley (Tipton Ranch), Nevada
PYR00	Pyramid Lake Indian Reserv. (Needle Rocks Hot Springs)
PYR00	Map showing spring and well locations and temperature data, Pyramid Lake area, Nevada

Proj	Figure
	PYR00-2 Probabilistic calculation of geothermal energy reserves, Pyramid Lake (Needles H.S.) area, Nevada
RAN00 Randsburg	
	RAN00-1 Map showing hole locations and temperature data, Randsburg area, California
	RAN00-2 Probabilistic calculation of geothermal energy reserves, Randsburg area, California
RYE00 Rye Patch-Humboldt House District	Field-wide summary
	RYE00-1 Map showing hole locations and temperature data, Rye Patch - Humboldt House district, Nevada
RYE01 Rye Patch-Humboldt House District	Rye Patch
	RYE01-1 Probabilistic calculation of geothermal energy reserves, Rye Patch area, Nevada
RYE02 Rye Patch-Humboldt House District	Humboldt House
	RYE02-1 Probabilistic calculation of geothermal energy reserves, Humboldt House, Nevada
SAL00 Salton Sea	Field-wide summary
	BRW00-2 Total depths and bottomhole temperatures of deep wells in the Salton Sea, Brawley, Niland and Westmoreland areas of the Imperial Valley, California
	SAL00-1 Hole locations and shallow thermal gradient maps of the Salton Sea geothermal area, California
	SAL00-2 Map showing geographic areas used for capacity estimate, Salton Sea geothermal field, California
	SAL00-3 Probabilistic calculation of geothermal energy reserves, Salton Sea field, California
SAW00 Salt Wells	Eight Mile Flat
	SAW00-1 Map showing hole locations and temperature data, Salt Wells Basin, Nevada
	SAW00-2 Probabilistic calculation of geothermal energy reserves, Salt Wells Basin, Nevada
SES00 Sespe Hot Springs	
	SES00-1 Probabilistic Calculation of Geothermal Energy Reserves, Sespe Hot Springs, Ventura County, California
SHO00 Shoshone-Reese River	
	SHO00-1 Map showing hole locations and temperature data, Shoshone-Reese River area, Nevada
	SHO00-2 Probabilistic calculation of geothermal energy reserves, Shoshone - Reese River area, Nevada
SIL00 Silver Peak	(Alum prospect)
	SIL00-1 Map showing hole locations and temperature data, greater Silver Peak area, Nevada
	SIL00-2 Map showing hole locations and temperature data, Alum (Silver Peak) prospect area, Nevada
	SIL00-3 Probabilistic calculation of geothermal energy reserves, Silver Peak (Alum Prospect), Nevada

Proj	Figure	
SOD00	Soda Lake	Soda Lake No.1/No.2
	SOD00-1	Well location map, Soda Lake, Nevada
	SOD00-2	Approximate temperature distribution at +2,000 ft (msl), Soda Lake, Nevada
	SOD00-3	Approximate temperature distribution at sea level, Soda Lake, Nevada
	SOD00-4	Probabilistic calculation of geothermal energy reserves, Soda Lake, Nevada
SOH00	Sou Hot Springs	(Seven Devils/Gilbert's H.S.)
	SOH00-1	Map showing hole locations and temperatures, Sou Hot Springs, Dixie Valley, Nevada
	SOH00-2	Probabilistic calculation of geothermal energy reserves, Sou Hot Springs, Dixie Valley, Nevada
STE00	Steamboat Hot Sprs	Field-wide Summary
	STE00-1	Well and lease location map, Steamboat geothermal field, Nevada
	STE00-2	Approximate initial temperature distribution at +4,000 feet (msl), Steamboat geothermal field, Nevada
	STE00-3	Approximate extent of the 320°F isotherm at +3,500 feet (msl), Steamboat geothermal field, Nevada
	STE00-4	Probabilistic calculation of geothermal energy reserves, Steamboat Hot Springs field, Nevada
STI00	Stillwater	Stillwater Geothermal 1
	STI00-1	Well locations and temperature contours, Stillwater, Nevada
	STI00-2	Probabilistic calculation of geothermal energy reserves, Stillwater field, Nevada
STI01	Stillwater	Stillwater N Expansion
	STI00-1	Well locations and temperature contours, Stillwater, Nevada
	STI01-1	Probabilistic calculation of geothermal energy reserves, Stillwater N Expansion, Nevada
SUL00	Sulphur Bank	Clear Lake
	SUL00-1	Geologic map of the Sulphur Bank Mine- Borax Lake area, with locations of four exploration test wells and lines of cross-sections
	SUL00-2	Geologic map of Sulphur Bank Mine, geologic cross-section A-A', pattern of fault intersections, and area of gas leakage
	SUL00-3	Isothermal cross-sections
	SUL00-4	Contoured temperature in °F at a depth of 100 feet.
	SUL00-5	Probabilistic calculation of geothermal energy reserves, Sulphur Bank anomaly, Clear Lake region, California
SUP00	Superstition Mountain	
	SUP00-1	Geology and isotherms at Superstition Mountain
	SUP00-2	Lease map with isotherm contours, Superstition Mountain

Proj	Figure	
	SUP00-3	Probabilistic calculation of geothermal energy reserves, Superstition Mountain, California
TRI00	Trinity Mountains District	Telephone Well area
	TRI00-1	Map showing hole locations and temperature data, Trinity District, Nevada
	TRI00-2	Map showing hole locations and temperature data in Telephone well area, Trinity District, Nevada
	TRI00-3	Probabilistic calculation of geothermal energy reserves, Telephone well area, Trinity District, Nevada
WAB00	Wabuska	
	WAB00-1	Map showing hole locations and temperature data, Wabuska Hot Springs, Nevada
	WAB00-2	Probabilistic calculation of geothermal energy reserves, Wabuska Hot Springs, Nevada
WES00	Westmorland	
	BRW00-1	Locations of geothermal areas of the Imperial Valley, California
	BRW00-2	Total depths and bottomhole temperatures of deep holes in the Salton Sea, Brawley and Westmorland areas of the Imperial Valley, California
	WES00-1	Deep well data: Westmorland area, Imperial Valley, California
WIL00	Wilson Hot Springs	
	WIL00-1	Map showing hole locations and temperture data, Wilson Hot Springs, Nevada
	WIL00-2	Probabilistic calculation of geothermal energy reserves, Wilson Hot Springs, Nevada

Appendix II
Project Data Summary Report
(example)

Hetch Hetchy/SFPUC Programmatic Renewable Energy Project
 Project: 1.3 New Geothermal Site Identification and Qualification
 Project Team: GeothermEx, Inc.
 Task: 1.3.10 Final Project Report
 Subject: D.1.3.10.3 Final Report

**Appendix II:
 Project Data Summary
 Report (example)**

Project Data Summary Report

PROJECT ID: **BEO00**

Project

PROJECT ID:	BEO00	Area:	1	MW installed:	16.7 -gr	16 -net			
Name - District/Area/Field:	Beowawe			MW produced (yr):	15 (1998)				
Name - Area / Power Plant:				Plant Technology:	Dual Flash				
Exploration -Development Category:	A	State:	NV	Lat:	40.55	Long:	113.62	Start Date (Yr):	1985
Generation Capacity Estimated:	Y	County:	Eureka-Lander			Notes - Project:	Power plant design: GHCB, 20/2, 2001. 1) A portion of the KGRA is in Lander Co. 2) Power is sold to Southern California Edison via a wheeling agreement with Sierra Pacific Power Company. 3) MW net is also found listed as 13.0		
Owner:	Caithness Energy, LLC			Developer:	Chevron Resources Co.			Financier:	
Operator:	Caithness Operating Co., LLC								

Government Funding

1997? DOE grant to Idaho National Engineering Laboratory, Contract DE-AC07-94ID13223 (Fan97a)

Landholding(s) (Any landholdings listed are as represented by developers or lessees and have not been otherwise confirmed)

Property Name:			
Twn-Rng-Sec:	T31N, R47E, Section 24 and portions of Sections 13, 14 and 23 T31N, R48E, Section 18 and portions of Sections 7, 8, 17 and 19.		
Base & Meridian:	Mt. Diablo	Acres:	
Private Owner Name:	various		
Comments:			
Lease Obtained (Yr):		Lease Expires (Yr):	

Exploration / Development History

Year	Exploration / Development Cost	Outcome/Comments
1959-1960	Drilling: 'full' diameter hole(s)	Exploration drilling: Magma Power Company (Magma) drilled 2 wells in the vicinity of the sinter terrace, an area of fumaroles, hot springs and geysers in Section 17. Both were non-commercial.
1960-1965	Drilling: 'full' diameter hole(s)	Discovery well: Magma drilled first productive well at Beowawe (Vulcan #1), located on top of the sinter terrace. Eleven other holes are drilled in the same general area; are some productive, some are non-commercial.
1973-1975	Geophysics: various	Chevron performed gravity, magnetic, seismic reflection, dipole-dipole resistivity, magnetotelluric, and self-potential surveys. Data entered public domain through the DOE Industry-Coupled Program (Swi79a).

1974	Drilling: 'full' diameter hole(s)	First deep productive well: Chevron drilled Ginn 1-13 to 9,563 feet and encountered deep production in a fractured interval associated with the down-dip extension of the Malpais Fault Zone (MFZ), at a location 1.1 miles SW of the sinter terrace area, in Section 13. Maximum temperature 420°F.
1974-1985	Drilling: 'full' diameter hole(s)	Development drilling: Chevron drilled 5 more full-sized wells along the MFZ. Three were productive (wells 33-17 (later abandoned), 85-18 (now an active injector), and Ginn 2-13). Two were non-commercial (wells Batz #1, Rossi 21-19). Another non-commercial full-sized well was drilled by Getty (Collins 76-17) southeast of the MFZ.
1986	Engineering: power plant on-line	Power plant on-line: Chevron put plant on line with capacity of 16.7 MW (gross). Production from 2 wells (Ginn 1-13 and Ginn 2-13) and injection into a third (Batz #1, later switched to well 85-18).
1988	Reservoir Engineering: field behavior	Cooling trend begins: Plant output begins to decline, reaching 12.5 MW (gross) by early 1991 (Ben97a).
1991	Drilling: 'full' diameter hole(s)	Make-up well: Oxbow drilled a make-up well 77-13 and put it on line. Plant output initially recovered to full capacity, but decline in reservoir pressure accelerated (Ben97a).
1991	Financial: project developer/owner	Change of operator: Oxbow assumed operatorship of surface facilities at Beowawe.
1994	Reservoir Engineering: field operations	Change injection strategy: Oxbow shifted injection from Batz #1 to 85-18. Reservoir pressure recovered to levels above those before 77-13 went on line, then leveled off (Ben97a).
1999	Financial: project developer/owner	Change of operator: Caithness bought out Oxbow's interest and became operator of the wellfield and the existing power plant.

Well Summaries

Well Type	Self-Flowing Production		Log Types Avail:	T, lith, various others	
Number - total			Locations Avail?	yes	
- active	3		Dev Svys Avail?	yes	
- standby					
TD	7000	to	SI WHP	Min.	Max.
Csg Shoc depth	1787		Flowing WHT		psig
Csg ID	9-5/8		Flowing WHP		°F
OH/Liner ID	7 bl		TD Rate		psig
Perm Zone depth	6700		Water Rate		Rate units:
Perm Zone Temp	420		Steam Rate		
BHT	420		Steam Pressure		psig
Max-T			Enthalpy		btu/lb
T Gradient (@ TD)			Capacity		5 MWgr
Inversions?			Pump Type(s)		
Closed Anomaly?			Pump Set Dpth		ft.
Comments/	Reservoir temperatures declined from an initial value of 420°F to a range of approximately 348° to 365°F (Ben97a)				
Notes	1) in one hole, the liner is cemented to 7,857 ft, in another, liner is hung to about 9,500 ft (NVGEOWEL) 2) liners are hung (in one well, cemented), from casing shoe to the top of the permeable zone, which is open hole (NVGEOWEL) 3) 5 MWgr is average 15 MW/3 wells.				

Well Type **Injection**Number - total **2**- active **1**- standby **1**

	Min.	Max.	
TD	5927	6000	ft.
CsgShoe depth			ft.
Csg ID			in.
OH/Liner ID			in.
Perm Zone depth	1500	1900	ft.
Perm Zone Temp	125	355	°F
BHT	255	320	°F
Max-T			°F
T Gradient (@TD)			°F / 100ft
Inversions?			
Closed Anomaly?			

Comments/ Well 85-18; standby injector is Batz #1 (formerly used). Minimum and maximum temperatures are prior to long-term injection in Batz #1 and
Notes 85-18, respectively (Ben93a). Data also from NVGEOWEL.

LogTypesAvail:

Locations Avail?

Dev Svys Avail?

	Min.	Max.	
SIWHP			psig
Flowing WHT			°F
Flowing WHP			psig
TD Rate			
Water Rate			Rate units:
Steam Rate			
Steam Pressure			psig
Enthalpy			btu/lb
Capacity			MWgr
PumpType(s)			
Pump Set Dpth			ft.

Well Type **Observation**

Number - total

- active **1**

- standby

	Min.	Max.	
TD		724	ft.
CsgShoe depth		201	ft.
Csg ID	10		in.
OH/Liner ID	10 OH		in.
Perm Zone depth		600	ft.
Perm Zone Temp		370	°F
BHT		370	°F
Max-T		370	°F
T Gradient (@TD)			°F / 100ft
Inversions?			
Closed Anomaly?			

Comments/ Vulcan No.2. Data in NVGEOWEL, Ben93a; temperature profile in Ben93a.
Notes

LogTypesAvail: T, lith

Locations Avail? yes

Dev Svys Avail? yes

	Min.	Max.	
SIWHP			psig
Flowing WHT			°F
Flowing WHP			psig
TD Rate			
Water Rate			Rate units:
Steam Rate			
Steam Pressure			psig
Enthalpy			btu/lb
Capacity			MWgr
PumpType(s)			
Pump Set Dpth			ft.

Well Type **Full Diameter Expl/Dev**Number - total **13**

- active

- standby

	Min.	Max.	
TD	237	9005	ft.

LogTypesAvail:

Locations Avail?

Dev Svys Avail?

	Min.	Max.	
SIWHP			psig

				PROJECT ID: BEO00	
CsgShoe depth	<input type="text"/>	<input type="text"/>	ft.	Flowing WHT	<input type="text"/>
Csg ID	<input type="text"/>	<input type="text"/>	in.	Flowing WHP	<input type="text"/>
OH/Liner ID	<input type="text"/>	<input type="text"/>	in.	TD Rate	<input type="text"/>
Perm Zone depth	<input type="text"/>	<input type="text"/>	ft.	Water Rate	<input type="text"/>
Perm Zone Temp	<input type="text"/>	<input type="text"/>	°F	Steam Rate	<input type="text"/>
BHT	<input type="text"/>	<input type="text"/>	°F	Steam Pressure	<input type="text"/> psig
Max-T	<input type="text"/>	<input type="text"/>	°F	Enthalpy	<input type="text"/>
T Gradient (@TD)	<input type="text"/>	<input type="text"/>	°F / 100ft	Capacity	<input type="text"/> btu/lb
Inversions?	<input type="text"/>			PumpType(s)	<input type="text"/> MWgr
Closed Anomaly?	<input type="text"/>			Pump Set Dpth	ft.
Comments/ Notes	Exploration and development holes drilled during 1959 - 1981 by Magma, Chevron, Getty. All in Section 17, most on the "sinter terrace" (hot spring area). Various outcomes (commercial producers, non-commercial). All but one have been abandoned (Rossi 21-19 is idle). (NVGEOWEL)				

Reservoir Properties: Chemical

Dominant Phase:	<input type="text"/> LD			
Fluid Composition				
WaterType:	<input type="text"/> Na-HCO3			
	Min.	Max.	Avg.	
TDS-Total Disch:	<input type="text"/> 890	<input type="text"/> 920	<input type="text"/> 910	ppm-wt
TDS-Sep. Water:	<input type="text"/>	<input type="text"/>	<input type="text"/>	ppm-wt
GasType:	<input type="text"/>			
	Min.	Max.	Avg.	
Gas/Steam:	<input type="text"/>	<input type="text"/>	<input type="text"/>	ppm-wt
Gas/Total Disch:	<input type="text"/>	<input type="text"/>	<input type="text"/>	ppm-wt
Comments	<input type="text"/>			
Minimum and maximum TDS values are from Ginn 2-13 and Ginn 1-13, respectively (Ben93a). Range of Cl among 6 samples (4 boiling hot springs and 2 boiling wells) is 30 - 70 mg/l (GEOTHERM)				

Chemical Geothermometers

	Min.	Max.	Avg.	
Quartz:	<input type="text"/> 390	<input type="text"/> 454	<input type="text"/> 427	°F
Chalcedony:	<input type="text"/> 363	<input type="text"/> 432	<input type="text"/> 403	°F
Na-K-Ca:	<input type="text"/> 385	<input type="text"/> 470	<input type="text"/> 430	°F
Na-K-Ca-Mg:	<input type="text"/> 381	<input type="text"/> 466	<input type="text"/> 426	°F
K-Mg:	<input type="text"/>	<input type="text"/>	<input type="text"/>	°F
SO4-H2O Iso.:	<input type="text"/>	<input type="text"/>	<input type="text"/> 484	°F

Comments

Ranges and averages among 6 samples (4 boiling hot springs and 2 boiling wells). Adiabatic corrections have been applied to the silica temperatures. Mg at 0.1 to 0.2 mg/l (GEOTHERM). SO4-H2O isotope temperature from USGSOF79-1135.

Reservoir Properties: Physical

	Min.	Max.	MLk.	Comments
Temperature:	<input type="text"/> 400	<input type="text"/> 420	<input type="text"/> 410	°F
				Max is at the permeable zones of the production wells. Min is suggested by the chalcedony temperature. Mlk is the average.
Depth to Top:	<input type="text"/> 6000	<input type="text"/> 7000	<input type="text"/> 6500	ft.
				Temperature model (Figure BEO00-2) suggests that the reservoir above about 6,500 ft is confined to a very narrow zone within the Malpais fault. Uppermost major permeability is at c.6,700 ft. Min and Max represent uncertainty.
Thickness:	<input type="text"/> 3100	<input type="text"/> 4100	<input type="text"/> 3600	ft.
				Thicknesses from top to 10,100 ft (deepest production plus 500 ft)
Area:	<input type="text"/> 2.0	<input type="text"/> 3.0	<input type="text"/> 2.5	mi ²
				MLk is based on a high temperature area of about 3 square miles at 10,000 ft (Figure BEO00-2), adjusted downwards for cooler conditions and more limited area at higher levels particularly at the NE end. Min and Max represent an uncertainty of ±0.5 mi ² .
Porosity:	<input type="text"/> 3.0	<input type="text"/> 7.0	<input type="text"/>	%
				Standard values
Recovery Factor:	<input type="text"/> 5.00	<input type="text"/> 20.00	<input type="text"/>	
Rejection Temp:	<input type="text"/>	<input type="text"/> 59	<input type="text"/> °F	

Setting/Lithology: _____

Operational Constraints

Constraint	Description

Estimated Generation Capacity**MW for 30 years**

Minimum (90% probable)	Most-Likely (modal)	Mean	Standard Deviation
30	41	58	21

Comments/Notes

Figure BEO00-3. Based on relatively good and complete data. Estimate does not include heat reserves in the discharge (upflow) zone to the hot springs area (above a depth of about 6,500 ft), but the temperature model (Figure BEO00-2) suggests that the volume of this zone is quite small relative to deeper reserves. The histogram of estimated values has a broad maximum, which makes the most-likely value relatively non-unique.

Figures

Number	Name
BEO00-1	Well location map, Beowawe geothermal field
BEO00-2	Beowawe initial-state temperatures within Malpais fault zone
BEO00-3	Probabilistic calculation of geothermal energy reserves, Beowawe, Nevada

(1) Geographic Areas:**Area 1 – Greater Reno, Nevada (includes California locations)****Area 2 – Nevada sites with direct access to the California grid****Area 3 – Other Nevada locations****Area 4 – All other California****(2) Exploration-Development Categories:****A – Existing power plant operating****B – One or more wells tested at ≥ 1 MW (no power plant in operation)****C – Minimum 212°F logged downhole (no well tests at ≥ 1 MW)****D – Other exploration data and information available ($\geq 212^{\circ}\text{F}$ not proven)****No category assigned – area does not meet the minimum criteria (see Final Report section 2.2)**

Appendix III
Methodology of Estimating Generation Capacities
(Geothermal Energy Reserves)

Hetch Hetchy/SFPUC Programmatic Renewable Energy Project
Project: 1.3 New Geothermal Site Identification and Qualification
Project Team: GeothermEx, Inc.
Task: 1.3.10 Final Project Report
Subject: D.1.3.10.3 Final Report

APPENDIX III

METHODOLOGY OF ESTIMATING GENERATION CAPACITIES (GEOTHERMAL ENERGY RESERVES)

1. THEORETICAL BASIS OF THE ESTIMATION METHOD

1.1 Introduction

To estimate energy reserves in the various project areas, we have used a methodology that has been used by GeothermEx over the past two decades. This methodology is a volumetric reserve estimation approach introduced by the U.S. Geological Survey (ref: USGSC790), modified to account for uncertainties in some input parameters by using a probabilistic basis (Monte Carlo simulation).

This technique to estimate reserves is based on a volumetric calculation of the heat-in-place at each project area, with reasonable assumptions made about:

- the percentage of that heat that can be expected to be recovered at the surface; and
- the efficiency of converting that heat to electrical energy.

As explained below, the heat-in-place calculation takes into account only a volume of rock and water that is reasonably likely to contain adequate permeability and temperature for the generation of electricity using contemporary technology. Hot rock that is deeper than likely to be economically drillable in a contemporary commercial project is not included.

The term "reserves" as used herein is analogous to the "geothermal reserve(s)" of USGSC790 (p.4), and different from the overall "geothermal resource," which includes all heat underground. In USGSC790 the concept of "resource" is further subdivided into "inaccessible" (very deep) and "accessible" (likely to be drillable in the 'foreseeable' future), and "accessible" resource is further subdivided into "residual" (too deep for present economics) and "useful" (perhaps drillable at currently acceptable cost). Finally "useful" is subdivided into "subeconomic" (probably too deep, especially if the resource temperature is not very high, or displaying inadequate permeability), and "economic" (considered likely to be viable).

In USGSC790 (p.4) the term "geothermal reserve" is defined as "that part of the geothermal resource that is identified and also can be extracted legally at a cost competitive with other commercial energy sources at present." It must be emphasized that an estimate of reserves using the volumetric method does not imply any guarantee that a given level of power generation can be achieved. Before a given level of generation can be realized, wells capable of extracting the heat from the rock by commercial production of geothermal fluid must be drilled and tested. This is the only

Hetch Hetchy/SFPUC Programmatic Renewable Energy Project
Project: 1.3 New Geothermal Site Identification and Qualification
Project Team: GeothermEx, Inc.
Task: 1.3.10 Final Project Report
Subject: D.1.3.10.3 Final Report

way to unequivocally establish the presence of commercially viable reserves and demonstrate the desired generating capacity of each locally defined resource.

1.2 Calculation of Generation Capacity

In the GeothermEx method, the maximum sustainable generation (power plant) capacity (E) is given by:

$$E = V C_v (T - T_o) \cdot R / F / L \quad (1.1)$$

where V = volume of the reservoir,

C_v = volumetric specific heat of the reservoir,

T = average temperature of the reservoir,

T_o = rejection temperature (equivalent to the average annual ambient temperature),

R = overall recovery efficiency (the fraction of thermal energy in-place in the reservoir that is converted to electrical energy at the power plant),

F = power plant capacity factor (the fraction of time the plant produces power on an annual basis), and

L = power plant life.

The parameter R can be determined as follows:

$$R = \frac{W \cdot r \cdot e}{C_f \cdot (T - T_o)} \quad (1.2)$$

where r = recovery factor (the fraction of thermal energy in-place that is recoverable as thermal energy at the surface),

C_f = specific heat of reservoir fluid,

W = maximum available thermodynamic work from the produced fluid, and

e = utilization factor to account for mechanical and other losses that occur in a real power cycle.

The parameter C_v in (1.1) is given by:

$$C_v = \rho_r C_r (1 - \phi) + \rho_f C_f \phi \quad (1.3)$$

Hetch Hetchy/SFPUC Programmatic Renewable Energy Project
Project: 1.3 New Geothermal Site Identification and Qualification
Project Team: GeothermEx, Inc.
Task: 1.3.10 Final Project Report
Subject: D.1.3.10.3 Final Report

where ρ_r = density of rock matrix,

C_r = specific heat of rock matrix,

ρ_f = density of reservoir fluid, and

ϕ = reservoir porosity.

The parameter W in (1.2) is derived from the First and Second Laws of Thermodynamics as follows:

$$dW = dq (1 - T_0 / T) \quad (1.4)$$

and

$$dq = C_f dT \quad (1.5)$$

where q represents thermal energy and T represents absolute temperature.

2. ASSIGNMENT OF PARAMETERS FOR GENERATION ESTIMATES

In the Monte Carlo simulation method of calculating reserves, some parameters in equations 1.1 to 1.3 are assigned fixed values, and others are assigned ranges of values believed to be likely, on the basis of available information about the resource. These ranges may include only a minimum (Min) and a maximum (Max), or may also include a most-likely (Mlk) value.

The Monte Carlo method proceeds by calculating a large number of generation estimates (for this project, 10,000 estimates). Each time the calculation is done, each uncertain parameter is assigned a random value within the span of Min and Max, or a random value within a triangular probability distribution that is defined by Min, Mlk and Max. The results of the multiple generation estimates are then compiled to obtain an overall Minimum Generation Capacity Estimate (here defined as the capacity value with a cumulative probability of more than 90%; i.e. 90% of estimates will be equal to or greater than this value), and a Most-likely Generation Capacity Estimate (here defined as the modal generation capacity; i.e. the most-frequently estimated value). The mean (average) of the estimated values is also recorded, as well as the standard deviation of the mean.

2.1 Parameters Assigned a Statistical Uncertainty

2.1.1 Reservoir Temperature (T)

If there is deep drilling, testing and/or production data, this information is used to estimate minimum, maximum and most-likely average temperatures for the hydrothermal system within the likely reservoir volume. There is a certain amount of feed-back

Hetch Hetchy/SFPUC Programmatic Renewable Energy Project

Project: 1.3 New Geothermal Site Identification and Qualification

Project Team: GeothermEx, Inc.

Task: 1.3.10 Final Project Report

Subject: D.1.3.10.3 Final Report

between this process and the process of defining the thickness and area of the reservoir, to insure that the temperature values and volumetric parameters are compatible.

If the amount of down-hole temperature information is limited (usually the case if there is no developed geothermal field), then temperature estimates are chosen from the chemical and isotope geothermometers and from such drilling data as may be available. In most cases, the geothermometers provide at least two temperature estimates: the maximum temperature that is likely to be present in the hydrothermal system, and a minimum temperature that reflects the latest full or partial chemical equilibration between hot water and hot rock, usually in the shallowest part of the hydrothermal system. A most-likely average temperature is estimated from the minimum and maximum, from a third chemical temperature if suitable, or from drilling data. Explanations for the choice of minimum, maximum and most-likely average temperature are included with the reservoir physical properties of each project area.

Prospect areas where there are no deep drilling data and no chemical data (the thermal anomaly is blind and/or there are no chemical data) present a special problem for both the thickness of the reservoir (as discussed below) and for temperature. In all such cases there is a thermal anomaly that is indicated by shallow temperature gradient drilling (generally to 300 or 500 ft), and sometimes also by ID (Intermediate-Depth) slim-hole drilling (to about 2,000 ft). Elevated gradients in multiple holes can establish the approximate surface area of an anomaly (see more below), but otherwise they indicate only the rate of temperature increase moving downwards. Temperature gradients do not indicate at what (greater) depth and temperature a reservoir is present.

In these cases:

- If there is some indication that a hot aquifer has been reached in some holes, and a likely minimum temperature can be inferred, then that temperature is used as the minimum average (such as 250°F at the Aurora, Nevada, project AUR00). If there are insufficient data to indicate even a likely minimum temperature, then the default minimum average temperature that is used is 225°F, which is the lowest average production zone temperature at 11 geothermal fields in Nevada, with no known or suspected volcanic heat source, that are actually in commercial production or extensively drilled (part A of Table III-1¹; Wabuska project).
- The default maximum average that is assigned is 440°F, which is the highest average permeable zone temperature at the same set of 11 geothermal fields (part A of Table III-1; Dixie Valley project).

¹ Temperatures from Table III-1 are herein rounded to the nearest 5°F.

Hetch Hetchy/SFPUC Programmatic Renewable Energy Project

Project: 1.3 New Geothermal Site Identification and Qualification

Project Team: GeothermEx, Inc.

Task: 1.3.10 Final Project Report

Subject: D.1.3.10.3 Final Report

- The default most-likely average reservoir temperature that is assigned is 345°F, which is the average of the 11 geothermal fields (part A of Table III-1).

In all of these cases we have based the averages on well-known fields without volcanic heat sources because few, if any, of the new fields being estimated are likely to have a volcanic heat source. Exceptions are handled as individual cases.

2.1.2 Reservoir Thickness (factor of V)

Reservoir volume (see Section 1.2 of this appendix) is calculated as the product of reservoir thickness and reservoir area, which are each separately assigned a statistical uncertainty. The database of geothermal project areas also includes (among reservoir properties) the depth to top of reservoir. This parameter is not used for the actual reserves calculation, but it is documented because it provides a guideline for required minimum drilling depths.

The top, bottom and corresponding thickness of the reservoir (all assumed to be average values) are based on drilling data if available. Typically, the thickness value is adjusted by adding 500 ft, to allow for the probability that the deepest permeable zones reached by drilling will be mining the heat and fluid from another 500 ft below². This adjustment may be omitted, however, if there is evidence that the commercial reservoir zone overlies a temperature inversion.

Often, the top is reasonably well-established but the bottom is uncertain because deeper drilling has not been done at all, or has not been done in enough wells to support a very confident estimate.

If the depth to bottom or depths to both top and bottom are unknown, then default average thickness values are applied, based on the thicknesses of permeable intervals in the 11 geothermal fields of Table III-1: the minimum permeable thickness is 2000 ft, the maximum is 5,000 ft, and the average is 3,000 ft. As with the data from drilling, these values are adjusted by adding 500 ft, to allow for the probability that heat and some fluid can be mined from below the principal zone of permeability. Therefore, the minimum reservoir thickness that is assigned is 2,500 ft (0.8 km), the maximum reservoir thickness that is assigned is 5,500 ft (1.7 km), and the adjusted average, 3,500 ft (1.1 km) is used for the most-likely value.

Corresponding thicknesses in Circular 790 were 30% to 50% greater (1 km, 2.5 km and 1.5 km). The more conservative thickness values used herein are justified by three

² This 500 ft interval is seen as an integral part of the "reservoir" and of the initial "reserves," and is not a "recharge" or "resupply" increment, since thermal recharge (or resupply) is not included in the heat-in-place calculation.

Hetch Hetchy/SFPUC Programmatic Renewable Energy Project
Project: 1.3 New Geothermal Site Identification and Qualification
Project Team: GeothermEx, Inc.
Task: 1.3.10 Final Project Report
Subject: D.1.3.10.3 Final Report

observations. First, they are supported by the data in Table III-1 (largely obtained since 1979). Second, most field developments since 1979 have succeeded in developing only a fraction of the reserves estimated in Circular 790. Third, drilling costs have a practical limit on the commercial viability of development, particularly for moderate-temperature resources. In Circular 790 the heat reserves were calculated to a standard depth of 3 km (9,800 ft), but this depth is likely to exceed the limits of practical commercial viability for heat extraction if the resource temperature is less than the average 345°F.

2.1.3 Reservoir Area (factor of V)

If there is actual evidence concerning the reservoir area, from temperature contours based on deep well logs or from temperature gradients in shallower wells, this information is used to pick the minimum, maximum and most-likely areas. Hot spring locations and temperatures are used to guide the estimates, knowing, however, that a hot spring represents the outflow from a hydrothermal system which may be horizontally displaced from the principal area of the deep reservoir, at distances of several miles or more.

If downhole information is very limited, and the existence of a reservoir is implied only by the presence of a hot spring, then the most-likely area is considered to be 0.8 square miles, which is very close to a circle of one-half mile radius (0.79 square miles or 2.03 square km). The minimum is taken as one-half of this, or 0.4 square miles (1.04 sq km), and the maximum assigned area is 1.2 square miles (3.11 sq km). These values are nearly equal to the 1, 2 and 3 square km areas assigned in Circular 790.

It is reasonable to relate the minimum, most-likely and maximum areas using simple multiples of the minimum area (1, 2 and 3), instead of expanding the radius of a minimum circle by some multiple, because most geothermal reservoirs that are heated by deep circulation in a tectonic regime (the dominant type in Nevada) tend to be elongated in one direction, rather than circular in shape. Sometimes the elongation is extreme, as at Empire (San Emidio), Nevada (project EMP00). In fact, the real shape of the default most-likely area of 0.8 square miles is likely to be closer to a rectangle or elongate oval, with an aspect ratio somewhere between 5:1 and 1.5:1, than to a circle.

In areas where two or more hot springs or wells are present and it is believed that a continuous reservoir volume or heat anomaly is likely to connect them, but the boundaries of the thermal anomaly remain uncertain, the most-likely value is the area encompassed by the springs and wells to a distance of 0.5 mile radius around the outer-most points³. The minimum area is one-half of the most-likely area, and the maximum is 1.5 times the most-likely area.

³ For example, if two points are separated by 2 miles, then the most-likely area is calculated as a rectangle with rounded corners ($r = 0.5$ mile) that is three miles long ($0.5 + 2.0 + 0.5$) and one mile wide ($0.5 + 0.5$), or 3 square miles, minus 0.05 square mile at each corner. The total area is thus 2.8 square miles.

Hetch Hetchy/SFPUC Programmatic Renewable Energy Project
Project: 1.3 New Geothermal Site Identification and Qualification
Project Team: GeothermEx, Inc.
Task: 1.3.10 Final Project Report
Subject: D.1.3.10.3 Final Report

2.1.4 Porosity (ϕ)

Unless there is a compelling reason to apply other values, a default minimum porosity of 3.0% and a default maximum porosity of 7.0% are used, without a most-likely value. Reservoirs known or likely to reside in sedimentary rocks with significant inter-granular porosity (as in the Imperial Valley of California) are assigned a range of 10% to 20%. Porosity has very little effect on the overall outcome of the generation capacity estimate, because it represents only the small fraction of the overall reservoir volume that is occupied by water instead of rock. Water has a smaller heat capacity than rock, so a higher porosity translates into less heat in place.

2.1.5 Recovery Factor (r)

In Circular 790, the U.S.G.S. used a recovery factor of 0.25 for reserves estimates of individual hydrothermal convection systems. Based on our assessment of more than 100 geothermal sites around the world, we have found it more realistic to apply a recovery factor in the range of 0.05 (Min) to 0.2 (Max) without application of a most-likely value. These values are assigned herein as default values. For a specific site that is reasonably well-known, this range is adjusted based on an integrated analysis of the available exploration, drill and production data. For example, at the reservoirs in sedimentary rocks of the Imperial Valley of California the Min value is adjusted to 0.10 (Min), because the reservoir fluids in these sedimentary systems are considered less likely than elsewhere to short-circuit through specific fractures.

2.2 Parameters Assigned a Fixed Value

2.2.1 Rock Volumetric Heat Capacity (C_v)

A default average value of 39 BTU/cu.ft °F (2,613 kJ/m³°C) is used, based on data for heat capacities in a variety of rocks at 350°F in Prats, 1982 (Pra82a) and an average crustal density of 168.6 lb/cu.ft (2.7 gm/cc). The heat capacity used herein is slightly lower than the value of 2,700 kJ/m³°C (c.40 BTU/cu.ft °F) used in Circular 790. Differences of heat capacity between different types of well-consolidated rock are fairly small, and much smaller than other uncertainties in the generation estimate.

2.2.2 Rejection Temperature (T_0)

A default value of 59°F (15°C) is applied, unless there is specific knowledge of the local mean annual air temperature.

2.2.3 Utilization Factor (e)

Utilization factor (e) represents the efficiency of power generation at a given power plant in converting theoretically available work to actual electrical energy. The value of e can

Hetch Hetchy/SFPUC Programmatic Renewable Energy Project

Project: 1.3 New Geothermal Site Identification and Qualification

Project Team: GeothermEx, Inc.

Task: 1.3.10 Final Project Report

Subject: D.1.3.10.3 Final Report

vary considerably, from about 0.2 to about 0.5, depending on many factors that include the efficiency of the basic power plant design, the resource temperature, the concentration of dissolved gases in the reservoir fluid, and the condition of plant maintenance. For example, the value of an air-cooled binary plant will be lower than a water-cooled binary plant. The exact efficiency of a given plant is often difficult to determine without a detailed knowledge of historical plant and resource performance, and the efficiency of a proposed plant (not yet in operation) is subject to the claims of manufacturers and designers that may be less than fully documented. In addition, the efficiency of a plant may change with time during operations. General examples are included in Circular 790.

Because of these uncertainties, a default value of e is applied. Circular 790 used a value of 0.4, but we believe that advances in plant efficiency since the publication of Circular 790 justify a default value of 0.45, which is used herein.

2.2.4 Plant Capacity Factor (F)

A value of 0.90 is used, which is reasonably typical of modern geothermal plants that are well-maintained and operated.

2.2.5 Power plant life (L)

All cases herein assume a power plant (and project) life of 30 years.

Table III-1: Physical characteristics of producing geothermal fields

A. Areas with no volcanic heat source

Project ID	Name	Depths of Major Permeable					
		Zones (ft) ¹		Thickness(ft) ²		Temperature (°F) (initial conditions)	
		min	max	min	max	avg ³	
BEO00	Beowawe	6700	9600	2900	420	420	420
BRA00	Brady's Hot Springs	1000	5500	4500	340	390	365
DES00	Desert Peak	2500	4200	1700	390	419	405
DIX00	Dixie Valley	5600	9500	3900	402	478	440
EMP00	Empire	1700	3700	2000	305	306	306
FIS00	Fish Lake Valley	5000	10000	5000	360	390	375
HON01-03	Honey Lake - all projects	1300	5300	4000	223	250	237
RYE01	Rye Patch - Humb. District (Rye Patch)	1900	4000	2100	260	405	333
SOD00	Soda Lake	1000	4000	3000	360	375	368
STI01-02	Stillwater	1000	3000	2000	320	360	340
WAB00	Wabuska	2000	4000	2000	220	227	224
Average of 11 resources		2700	5709	3009	327	365	346
Standard Deviation		1966	2532	1111	66	72	66
Median				2900			365

B. Areas with Identified or possible volcanic heat source

Project ID	Name	Production Zone		
		Temperature (°F) (initial conditions)		
		min	max	avg
COS00	Coso	392	650	521
LVC00	Long Valley - Casa Diablo (Mammoth Pacific Field)	320	355	338
STE01-03	Steamboat H.S. - all Lower Steamboat projects	320	340	330
STE04	Steamboat H.S. - Yankee/Caithness project	434	480	457

1. Production zones and permeable hot injection zones (significantly shallower or cooler injection zones not included).
2. This thickness is the simple difference between min and max depth and may not be equal to the most-likely reservoir average thickness used in the calculation of the project's estimated generation capacity.
3. This average is the simple mean between the min and max and may not be equal to the most-likely reservoir average temperature used in the calculation of the project's estimated generation capacity.

Appendix IV

Methodology of Estimating Exploration and Confirmation Costs

Hetch Hetchy/SFPUC Programmatic Renewable Energy Project

Project: 1.3 New Geothermal Site Identification and Qualification

Project Team: GeothermEx, Inc.

Task: 1.3.10 Final Project Report

Subject: Deliverable 1.3.10.3 Final Report

APPENDIX IV

**METHODOLOGY OF ESTIMATING
EXPLORATION AND CONFIRMATION COSTS**

1. INTRODUCTION

Exploration and confirmation costs are estimated for every geothermal project in the database that has a corresponding estimation of generation capacity.

1.1. Exploration Background

In the context of this study, exploration encompasses all activities up to and including the site selection for drilling either: A) the first deep, full-diameter confirmation well (projects in Exploration-Development Category C or D) or; B) a first additional production well (projects in Exploration-Development Category A or B). In some other contexts, the first well might be termed an "exploration well," but herein, all deep, full-diameter drilling is part of confirmation and development.

An exploration cost estimate is not made if a project area is considered adequately explored to enable a well to be sited. This includes most Category A projects, and some Category B projects. "Adequately explored" means that exploration has been carried out and the data and information obtained are likely to be available in some combination of the public and private domains.

There are numerous Category B to D projects which have explored by private developers, but for which the amount and quality of past exploration (including adequate documentation) remains relatively uncertain because much of the information remains in private hands. In such cases, we have chosen to estimate that new exploration work must be done. Although privately held exploration data may be available for purchase, we have not attempted to estimate such purchasing costs, but rather estimate the costs of a new exploration program.

The program components and unit costs of the estimated exploration projects are discussed below.

1.2. Confirmation Background

In the context of this study, confirmation comprises successfully demonstrating, at the wellhead, 25% of the previously unconfirmed but estimated overall generation capacity of the resource. This is done by drilling and testing deep, full-diameter wells designed for production.

Based on GeothermEx's experience, 25% is about the amount of proven wellhead capacity that is likely to be required by a bank before it will provide credit for complete field development and power plant design and construction. (Some banks may require

Hetch Hetchy/SFPUC Programmatic Renewable Energy Project
Project: 1.3 New Geothermal Site Identification and Qualification

Project Team: GeothermEx, Inc.

Task: 1.3.10 Final Project Report

Subject: Deliverable 1.3.10.3 Final Report

higher or lower percentages based on field-specific risk factors.) In estimating the confirmation costs, it is assumed that a certain percentage of holes drilled will not be successful producers (the dry hole fraction; see below), and a reservoir study that confirms the likely total capacity is also included.

Lender's likely requirements for injection capacity are typically less predictable than requirements for production capacity, but injection capacity is considered, particularly when only one production confirmation well is expected to be required. In such cases, it is usually estimated that a second well must be drilled, unless there are existing holes that might be used for reservoir- and well-testing purposes. In some cases, "existing holes" may include ID (Intermediate-Depth) slim holes (see below) drilled already or planned during exploration.

Confirmation costs are estimated for both the Minimum (Min) Generation Capacity Estimate (Monte-Carlo 90% probability) and Most-Likely (Mlk) Generation Capacity Estimate (Monte-Carlo modal estimate). For some Category A projects the Min Capacity Estimate is smaller than current production, and in such cases no confirmation cost is estimated for that Capacity value.

2. PROGRAM COMPONENTS AND UNIT COSTS

The exploration and confirmation program components and unit costs for each component are listed and described in Table IV-1. The unit costs listed therein are used as a starting point for program cost estimation. To accommodate differences among the various geothermal projects, all exploration unit costs and some confirmation unit costs may be adjusted within a particular cost estimate, by applying cost adjustment factors (Appendix V is an example).

2.1. Exploration Program Components

The exploration program components (Table IV-1) are those considered to be most likely useful for evaluating the resource, constructing a conceptual model, and siting a confirmation well.

By far, the most expensive exploration component is ID slim-hole drilling. In the context of exploration costs this refers to a hole that is drilled to approximately 2,000 ft (occasionally less), which is not designed for commercial production, but which is drilled with blowout prevention equipment and designed with casing to stabilize the hole to permit injection testing and (in a few instances) limited production testing¹. Such a hole is typically drilled to obtain a combination of information on geology, temperature and

¹ This definition is somewhat more restricted than the definition applied to ID slim hole within the database of resource characteristics (see Final Report chapter 7 (Glossary) and the Abbreviations & Definitions button on the Projects screen of the PRP Geothermal Database).

Hetch Hetchy/SFPUC Programmatic Renewable Energy Project

Project: 1.3 New Geothermal Site Identification and Qualification

Project Team: GeothermEx, Inc.

Task: 1.3.10 Final Project Report

Subject: Deliverable 1.3.10.3 Final Report

permeability. The cost of testing an ID slim hole is included in the exploration program when it is deemed reasonably likely that permeability will be encountered at a commercially interesting temperature.

The estimated basic unit (per foot) cost of drilling an ID slim hole is about 10 times that of drilling a simple temperature gradient hole (restricted in the exploration programs to 500 ft), and about one-half the cost of drilling a full-diameter production hole. Because ID slim holes are relatively expensive yet cannot be used for commercial production, there has been little consistency in the historic use of ID slim-hole drilling. Some developers have chosen to skip ID slim holes entirely, and proceed directly to full-diameter drilling. The historic trend of geothermal exploration has been to increasingly include ID slim holes, as a way to reduce initial exploration/confirmation risk at the potential expense of higher eventual overall cost, so the bias herein is to include ID slim holes in the exploration programs.

The second most expensive exploration component is a magneto-telluric (MT) or direct-current (DC) resistivity survey. It has been GeothermEx's experience that these surveys have mixed success in aiding the siting of ID slim holes and deep full-diameter holes at the small- to moderate-sized resources of Nevada and California (greater success has been found at larger resources hosted by young volcanic systems). Accordingly, these surveys are included in only a few projects, where there is already a relatively confident indication of high temperature and generation capacity, which reduces the risk associated with the substantial expense of this geophysical method.

2.2. Confirmation Program Components

The confirmation program is basically a combination of deep, full-diameter drilling with testing, reporting, administration and regulatory costs (see Table IV-1).

Total drilling costs for confirmation are estimated using the formula that relates well cost to total well depth (Table IV-1 and Final Report section 3.3). This cost includes road and pad construction, mobilization, drilling, mud logging, temperature logging, geophysical logging and a short flow or injection test with the drilling rig still on the hole (rig test).

Total drilling cost is thus a product of (cost/depth) times (average depth/well) times (expected total number of wells required):

1. Average depth/well is calculated as the sum: (most-likely average depth to top of reservoir) + (most-likely average reservoir thickness) - 500 ft. These thicknesses are included in the reservoir physical properties section of the PRP Geothermal Database.

If a project's most-likely (Mlk) value is not listed, then the average of minimum (Min) and maximum (Max) values is used. It should be noted that this estimate provides for drilling to nearly the bottom of the reservoir, and some wells will be

Hetch Hetchy/SFPUC Programmatic Renewable Energy Project

Project: 1.3 New Geothermal Site Identification and Qualification

Project Team: GeothermEx, Inc.

Task: 1.3.10 Final Project Report

Subject: Deliverable 1.3.10.3 Final Report

successful at shallower depths. A lesser thickness is not used for cost estimation because many wells need to penetrate multiple permeable zones, and some wells may be shallower, but deviated. When depth-to-top is unknown, a default value of 2700 ft is substituted: this is the average depth to uppermost permeability among 11 geothermal systems in Nevada².

2. Expected total number of wells is a function of:

- a. MW sought (size of project). This is equal to the Estimated Generation Capacity (the Monte-Carlo Min or Monte-Carlo Mlk value) minus any existing generation capacity (MW currently being produced).

- b. Expected MW/well. This is calculated from average reservoir temperature and well productivity (MW) as a function of temperature (see Final Report section 3.3.2 and Table IV-1).

Average temperature is the Mlk estimated average value if one is listed under reservoir physical properties. Otherwise, the average of Min and Max estimated average temperatures is used. If a given project is likely to have a different MW/well value, an adjustment is made using the drilling cost factor.

- c. A standard unsuccessful hole factor of 40% (60% of confirmation holes successful as commercially viable production wells; 40% dry or otherwise unsuccessful). See below and Table IV-1.

- d. The requirement (described above) that 25% of the wellhead power capacity sought be confirmed by successful drilling. At a few projects some of this capacity has already been confirmed (successful production wells drilled but not in use).

The unsuccessful hole factor is a parameter that is difficult to predict for any individual project. Historical experience at geothermal projects in California and Nevada has included a very wide range of unsuccessful hole factors, which has varied partly in relation to the difficulty of finding adequate permeability and/or temperature at depth, and partly in relation to historical context. At many projects that were started in the 1960s and 1970s there was a considerable amount of drilling that was done with limited geothermal drilling experience and relatively little geotechnical support for well siting. Some of the wells drilled were unsuccessful, and in some cases this was due to lack of drilling experience. Other

² See Appendix III, Table III-1. The Nevada average is used because the project areas that need assignment of a default value are all in Nevada (with one exception: Superstition Mountain in the Imperial Valley of California).

Hetch Hetchy/SFPUC Programmatic Renewable Energy Project

Project: 1.3 New Geothermal Site Identification and Qualification

Project Team: GeothermEx, Inc.

Task: 1.3.10 Final Project Report

Subject: Deliverable 1.3.10.3 Final Report

holes, although successful, were never used because the binary technology needed to exploit moderate temperature resources was not yet available. Accordingly, many of these holes were eventually abandoned unused, and many would not be drilled in the context of a project started in year 2003. Reasons for abandonment are not always clear, and it is not possible to simply ignore all of the early drilling experience, because the results of these early holes helped to guide the siting of subsequent holes.

To approach the question of an appropriate unsuccessful hole factor, we have compiled historical drilling information from the public domain into Table IV-2 (Totals of full-diameter, production and injection wells at geothermal projects in California and Nevada). These data show that if the sum of total available (active and idle) production (P) and injection (I) wells at a project is divided by the number of full-sized wells drilled (T), the result $(P+I)/T$ has ranged from about 0.3 to 1.0, and the historical average $(P+I)/T$ is about 0.65. When experience is considered and the total T is adjusted to a best estimate for each project if developed in year 2003, the adjusted $(P+I)/T$ becomes 0.5 to 1.0, with an average of about 0.8.

This suggests that about 80% of all holes drilled will be successful as production or injection wells, and 20% will not be successful. A separate value for production wells only has not been estimated in Table IV-2, because there is no way (without much more detailed information) to know which injection wells are converted or unsuccessful (dry or cool) producers, and which were drilled only for injection.

The 80% overall success rate suggests that a 60% success rate for production wells during the confirmation phase is probably reasonable, because confirmation drilling is based on very limited data about the deep resource, and the reservoir information gathered during confirmation later leads to the higher overall success rate of combined confirmation and development.

3. DISCLAIMER

It is emphasized that the exploration and resource confirmation programs herein are not necessarily the ones that will be followed by geothermal developers, since every developer brings its own experience and bias to the exploration/confirmation process. Additionally, the estimated costs are only approximate, since real program costs can vary significantly from area to area and time to time, due to economic factors that may be out of the control of any given project. Drilling costs, for example, vary historically with the amount of competing activity at other projects and the availability of drilling rigs. However, the programs and estimated costs herein are believed to be reasonable.

Hetch Hetchy/SFPUC Programmatic Renewable Energy Project
Project: 1.3 New Geothermal Site Identification and Qualification
Project Team: GeothermEx, Inc.
Task: 1.3.10 Final Project Report
Subject: D.1.3.10.3 Final Report

Table IV-1: Unit Costs and Other Factors for Exploration and Confirmation

Phase Method	Unit	Cost per unit	Comment
Exploration			
Drilling: ID slim hole(s)	foot	\$140.00	Based on recent experience in Nevada. The cost may be as low as \$100/ft if drilling is easy (as in poorly consolidated sediments) and a rig is available locally, to \$200/ft if drilling is difficult and mobilization costs are high. For the exploration associated with a given project area and with the goal of developing several 10s of MW, a developer would be unlikely to spend more than \$600 - \$1000K on ID Slim holes. Accordingly, the number of holes and estimated footage to be drilled is limited to not exceed this range. This cost includes mobilization. Access (roads and pads) to the drill site(s), and temperature logging are separate items.
Drilling: ID Slim hole(s): roads and pads	well	\$50,000.00	May be much less on flat topography
Drilling: ID Slim hole(s): temperature logs	well	\$5,000.00	Most of the cost is mobilization, so decreases with an increasing number of holes to be logged.
Drilling: TG hole(s)	foot	\$15.00	Based on past experience in Nevada. The cost may be as little as several thousand dollars per 500 ft hole (about \$5/ft) to \$25-\$50/ft, depending upon the difficulty of drilling and access. Includes mobilization, access (roads/skidding/pads) and the cost of temperature logging.
Geochemistry surveys	project	\$30,000.00	Approximate lumped cost for a selected combination of spring/well water, spring/well gas, soil gas (helium or radon) and soil mercury surveys for the (new or additional) exploration of an area where the amount of existing fluids chemistry data and information is small. Any one of these surveys is likely to cost \$10,000-\$20,000 and doing more than two is likely to be difficult to justify. Many exploration sites, after initial reconnaissance (assumed already done) and especially in dry lands areas, will have only a few springs and wells of interest. Spring and well data can be very useful. Soil gas and soil mercury have historically yielded minimally useful results.
Geology: field mapping	project	\$20,000.00	Cost of field mapping in sufficient detail to assist well siting. May be much less depending upon amount of existing data and extent of rock exposures.

Phase Method	Unit	Cost per unit	Comment
Geophysical survey: gravity	project	\$25,000.00	Often very useful to assist well siting. Generally considered to be cost-effective.
Geophysical survey: ground magnetics	project	\$12,500.00	Generally considered to be cost-effective although results do not always have a clear interpretation.
Geophysical survey: MT or DC resistivity	project	\$200,000.00	Based on about 200 stations at a cost of \$1,000/station. Includes reporting and modeling of the results. Generally, a survey requires 50 to 200 stations to yield enough information to be useful and allow the calculation of a resistivity model. MT includes related techniques (TDEM, CSAMT, AMT).
Other	project	\$10,000.00	Default cost allows for minor data collection. Other surveys may be considered and added to this category. Includes: a) seismic surveys (active reflection and refraction and passive monitoring) b) hydrologic surveys c) self-potential (SP) surveys, and d) 1-meter soil temperature surveys.
Well Test: ID slim hole, 3-10 days	well	\$40,000.00	Usually an injection test. Rarely a flow test. The common cost range is \$30,000 - \$50,000.
Administration	project		Standard cost: 10% of all other exploration costs
Reporting-Doc: data integration/study/model	project		Standard cost: 10% of all other exploration costs except administration
Confirmation			
Drilling: 'full' diameter hole(s)	foot		Cost per foot is calculated using the formula that relates well cost to total well depth. See final report section 3.3 and Table 6. This cost includes drilling, mud logging, temperature logging, geophysical logging, mobilization and road and pad construction. Cost in \$ = $240,785 + 210^*(\text{depth in feet}) + 0.019069^*(\text{depth in feet})^2$. Adjustments for special cases are handled using the drilling cost factor or the Other Cost component.
Drilling: Hole Productivity	°F		Hole productivity (used in the estimation of total feet to be drilled) is estimated using the formula that relates well productivity to resource temperature. See final report section 3.3 and Table 6. MW/well = (average reservoir temperature in °F)/50 – 3.5. This relationship is very approximate, and adjustments are made for individual projects using the drilling cost factor.
Drilling: Unsuccessful hole factor	%		A standard unsuccessful hole factor of 40% (60% of confirmation holes successful as commercially viable production wells; 40% dry or otherwise unsuccessful). See Appendix IV.
Other	project	\$20,000.00	Default cost allows for other data collection and contingencies. A re-visit to exploration surveys may be considered and added to this category, to assist on-going well siting.

Phase Method	Unit	Cost per unit ⁽¹⁾ Comment
Well Test: full diameter hole, 3-10 days	well	\$70,000.00 Each successful deep hole is assumed to require a test.
Well Test: multi-well field test, 15-30 days	project	\$100,000.00 Each successful confirmation project is assumed to require a test, which may include reservoir interference measurements in both production and injection wells. The cost may vary from about \$100,000 to \$200,000, depending upon the number of wells.
Administration	project	Standard cost: 7.5% of all other confirmation costs
Regulatory compliance	project	Standard cost: 5.0% of drilling. Includes permitting and environmental compliance (the cost of which may be highly variable, depending upon local conditions and regulations).
Reporting-Doc: data integration/study/model	project	Standard cost: 5.0% of drilling costs. Includes data compilation, integration, interpretation and the preparation of a bankable report.

(1) These costs per unit serve as an initial guide for developing exploration and confirmation program cost estimates. When the estimates are made, all exploration unit costs and most confirmation unit costs may be adjusted by applying a cost adjustment factor.

Table IV-2: Totals of full-diameter, production and injection wells at geothermal projects in California and Nevada¹

PROJID	Dist/ Area/ Field	Area/ Power Plant	P P A re a y	Installed MW			MW Produced (year)	Plant Technology	Total Drill (T)	Production (P)		Injection (I)		P+I ²	Active I/P	(P+I)/T	(P+I)/T ³	Adj. (P+I)/T ⁴	Comment
				St.	gr	net				Tot.	Act.	Tot.	Act.						
BEO00	Beowawe		1	NV	16.7	16	15 (1998)	Dual Flash	17	3	3	2	1	5	0.33	0.29	0.56	Total drilled (from Figure BEO00-1) includes many wells drilled very early. Adjusted (P+I)/T assumes total of 9.	
BRA00	Brady's Hot Springs		1	NV	26	20	15.0 gr (2000)	Dual Flash + Binary	39	11	7	9	9	20	1.29	0.51	0.77	Adjusted (P+I)/T assumes total of 26.	
COS00	Coso	Field-wide Summary	4	CA	300	270	281 (2001)	Dual Flash	153	84	84	32	31	116	0.37	0.76	0.94	T includes c.30 abandoned producers and injectors and about 8 "non-commercial" wells. Adjusted (P+I)/T assumes total of 124.	
DES00	Desert Peak		1	NV	11	9.9	9.9 (2000)	Dual Flash	7	3	2	1	1	4	0.50	0.57	0.67	Adjusted (P+I)/T assumes total of 6.	
DIX00	Dixie Valley	Caithness Dixie Valley	2	NV	62	56	66+(2000)	Single Flash	25	9	7	10	10	19	1.43	0.76	0.76		
EAS00	East Mesa	Field-wide summary	4	CA	73	56	49.7	Cooled(N1)	104	45	35	51	44	96	1.26	0.92	0.92		
EMP00	Empire (San Emidio)	Field-wide summary	1	NV	4.8	4.6		Binary	25	3	3	8	3	11	1.00	0.44	0.69	Adjusted (P+I)/T assumes total of 16.	
FIS00	Fish Lake (Valley)		2	NV					5	2	2								
GEY00	Geysers	Field-wide Summary	4	CA	1000	900	850 (c.2002)	Dry Steam		424		43		467		0.10			
HEB01	Heber	Heber (HGC)	4	CA	52	47		Dual Flash	42	11	11	10	10	21	0.91				
HEB02	Heber	Second Imperial Geoth. (SIGC)	4	CA	48	32		Binary	26	11	11	15	11	26	1.00			Adjusted (P+I)/T assumes a total of 56.	
HON01	Honey Lake	Amedee	1	CA	3.2	1.5	0.75 net (2002-3)	Binary-Water Cooled	5	2	2			2	0.00	0.40	0.67	(P+I)/T-adjusted assumes total of 3	
HON02	Honey Lake	Wendel/Mineagle	1	CA	0.7	0.4	0.4 net	Binary-Water Cooled	2	1	1			1	0.00	0.50	0.50		
HON03	Honey Lake	Wendel/Honey Lake Power	1	CA	2.5	1.5		Hybrid	3	2	1	1	1	3	1.00	1.00	1.00		
LAK00	Lake City / Surprise Valley	Lake City	4	CA					5	1									
LVC00	Long Valley - Casa Diablo	MP Field Summary	4	CA	40	30.1		Binary-Air Cooled	c.28	12	8	7	5	19	0.63	0.68	0.86	(P+I)/T-adjusted assumes total of 22.	
MED02	Medicine Lake	Telephone Flat	4	CA				Dual Flash	4	3				3	0.75	0.75	0.75	Unknown whether the NC/Dry hole(s) could be used for injection.	
NIL00	Niland		4	CA					5	3									
RYE01	Rye Patch-Humboldt House District	Rye Patch	1	NV					11	6?								Several producers may be marginal and several NC/Dry may be suitable for injection.	
SAL00	Salton Sea	Field-wide summary	4	CA	335	326	340+	Dual Flash	103		31	26		57	0.84	0.55	0.90	T does not include many sidetracks and re-drills, does include some early exploration wells and many production wells abandoned and replaced with newer titanium casing. Adjusted (P+I)/T assumes total of 63.	
SBK00	Sulphur Bank	Clear Lake	4	CA					5	1									
SOD00	Soda Lake	Soda Lake No.1/No.2	1	NV	28.1	16.8	10 net (2000)	Binary-Air Cooled	c.25	5	5	5	5	10	1.00	0.40	0.67	(P+I)/T-adjusted assumes total of 15.	
STE01	Steamboat Hot Sprs	Lower SB: Steamboat I-1A	1	NV	9.2	7.1	2.23 (2001)	Binary-Air Cooled	18	12	11	6	6	18	0.55	1.00	1.00		
STE05	Steamboat Hot Sprs	Upper SB: Yankee-Caithness	1	NV	14.4	13	14.44 (2000)	Dual Flash	c.8	6	3	1	1	7	0.33	0.88	0.88		
STI00	Stilwater	Stilwater Geothermal 1	1	NV	19	10	7.5 net (2000)	Binary-Air Cooled	c.16	7	4	5	3	12	0.75	0.75	0.86	(P+I)/T-adjusted assumes total of 14.	
STI01	Stilwater	Stilwater N Expansion	1	NV					3	3									
WAB00	Wabuska		1	NV	1.45	1.2	1.2 (2000)	Binary	c.5	1	1			1	0.00	0.2	0.5	(P+I)/T-adjusted assumes total of 2.	

Averages 0.66 0.63 0.77 Average of all data entries BEO00 through WAB00.
 Average all projects with injection (except Geysers) 0.82 0.68 0.82
 Average flash plants 0.75 0.63 0.79
 Average binary plants (excluding plants without injection) 0.93 0.67 0.82

Notes:

- 1) Data in this table have been compiled from the Hetch Hetchy / SFPUC Programmatic Renewable Energy Project geothermal database, of which this table is a part. Source documents for the data in this table are contained therein.
- 2) Sum of total P and I wells, if available, otherwise, sum of active P and I wells.
- 3) Total wells drilled often includes holes drilled in the 1960s - 1970s which were questionably sited and/or designed, or drilled before field development was economically or technically possible. Adjusted (P+I)/T reflects an adjustment of T to a value that is believed likely at the same project if it were started in year 2003, in the context of contemporary exploration/confirmation and development technology and economics.

Appendix V
Exploration, Confirmation and Development Costs –
Detail by Project
(example)

Hetch Hetchy/SFPUC Programmatic Renewable Energy Project
 Project: 1.3 New Geothermal Site Identification and Qualification
 Project Team: GeothermEx, Inc.
 Task: 1.3.10 Final Project Report
 Subject: D.1.3.10.3 Final Report

**Appendix V:
 Exploration, Confirmation and
 Development Costs - Detail by
 Project (example)**

Exploration, Confirmation and Development Costs - Detail by Project

MW installed: -gr -net
 MW produced (yr):
 Start Date (Yr):

PROJID
 Name - District/Area/Field
 Name - Area / Power Plant
 State PRP Area:
 County

Exploration Program⁽¹⁾

<i>Method</i>	<i>Unit</i>	<i># of Units</i>	<i>Std. Cost/unit</i>	<i>Cost Adjustment Factor</i>	<i>Cost</i>	<i>Comment</i>
Drilling: ID slim hole(s)	foot	4000	\$140	1.0	\$560,000	Two holes to 2000 ft each
Drilling: TG hole(s)	foot	2500	\$15	1.0	\$37,500	Five holes to 500 ft each, to better define the heat anomaly between the Aurora hole and the hot area at Borealis mine.
Drilling: ID Slim hole(s): roads	well	2	\$50,000	0.5	\$50,000	
Drilling: ID Slim hole(s): tempe	well	2	\$5,000	1.0	\$10,000	
Geology: field mapping	project	1	\$20,000	1.0	\$20,000	May be less if Phillips data can be obtained.
Geophysical survey: gravity	project	1	\$25,000	1.0	\$25,000	May be less if Phillips did survey and data can be obtained.
Geophysical survey: ground m	project	1	\$12,500	1.0	\$12,500	May be less if Phillips did survey and data can be obtained.

<i>Subtotal:</i>	<u>\$715,000</u>
<i>Reporting-Documentation:</i>	<u>\$71,500</u>
<i>Administration:</i>	<u>\$71,500</u>
<i>Exploration Total:</i>	<u>\$858,000</u>

Confirmation Program for Minimum (90% Probable) Estimated Capacity (2)

Estimated Capacity	31 MW	Cost Factor: Drilling	1.0	Total Drilling:	\$8,748,000	Comment
Wellhead MW in use	. MW	Cost Factor: Well Test(s)	1.0	Well Tests:	\$140,000	
Wellhead MW unused	. MW	Cost Factor: Field Test	1.0	Field Test:	\$100,000	
Additional MW needed	31. MW			Other Cost(s):	\$0	
Need To Confirm	7.8 MW			Regulatory:	\$437,000	
Expect/well	3.4 MW			Reporting:	\$437,000	
Expect to drill	4 wells			Administration:	\$740,000	
Expected TD/well	6000 ft					
Expected Cost/well	\$2,187,000					

Estimated Total Confirmation Cost : \$10,602,000

PROJID: AURO0

Confirmation Program for Most-likely (Modal) Estimated Capacity (2)

Estimated Capacity	51 MW	Cost Factor: Drilling	1.0	Total Drilling:	\$13,122,000	Comment
Wellhead MW in use	. MW	Cost Factor: Well Test(s)	1.0	Well Tests:	\$280,000	
Wellhead MW unused	. MW	Cost Factor: Field Test	1.0	Field Test:	\$100,000	
Additional MW needed	51. MW			Other Cost(s):	\$0	
Need To Confirm	12.8 MW			Regulatory:	\$656,000	
Expect/well	3.4 MW			Reporting:	\$656,000	
Expect to drill	6 wells			Administration:	\$1,111,000	
Expected TD/well	6000 ft					
Expected Cost/well	\$2,187,000					

Estimated Total Confirmation Cost : \$15,925,000

PROJID: AURO0

Development Program for Minimum (90% Probable) Estimated Capacity (3)

Estimated Capacity	31 MW	Plant + Gathering System (On-Site Capital)	Comment	PROJID: AUR00
Drilling (well) Cost:		<i>Existing plant</i>	.0 MW	
<i>In use at wellhead</i>	. MW	<i>New Plant</i>	31.0 MW	
<i>Unused at wellhead</i>	. MW	<i>On-site Unit Cost</i>	\$ 1,500 /kW	
<i>Confirmation plan</i>	7.8 MW at wellhead	<i>Total On-site Capital</i>	\$46,500,000	
<i>Development drilling plan</i>	24.8 MW for 105% at wellhead			
<i>Expect/well</i>	3.4 MW	Other:		
<i>Production need (P)</i>	7 wells	<i>Other Development Cost</i>	\$0	
<i>Injectors/Producers</i>	0.95	Subtotal all On-Site Costs:		
<i>Injection need (I)</i>	7 wells	<i>Total Site Development</i>	\$85,866,000	
<i>P+I success rate</i>	0.80	Transmission Line:		
<i>Expect to drill total</i>	18 wells	<i>Line Cost (unit or tot.):</i>	\$268,000	Transmission Line Comment:
<i>Expected TD/well</i>	6000 ft	<i>Cost Factor (1 or tot.):</i>	2.0	Cost Factor = about 2 miles to an existing 55-69 kV transmission line.
<i>Expected Cost/well</i>	\$2,187,000	<i>Total Trans Ln:</i>	\$536,000	
<i>Cost Factor</i>	1.0			
<i>Dev. Drilling</i>		Total Development Cost:		
Total Dev. Drilling	\$39,366,000		\$86,402,000	

Development Program for Most-likely (Modal) Estimated Capacity (3)

Estimated Capacity	51 MW	Plant + Gathering System (On-Site Capital)	Comment	PROJID: AUR00
Drilling (well) Cost:		<i>Existing plant</i>	.0 MW	
<i>In use at wellhead</i>	. MW	<i>New Plant</i>	51.0 MW	
<i>Unused at wellhead</i>	. MW	<i>On-site Unit Cost</i>	\$ 1,500 /kW	
<i>Confirmation plan</i>	12.8 MW at wellhead	<i>Total On-site Capital</i>	\$76,500,000	
<i>Development drilling plan</i>	40.8 MW for 105% at wellhead			
<i>Expect/well</i>	3.4 MW	Other:		
<i>Production need (P)</i>	12 wells	<i>Other Development Cost</i>	\$0	
<i>Injectors/Producers</i>	0.95	Subtotal all On-Site Costs:		
<i>Injection need (I)</i>	11 wells	<i>Total Site Development</i>	\$139,923,000	
<i>P+I success rate</i>	0.80	Transmission Line:		
<i>Expect to drill total</i>	29 wells	<i>Line Cost (unit or tot.):</i>	\$268,000	Transmission Line Comment:
<i>Expected TD/well</i>	6000 ft	<i>Cost Factor (1 or tot.):</i>	2.0	Cost Factor = about 2 miles to an existing 55-69 kV transmission line.
<i>Expected Cost/well</i>	\$2,187,000	<i>Total Trans Ln:</i>	\$536,000	
<i>Cost Factor</i>	1.0			
<i>Dev. Drilling</i>				
Total Dev. Drilling	\$63,423,000	Total Development Cost:	\$140,459,000	

Summary of Total Exploration + Confirmation + Development Cost

PROJID: AUR00

	<u>GENERATION ESTIMATE</u>	
	<u>Minimum (90% Probable)</u>	<u>Most-likely (Modal)</u>
<i>Resource Capacity Estimate:</i>	31.0 MW	51.0 MW
<i>Estimate exceeds current used + excess proven wellhead capacity by:</i>	31.0 MW	51.0 MW
<i>Estimate exceeds current power plant generation capacity by:</i>	31.0 MW	51.0 MW
<i>Net new development:</i>	31.0 MW	51.0 MW

COST ESTIMATES TO EXPLORE, CONFIRM AND DEVELOP TO ESTIMATED RESOURCE CAPACITY

<i>Total Exploration:</i>	\$858,000	\$858,000
<i>Total Confirmation:</i>	\$10,602,000	\$15,925,000
<i>Total Exploration + Confirmation:</i>	\$11,460,000	\$16,783,000
<i>Total Site Development:</i>	\$85,866,000	\$139,923,000
<i>Total Exploration + Confirmation + Site Development:</i>	\$97,326,000	\$156,706,000
<i>Transmission Line:</i>	\$536,000	\$536,000
<i>Total Exploration + Confirmation + Site Development + Transmission:</i>	\$97,862,000	\$157,242,000

NOTES:

(1),(2) See definitions of terms and headings in Appendices III, IV and VI.

(2) Estimated Capacity is the total estimated generation capacity of the resource (Monte Carlo heat-in-place estimate Minimum or Most-likely value). Wellhead MW in use and unused are based on current production and/or the results of drilling and testing wells that are not in use. Additional MW needed is the difference between Estimated Capacity and the sum of Wellhead MW in use and unused. Need to Confirm is 25% of the expansion from current production to Estimated Capacity, minus wellhead MW proven but unused. It is likely that a lending institution will demand that this percentage be proven at the wellhead, before committing to loan funds for field development and power plant construction.

Expect/well is the expected average MW per successful production well, calculated as a function of resource temperature (see main report section 3.3 and Table IV-1 of Appendix IV).

Expect to drill is the number of wells planned to prove the Need to Confirm value, calculated from Expect/well and Need to Confirm, and assuming a success rate of 0.6.

Expected TD/well is the expected average well depth, calculated from most-likely average depth to top of reservoir, and most-likely average reservoir thickness (see database entries under Reservoir Physical Properties). If most-likely values have not been estimated, then then the average of estimated minimum and maximum is used.

Expected Cost/well is the expected cost for the expected TD, calculated as a function of depth (see main report section 3.3 and Table IV-1 of Appendix IV).

Drilling, Well Test and Field Test Cost Factors are adjustments that may be applied to local conditions, as explained under Comments.

Total Drilling Cost is the product of (Expect to Drill) * (Expected Cost/well) * (Drilling Cost Factor).

Well Tests Cost is the product (number of successful confirmation wells needed) * (standard cost of testing, as reported in Units Costs for Exploration and Confirmation) * (Well Test Cost Factor).

Field Test Cost is the cost of a medium to long-term multi-well field test, including pressure interference measurements, that is likely to be required by a lending institution.

Other Costs(s) may be included, and explained under Comments.

Regulatory, Reporting and Administration are standard percentages of other costs, as explained in Table IV-1 of Appendix IV.

(3) See definitions of terms and headings under note (2) above, and in Appendix VI.

Appendix VI

Methodology of Estimating Development Cost

Hetch Hetchy/SFPUC Programmatic Renewable Energy Project
Project: 1.3 New Geothermal Site Identification and Qualification
Project Team: GeothermEx, Inc.
Task: 1.3.10 Final Project Report
Subject: Deliverable 1.3.10.3 Final Report

APPENDIX VI

METHODOLOGY OF ESTIMATING DEVELOPMENT COST

1. BACKGROUND

For every project with an estimation of generation capacity, development cost is estimated as the sum of three components:

1. Drilling Cost
2. All other On-site Capital Costs, and
3. Transmission Line Cost.

2. DRILLING COST

The cost of development drilling (which includes well completion) is calculated using an approach similar to the cost of confirmation drilling (see Appendix IV), adjusted to account for the wellhead MW already confirmed, and for drilling injection wells.

Injection wells are not included in the confirmation estimate, as it is assumed that well tests can be conducted by injecting into other successful production wells, unsuccessful production wells and/or existing slim holes.

2.1. General Process

The process of development drilling cost estimation is as follows:

- Expected MW/well is estimated from reservoir temperature. (The relationship between temperature and productivity is described in the main report section 3.3.2, and also listed in Table IV-1 of Appendix IV.)
- Number of production wells needed (P) is estimated from MW/well and the total wellhead MW needed for development (including a 5% reserve), after subtracting the 25% of required wellhead capacity already demonstrated at the stage of project confirmation.
- All projects with an average reservoir temperature of 380°F or less are assumed to be binary, and projects with average reservoir temperature above 380°F are assumed to be flashed steam (except for The Geysers, which is assumed to be dry steam).
- Number of injection wells needed (I) is initially assumed to be 75% of production wells in the case of a flashed steam project, 95% of production wells in the case of a binary project, and 10% of production wells for The Geysers (dry steam). (This is based on data in Table IV-2 of Appendix IV, see section 2.2 below.) The ratio (I/P) can be changed for an individual project,

Hetch Hetchy/SFPUC Programmatic Renewable Energy Project

Project: 1.3 New Geothermal Site Identification and Qualification

Project Team: GeothermEx, Inc.

Task: 1.3.10 Final Project Report

Subject: Deliverable 1.3.10.3 Final Report

based on specific considerations, as described in the comments on development cost estimates (Table 10).

The I/P ratio is applied only to development drilling, *i.e.*, it is assumed that the confirmation program will have yielded enough injectivity that injection from successful confirmation holes later used as producers can be handled by other confirmation holes or other existing holes. This may cause the total number of needed injectors to be underestimated by up to 25% and the total number of development wells to be underestimated by up to about 12%. It is assumed that this is offset by the assumption of identical cost for production and injection wells (see section 2.3 below).

- The estimated total number of producers (P) and injectors (I) is corrected by a success rate $(P+I)/T$, where T is total wells drilled (see section 2.2 below). The default value of this ratio is set at 0.8 (also based on data in Table IV-2).
- Numbers of production, injection and total wells are calculated in sequence, and all interim and final residuals are rounded as follows:
 - i. all residuals < 0.5 are rounded down to the nearest lower integer value
 - ii. all residuals ≥ 0.5 are rounded up to the nearest higher integer value
 - iii. any value > 0 and < 1 gets rounded to 1.

For example: 3.3 producers is rounded to 3. At I/P = 0.95 this means 2.85 injectors, which is rounded to 3. At total success rate 0.8 this means 7.5 wells, which is rounded to 8.

- Production and injection wells are assumed to have identical depths and costs per well (see section 2.3 below). Average well depth is calculated from reservoir characteristics, and cost/well is calculated from depth. (Drilling cost/foot is described in the main report, section 3.3.1, and listed in Table IV-1 of Appendix IV.)
- A development drilling cost factor is applied, to correct for assumptions made that are likely to be inaccurate. For example, if MW/well based on temperature is 6 MW, but historic drilling results in the area indicate 3 MW, then the Cost factor is 2.0 (twice as many wells needed).
- Total development drilling cost is estimated as (total number of wells) * (cost factor) * (cost/well). The wells at some hypersaline fields in the Imperial Valley of California are assumed to need corrosion-resistant titanium casing, which is included later as a separate component of total development cost.

Hetch Hetchy/SFPUC Programmatic Renewable Energy Project
Project: 1.3 New Geothermal Site Identification and Qualification
Project Team: GeothermEx, Inc.
Task: 1.3.10 Final Project Report
Subject: Deliverable 1.3.10.3 Final Report

2.2. Production/Injection Well Ratio and Drilling Success Rate

Table IV-2 of Appendix IV is a compilation of historic well information from projects in the database, which shows that the ratio of active injection wells to active production wells ranges from as little as 0 at a few small projects where there is no injection, to 0.1 at The Geysers steam field, to as high as 1.3 at Bradys Hot Springs (Flash and Binary) and East Mesa (Binary) and 1.4 at Dixie Valley (Flash). The average of all projects with injection (excluding The Geysers) is 0.82, the average at flash steam projects is 0.75 and the average at binary plants (excluding plants without injection) is 0.93. Although the flash and binary averages are used in the development cost calculation, it is recognized that these averages have a very high standard deviation, and an adjustment is made for each individual project if information allows.

Table IV-2 also shows that if the sum of total available (active and idle) production (P) and injection (I) wells at a project is divided by the number of full-sized wells drilled (T), the result $(P+I)/T$ has ranged from about 0.3 to 1.0, and the average $(P+I)/T$ is about 0.65. When experience is considered and the total T is adjusted to a best estimate for each project if developed in year 2003, the adjusted $(P+I)/T$ becomes 0.5 to 1.0, with an average of about 0.8. This suggests that about 80% of all holes drilled at a project in year 2003 will be successful as production or injection wells, and 20% will not be successful. A separate value for production wells only has not been estimated in Table IV-2, because there is no way (without much more detailed information) to know which injection wells are converted or unsuccessful producers, and which were drilled only for injection.

The information in Table IV-2 suggests using 0.8 (80%) as the ratio of successful production and injection wells drilled to total wells drilled during field development. Strictly speaking, if the overall success rate is 80% and the success rate for confirmation of 25% of needed wellhead capacity is 60% (used for confirmation cost estimates, as explained in Appendix IV), then it follows that development drilling to 100% wellhead capacity should have a success rate of 86.67%, and development drilling to 105% wellhead capacity should have a success rate of 81.25%. We believe that 80% is a more reasonable default value for future projects where exploration has not even been completed, and an adjustment is made for each individual project if information allows.

2.3. Production and Injection Well Design and Drilling Cost

Injection wells are sometimes cheaper to drill than production wells, especially if shallower and/or designed with a less-expensive diameter and/or casing program. However, some wells used for injection are originally designed and drilled for production, some injection wells are deeper than corresponding production wells, and sometimes the success rate of injection well drilling is no better than the success rate of

Hetch Hetchy/SFPUC Programmatic Renewable Energy Project
Project: 1.3 New Geothermal Site Identification and Qualification

Project Team: GeothermEx, Inc.

Task: 1.3.10 Final Project Report

Subject: Deliverable 1.3.10.3 Final Report

production well drilling. Considering these uncertainties, it is assumed herein that the production wells and the injection wells are identical in terms of cost per well.

3. ON-SITE CAPITAL COSTS

On-site capital costs in addition to drilling and well completion include the costs of pumps for binary systems, water and/or steam gathering and disposal systems (including injection pumps but not injection wells), steam/water separation systems (flash plants only), the power plant, the local substation and transmission line connections (see section 4, below), pollution abatement systems (as needed), other infrastructure, surface facilities and civil works, land, regulatory and environmental compliance, other legal costs, engineering, all construction and assembly, permits, interest, administration, and initial system testing and start-up.

It is typical to consider the aggregate cost of all of these components, described simply as the cost of the power plant and gathering system, and the value used herein is US\$1,500/kW installed. This is multiplied times the difference between Estimated Generation Capacity in MW (resource capacity) and gross MW of existing installed plant capacity (if any).

The \$1,500/kW value is only approximate and has an uncertainty of about +25% or even more. It is based on data and information in a number of recent publications, which include Brugman and others (1996)¹, Entingh and McVeigh (2003), Entingh (1997), Fredriksens and others (2000), Gawlik and Kutscher (2000), Girelli and others (1995), Greider (1998), Hiriart and Andaluz (2000), Jenkins and others (1996), Liguori (1995), Miller (1996), Owens (2002), Stefansson (2002), Tiangco and others (1996) and Wheble and Islam (1995).

The development costs listed in these publications are not always compatible, because some describe or estimate only the cost of the power plant, others consider only a total capital cost that includes drilling and exploration, some appear to consider "plant" to include the gathering system, but are not specific about this, and only a few consider specifically the combination of plant + gathering system. In addition, very few clearly indicate that the local electrical substation (typical cost about \$60/kW) is included.

Entingh and McVeigh (2003) consider that the power plant (60%) and field piping (5%) are typically about 65% of total capital cost, and exploration, confirmation and development wells are about 35%. We consider this to be a reasonable breakdown, and using these percentages applied to cases of total development cost that includes drilling,

¹ The references cited herein are listed in the main report chapter 6, section 6.1. In the Access database they appear under All Other References (General Citations) and as the report entitled Section 6.1 General References.

Hetch Hetchy/SFPUC Programmatic Renewable Energy Project

Project: 1.3 New Geothermal Site Identification and Qualification

Project Team: GeothermEx, Inc.

Task: 1.3.10 Final Project Report

Subject: Deliverable 1.3.10.3 Final Report

some of the estimates of power plant and gathering system are as follows, sorted by increasing cost/kW (the various references cite dollar bases that range from about 1994 to 2003, but corrections for inflation are not included):

<u>Plant Type</u>	<u>Plant and Gathering System (US\$/kW)</u>	<u>Reference</u>	<u>Comment</u>
Single flash	\$872	Stefánsson (2002)	Plant, gathering system and exploration. Svartsengi, Iceland co-generation plant, (heat and electricity, 30 MW, constructed 1999) ¹
Single flash	\$970	Stefánsson (2002)	Plant, gathering system and exploration. Bjarnarflag, Iceland (detailed planning report, 40 MW, 1994) ¹
Single flash	\$1,039	Stefánsson (2002)	Plant, gathering system and exploration. Nesjavellir, Iceland co-generation plant (heat and electricity, 60 MW, constructed 1998) ¹
Single flash	\$1,040	Entingh and McVeigh (2003)	Calculated from total development
Single flash	\$1,047	Stefánsson (2002)	Plant, gathering system and exploration. Krafla, Iceland (detailed planning report, 40 MW, 1999) ¹
Single flash	\$1,150	Stefánsson (2002)	Plant, gathering system and exploration. Bjarnarflag, Iceland (detailed planning report, 20 MW, 1994) ¹
Dual flash	\$1,166	Tiangco and others (1996)	Calculated from plant average
Dual flash	\$1,170	Entingh and McVeigh (2003)	Calculated from total development
Binary	\$1,372	Owens (2002)	Calculated from total development

Hetch Hetchy/SFPUC Programmatic Renewable Energy Project
Project: 1.3 New Geothermal Site Identification and Qualification
Project Team: GeothermEx, Inc.
Task: 1.3.10 Final Project Report
Subject: Deliverable 1.3.10.3 Final Report

<u>Plant Type</u>	<u>Plant and Gathering System</u> (US\$/kW)	<u>Reference</u>	<u>Comment</u>
Dual flash	\$1,546	Tiangco and others (1996)	Calculated from total average
Binary	\$1,560	Entingh and McVeigh (2003)	Calculated from total development
Flash	\$1,564	Owens (2002)	Calculated from total development (flash type not specified)
Binary	\$1,836	Tiangco and others (1996)	Calculated from plant average
Single flash	\$1,837	Wheble and Islam (1995)	Calculated from plant, Leyte Philippines (180 MW)
Single flash	\$1,938	Wheble and Islam (1995)	Calculated from plant, Tongonan Philippines (120 MW)
Binary	\$1,940	Tiangco and others (1996)	Calculated from total average
Unspecified - maximum	\$2,012	Miller (1996)	Calculated from plant
Flash	\$2,270	Jenkins and others (1996)	Calculated from plant (flash type not specified)
Unspecified-minimum	\$2,513	Miller (1996)	Calculated from plant
Binary	\$3,372	Gawlik and Kutscher (2000)	Calculated from plant average. Estimates for 17 small (<1 MW) and very low temperature projects in the Western USA (185°F – 300°F, one 346°F)
Binary	\$3,475	Jenkins and others (1996)	Calculated from plant
1. The estimates of Stefansson (2002) include exploration, but no correction for the exploration component is attempted herein, because exploration is described as a "very small fraction" of the total investment costs of power plants larger than 5 – 10 MW.			

The large range of these estimates is obvious and due, in no small part, to severe limitations on the amount and detail of geothermal cost data that gets released to the

Hetch Hetchy/SFPUC Programmatic Renewable Energy Project
Project: 1.3 New Geothermal Site Identification and Qualification
Project Team: GeothermEx, Inc.
Task: 1.3.10 Final Project Report
Subject: Deliverable 1.3.10.3 Final Report
public domain from private developers in the USA (Entingh, personal communication, 25 September 2003).

The average of all \$/kW values in the table above, excluding the two highest, is \$1,500/kw, with a standard deviation of \$470/kw.

Entingh and McVeigh (2003) note that their estimates are lower than previous estimates, but cite evidence of large cost reductions in the past twenty years for both flash and binary technologies. The flash plants installed in the U.S. are typically dual flash, so the average \$1,500 /kW used herein can be compared with the Entingh and McVeigh (2003) dual flash value of \$1,170/ kW.

4. TRANSMISSION LINE COST

Transmission line costs are estimated on top of on-site capital development costs, as described in the following sections. In the case of an existing project where generation capacity is expanded, it is assumed that existing transmission lines can handle this expansion. The Salton Sea field of the Imperial Valley is an exception, for which major expansion and new transmission capability are estimated.

Each transmission line estimate is based on a single chosen alternative for connection to existing or new grid capacity. It is recognized that alternative connections may be available now or in the future, but an attempt to evaluate all of the available alternatives would be outside the scope of this investigation.

4.1. Area 1 (Greater Reno area of Nevada and California)²

Transmission line costs are based on estimates provided by Woodford (2003) (Electranix Corporation), listed as Woo03a in section 6.1 of the main report. Woodward (2003) assumes that sets of new geothermal, wind power and pumped storage projects are developed in several stages, and makes cost estimates for an integrated power delivery system (referred to herein as the Woodford grid) constructed to serve these sets of new projects. These estimates include 16 geothermal projects in Northern Nevada (Table VI-1; total 662 MW)³, plus two large wind farms (500 MW each) and one pumped storage facility (600 MW). The total estimates provided by Woodford (2003) represent the cost of connecting the new generation to the 1000-kV Pacific Direct-Current Intertie

² The geographic Areas are described in the body of the final report, section 2.4.

³ The geothermal MW values used by Woodford (2003) and listed in Table VI-1 are estimates that were contained in draft deliverables under Project 1.3 that have since been updated for this final report. The new total for the same 16 projects is 495 MW (most-likely estimate). It is assumed this change would not affect the transmission line cost estimates.

Hetch Hetchy/SFPUC Programmatic Renewable Energy Project

Project: 1.3 New Geothermal Site Identification and Qualification

Project Team: GeothermEx, Inc.

Task: 1.3.10 Final Project Report

Subject: Deliverable 1.3.10.3 Final Report

(PDCI, referred to elsewhere in the present report as the HVDC intertie). Schematic diagrams and a map of the Woodford grid are included in Woodford (2003).

Table VI-1 is a summary of the collection and delivery systems for the 16 geothermal projects alone, which has been developed by GeothermEx using the data in Woodford (2003). This includes common lines within the geothermal collection system (lines shared by more than one project), but not the collector lines from the wind farms and the pumped storage.

The local site substations at the 16 geothermal projects (Table VI-1) have per-kW costs that range from \$21 to \$186, with an average cost of \$57/kW (standard deviation \$44/kW). As explained in section 3 (above), this cost is assumed to be part of the on-site per-kW capital development cost, not part of the transmission cost.

The total transmission line cost for the integrated system that delivers power from 16 projects is \$125 million for 468 miles, with an overall average of \$268,000/mile (standard deviation \$145,000/mile). For individual transmission lines there is a wide range of line cost per mile, from \$133,000/mile to \$670,000/mile, because both 115/120-kV and 345-kV lines are involved, and each separate estimate is affected by multipliers for terrain, length, and permitting and environmental factors. The 115/120-kV lines alone (251 miles) average \$164,000/mile, and the 345-kV lines alone (217 miles) average \$388,000/mile.

The integrated collection system also includes upgrades to some substations and taps into the 345-kV common line for wind, pumped storage, and geothermal projects. Those upgrades and taps total \$49 million. If this is combined with the total line cost, then the cost per mile increases from \$268,000/mile to \$372,000/mile. However, if the line cost is adjusted to a value that would represent 115/120 kV only and combined with the \$49 million, then the cost per mile remains at approximately \$268,000.

In summary, the total transmission line cost for each of the 16 individual projects is a combination of two components: a) the transmission line from the site substation to the first node in the delivery network where power from that project is combined with power from at least one other project; and b) the project's MW-weighted share of all common lines from that node forward, including new and/or upgraded substations and taps within the common system. These costs have been calculated, using the data in Table VI-1, and the results for the 16 projects are included in the total development costs in the MS Access database for Project 1.3. The range of transmission line costs per project in Area 1 is as low as \$3.7 million and as high as \$31.6 million, and the range per kW is as low as \$99/kW and as high as \$627/kW.

Area 1 projects that are not in the set of 16 considered by Woodford (2003) are handled by assuming that they can be connected to the Woodford grid, or otherwise to an existing transmission line, if closer. (It is assumed that the Woodford grid or the existing line can

Hetch Hetchy/SFPUC Programmatic Renewable Energy Project
Project: 1.3 New Geothermal Site Identification and Qualification
Project Team: GeothermEx, Inc.
Task: 1.3.10 Final Project Report
Subject: Deliverable 1.3.10.3 Final Report
handle the extra capacity, which is not necessarily true.) The reference for existing lines is Nevada Bureau of Mines and Geology Map 126 (Shevenell and others, 2000; She00a), which shows transmission lines greater than or equal to (\geq) 55 kV in Nevada, supplemented by project and transmission line locations on U.S.G.S. topographic maps. The cost of connection is calculated on the basis of estimated distance from the project location to the nearest point along the line, at \$268,000/mile. Any exceptions are explained in comments to the transmission line cost estimates in the MS Access database.

4.2. Area 2 (Nevada with direct access to California)

These projects are assumed to be connected to the line into California from Dixie Valley (230-kV Dixie Valley – Sierra Pacific line), or to another existing line (Shevenell and others, 2000, and U.S.G.S. topographic maps), if closer. (It is assumed that the existing line can handle extra capacity, which is not necessarily true.) The approximate cost is calculated on the basis of estimated distance from the project location to the nearest point along the line, at \$268,000/mile. Note that connection of a single project directly to the PDCI is regarded as not possible, even if the project is closer to the PDCI.

4.3. Area 3 (Other Nevada)

These projects are assumed to be connected directly to the Woodford grid, or to another existing line (Shevenell and others, 2000, and U.S.G.S. topographic maps), if closer. (It is assumed that the existing line can handle extra capacity, which is not necessarily true.) The approximate cost is calculated on the basis of estimated distance from the project location to the nearest point along the line, at \$268,000/mile. Note that connection of a single project directly to the PDCI is regarded as not possible, even if the project is closer to the PDCI.

4.4. Area 4 (All Other California)

The cost of connecting 2,000 MW of new power generation in the Salton Sea area (Imperial Valley) to the PDCI has been estimated by Woodford (2003), in which the total for a 500-kV transmission line plus substations is \$237.1 million. Transmission estimates for resources in the broader Salton Sea area are assigned as follows.

1. Projects BRW01, BRW02, BRW03, NIL00, SAL00 (all \geq 62 MW):

The current estimate for most likely new or expanded capacity at these fields is 1802 MW, which is close to the 2000 MW used by Woodford (2003). The \$237.1 million cost is apportioned among these 5 projects on a MW fraction basis. In addition, it is assumed that \$237.1 million represents transmission starting at the Salton Sea field (project SAL00), so transmission to that location from the other projects is also estimated, at

Hetch Hetchy/SFPUC Programmatic Renewable Energy Project

Project: 1.3 New Geothermal Site Identification and Qualification

Project Team: GeothermEx, Inc.

Task: 1.3.10 Final Project Report

Subject: Deliverable 1.3.10.3 Final Report

\$200,000/mile, which is assumed to cover a 115/120-kV line plus substations and taps to the 500-kV line.

2. New small projects at the margins of the Imperial Valley (DUN00, GLA00, SUP00):

It is assumed that transmission can tap into an existing transmission line at the nearest existing geothermal power plant, and the line cost to that location is estimated at \$180,000/mile, which is assumed to cover a 115/120-kV line only.

3. Expansions at existing projects (except SAL00):

As for existing power generating projects in the other geographic Areas, it is assumed that there is no new transmission line cost.

Transmission line costs for Area 4 projects not in the Imperial Valley (e.g. Medicine Lake) are handled as individual cases and presented (with annotations) in the PIER Geothermal Database.

5. DISCLAIMER

It is emphasized that the development programs used herein for cost estimation are only approximate and may not be followed, since every developer brings its own experience, bias and opportunities to the development process. Additionally, real program costs can vary significantly from area to area and time to time, due to economic factors that may be out of the control of any given project. Drilling costs, for example, vary historically with the amount of competing activity at other projects and the availability of drilling rigs. Transmission line costs depend both on project location and on the location and availability of existing transmission capacity (which is a major uncertainty). In spite of these uncertainties, the estimated overall costs herein are believed to be reasonable.

Hetch Hetchy/SFPUC Programmatic Renewable Energy Project
 Project: 1.3 New Geothermal Site Identification and Qualification
 Project Team: GeothermEx, Inc.
 Task: 1.3.10 Final Project Report
 Subject: D.1.3.10.3 Final Report

Table VI-1: Summary of estimated costs of site substations, transmission lines and collector/line substations and taps for geothermal projects in Nevada (from Woodford, 2003)

Project	Site substation					Line			Collector/Line substations/taps			
	kV	\$ million	MW	\$/kW	miles	From>To	kV	\$ million	\$/mile	Name	kV	\$ million
Stage 2^(a)												
Fly Ranch	115	\$ 1.3	23.5	\$ 55	16	Fly>Ger	115	\$ 2.7	\$ 168,750			
Gerlach	115	\$ 1.5	37	\$ 41	10	Ger>PDCI ¹	115	\$ 2.2	\$ 220,000	PDCI Tap frm Gerlach	115/345	9.7
Stage 3^(b)												
Lee H.S.	115	\$ 1.3	9.5	\$ 137	17	Lee>Salt W	115	\$ 3.7	\$ 217,647			
Salt Wells	115/345	\$ 7.8	133	\$ 59	10	Salt W>Fall/Car	345	\$ 6.7	\$ 670,000			
Fallon/Carson	345	\$ 3.2	65	\$ 49	51	Fall/Car>NV	345	\$ 19.1	\$ 374,510			
North Valley (NV)	345	\$ 7.2	71	\$ 101	27	NV>Tracy	345	\$ 10.1	\$ 374,074	Tracy upgrade	345	2.7
Hazen	115	\$ 1.3	12	\$ 108	19	Hazen>Eagle	115	\$ 4.1	\$ 215,789	Eagle upgrade	115	1.0
Stage 4^(c)												
Blue Mtn	120	\$ 1.5	32	\$ 47	35	Blue Mtn > Rye P	120	\$ 4.7	\$ 134,286			
Rye Patch - Humb. Hse - HH ¹	120	\$ 1.7	81	\$ 21	5	Humb Hse > Rye P	120	\$ 1.3	\$ 260,000			
Rye Patch - Humb. Hse - RP					48	Rye P > Oreana (2 lines)	120	\$ 6.4	\$ 133,333			
Colado	120	\$ 1.3	7	\$ 186	8	Colado > Oreana	120	\$ 1.9	\$ 237,500	Oreana upgrade	120	5.2
New York Canyon (NYC)	120	\$ 1.5	36	\$ 42	28	NYC > Oreana	120	\$ 3.8	\$ 135,714			
Pumpemickel Valley (PV)	120	\$ 1.3	18	\$ 72	65	PV > Oreana ²	120	\$ 8.8	\$ 135,385			
Leach	120	\$ 2.3	24	\$ 96	0	along PV > Oreana						
Kyle H.S.	120	\$ 1.5	30	\$ 50	0	Tap PV > Oreana	120	\$ 1.5				
					71	Oreana > North Valley	345	\$ 26.5	\$ 373,239	New Oreana	120/345	20.3
Trinity Mtns.	345	\$ 3.3	83	\$ 40	0	along Oreana > North V ³				North Valley upgrade	345	7.4
					58	North Valley > PDCI Tap	345	\$ 21.7	\$ 374,138	PDCI Tap upgrade (geoth inlet portion only)	345	2.7
16 GEOTHERMAL PROJECT AREAS												
Totals/Averages	\$ 38	662	\$ 57	468		Line		\$ 125	\$ 207,521	Coll./Ln. subs/taps		\$ 49
						Line			\$ 145,418	Common Line		\$ 48
Totals/Averages					468	Line+Coll./Line subs/taps		\$ 174	\$ 372,253	(Oreana >NV>PDCI)		
					251	115-120 kV Line		\$ 41.1	\$ 163,745	Total		\$ 97
					217	345 kV Line		\$ 84.1	\$ 387,558			
					468	all Line as 115-120 kV		\$ 76.6	\$ 163,745	Project Line		\$ 77
					468	Line as 115-20 kV +		\$ 126	\$ 268,476	Total Line + Coll./Ln		\$ 174
					468	Coll./Line subs/taps				sub/taps		

1. Split is Humbolt House 51 MW, Rye Patch 30 MW.

(a) Not including Honey Lake - Alturas 345 kV extension and substations at Honey Lake (345 kV) and Alturas (345 kV) and Capt. Jack A6(345/500 kV)

2. Assume that Pumpemickel Valley > Leach is 12 miles, Leach>Kyle is 24 miles and Kyle>Oreana is 29 miles

(b) Not including Trans Sierra ac transmission line at 500 kV from Honey Lake to Table Mtn.

3. Assume Oreana>Trinity Mtns is 45 miles, and Trinity Mtns>North Valley is 26 miles

(c) Not including 1500 MW, +/-500 kV DC Tap at PDCI

Appendix VII

How to Use the Database / Technical Information

Hetch Hetchy/SFPUC Programmatic Renewable Energy Project
Project: 1.3 New Geothermal Site Identification and Qualification
Project Team: GeothermEx, Inc.
Task: 1.3.10 Final Project Report
Subject: Deliverable 1.3.10.3 Final Report

APPENDIX VII

HOW TO USE THE DATABASE / TECHNICAL INFORMATION

1) DATABASE VERSION

The PIER Geothermal Database has been designed and created on a computer running Microsoft Windows XP, using Microsoft Access 2002©, with the Access 2000 file format setting. This means that the database should operate properly in Access 2000 or 2002. Users who need a file format compatible with Access 97 should contact GeothermEx (see below), and an Access 97 version can be supplied.

2) SETUP ON HARD DISK

The database MUST be opened into Access from a hard disk. It will not work properly from a CD, but can be copied to a hard disk from a CD.

When the database is copied from the CD to a hard disk, the READ-ONLY attribute of the database file remains set to ON, and it MUST be turned OFF. To do this:

- i) Copy the database from the CD to the hard disk.
- ii) Tag the filename (in Windows Explorer or other folder).
- iii) Right-click the mouse button and select Properties.
- iv) Look for the General Tab, and at the bottom there should be Attributes.
- v) Click on Read Only to turn it off, and close the Properties window.

3) REQUIRED VIDEO DISPLAY SETTINGS

a) Screen Resolution 1280 X 1024

The database user-interface has been designed for use at a screen resolution of 1280 x 1024 pixels. Video displays at lower resolution may cause some of the interface windows to over-fill the screen and make them awkward to use.

To increase the screen resolution to 1280 x 1024 pixels:

- i) On the Windows Desktop, right click the mouse button. A menu should open up.
- ii) Select Properties. The Display Properties Window should open up.
- iii) Select the Settings tab.
- iv) Drag the Screen Resolution arrow to the right, and stop at 1280 x 1024 (usually the far right).
- v) Click OK.

Hetch Hatchy/SFPUC Programmatic Renewable Energy Project

Project: 1.3 New Geothermal Site Identification and Qualification

Project Team: GeothermEx, Inc.

Task: 1.3.10 Final Project Report

Subject: Deliverable 1.3.10.3 Final Report

b) Font Size and/or DPI Setting

Some users (particularly with older versions of Windows) may find that screen fonts in the database (e.g. on data input screens) are truncated either vertically or horizontally, or command buttons appear to have incomplete captions.

These problems can be related to an inability of Windows and Access to correctly manage one of the Display settings of the Windows desktop, and can be corrected by changing the display font size (all versions of Windows) and/or DPI setting (newer versions only):

- i) Right click on the Windows desktop
- ii) Select in sequence:
 - (1) Properties (a menu option)
 - (2) Settings (a tab)
 - (3) Advanced (a button on the Settings tab)
 - (4) General (a tab on a video properties window)
- iii) At this point, the General tab will show a pull-down list of options that says either:
 - (1) Display Font Size (older versions of Windows) - Choose Large Fonts or
 - (2) DPI Setting (newer versions of Windows) - Choose Large Size (120 DPI)
- iv) Select OK or Apply, and re-boot

If the formatting problem remains, it may be necessary to change the Display Font Size setting that alternatively appears under Properties (menu option) Appearance (tab). The database has been designed with "Normal" size.

If there are additional formatting problems, please contact GeothermEx (see below)

4) DATABASE FIGURES AND DOCUMENTS DISPLAY

The database includes figures and some documents as embedded Adobe Acrobat .pdf files. Be aware of the following:

- a) A .pdf file is opened by double-clicking on the icon that represents in a database figure list or report.
- b) The user's computer must have the Acrobat reader installed.
- c) Most (not all) of these .pdf files are programmed to open in "Full screen mode", i.e. the Acrobat window frame and menus are hidden.

Hetch Hetchy/SFPUC Programmatic Renewable Energy Project

Project: 1.3 New Geothermal Site Identification and Qualification

Project Team: GeothermEx, Inc.

Task: 1.3.10 Final Project Report

Subject: Deliverable 1.3.10.3 Final Report

- d) To close the figure (i.e., the .pdf), hit Esc. This causes it to revert to the Acrobat window. Once in the Acrobat window, the figure can be closed by closing it (closing the .pdf file) or closing Acrobat, or it can be zoomed to see fine detail, printed, etc..
- e) Interactions between Access, Windows and Acrobat are imperfect, and double-clicking the .pdf icon in Access occasionally produces a blank screen, or a blank document in the Acrobat window.
- f) In such cases, it has been found sufficient to close the Acrobat screen or document (use the Esc key and close the .pdf or close Acrobat), then re-load the .pdf from Access by again double-clicking on the .pdf icon.

5) STRUCTURE OF THE DATABASE

The database comprises a set of:

- a) Tables which contain data and information,
- b) Forms for viewing the data,
- c) Reports that generate detailed or summary lists of the data on screen and/or to a printer,
- d) Queries that extract the data for the Forms and Reports (see below),
- e) Modules (essentially hidden from the user) that contain code, and
- f) Figures and Documents, which are stored in Adobe Acrobat (.pdf) format and embedded into the database as "OLE" objects.

There are also hidden Relationships which link the data tables.

The Tables, Forms, Reports, Figures, Documents and some of the Queries are accessed via the Database Startup Form, as follows.

6) USING THE DATABASE

- a) When the database is opened in Access, the user is presented with a window entitled "PIER Public Renewable Partnership Geothermal Database Startup" (Figure 2). This has command buttons:
 - i) View Projects Data and Figures - puts the user into the Projects window, from which the data for individual projects can be viewed in a set of different forms, project pictures can be accessed, reports for the currently displayed project can be generated, and certain other reports and queries can be generated.

Hetch Hetchy/SFPUC Programmatic Renewable Energy Project
Project: 1.3 New Geothermal Site Identification and Qualification
Project Team: GeothermEx, Inc.
Task: 1.3.10 Final Project Report
Subject: Deliverable 1.3.10.3 Final Report
Move from one project to another by using the Page Up and Page Down keys, or by using the Projects List under "Choose Project" at upper left (see further help at the list box). Each project has a unique Project ID number, which serves to establish its unique identity.

- ii) Preview and Print Reports and Documents - puts the user directly into a window from which pre-formatted Reports and Documents can be generated or viewed. A button in the Projects window ("Multi-Project Reports & Documents") also accesses this reports window.

Some reports prompt the user to specify which project(s) are to be included, using the Project ID number. It is possible to enter a single project (e.g. AUR00), or a set of related projects using wildcards (e.g. LVM*)

7) ABOUT QUERIES, EXPORTING DATA AND USING ADVANCED FEATURES OF ACCESS

A Query is a structured command that extracts information from a database according to the criteria written into the query. The information gets extracted into a table viewed on screen, or in background mode into a report or form that displays data on-screen or to a printer. Most of the queries in this database are hidden from the casual user, but can be accessed as described below. One query is made available via a button on the Projects window ("Query Main Facts"). This displays a large amount of basic information from the database in a simple tabular format that is suitable for export to MS Excel. Instructions for doing this are given at the adjacent help ("?") button.

Data can also be exported from any Database Report into MS Excel or MS Word by displaying the report on-screen and selecting Tools/Office Links from the main menu. This process successfully transfers data and variable names, but will not completely transfer all of the information in column headings that have a complex format.

If the user who is familiar with Access desires to further explore the project data using more complicated queries, the normal Access database window (all tables, forms, queries, macros, modules, etc.) can be obtained as follows:

- i) close the Database Startup Form but do not close Access.
- ii) re-open the database via the File pull-down on the Access main menu, by selecting the database name at the top of the "most recently used" list at the bottom of the File menu.

GeothermEx, Inc.

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e-mail mw@geothermex.com. Put "Attn: Chris Klein" in the Subject line.