NVO-196-13

NEVADA NUCLEAR WASTE STORAGE INVESTIGATIONS

FY 1980 PROJECT PLAN AND FY 1981 FORECAST

FEBRUARY 1980

UNITED STATES
DEPARTMENT OF ENERGY
NEVADA OPERATIONS OFFICE
LAS VEGAS, NV

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Department of Energy
Washington, D.C. 20545

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Distribution

NEVADA NUCLEAR WASTE STORAGE INVESTIGATIONS PROJECT PLAN

This Project Plan was prepared by the Nevada Operations Office of the U. S. Department of Energy (DOE). This Plan has been approved by the Division of Waste Isolation of DOE's Office of Nuclear Waste Management for use as a basis for planning of activities to be conducted during fiscal year 1980. It is not proposed that a formal revision of this document will be made during fiscal year 1980 although changes will be incorporated in the details of the Project as additional information is obtained. A formal revision is planned for each fiscal year.

Similar program plans for work conducted by the Office of Nuclear Waste Isolation (ONWI) operated by Battelle Memorial Institute under contract to the U. S. Department of Energy and for the Basalt Waste Isolation Program at the Hanford Site are also being made available for information.

Colin A. Heath, Director
Division of Waste Isolation
Office of Nuclear Waste Management

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FY 1980 PROJECT GUIDANCE

The following is the FY 1980 Program Guidance from the Office of Nuclear Waste Management, U.S. Department of Energy (DOE), Washington, D.C., which pertains to the DOE, Nevada Operations Office (NV) portion of the National Waste Terminal Storage Program.

Site Evaluation

- *Pursuant to the documented findings at the end of FY 1979 that there are no major geologic and hydrologic impediments that would exclude the Nevada Test Site (NTS) from being considered as a location for a repository, planning of activities for FY 1980 should be focused on the evaluation of a specific location for a repository.*

  - *Sufficient time should be allowed after transmittal of these findings throughout the National Waste Terminal Storage (NWTS) Program to resolve any issues raised prior to beginning geologic investigations requiring large dollar outlays.*

  - *Drilling of stratigraphic hole (G-1) in Yucca Mountain can begin as planned in November; however, if it is determined in the review that there are major impediments in the area, NV should be prepared to suspend drilling operations.*

- *Major emphasis of site evaluation should focus on the hydrologic environments.*

  - *In view of the regional geologic drilling that has been indicated and proposed in the FY 1981 budget, a plan outlining the details of this activity and the questions to be resolved about the regional hydrology should be available for the FY 1981 Budget and Program Review in late July of 1980.*

- *To support the determination that volcanism does not represent a specific threat to NTS, the preliminary volcanic hazard analysis should be expanded and refined as far as possible with existing data, and the acquisition of new pertinent data should be accelerated.*

  -- *Sensitivity studies of consequence modeling done during FY 1980 should be reported and used to direct the program of drilling in Crater Flats and of identifying the most sensitive parameters of the volcanic risk assessment.*

- *In view of the potential generic importance of the use of a seismic network to the evaluation of seismic hazard of an area, the reasoning for recording and analyzing seismicity should be documented by the end of the year to show how the data will be used to improve already published seismic and volcanic hazards for the NTS region.*

- *Efforts to involve the State of Nevada in the planning and evaluation should receive priority attention.*

  -- *By the end of FY 1980 the working group should have prepared draft criteria by which to determine if a site in southern Nevada is suitable.*

  -- *After the site selection criteria are established, NV should prepare a report that documents the site characterization work at NTS and present the reasons why certain specific locations at the NTS are or are not suitable for a radioactive waste repository.*

  -- *Cooperative efforts with the State to evaluate the mineral resources in the southern four counties should continue at a minimum level of effort. This study should consider whether there are any potential resource conflicts on or adjacent to the NTS.*

  -- *No work aimed at identifying potential sites away from the southern four counties of Nevada is to be done in FY 1980.*

-- *Geologic evaluation off-NTS should be considered as part of the National Survey of Alternative Media. Such work in the State of Nevada will be under the direction of the Nevada Operations Office, but is essential that this work be coordinated with RL-C. The output of the National Survey should be consistent for all areas of the country.*

Technology Development

o *Work should continue to evaluate the effects of ground motion on subsurface facilities.*

-- *The major effort in the coming year should be the investigation of the variation of ground acceleration with depth. The FY 1980 Program Plan should indicate when this issue will be resolved.*

-- *Any effort to improve the accuracy of prediction of ground motion with distance from a test area should be discontinued and the results to date should be summarized in a final report.*

o *Evaluation of media should continue with primary attention devoted to tuff. The major objective of this effort will be to establish a strong technical basis on which to judge whether or not tuff is a good media for consideration for a radioactive waste repository.*

-- *In accordance with a previous presentation and the Project Plan, an interim report should be prepared by June 1980 on the suitability of tuff. Plans should be made to present the information to the National Academy of Sciences by the end of FY 1980.*

-- *Efforts on the study of other media at NTS should be limited to documentation of work already completed.*

-- *Documentation of Heater Test 1 in the Climax Granite conducted in an earlier fiscal year should be completed and published at the earliest possible date.*

In Situ Testing

- *The spent fuel test at Climax remains as a top priority activity. Every effort is to be made to maintain this activity on schedule so that spent fuel will be emplaced by March of 1980.*

  -- *HQ concurs in the recommendation of NV concerning response to the Spent Fuel Test Review Group. Recommendations of the peer reviewers that do not delay the start of the test should be implemented.*

  -- *Detailed planning for laboratory experiments to evaluate the effects of radiation on properties of granite should be completed early in FY 1980 and the experiments initiated during the year.*

- *NV should address the issue of the need for a Rock Mechanics Test Facility. This issue needs to be reviewed with RL-C and members of the rock mechanics community. The major objective of this review is to determine what specific information and specific experiments are needed to allow a repository to be designed in hard rock.*

Miscellaneous

- *Quality assurance needs to be stressed. This is of particular importance in the area of geologic investigations. Special attention should be given to documenting the procedures used to collect geologic and hydrologic data in the field.*

The following headquarters controlled milestones are proposed for FY 1980:

Complete written findings of no major impediments on NTS	*10/79*
Initiate spent fuel emplacement at Climax Spent Fuel Test	*3/80*
Complete interim report on suitability of tuff	*6/80*
Complete regional geologic drilling plan	*9/80*

INTRODUCTION

The DOE is responsible for developing or improving the technology for safely and permanently isolating radioactive wastes from the biosphere. The National Waste Terminal Storage Program, which is a part of the U.S. Nuclear Waste Management Program, is concerned with disposing of the high-level wastes associated with DOE and commercial nuclear reactor fuel cycles.

The DOE/NV has been delegated the responsibility to evaluate the geohydrologic setting and underground rock masses of the Nevada Test Site (NTS) area to determine whether a suitable site exists for constructing a repository for isolating highly radioactive solid wastes. Accordingly, the Nevada Nuclear Waste Storage Investigations (NNWSI) were established by NV to conduct these evaluations.

The NNWSI are managed by the DOE/NV, but the field and laboratory investigations are being performed by scientific investigators from several organizations. The four primary organizations involved are: Los Alamos Scientific Laboratory (LASL), Lawrence Livermore Laboratory (LLL), Sandia Laboratories (SL), and the U.S. Geological Survey (USGS). DOE/NV is responsible for coordinating these investigations.

This document presents the Project Plan for the NNWSI for FY 1980 and forecasts activities for FY 1981. Each task is divided into subtasks and described. This Plan is subject to periodic review and revision by the DOE/NV. Changes will be addressed as they occur in NNWSI Quarterly Reports. This document also presents information on the Project's technical approach as well as its history, organization, and management.

PROJECT HISTORY

In 1977, the NNWSI were formally organized to investigate the suitability of geologic media on the NTS and contiguous federal lands for permanently disposing of highly radioactive wastes. The investigations primarily deal with the geology and hydrology of specific sites and their regional geohydrologic setting, the properties of candidate host-rock media, and the effects of siting a repository near nuclear weapons testing activities. The potential for radioactive substances to migrate through potential host-rock media and regional geologic environments is being investigated to determine the effectiveness of natural radionuclide transport barriers. Experiments and tests are being conducted to determine the behavior of potential host-rock media exposed to nuclear wastes that emit heat and radiation over long periods of time. Whether a waste repository would interfere with nuclear weapons testing--the primary mission of the NTS--is another major siting consideration.

The NNWSI involve the participation of scientists and engineers from many fields. Geologists, hydrologists, seismologists, volcanologists, geophysicists, material scientists, and others are systematically studying the geology, hydrology, and rock masses underlying the NTS area. Their investigations seek to determine the present geohydrologic conditions of potential host-rock masses and the changes that have occurred in them over millions of years into the past. Furthermore, the dynamic interrelations of repository-induced effects on various candidate host-rock media are being determined. Investigations are being conducted to provide the detailed site-specific, regional, and material properties information needed for sound decision-making in regard to the feasibility of siting a permanent nuclear waste isolation repository in the NTS area.

FY 1978 PROJECT

One of the major siting considerations addressed in FY 1978 was concerned with determining whether a waste repository would be compatible with present and future nuclear weapons testing activities. Measurements of the ground motion induced by weapons tests indicated that it attenuates to a greater

degree than estimated by previous calculations. Consequently, the ground motion induced by nuclear weapons testing was judged to allow the construction of a repository if it were located at a sufficient distance from weapons testing activities.

In mid-FY 1978, the southwest portion of the NTS was established as an area where a nuclear waste isolation facility would not interfere with current and known future weapons testing requirements. The Climax Stock, Twinridge Hill, and Timber Mountain areas, which were being considered as possible repository sites, were deferred from further consideration because of their proximity to current or potential future weapons testing areas. Investigations of the central block of the Syncline Ridge were suspended because of its geologic complexity and, shortly thereafter, the entire Syncline Ridge area was also deferred from further consideration because of its proximity to weapons testing areas. Subsequent exploratory drilling and surface work was concentrated on selected areas of the southwest quadrant. These areas included Wahmonie, Calico Hills, and Yucca Mountain.

The properties of four of the rock types existing on the NTS were studied during FY 1978. Consideration of one medium, alluvium, was suspended because of its low thermal conductivity. Studies of the three other potential media, granite, argillite, and tuff, continued into FY 1979. The results of laboratory studies and an underground heater experiment in granite indicated that this medium should be able to withstand the thermal load imposed by spent fuel. Surface preparation and site development was accomplished for the Eleana argillite heater test which was begun in FY 1978. Exploratory fieldwork and the conceptual design of a spent fuel test to be conducted deep within an underground granite formation were completed. The exposed granitic rock masses in southern Nevada were inventoried during FY 1978. Analytical and inventory work was also begun on shale, argillite, and tuff rocks masses. Laboratory sorption and permeability studies were begun to determine the extent to which the radioactive species associated with spent fuel are immobilized by various geological media.

A variety of geologic, geophysical, and hydrologic studies were initiated or intensified during FY 1978. Most of the measurement stations in a seismic

net covering an area of about 100 miles in radius around the NTS were deployed to refine the degree of resolution and sensitivity in mapping and measuring seismicity in the NTS area. Efforts were also focused on mapping faults that offset Quaternary deposits and on determining the probability of the recurrence of volcanism. Available data on the hydrologic conditions on and near the NTS were collected and compiled. In addition, field and laboratory techniques were used to assess the geohydrologic environment of the NTS area. Two exploration holes were drilled to depths of about 2,500 feet at the Calico Hills and Yucca Mountain; geophysical logs were collected; and the cores were shipped to participating laboratories for analysis.

FY 1979 PROJECT

During FY 1979, the underground facility for testing the storage of spent fuel in the Climax granite was constructed about 1,400 feet below the surface of the NTS. A vertical access hole connecting the surface to the underground emplacement drift was drilled and most of the various handling, encapsulation, and emplacement systems were designed and manufactured. Twenty-foot-deep storage holes were drilled in the granite floor of the facility and special steel liners were installed in preparation for the emplacement of spent fuel canisters scheduled for March 1980. Major objectives of the test are to demonstrate a capability to transport, encapsulate, and emplace spent fuel in a mined facility and to provide data on the in situ behavior of granite subjected to continuous heat and radiation output over a period of several years.

The Eleana full-scale heater test was completed and axisymmetric thermal and mechanical modeling of the test results was accomplished. Post-test gas transmissivity measurements showed that the transmissivity of the argillite increased by three orders of magnitude within 4 feet of the main heater hole during the course of the test. Increases of about one order of magnitude were evident to distances as great as 11 feet.

Several hydrologic studies were conducted during FY 1979 to determine the distribution and movement of groundwater in the NTS region. These studies involved field mapping of discharge areas, monitoring of static water levels

in available wells, sampling of groundwater for chemical analyses and isotopic dating, and construction of a two-dimensional, finite difference model of an area 100 miles in radius around the NTS. A sensitivity analysis of this regional groundwater transport model was initiated during FY 1979. A major conclusion reached in the paleohydrologic study of the NTS area was that the water table was approximately 200 feet above its present position during the Pleistocene (glacial) Epoch. This study is concerned with determining the potential changes in a repository environment which may result from dramatic future climatic changes. In addition, hydrologic field mapping and reconnaissance were conducted in other areas of southern Nevada to gain more detailed knowledge of regional hydrologic conditions.

A study of regional volcanism resulted in preliminary determinations of the probability of a recurrence of basaltic volcanism in the NTS area. The Black Mountain volcanic center, the youngest major silicic eruptive center in the NTS area, is about 6 to 8 million years old. Potassium-argon dating showed that the silicic volcanism in the NTS area terminated during the Pliocene Epoch. This conclusion is supported by a fission-track age of about 6 million years on zircon from a sample of rhyolitic lump pumice collected from beneath the basalt in southeastern Crater Flat. A basalt from above the Timber Mountain tuff and below a huge tectonic slide block of Paleozoic rocks near the south end of Crater Flat was dated at 10.4 million years, which indicates the approximate end of major volcanism and tectonism in the Timber Mountain caldera area of the NTS.

After reviewing the geologic, geophysical, and hydrologic data for the Wahmonie, Yucca Mountain, and Calico Hills/Topopah Wash areas, the U.S. Geological Survey recommended that exploration be focused on the tuffaceous media of Yucca Mountain. Consequently, exploration and characterization efforts were intensified on Yucca Mountain and no new studies were initiated for the other areas of the NTS. Laboratory efforts focused on determining the permeability and sorption characteristics of tuff. A water migration/heater experiment was designed and site preparations were made in the welded Grouse Canyon tuff in the G-Tunnel complex at NTS during FY 1979. This experiment is designed to provide data on the influence of a thermal field on intrarock water migration and other effects.

A site evaluation subtask was initiated in FY 1979 to ensure that the evaluation of potential repository sites on the NTS occurs on a timely basis and is coordinated with the National Waste Management Program schedule. A Site Evaluation Steering Committee was formed to impanel a Site Evaluation Working Group of scientific and technical experts; to guide the Working Group in developing evaluation criteria and in performing the preliminary evaluation of potential sites; to establish criteria based on the development efforts of the Working Group; and to identify and recommend potential repository sites by evaluating the reports of the Working Group in relation to the criteria established.

During FY 1979, quality assurance activities included a comprehensive review of the Quality Assurance Program Plans of participating organizations and the implementation of several new quality assurance procedures. An overall Quality Assurance Program Plan for the NNWSI was in final review at the end of FY 1979. Four scientific peer reviews were conducted to permit external experts to assess the adequacy of ongoing media, geohydrologic, and tectonic investigations and the spent fuel test in granite. As a result of the spent fuel test review, another meeting of peer reviewers, the Office of Nuclear Waste Isolation, and the DOE Office of Nuclear Waste Management resulted in an agreement to augment the experimental design of the spent fuel test to obtain additional rock mechanics and radiation dosimetric data during the test. In addition, the peer reviewers recommended that a separate or adjoining underground rock mechanics experimental facility should be considered as a means for obtaining further data on the thermal behavior of potential host-rock media. The evaluation of a plan for designing an in situ rock mechanics testing laboratory was begun during FY 1979.

MANAGEMENT STRUCTURE

The DOE/NV is responsible to the DOE/HQ, Office of Nuclear Waste Management, for conducting the NNWSI Project. The NNWSI Project Office consists of the Project Manager and Project Coordinators and is responsible to the Manager, DOE/NV. The DOE/NV staff and the NTS Support Office provide the Project Office with various kinds of assistance and support, including the support of the NTS support contractors, necessary to conduct the NNWSI Project.

The investigations and the spent fuel test are being conducted by Principal Investigators working under the supervision of Technical Project Officers from the Los Alamos Scientific Laboratory, the Lawrence Livermore Laboratory, Sandia Laboratories, and the U.S. Geological Survey.

The Technical Overview contractor and the Quality Assurance Overview contractor oversee and advise the Project Manager on the technical aspects of the NNWSI. The Site Evaluation Activity consists of the Site Evaluation Steering Committee and the Site Evaluation Working Group and is primarily responsible for developing site evaluation criteria and the methodology for screening potential repository sites on or in the vicinity of the NTS. The NNWSI organization chart is shown in Figure 1. The following is a description of the responsibilities of each managerial element or position.

PROJECT MANAGER

The Project Manager is responsible to the Manager, DOE/NV, for overall Project planning, achievement of Project goals, and review of results from the NNWSI in accordance with the Office of Nuclear Waste Management, DOE/HQ, Project guidance and direction. This responsibility includes:

Planning--Planning accomplishments in accordance with Project guidance, determining the required resources, and identifying the best methods for obtaining results.

-- Establishing Project goals.

-- Developing plans to achieve goals.

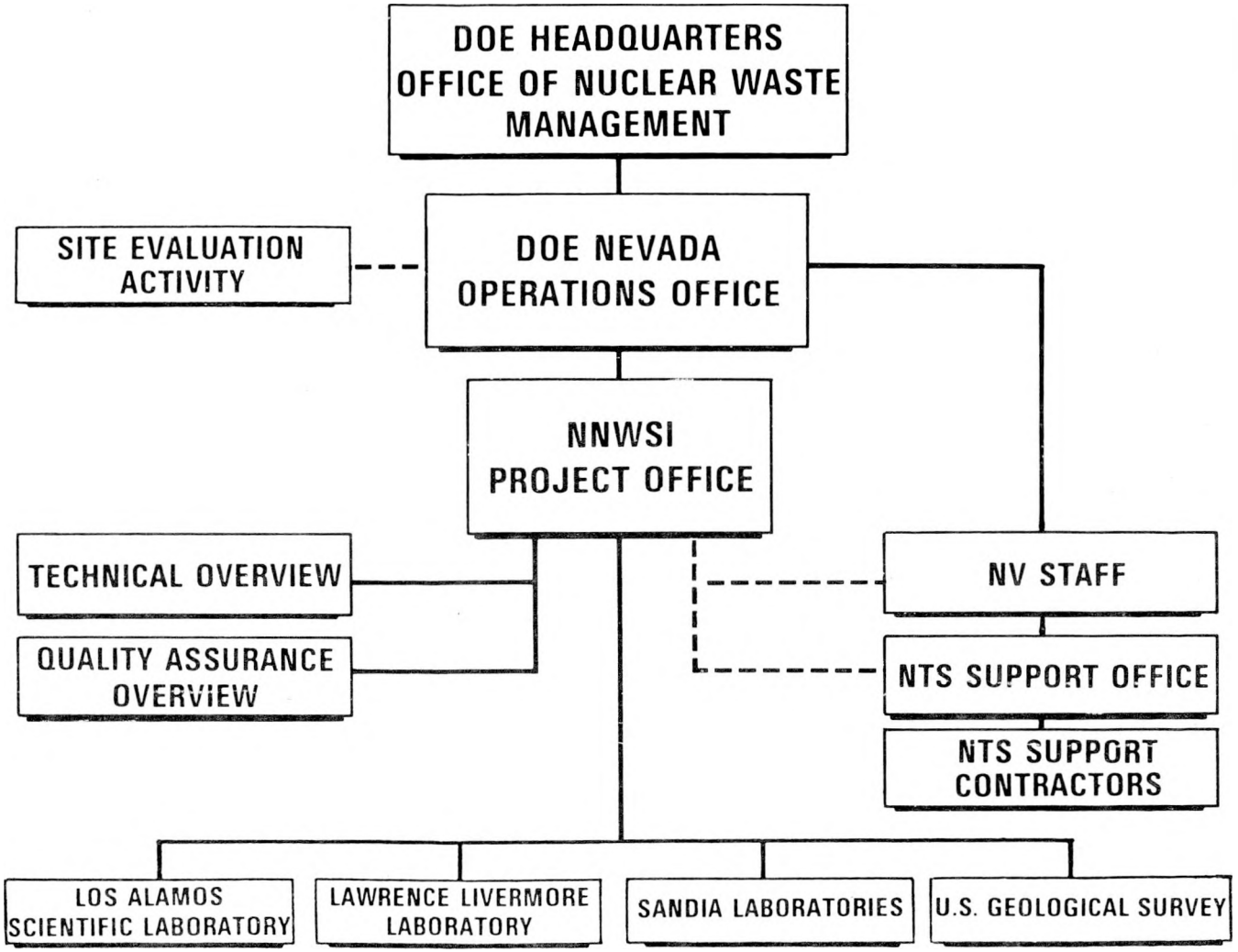


Figure 1. NNWSI Organization Chart

-- Establishing a Project management plan.

-- Determining resources that will be required.

-- Developing budget plans and projections to obtain the needed resources.

Achieving Project Goals--Guiding and motivating participants to achieve their individual objectives.

-- Delegating the authority to participants for tasks, subtasks, and activities.

-- Guiding participants and the DOE/NV staff to achieve timely and economic completion of assigned tasks, subtasks, and activities.

Reviewing Results--Evaluating the degree to which objectives and milestones are achieved.

-- Measuring progress and achievement.

-- Taking corrective action to improve performance.

-- Developing reporting procedures for Project participants.

-- Reviewing documents for programmatic and policy content.

-- Reporting Project costs, progress, technical status, and performance to the Office of Nuclear Waste Management, DOE/HQ.

PROJECT COORDINATORS

The Project Coordinators, who are part of the Project Office, are responsible to the Project Manager for assistance with overall Project planning, coordination of the DOE/NV support contractor requirements with the Nevada Test Site Support Office, day-to-day monitoring and coordination of Project participants, and reporting progress and performance of the Project to the Office of Nuclear Waste Management, DOE/HQ. These responsibilities include:

-- Assisting the Technical Project Officers (TPOs) in the development of work plans, budgets, estimates, and projections.

-- Coordinating the work plans of participants with Project management objectives and cost plans.

-- Preparing the Project management plans and cost plans.

-- Providing budgetary and policy recommendations to the Project Manager.

-- Reviewing the criteria letters of TPOs requesting DOE/NV contractor support.

-- Preparing periodic cost, progress, and milestone status reports and maintaining an up-to-date Project Plan.

-- Monitoring Project status and developments, identifying potential problems, providing a basis for problem solving, and recommending solutions for decision making by the Project Manager.

NV STAFF

The DOE/NV staff will assist and support the NNWSI Project Manager through matrix management assignments. The kinds of assistance and support that will be provided include: finance, budgets, contracts, operations coordination, planning, reports, legal council, security, occupational and radiation safety, property management, and public affairs. The DOE/NV staff will also provide reviews, recommendations, and expertise on various aspects of the Project, as appropriate, in terms of their respective functional responsibilities.

TECHNICAL OVERVIEW

The Technical Overview contractor is responsible to the Project Manager for three categories of activities:

Technical Integration, Coordination, and Documentation--This category of activities includes lead responsibility for:

-- Coordinating the NNWSI with the overall National Waste Terminal Storage Program on technical issues.

-- Integrating and coordinating the documentation of the Project Plan.

-- Preparing or coordinating the preparation of periodic or special status reports.

-- Coordinating and integrating technical data for site-screening evaluations and site-specific safety analyses.

Technical Planning, Review, and Advice--This category of activities includes lead responsibility for:

-- Developing long-range plans and preparing and maintaining long-term network analyses for the NNWSI.

-- Organizing the technical peer review process.

-- Reviewing National Waste Terminal Storage Program technical documents which may have a significant impact on technical aspects of the NNWSI.

-- Advising the Project Manager concerning technical aspects of existing or proposed NNWSI tasks.

-- Advising the Project Manager regarding the technical integration, coordination, and implementation of the Project Plan.

Specific Technical Activities--This category of activities involves long-term in-depth technical studies which cut broadly across NNWSI activities. The exact scope of future long-range studies cannot be defined at present, but two areas are clearly within the lead responsibility role of Technical Overview:

-- Developing technical site-screening criteria and application methodology.

-- Performing repository safety analyses.

QUALITY ASSURANCE OVERVIEW

The Quality Assurance Overview contractor is responsible to the Project Manager for developing and implementing the Quality Assurance Program for the NNWSI (see Subtask 5.1). This responsibility includes:

-- Developing requirements for and assisting the Project Manager in administering the overall Quality Assurance Program.

-- Developing the Quality Assurance Program Plan.

-- Informing participant quality assurance organizations of the requirements for Quality Assurance Programs or quality assurance procedures based on current and anticipated regulatory requirements and Project objectives.

-- Reviewing the Quality Assurance Programs of Project participants.

-- Conducting quality assurance audits of Project activities.

TECHNICAL PROJECT OFFICERS

The TPOs from the participating laboratories and government agency are responsible to the Project Manager for accomplishment of their designated tasks, subtasks, activities, and milestones. This responsibility includes:

-- Developing work plans for their designated tasks, subtasks, and activities.

-- Performing delegated assignments in an economic and technically effective manner.

-- Providing the Director, Nevada Test Site Support Office, with criteria letters requesting initiation of action by the NTS support contractors.

-- Providing the Project Manager with advice on Project planning, budget, and policy concerns.

-- Assisting the Project Manager in reviewing the progress of Project tasks, subtasks, and activities.

-- Reviewing proposed work plans to assist the DOE/NV in assuring the compatibility and balance of the overall Project.

-- Providing periodic cost, progress, and technical status reports to the Project Manager.

-- Providing technical assistance to the Project Manager for Project and public information briefings and Project planning.

PRINCIPAL INVESTIGATORS

The Principal Investigators from the participating laboratories and government agency are responsible to the TPOs for conducting the scheduled subtask activities in a timely and efficient manner. This responsibility includes:

-- Obtaining and implementing the resources necessary to conduct scheduled subtask investigations.

-- Informing TPOs of subtask progress, plans for required resources, and delays or cancellation of scheduled activities.

-- Assisting the TPOs in preparing work plans for subtask activities.

-- Maintaining communication with other Project elements to assure coordination of all investigative activities.

SITE EVALUATION STEERING COMMITTEE

The Manager, DOE/NV, has the overall management responsibility for site recommendation to the Office of Nuclear Waste Management, DOE/HQ; preparation of documentation for license application; and operation of a DOE waste repository if it is sited on the NTS or nearby areas. To ensure that the evaluation of potential sites on the NTS occurs on a timely basis and is coordinated with the national schedule, a Site Evaluation Activity (see Subtask 6.2) was established by the Manager, DOE/NV, during FY 1979. The Site Evaluation Steering Committee is chaired by the NNWSI Project Manager and consists of other federal employees with expertise in geology, hydrology, NTS operations, health physics and radiation safety, physical and biological sciences, program management and budgets, and energy resource coordination. The Site Evaluation Steering Committee receives policy and management direction from the Manager, DOE/NV. The Steering Committee is responsible for:

-- Impaneling a Site Evaluation Working Group of scientific and technical experts.

-- Providing direction to the Site Evaluation Working Group to guide the development of repository site evaluation criteria and screening methodology and to conduct preliminary evaluations of potential repository sites.

-- Establishing criteria based on the development effort of the Site Evaluation Working Group.

-- Identifying potential repository sites by evaluating the reports of the Site Evaluation Working Group in terms of the evaluation criteria developed.

-- Evaluating the reports of the Site Evaluation Working Group in terms of their compatibility with other DOE/NV activities and policies.

SITE EVALUATION WORKING GROUP

The Site Evaluation Working Group is chaired by one of the DOE/NV Project Coordinators and consists of representatives from the participating laboratories,

government agency, and other members as requested by the Working Group and approved by the Steering Committee. The Working Group takes guidance from the Steering Committee and is responsible for:

-- Developing repository site evaluation criteria.

-- Developing a methodology for evaluating potential repository sites against the evaluation criteria.

-- Compiling reports and technical documents on the results of its activities as directed by the Steering Committee.

NEVADA TEST SITE SUPPORT OFFICE

The Director, Nevada Test Site Support Office (NTSSO), is responsible for field direction of NTS support contractor operations, including architectural engineering, drilling, mining, construction, and logistical support for work performed at the NTS. This responsibility includes:

-- Initiating action by NTS support contractors based on criteria letters submitted by the TPOs.

-- Providing field direction to NTS support contractors on authorized work.

-- Maintaining effective communications with the Project Manager and Project Coordinators on the execution of NTS support contractor work.

-- Monitoring NTS support contractor progress.

-- Monitoring ongoing Project field support requirements, identifying potential problems, providing a basis for problem solving, and recommending solutions to the Project Manager.

TECHNICAL APPROACH

The NTS is of interest for the storage and ultimate disposal of radioactive waste for three principal reasons:

-- Present knowledge of the regional hydrology of this desert area indicates that it has excellent potential for isolating nuclear wastes from the biosphere.

-- It is controlled by the Federal Government and already requires long-term monitoring and administrative control.

-- A strong base of logistical support already exists.

Despite these favorable characteristics, the DOE/NV cannot implement an application to license a repository until three major issues are resolved:

-- Is the geologic isolation of radioactive wastes compatible with the NTS prime mission of nuclear weapons testing?

-- Is the hydrologic and geologic setting of the NTS suitable for confident prediction of waste isolation for the required period of time?

-- Do any of the rock masses on or adjacent to the NTS possess suitable properties for constructing a permanent nuclear waste repository?

The current focus of the NNWSI are to resolve these basic issues and to determine whether a specific site exists on or near the NTS that is suitable for the establishment of a licensed nuclear waste repository. If negative results are obtained for the NTS area, it is the intent of the Project to determine whether suitable sites exist elsewhere in the southern four counties of Nevada. Available information about the regional hydrology and geology of arid southern Nevada indicates that this area has excellent potential as a location for isolating radioactive wastes and their chemical derivatives from the biosphere.

In this section, the programmatic approach is summarized by listing a series of critical questions which must be answered before the foregoing issues can be resolved. The technical work plans designed to address these questions are described later in this Plan according to the subtasks of the work breakdown structure (Figure 2). The following categories of questions are applicable to all potential exploration areas and rock formations of the NTS and surrounding areas.

GROUND MOTION INVESTIGATIONS

The basic technical question regarding the compatibility of geologic waste isolation and weapons testing at the NTS is whether a repository could withstand ground shocks produced by underground nuclear explosions. With regard to natural seismicity, the NTS lies within Seismic Zone 2 and close to the boundary of Zone 3. Important questions addressing weapons-produced (Task 1) and natural seismicity (Subtask 2.5) arise:

-- What will be the frequency and magnitude of ground motion resulting from future weapons tests and natural seismic events at potential repository sites?

-- How well can ground motion be predicted at potential repository sites?

-- What is the statistical uncertainty in the predictions?

-- Do unique geologic conditions around potential repository sites result in anomalies which would yield ground motion substantially different than that predicted from regional attenuation equations?

-- To what degree is ground motion in the depth range being considered for siting a repository different from that at the surface?

REGIONAL GEOLOGIC INVESTIGATIONS

The suitability of deep subsurface environments for siting a nuclear waste repository depends in large part on regional geologic phenomena. Among the questions to be addressed are:

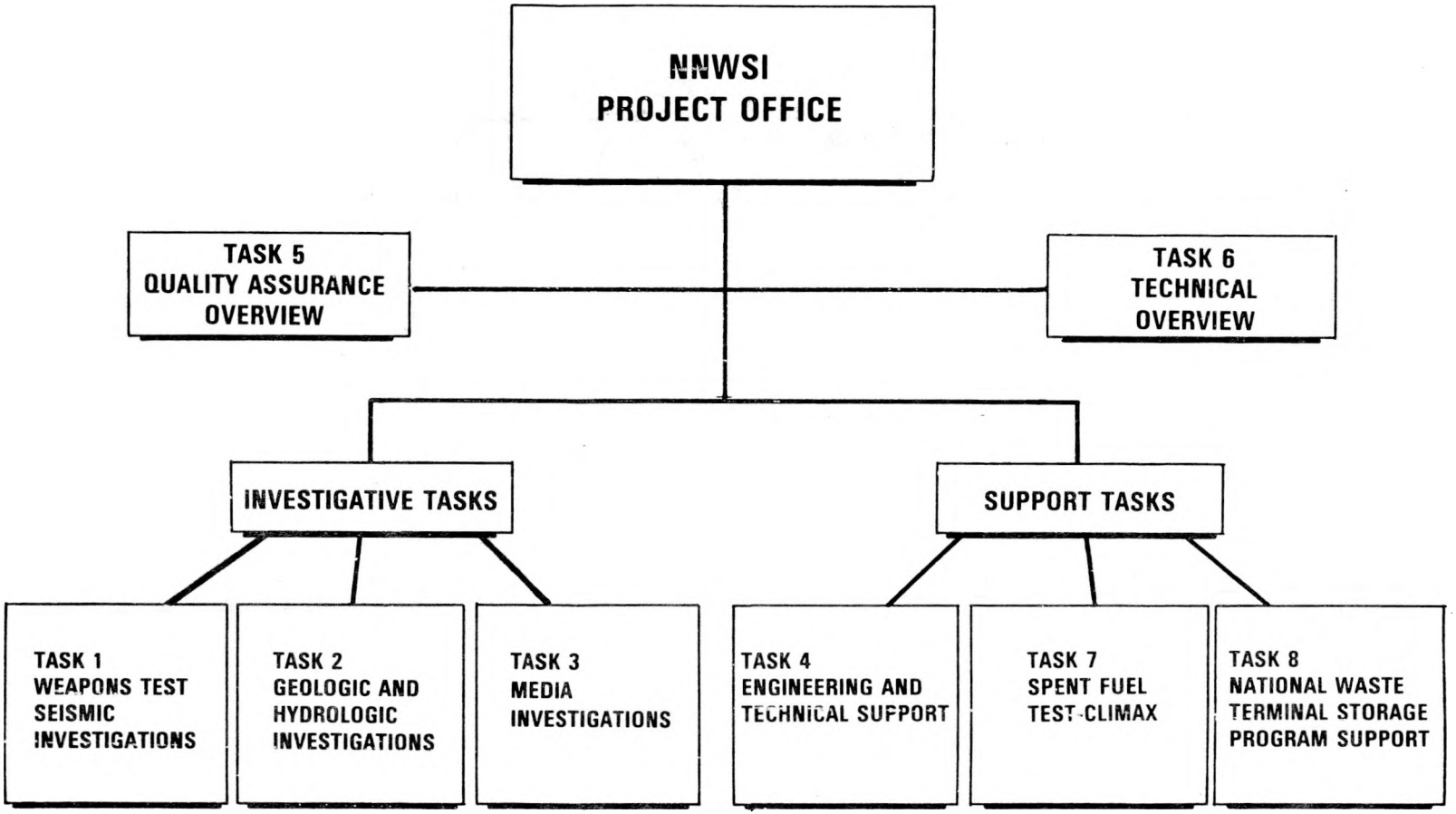


Figure 2. NNWSI Work Breakdown Structure

-- What is the degree of faulting and how is it distributed?

-- What would be the effects of potential fault movements on repository performance?

-- Are the active fault zones migrating and, if so, in what directions and at what rates?

-- What is the potential for renewed volcanism and igneous intrusion within and near the NTS?

-- What would be the effects of volcanism and igneous intrusion on repository performance?

-- What rates of uplift or subsidence can be anticipated, and what erosional or depositional consequences will result?

-- What is the degree of fracturing and alteration within the rock masses at potential sites and what are their effects on repository performance?

-- How do the volcanic and seismic potentials along active as well as ancient zones of weakness differ from regional patterns?

-- Do any relatively homogeneous, undeformed rock masses exist on the NTS or in its vicinity that are of sufficient size for constructing a repository?

REGIONAL HYDROLOGIC INVESTIGATIONS

Because migration with groundwater is the most credible way radioactive waste might reach the biosphere, it is necessary to address the potential for radionuclide transport in the groundwater systems of the NTS and the surrounding region. Questions to be addressed are:

-- What are the present pathways and velocities of groundwater movement?

-- What will be the likely groundwater pathways and velocities if climatic conditions change?

-- What kinds and concentrations of radionuclides are likely to migrate along groundwater pathways from the repository?

-- Where are the likely discharge areas for groundwater migrating through a repository on or near the NTS?

-- How long would it take for initial and peak concentrations of radionuclides originating from a repository to migrate to groundwater discharge points?

-- To what degree are concentrations of radionuclides originating from a repository likely to be changed by geologic media prior to groundwater discharge to the biosphere?

-- What effects do fault zones, crustal movements along faults, and other structural heterogeneities have on groundwater movement?

HOST-ROCK INVESTIGATIONS

Potential host-rock masses located on the NTS include granite, argillite, and tuff. The suitability of these rocks is only partially evaluated; consequently, additional investigation and testing are required to determine whether a repository can be designed and sited in such media with confidence. The following questions are critical:

-- What mechanical stresses will be induced in the host rock by repository construction and operation activities and what will be their effects on repository performance?

-- How will potential host-rock masses respond to the thermal and radiation loads imposed on them by high-level radioactive wastes over the intended life-span of a repository and what will be their effects on repository performance?

-- How extensive does a relatively homogeneous rock mass have to be to effectively contain radionuclides for the required period of time?

-- What are the media-dependent repository design requirements for a continuous mass of relatively homogeneous host rock?

-- How do the hydrologic properties of host-rock media, e.g., porosity, permeability, and water content, affect the containment of radioactive wastes?

-- What are the radionuclide sorption-desorption properties of potential host-rock media?

-- What are the solution-precipitation mechanisms for contaminated groundwater solutions moving across the thermal and pressure gradients surrounding a repository?

TASK 1. WEAPONS TEST SEISMIC INVESTIGATIONS

This task will provide the predictive models and site-specific data needed to establish the effects of ground motion resulting from underground nuclear weapons tests on an underground nuclear waste repository on or in the vicinity of the NTS.

SUBTASK 1.1 SEISMIC DATA PROCESSING AND ANALYSIS

Objective: To predict the potential effects of ground motion resulting from underground nuclear weapons tests on an underground repository and to develop sufficient data on weapons-test-induced seismicity to satisfy anticipated future licensing requirements.

Descriptive Summary

A nuclear waste repository located on or near the NTS will be subjected to ground motion from the ongoing nuclear weapons testing program. The magnitude of the motions will depend on the distance of the repository site from the weapons test area, the yield of the test, the depth of the repository site, and the geologic media at and between the repository site and the site of detonation. There are 13 stations from which data are being obtained. While many of the stations serve a dual purpose, five pairs (one surface and one downhole) primarily support the study of depth effects, two surface stations (augmented by four additional stations for large-yield events) support the study of the NRDS anomaly, and the remaining six are surface stations at potential repository sites in the southwest area of the NTS.

During FY 1979, equations were developed from on-site data to predict peak vector acceleration as a function of yield and distance. The equations developed to date show that the data base for the prediction equations is adequate. However, it is insufficient for determining the effects of depth, geology, and seismic anomalies.

During FY 1980, efforts will concentrate on learning more about the effects of depth on ground motion and the significance of the Jackass Flats seismic anomaly. Since these efforts must be preceded by the digitizing and processing of data obtained by Subtask 1.2, it is anticipated that little progress will be made during FY 1980 with the anticipated funding; therefore, no date can be predicted for resolution of the at-depth issue and no technical reports are expected.

During FY 1981, work will continue on developing prediction equations and characterizing the depth- and geology-related effects as well as determining the significance of the Jackass Flats seismic anomaly. A tentative repository site selection will presumably have been made and funding will be available for more analysis relative to that site.

Liaison will be maintained to facilitate colocation, both at the surface and downhole, of some of the weapons test ground motion measurement stations with those for measurement of natural earthquake motions (Subtask 2.5). Techniques of data processing will be discussed to be certain the data are as comparable as possible.

SUBTASK 1.2 WEAPONS TEST GROUND MOTION MEASUREMENTS

Objective: To measure weapons-test-induced ground motion for determining its changes with distance, yield, and depth and to obtain site-specific ground motion data for evaluating potential repository sites.

Descriptive Summary

Measurement data are acquired on analog tape and are digitized. These data are fed directly into Subtask 1.1. Consequently, this subtask has the same applicability to the test program as Subtask 1.1.

During FY 1979, measurements were made at the locations agreed upon by the Project Officers as contributing to the objectives of the Project. Table 1-1 shows the past and current locations of weapons test ground motion measurement stations. A downhole station is planned for Yucca Mountain when a hole of suitable diameter is available.

During FY 1980 and FY 1981, data acquisition will continue. Some of the surface and downhole weapons-test ground motion measurement stations will be used for colocation with stations measuring natural earthquake motions. Reynolds Electrical & Engineering Co., Inc., will provide support services for reconditioning and installing the seismic measuring equipment. Fenix & Scisson, Inc., will provide engineering support services associated with the drilling requirements. Holmes & Narver, Inc., will provide engineering support services such as surveying.

TABLE 1-1
WEAPONS-TEST-INDUCED GROUND MOTION MEASUREMENT STATIONS

Station	Location	Hole Number	Coordinates North	Coordinates East	Elevation	Medium	Date Installed
1	Area 16	None	840,515	634,760	Surf. ∿5325 ft	Eleana	8/77 (Removed 11/77)
2	Syncline Ridge	None	∿843,250	∿646,250	Surf. ∿4785 ft	Limestone over Eleana	8/77 (Removed 6/78)
3	Piledriver	UE15.01	901,147	677,016	Surf. 5036 ft	Alluvium over Granite	9/77
					Tun. 3669 ft (1367 ft)	Granite	9/77
4	Area 6	UE6b	810,000	678,450	Surf. 3933 ft	Alluvium	4/77 (Stopped recording 5/78)
					Hole 3505 ft (428 ft)	Alluvium	4/77 (Removed 5/78)
5	Skull Mtn.	None	∿743,950	∿633,150	Surf. ∿4563 ft	Tuff	10/77
6	ETS-2	None	758,073	604,467	Surf. ∿3810 ft	Alluvium	10/77
7	Calico Hills	None	∿770,900	∿607,100	Surf. ∿4390 ft	Eleana	10/77
8	Yacht Hole	UE1L	837,000	654,001	Surf. ∿4465 ft	Alluvium over Eleana	11/77 (Removed 8/78)
					Hole ∿2265 ft (2228 ft)	Eleana	3/78 (Stopped recording 8/78)

TABLE 1-1 (Continued)
WEAPONS-TEST-INDUCED GROUND MOTION MEASUREMENT STATIONS

Station	Location	Hole Number	Coordinates North	Coordinates East	Elevation	Medium	Date Installed
9	Rainier Mesa	U12g.08 CH #1	882,173	633,268	Surf. 7602.2 ft	Tuff	12/77
					Tun. 6186.15 ft (1416 ft)	Tuff	12/77
10	Well J-11	J-11	740,768	611,764	Surf. 3442 ft	Alluvium	3/78
			740,968	611,764	Hole ∿2116 ft (1329 ft)	Tuff	4/78
10'	200	J-11'	∿740,918	∿611,764	Hole 3245 ft (200 ft)	Alluvium	3/78
11	Area 4	UE4aa	854,145	666,794	Surf. 4210 ft	Alluvium	3/78
					Hole 3076 ft (1134 ft)	Limestone	3/78
13	Area 18	UE18r	868,100	564,700	Surf. 5538 ft	Tuff	6/78
					Hole 3038 ft (2500 ft)	Welded Tuff	
14	Yucca Mtn.	None	∿764,900	∿568,400	Surf. 4070 ft	Tuff	10/78
15	Dome Mtn.	None	∿813,804.	∿579,416	Surf. 6193 ft	Lava	10/78
16	Fortymile Canyon	None	∿810,000	∿585,600	Surf. 4200 ft	Rhyolite	10/78
17	N. Timber Mtn.	None	∿850,800	∿560,200	Surf. 7422 ft	Tuff	7/78
18	S. Timber Mtn.	None	833,950	∿557,896	Surf. 7239 ft	Tuff	7/78

TASK 2. GEOLOGIC AND HYDROLOGIC INVESTIGATIONS

This task will provide the regional and site-specific goelogic and hydrologic data needed to identify a suitable site for establishing a nuclear waste repository on or in the vicinity of the NTS.

SUBTASK 2.1 GEOLOGIC AND HYDROLOGIC PROJECT COORDINATION

Objective: To coordinate and ensure an effective interdisciplinary approach to geologic and hydrologic exploration and evaluation and to ensure that Task 2 subtasks interface with NV objectives and Project requirements.

Descriptive Summary

USGS will coordinate the technical investigations of all organizations participating in Task 2 studies to assure that each subtask obtains the maximum benefit from the data and interpretations generated by other subtasks. As the subtasks are defined generally in accordance with the organizational structure of the USGS, it will also be the responsibility of Subtask 2.1 to compile and integrate the results. This will be accomplished for periodic reports and reviews by compiling the technical highlights, overall progress, and major interfaces applicable to specific areas and media being investigated.

This subtask will ensure that all interfaces necessary for interdisciplinary investigations of geologic and hydrologic problems take place in a timely and effective manner. Consequently, this subtask will interface continuously with all Task 2 subtasks. In addition, it will assure that necessary and desirable communications are maintained with all NNWSI participants.

SUBTASK 2.2 GEOLOGIC INVESTIGATIONS

Objective: To locate and characterize rock masses on or near the NTS to determine their suitability for hosting a nuclear waste repository.

Descriptive Summary

During FY 1980, the USGS will compile all pertinent existing data on the geology, drill holes, and geophysical surveys for the entire southwest quadrant of the NTS. Potentially favorable sites (in any rock medium) will be evaluated and recommendations will be made concerning the sites which merit further exploration.

During FY 1981, the study of the entire southwest quadrant of the NTS will be completed and a preliminary report issued.

Shale/Argillite--This activity will complete the report on the geologic evaluation of the (1) Syncline Ridge and (2) Calico Hills/Topopah Wash areas.

Tuff--This activity will: (1) determine the structure, stratigraphy, geometry, and condition of the tuffaceous media in the Yucca Mountain area through detailed surface studies and analyses of Geology-1 (G-1) drill-hole cores and (2) complete the analysis and interpretation of the conductor drill holes at Yucca Mountain.

During FY 1980, the USGS will complete the geologic analysis of the conductor drill holes at Yucca Mountain. A draft report of these findings will be issued. Final criteria for geologic drill hole G-1 (on Yucca Mountain) will be prepared and transmitted to NV. USGS will prepare the drilling program for drill hole G-1 and log and analyze the core, including fractures in the core. USGS will conduct detailed field mapping of the Yucca Mountain area to further evaluate its geologic structure. The USGS will prepare a complete drilling plan for the Yucca Mountain and adjacent areas. This plan will include the drilling of geologic, geophysical, volcanic, and hydrologic holes.

During FY 1981, surface and drill core examinations of the Yucca Mountain site will be continued and a preliminary evaluation of the G-1 drill-hole data will be conducted to aid in siting, if necessary, of the drill hole Hydrology-1 (H-1). Detailed analysis of the drill core and related data from the G-1 hole will continue and be supported by interpretation of geophysical data. If the results from drill hole G-1 are favorable, the USGS will prepare the criteria for drill holes G-2 and G-3.

Granite and Other Plutonic Igneous Rocks--This activity will complete the geologic and magnetic interpretation of the Twinridge pluton at the NTS. During FY 1980, the USGS will incorporate interpretations of aeromagnetic data in the final revision of the report on geologic evaluation of the Twinridge granitic pluton.

SUBTASK 2.3 GEOPHYSICAL INVESTIGATIONS

Objective: To determine the subsurface distribution of physical properties at potential repository sites on or near the NTS.

Descriptive Summary

Geophysical techniques provide a means for obtaining information about the earth's subsurface without resorting to drilling. Hence, they provide a nondestructive method of investigating the physical character of potential repository environments at depths of interest. Such techniques are being used in the site-specific and regional geologic studies to assist in identifying and characterizing specific sites, to identify the structural features associated with groundwater movements, and to provide information about the subsurface environment relevant to determining the potential for future tectonism and volcanism.

The geophysical data and interpretations generated by this subtask will greatly influence and be influenced by interpretations of subsurface geologic conditions. Several geophysical techniques to be employed will provide site-specific information that is helpful in assessing water content, water quality, and permeability. The geophysical investigations will provide information about faults, structural or mineralogic features, and the depth to the curie isotherm that will be of use in tectonic interpretations. Physical properties determined from laboratory testing of core samples will be closely coordinated with Task 3 in order to prevent unnecessary duplication of effort and to provide sufficient cross-checks to assure the reliability of the data.

During FY 1978 and FY 1979, extensive geophysical investigations were carried out first at Syncline Ridge and then at Calico Hills-Topopah Wash, Wahmonie, and Yucca Mountain areas. The results of this work, along with that of other subtasks, resulted in termination of field exploration at all sites but the Yucca Mountain site; work in progress at the other areas will be completed and the results documented.

Gravitational, magnetic, and galvanic electrical measurement techniques were used on a semiregional scale to obtain subsurface structural data related to the groundwater systems of the southwestern part of the NTS and the Amargosa desert. These techniques, along with electromagnetic methods, were also used to help assess the structural framework of the region in relation to the potential for tectonism and volcanism.

Gravitational, Magnetic, and Seismic Studies--During FY 1980, gravitational intensity surveys will be made in the Yucca Mountain area to help define the major faults and gross details of the bedrock structure. Detailed profiles will be obtained across Fortymile Wash and the major washes in the Yucca Mountain area to check for possible low-density zones of nonwelded tuffs or to detect zones of high permeability.

Measurements of magnetic properties of drill core and surface samples will be reported and integrated with computer modeling of magnetic anomalies.

A limited seismic refraction/reflection survey will be made at Yucca Mountain to obtain the general velocity structure, energy absorption characteristics, and optimum surveying parameters to help guide a high-resolution survey of the Yucca Mountain area.

Two-dimensional computer modeling of gravitational and magnetic data obtained in FY 1979 at Calico Hills/Topopah Wash and Wahmonie areas will be done and integrated with the seismic and electrical studies.

A review will be made of heat flow measurements at the NTS, including recently obtained data.

For FY 1981, extended gravitational intensity, magnetic, and seismic surveys may be required to delineate the Yucca Mountain area and to assess other potential repository sites at the NTS. The gravity and magnetic data will be compiled and compared with existing and new geologic data.

Electrical Studies--For FY 1980, site-specific work will follow up on FY 1979 studies at Yucca Mountain which have identified an electrical boundary associated with the northwest-trending washes in which UE25a-1 is located. Because this boundary bisects the site and appears to extend to a depth of at least several thousand feet, its nature is of critical importance to identification of the areal extent of the potential site. Electrical studies will focus on providing a better definition of this structure and subsidiary northwest-trending structures. The techniques used will be those found to be effective in FY 1978, principally slingram, vertical electrical sounding (VES), and induced polarization (IP) dipole/dipole.

When the G-1 hole location is firmly established, additional electrical surveys will be made in the G-1 hole vicinity to provide further matrix data for running the borehole geophysical logs in the hole. The electrical surveys will also be extended along the northern and western boundaries of Yucca Mountain.

In regard to work in support of groundwater studies, VES work was started in late FY 1979 to supplement prior data. This work, which will concentrate on the Lathrop Wells region. The data resulting from this work and prior data will be integrated with other geophysical, geologic, and hydrologic data in an interim report. Additional work will be initiated to provide more information about Crater Flat and Fortymile Wash.

Telluric data in the Fortymile Wash area will be extended and correlated with magnetotelluric (MT) data for the region. Dipole/dipole work in Fortymile Wash and Crater Flat will also be evaluated. Contracts will be let for remote-reference MT data at or near selected sites of the seismic net.

Draft reports on the electrical studies at the Calico Hills and Wahmonie sites will be issued. Completion of the Syncline Ridge summary report on geophysics is scheduled for mid-FY 1980.

For FY 1981, assuming that the G-1 drill hole results indicate that the Yucca Mountain site is favorable, the depth to a repository medium of welded tuff will have been established and data for input into models will be available. Auxiliary data will be obtained at all planned drilling sites to provide

further control on the surface geophysical data. Additional data will be obtained in support of locating the G-2 and G-3 drill hole sites.

Work in support of hydrologic studies will be expanded north along Forty-mile Wash and Crater Flat to better define the possible hydraulic flow paths.

Geophysical Borehole Studies--For FY 1980, the USGS will conduct limited borehole operations in two distinct phases--geophysical logging and hole-to-surface and/or hole-to-hole investigations at exploratory drill holes defined in coordination with other Project participants. Electrical, sonic, caliper, radiometric, and magnetic logs will be completed by USGS and/or an NV contractor for the entire depth of exploratory holes in order to provide data on the near-field environment for modeling and calibration of hole-to-surface and hole-to-hole experiments.

Extensive hole-to-hole surface work was done upon completion of UE25a-4, -5, -6, and -7 in late FY 1979. Analysis of the large amount of data will take much of available resources for borehole studies in FY 1980. Assuming the holes remain in good condition, some hole-to-hole subsurface work will also be attempted.

All new exploratory holes will be logged upon completion (or at intermediate depths as drilling conditions dictate) and then will be utilized for hole-to-surface and, if suitably located, hole-to-hole direct current resistivity, electromagnetic, and seismic measurements. An important part of these experiments will be to assess the state-of-the-art techniques and to define the limiting hole-to-hole distances for borehole methods.

In support of both surface and borehole geophysics, physical property measurements will continue on selected core samples from exploratory holes. To provide some quality control on laboratory physical property measurements of drill core, particularly density and electrical properties, an experimental laboratory at the drill site will be used to measure those properties and to compare them with laboratory measurements made after handling and shipping.

In FY 1981, geophysical borehole work will essentially be a continuing program from FY 1980. The amount of borehole work that can be done is tied directly to the availability of drill holes.

SUBTASK 2.4 HYDROLOGIC INVESTIGATIONS

Objective: To determine the present and past hydrologic regimes of the NTS and surrounding area as a basis for predicting the potential for hydrologic transport of nuclear wastes to the biosphere.

Descriptive Summary

This subtask will assemble data on the present and past hydrology of the NTS and the surrounding area to define the site-specific and hydrologic settings of candidate repository sites and to characterize the hydrogeology of pathways from such candidate sites to points of present and possible future discharge.

Hydrology--This activity will (1) define in detail the local hydrology of candidate repository sites at or contiguous to the NTS, including their relationships to regional systems; (2) monitor hydrologic phenomena; and (3) perform hydrologic tests at the NTS and in its vicinity.

During FY 1980, the maximum effort will be expended in examining Yucca Mountain as a possible repository site. Fluid levels will be monitored to determine the hydrologic parameters of existing holes in the southwest quadrant. Hydraulic testing will be conducted at selected formation intervals in a proposed exploratory hole, G-1, in Yucca Mountain. The spatial subsurface distribution of head, permeability, porosity, and rock and water chemistry will be evaluated at Yucca Mountain.

During FY 1981, one or more hydrologic holes will be drilled and tested at or near Yucca Mountain. Hydrologic testing techniques will include packer testing and chemical analyses, as well as specialized techniques such as Tracejector and salinometer surveys and temperature logging. The monitoring of fluid levels in existing holes will continue in FY 1981.

Paleohydrology--Because of the likelihood of climatic changes in time frames of tens of thousands of years, future hydrologic systems are expected to differ from those of today. The paleohydrology activity will define precipitation, recharge, water table depths, gradients, and pathways to points of groundwater discharge during Pleistocene pluvial cycles in southern Nevada.

Relationships between paleoclimates and the hydrologic conditions that existed can be used to predict hydrologic conditions resulting from similar potential future regimes.

Transport of nuclides away from a repository by groundwater is generally accepted as the most probable pathway to the biosphere. During the Pleistocene (glacial) Epoch, several worldwide changes in climate occurred and similar future climatic changes are probable. The differences between present hydrologic systems and those that would occur under wetter climates in the future are being assessed by defining the systems that existed under pluvial climates of the past.

During FY 1979, the USGS examined spring deposits in the NTS area and issued a draft report for colleague review. One conclusion is that in the southern part of the NTS, the ancient water table never stood more than 200 feet above its present position during pluvial phases of the Pleistocene Epoch. More information is needed in the central and northern parts of the NTS to adequately define ancient groundwater gradients in the southwest quadrant of the NTS.

Also in FY 1979, the USGS examined mineral assemblages in existing drill cuttings and playa deposits and concluded that enough evidence exists to suggest a unique clay mineralogy related to past positions of the water table. During FY 1980, the USGS will continue its study of the clay mineralogy of drill cuttings from the unsaturated zone and issue a report at the end of the fiscal year.

A third paleohydrologic investigation, the dating and analysis of vegetation remains in pack rat middens, was established in FY 1979. Further work in FY 1980 and FY 1981 will translate findings from these studies into a paleoclimatic scenario from which estimates of past precipitation can be made. Rat midden samples will be collected at low, intermediate, and high elevations and dated.

During FY 1981, further analysis of midden samples will be completed and a report of the findings will be issued at the end of the fiscal year.

Solute-Transport Model--This activity will predict the rates and directions of movement of radioactive species and their concentrations in groundwater if they should be released from a waste repository in the vicinity of the NTS.

During FY 1979, the USGS developed a preliminary finite-difference, hydraulic model of the NTS and vicinity. After testing the model, it was concluded that a more flexible finite-element approach would be more appropriate. Consequently, a two-dimensional, steady-state, finite-element model was developed. During the year, inverse runs were made in order to estimate hydrologic parameters. In cooperation with Sandia Laboratories, sensitivity analyses were performed to determine the relation of hydraulic gradients to each of the other hydrologic parameters in the vicinity of Yucca Mountain.

During FY 1980, the inverse modeling and sensitivity analysis for the two-dimensional model will be completed and a report issued. Modeling of radionuclide transport, concentrating on the Yucca Mountain areas and areas downgradient, will be initiated.

During FY 1981, transport modeling will be completed and a report issued. Assuming that a well-defined site has been chosen for a possible repository, the effort will be directed toward developing a close-in, three-dimensional model.

Short-Term Hydraulic Effects--The presence of a mined underground opening and the thermal loading of a repository will drastically change the local hydrologic regime from its undisturbed condition. Heater experiments have been conducted in granite at the NTS to simulate the thermal and dynamic stresses that would be expected from waste-induced heating. The objectives of those activities are to understand the effects of these stresses upon the rocks and to simulate the multiphase hydrodynamic response of a repository.

Thermal loads in rocks containing significant amounts of water can be expected to produce increased pore-fluid pressures. In the most intense part of the thermal field, steam may be produced, causing large pressure increases even in partly saturated rocks. Where rock permeability is low, the increase

in pore fluid pressures may seriously decrease bulk rock strength by hydraulic or steam fracturing.

During FY 1978, the USGS monitored heat and pressure transients in satellite holes surrounding an electrical heater in the Climax Stock. During FY 1979, the data were compiled and analysis was begun.

During FY 1980, the USGS will examine and analyze the data from the heater experiments and report on the results. Based on an evaluation of the heater experiment results, a determination will be made about whether to model the results. If so, modeling will begin in FY 1980. At present, no program plans have been formulated for FY 1981.

SUBTASK 2.5 TECTONIC, SEISMIC, AND VOLCANIC INVESTIGATIONS

Objective: To assess the potential for faulting, damaging earthquakes, volcanic activity, and accelerated erosion to affect long-term repository performance.

Descriptive Summary

This subtask will be accomplished by investigating the rate, intensity, and distribution of faulting during the last 25 million years, with special emphasis on the last 10 million years; monitoring and interpreting present seismicity; studying the history of volcanism; and evaluating past rates of erosion and deposition.

Regional Tectonism and Volcanism--These studies will continue to increase our knowledge of the tectonic development of the southern Great Basin, particularly during the last 10 million years. From this understanding, the possibility that future volcanism and faulting will adversely affect the performance of a repository will be better defined. This long-term background investigation will provide the best possible insight into the tectonic stability conditions of the areas surrounding any proposed waste storage sites in the southern Great Basin. In FY 1980, work will continue to be focused on the NTS area, and particularly the southwestern part of the NTS.

The mapping of alluvium and certain bedrock areas begun in FY 1979 will be completed for the Jackass Flats, Yucca Mountain, Crater Flat, and the central Amargosa Valley areas. This information will result in a better understanding of the structural, hydrologic, and general geologic framework. Mapping of the alluvium will continue to improve expertise in this specialized field so that this work can be carried into other parts of the NTS region where it is needed to help with tectonic stability evaluations. The alluvial stratigraphy and the morphology of fault scarps must be known to date surface Quaternary faulting. The dating of carbonate materials and soils by uranium-series disequilibrium methods will be continued.

Work on geologic-tectonic maps of the NTS region, begun in FY 1979, will be completed in FY 1980. These maps will provide the basis for construction of volcanic histograms for the southwestern Nevada volcanic field and for other tectonic and structural work.

Volcanic/tectonic studies by LASL and USGS will continue to focus on the Pliocene and Quaternary volcanic activity of the southern Great Basin. In FY 1979, volcanic studies concentrated on the NTS area, and in particular the volcanic rocks of Crater Flat. Preliminary calculations, assuming a random distribution of volcanism, were made of the probability of disruption of a potential repository site at Yucca Mountain. In FY 1980, work will be expanded to include studying Pliocene and Quaternary basalts in analogous adjacent regions such as the Reveille-Pancake Range area north of the NTS. Further work will be done to investigate reasons for the occurrence of a relatively young (3.5 million years) tectonic or thermal event recognized in FY 1979 in an area west of the NTS.

In FY 1981, emphasis in the tectonics studies will shift to the characterization of Quaternary faulting in the east half of the Goldfield and Death Valley 2^{o} sheets. This will be done by compiling existing data and reconnoitering areas where youthful faulting is suspected. Geomorphic and geologic criteria will be developed to rate or classify the tectonic stability of basins and ranges on the basis of fault ages, the linearity and steepness of mountain fronts, basin fill depth, and so forth. This information will eventually be combined with seismicity data to evaluate and compare the activity of various structural blocks in the southern Great Basin.

A geodetic survey will be started if a potential repository site is selected in FY 1981. This survey will be needed on a site-specific basis to help determine the stability of the site area.

Preparation of a tectonic map of the NTS region, based on the geologic map prepared in FY 1980, will be started. The volcanic histogram for the same area will be completed during FY 1981.

Provided siting a repository in the western NTS area still appears feasible, geologic mapping of the Bullfrog Hills 15-minute quadrangle will be started in FY 1981. This is the only large area adjacent to the western part of the NTS where volcanic rocks have not been mapped in detail. Other mapped but unpublished quadrangles in this area will be completed for publication.

The dating and study of young volcanic rocks will continue as needed to refine volcanic risk assessments. Emphasis on the volcanic risk studies will be placed on consequence analyses, which will consider the intrusion of a repository by basaltic magma, using field data. The objective will be to provide sufficient data for volcanic dispersal models to allow eventual biodose calculations.

Seismicity--This activity will locate currently active faults and determine the recurrence rate of seismicity in the NTS region. These data, augmented by geological data, will be studied to formulate an improved seismotectonic model for the region that will serve as a basis for defining seismic source zones and calculating the seismic hazard to a nuclear waste storage facility. Also, this activity will evaluate the ground-shaking response at specific sites and at depths relevant to a storage facility; it will also provide earthquake data for evaluating the volcanic hazard in the NTS region.

The seismicity of the region will be studied in detail to determine the seismic hazard to a facility. Seismic source zones will be defined to assess the seismic potentialities, particularly as they may affect the temporary support facilities of a repository. While the location of currently active faults does not preclude the possibility of activity in the future on presently inactive zones, it is important to avoid locating the facility on or near active faults to the extent that these zones can be determined.

A 50-station seismic network has been installed within a 160-km radius of the NTS to locate earthquakes. This network covers the tectonic features of greatest significance relative to seismic hazard assessment at the NTS including: (1) Fish Lake Valley/Death Valley/Furnace Creek fault zones, (2) the apparent east-west belt of seismicity, and (3) the NTS paleoseismic zone. Research concerning the relationship between current seismicity and geological aspects

of these features will permit a more complete understanding of the seismic hazard to the nuclear waste storage installation. The regional extent of this network is necessary for these studies to include the possibility that a site may eventually be chosen off of the NTS. The locations of earthquakes will continue to be determined through FY 1981.

Data from the regional and temporary seismograph networks will also be employed to study the volcanic hazard. Travel-time and amplitude anomalies will be analyzed to locate the presence of magma bodies within the crust and upper mantle. A new phase of seismologic studies will be started in FY 1980 to use data from the seismic net to study seismic wave attenuation. This work will aid in the location of anomalous areas of seismic wave propagation. Correlation of this information with appropriate geophysical and geologic data may permit identification of potential magma chambers in the crust and extinct magma chambers which have crystallized.

Studies of site-transfer functions will determine the relationship between the magnitude of ground shaking occurring at the surface and that in the depth range of a potential disposal facility. These data will enable the extrapolation of predicted surface ground motions to the relevant depth. At two drill holes, a downhole-and-surface, three-component seismograph system will be installed. The data from these systems will be telemetered to Mercury where they will be recorded on magnetic tape. The data will be processed and analyzed in Golden. Finite-difference modeling of the response at each site will be conducted to predict ground motion at depth. This work will continue during FY 1980 and FY 1981.

The data obtained from these studies and other geologic studies will ultimately serve as the basis for establishing the seismic hazard at the NTS with more confidence than has been possible in the past. A seismic hazard evaluation will begin in FY 1981 at the earliest.

Work begun in FY 1979 to relocate important instrumentally recorded historic earthquakes of the southern Great Basin will be completed in FY 1980. The refinement of epicenters and the study of foreshock and aftershock sequences will improve velocity models and provide an insight into the behavior of seismic zones in Nevada.

SUBTASK 2.6 GEOCHRONOLOGIC INVESTIGATIONS

Objective: To provide potassium-argon, fission-track, uranium-trend, and uranium-series ages on geologic samples for use in determining the history of geologic events and conditions.

Descriptive Summary

Reliable geochronologic investigations are essential to the needs of the field geologists investigating the tectonic, volcanic, and hydrologic processes that are being evaluated for the selection of a suitable repository site.

Potassium-argon dating will be used for tuff and basalt samples where the age range is greater than about 100,000 years and for mineral separates obtained from granitic rock samples. This technique is most useful for determining the date of the youngest volcanism at or near the NTS.

Fission-track dating, particularly of apatite, but also of zircon and sphene, will be applied where these minerals can be separated from tuff, granitic rocks, and other igneous and metamorphic rocks. Fission tracks in apatite anneal at about 100° C. Fission-track dating is most useful in determining when various blocks of rock containing apatite most recently passed through the 100° C isochrone. Zircons and sphenes anneal at higher temperatures and are useful for dating the age of the rocks. Such dating complements potassium-argon dating and, in certain cases, fission-track dating can be done where potassium-argon dating cannot.

Uranium-trend dating has an age range of about 10,000 to 800,000 years; this technique may be useful in estimating the time of deposition of alluvial, eolian, or colluvial deposits and volcanic ash in lake beds. Initial results indicate that southern Nevada represents a suitable environment for uranium-trend dating, and this technique probably will be used to a greater extent than uranium-series dating for future investigations.

Uranium-series dating is applicable in the age range of 4,000 to 400,000 years and will be used to date carbonate-bearing samples. It is anticipated that most of the samples submitted will be either (1) calcite vein materials, (2) travertine, or (3) rock caliche. Dating of carbonate fracture fillings should aid in determining the age of faulting and recurrence of faulting. The technique is applicable to a greater age span than carbon-14 and should be applicable in studies where appropriate volcanic rocks (potassium-argon dating) or wood (carbon-14 dating) is unavailable.

Investigations will be expanded to include uranium-238, uranium-234, thorium-230, radium-226, and lead-210 systematics in fracture-filling material by gamma-ray and alpha spectrometry as a potential tool for assessment of the age of young fault movements.

SUBTASK 2.7 INVESTIGATIONS OFF THE NTS

Objective: To locate and characterize suitable rock masses for the storage of high-level radioactive waste in the southern four counties of Nevada.

Descriptive Summary

FY 1979 and earlier programmatic decisions have focused exploration efforts for suitable rock masses for the storage of high-level radioactive waste on the NTS. In the event of unfavorable results on the NTS, this subtask will identify and characterize potential masses of granite, shale/argillite, and tuff in southern Nevada as possible alternative candidates for repository sites. All geologic, geophysical, and hydrologic investigations conducted off the NTS will be limited to nonpenetrating reconnaissance surveys to assemble data for future use in the event no site on the NTS is judged suitable and a decision is made to consider other parts of southern Nevada for a possible repository site.

During FY 1980, the USGS will complete summary-data reports in the geologic evaluation of shale/argillite areas in southern Nevada. The Nevada Bureau of Mines will evaluate the potential for mineral resources in granitic rocks off the NTS in southern Nevada. A survey of the literature was completed in FY 1979. On the basis of that survey, the Nevada Bureau of Mines will conduct field studies in selected areas, with the first to be examined near Tonopah in the vicinity of Lone Mountain.

In FY 1981, the geologic, geophysical, and hydrologic reconnaissance of selected areas in southern Nevada which was initiated during FY 1978/1979 will be resumed. This reconnaissance will be conducted on the basis of the recommendations included in the studies to be reported in FY 1980. The Nevada Bureau of Mines will continue field examinations of selected areas to appraise their mineral resource potential.

TASK 3. MEDIA INVESTIGATIONS

This task will provide the rock properties data needed to determine the suitability of rock masses on or in the vicinity of the NTS to host a repository.

SUBTASK 3.1 ARGILLACEOUS MEDIA INVESTIGATIONS

Objective: To characterize and determine the suitability of argillaceous media for the permanent isolation of nuclear wastes.

Descriptive Summary

The near-surface Eleana Heater Experiment was conducted at Syncline Ridge during FY 1978/1979 to: (1) determine whether Eleana argillite can withstand sufficient thermal loading to allow economic isolation of high-level waste, (2) provide data for corroboration of thermal and mechanical models, and (3) assess the reliability and suitability of available test hardware and instrumentation and to determine the need for developing new instrumentation for future long-term tests. The near-surface heater test at Syncline Ridge began early in FY 1978. Supporting laboratory and modeling studies of Eleana argillite were also begun. Post-test operations and site cleanup were completed early in the third quarter of FY 1979.

Laboratory work was performed during FY 1978/1979 to determine the thermal, mechanical, mineralogical, physical, and chemical properties of samples from the Eleana formation as functions of temperature and pressure to allow assessment of the effectiveness of this medium as a waste migration barrier. During FY 1979, models were used to analyze the experimental data on the near-field thermal and structural response of argillite to evaluate and improve present models and to calculate the probable far-field response of the entire Syncline Ridge area.

During FY 1979, a programmatic decision was made to discontinue the investigation of the argillaceous media on the NTS at the end of FY 1980. The decision was based on the results of the geologic and geophysical exploration

of two NTS argillite locations, Syncline Ridge and the Calico Hills. The results of the geologic and geophysical investigations of those two areas indicated structural complexity.

The FY 1980 activities will focus on completing the documentation of the near-surface Eleana Heater Experiment and related laboratory and modeling studies. The documentation of these studies will include:

-- A comparison of the thermal and mechanical properties of argillite from Syncline Ridge and the Calico Hills.

-- An elucidation of the effects of expandable clays on the thermal expansion of argillaceous rocks.

-- An identification of compressive failure caused by overdriven in situ heater tests.

-- An identification of tensile joint openings that were related to the presence of expandable clays during the full-scale heater test. (This finding was corroborated by transmissivity measurements, post-test drill-back, and borehole examination at the heater site.)

-- The incorporation of laboratory and field results into thermal and mechanical models of argillite response.

-- The prediction of the near-field canister response at depth and far-field structural response of a hypothetical repository in argillite with new models.

In the documentation of the Eleana experiment and related studies, the feasibility of emplacing heat-generating waste in argillite will be evaluated using thermal and thermomechanical models of the far-field response of argillite to the emplacement of high-level nuclear waste. Computer calculations will be used to describe the effects of variable thermal expansion coefficients on far-field stresses. These calculations and all previous calculations that

assumed a constant positive expansion will be summarized in the final report. This report will include descriptions of all relevant operational, experimental, and modeling efforts directly related to the Eleana Heater Experiment. The final report on the Eleana Project will be submitted by the end of the third quarter and will cover all of the work completed. The final report will be based heavily on previous reports and will attempt to extrapolate the data on the argillite of the Eleana formation to what is known about other argillaceous rocks in an effort to evaluate the suitability of argillaceous rocks--as a group--for hosting a high-level nuclear waste repository.

No activity is planned for FY 1981.

SUBTASK 3.2 TUFFACEOUS MEDIA INVESTIGATIONS

Objective: To characterize and determine the suitability of tuffaceous media for use as a repository for high-level nuclear wastes.

Descriptive Summary

A tuff rock mass is not a continuum, but rather includes a discontinuous system of fractures, joints, and bedding planes (herein all falling under the category of joints). In addition, tuffs may contain large amounts of water, 7 to 9 percent by weight for welded tuffs and up to 35 percent by weight for nonwelded tuffs, whether the formations are above or below the water table. Joints and water content are known to affect the thermal, mechanical, and permeability properties of a rock mass.

In 1978, scoping activities were initiated to assess tuff as a potential emplacement media for a nuclear waste repository. Early in these activities, a number of issues were identified with some relating to the geological setting and others to the media. These issues and preliminary scoping results were presented to the National Academy of Sciences' Committee on Nuclear Waste Management in September 1978. The two principal issues for tuff as a media were identified as: (1) the high water content and (2) the jointing system in welded tuff. The welded tuff has been the focus for an emplacement medium because of its desirable thermal and mechanical properties. These two issues were identified based on a general examination of tuff. The assessment of tuff is currently directed to identify issues that are specific to the application as a repository media. These issues will be defined as a result of the mine design activity of this subtask.

This subtask will determine the suitability of tuffs to host a nuclear waste repository by conducting in situ and laboratory thermomechanical and geochemical experiments. The data obtained from these experiments will be used to develop a conceptual design for a siting repository in tuff and to model the effects of a nuclear waste repository on the tuffaceous host rock. An initial data report on tuffs will be generated at the end of the fiscal year for the National Academy of Sciences (NAS).

The in situ experiments will:

1. Provide the in situ physical, geochemical, and mechanical data needed to evaluate tuff as a viable repository host rock.

2. Provide the data needed for the NAS review of the suitability of tuff as a host rock.

3. Establish the data needed for developing a conceptual repository design in tuff.

The joint and water effects studies will determine the effects of joints and water content on the properties of tuffaceous media, particularly those properties which might affect mine stability, near-field interactions, and far-field containment.

The mine design studies will:

1. Develop a basic underground mined repository layout for tuffaceous media.

2. Define the power density, emplacement geometries, operating temperature, imposed stresses, and other parameters affecting the basic underground mined repository layout in tuff.

3. Develop in situ test plans for determining and evaluating the geochemical and thermomechanical environment of the conceptual underground mined repository in tuff.

4. Analyze and report the results of the in situ tests, laboratory work, and modeling studies needed for designing a viable repository in tuff.

5. Assess the feasibility of siting a high-level nuclear waste repository in the tuffaceous media at Yucca Mountain.

The geochemical studies of the radionuclide retention capacity of tuffaceous media will:

1. Determine the sorptive behavior of potential host-rock media as well as other rock types along the flow path from a repository site.

2. Determine the chemical properties of the groundwater.

3. Establish the groundwater flow rate.

In Situ Experimentation--Preparations for a small-scale, water migration/heater experiment in the welded Grouse Canyon tuff in the G-Tunnel complex at the NTS were begun in FY 1979. At the end of FY 1979, the heater and data acquisition system design and fabrication were completed, site preparation (drilling) was close to completion, and geological characterization of the site was under way. This experiment will examine water behavior and migration in tuff under the influence of a thermal field. The effects of water on heat transfer from the canister and the nature of the geochemical environment in which the waste canister exists will be determined. This experiment will use a four-inch-diameter heater operated at constant power; monitoring will determine temperature change, fluid migration, and thermal displacement in the rock. Several aspects of this test, including the fielding of a laser strain interferometer and relative humidity gauges at elevated temperatures, are developmental.

During FY 1980, the tuff water migration/heater experiment will be turned on and completed. The data will be analyzed and a draft final report on the experiment will be submitted to NV at the beginning of the fourth quarter of the fiscal year. Also in FY 1980, the conceptual in situ test plans resulting from the Mine Design Study will be prioritized and a detailed test plan will be developed for the first experiment. Assuming that supplementary funding is obtained early in FY 1980, field construction of the experiment site will begin in the third quarter of the fiscal year. The test will be conducted in the Grouse Canyon welded tuff in G-Tunnel. The kind of in situ experiments to be performed during FY 1981 and subsequent years is dependent on the technical issues arising from the findings of other activities and studies conducted within this subtask.

Joint and Water Effects Studies--The joint and water effects studies will define the effects on tuff which may affect mine stability, near-field interactions, and far-field containment. Consideration of tuff as a repository medium for the emplacement of high-level nuclear wastes began in late FY 1978. During FY 1979, several activities were carried out which were aimed largely at accumulating sufficient data to formulate an overall program directed toward assessing the generic feasibility of tuff as an emplacement medium. Reports were submitted concerning the general ambient-pressure thermal expansion, ambient-pressure thermal conductivity, and matrix mechanical properties of a broad range of tuffs.

During FY 1980, this task will determine the effects of joints and water on the thermal, thermomechanical, and permeability properties of both intact and jointed tuffs. Specific parameters that will be determined include porosity, degree of saturation, confining pressure, pore pressure, temperature, time, mechanical loading rate, and mineralogy. Joint properties to be considered include orientation, frequency, extent, aperture, roughness, mineralization, and gouge filling. Not all of these parameters are of equal importance, nor will all factors be investigated on all samples.

The thermal properties of tuffs are known to be a critical function of both water content and joint properties. Rock fabric (anisotropy) and mineralogy also appear to be important and may be of special concern in the evaluation of data collected on small samples. Thermal conductivity measurements are, therefore, essential for both intact and jointed samples as a function of sample saturation, temperature, and confining pressure. Initial SL studies will concentrate on the calibration of newly acquired apparatus and determination of the limits of accuracy for measurements on tuff. Until the apparatus is operational, studies under confining pressure will be carried out by Terra Tek, Inc.

The effects of joints and water on the mechanical properties of tuffaceous media are expected to be complex. LASL and SL have defined a cooperative program to cover many aspects of this interaction. Care will be taken to ensure that laboratory data are consistent with input for available models or will be useful for improving existing models. At SL, initial studies of joint

effects on mechanical properties and permeability will concentrate on the investigation of single, artificially prepared joints. Effects of joint roughness and joint fillings on the coefficient of friction will be determined directly by testing both saturated and air-dried samples. Joint permeability will be investigated as a function of normal stress and solution contact time. The definition of test parameters will give consideration to temperature, confining pressure, pore pressure, and loading rate. Mineralogical, time-dependent (creep), and hydrothermal alteration effects on the mechanical and permeability behavior of tuffs will be evaluated at LASL. Remote sensing techniques will be evaluated by LASL and SL for their usefulness in simultaneously measuring and correlating geophysical properties with mechanical properties for both jointed and intact rock.

The ideal code/model for predicting the effects of a repository design on crystalline rock must be a combined thermal/thermomechanical fluid-flow model, which includes the effects of joints. No code presently available completely meets this requirement. Therefore, efforts will first be directed at adding joint effects into the codes dealing with the individual facets of the problem. Constitutive models presently exist for both very widely spaced and very closely spaced joints; no present code can treat the problem of joints that are spaced at intermediate distances, i.e., 0.1 to 1.0 meter. Therefore, a finite element code will be altered or developed that will limit the number of joints in an element to a maximum of one. In addition, the model will treat both dilatant and nondilatant behavior during deformation. A laboratory-scale validation test of the code developed will be devised and carried out. Available thermal codes will also be modified to include the effects of joints. Effects due to possible water migration and thermal conductivity changes with saturation and temperature will be included in this code. Laboratory experiments in support of water migration theory will continue.

Reporting during FY 1980 will be focused on one main event. A preliminary status report summarizing the status of joint/water interaction studies will be submitted in June. This submission date will permit inclusion of the foregoing information in the preliminary data report to the NAS.

FY 1981 activities in the joint/water interaction studies will largely be an extension of activities carried out in FY 1980. This is due to the complexities inherent in the problems being considered. No specific FY 1981 milestones are defined for this activity at the present time.

Mine Design Studies--The tuff mine design studies are part of the NNWSI Project starting in FY 1980. The study will be conducted by a working group made up of representatives from SL, LASL, RE/SPEC, and Texas A&M University. These studies will: (1) develop a basic underground mined repository layout in tuff; (2) define the probable geohydrologic environment for the conceptual repository; (3) predict the thermal and mechanical response resulting from high-level nuclear waste emplacement; and (4) define the geochemical environment of a repository sited in tuff. These studies will address the near-canister, room-suite, and far-field thermal and mechanical response of tuff to the thermal load from high-level nuclear waste. This evaluation is important for assessing the engineered and natural barriers for containing waste in tuff. In the course of all these efforts, the recognized concerns of high water content and joint frequency will be considered. These efforts, which will also tentatively define the repository environment for disposal in tuffs, will require approximately nine months.

Development of the conceptual study plans will begin in the last quarter of FY 1980. A draft report of the objectives to be addressed in these studies will be submitted September 1, 1979. During FY 1981, it is anticipated that definition of the repository environment will be using the results from the FY 1980 water/joint effects study and that the conceptual development of the in situ test plan will continue.

Yucca Mountain Analysis--The Yucca Mountain analysis will assess the feasibility of siting a waste disposal repository at Yucca Mountain. Evaluation of Yucca Mountain as a potential waste repository site first began with the drilling of hole UE25a-1 in late FY 1978. This hole, which is located at the western edge of Jackass Flats, defined the tuff stratigraphy at one edge of the study area. During FY 1979, laboratory activities related to Yucca Mountain focused on the collection of preliminary material property data on the tuffs from UE25a-1. These preliminary data indicated the scope of the general

thermal and mechanical properties. Also, a report was submitted presenting the preliminary one-dimensional thermal modeling of waste disposal in Yucca Mountain tuffs aimed at gaining a first level of understanding about the sensitivity of acceptable power densities to variables such as geothermal flux, waste form, depth of emplacement, and stratigraphic variability.

Two major milestone activities are planned for FY 1980. In June 1980, there will be a preliminary draft tuff data report made to the NAS. Though this report is predominantly generic in nature, a large portion of the data included in it will be taken from the analysis of Yucca Mountain core. Finally, in August 1980, a report will be submitted which will summarize the state of analysis of the emplacement of waste at Yucca Mountain at that time. This report will utilize more recent property data and the stratigraphic information that will come from the G-1 exploratory hole to be drilled into Yucca Mountain. Thus, the data base on which this report is based will be much broader than that presently available. The scheduling and content of this report will, however, be critically dependent upon the completion data of G-1. The report will include two-dimensional thermal, mechanical, and transport analyses based on the stratigraphy in UE25a-1 and G-1.

Analysis of Yucca Mountain in FY 1981 will utilize the three-dimensional stratigraphic information and improved property definition obtained during FY 1980. The timing of reports will depend largely upon completion of additional exploration holes and definition of near-field requirements.

Geochemical Studies--The geochemical studies will determine the extent radionuclides can be transported by groundwater through tuffaceous media. The sorptive properties of the host rock as well as for the other rock types present along the flow path, the chemical properties of the groundwater, and the groundwater flow rate all influence radionuclide transport. A thorough understanding of the radionuclide transport environment of a repository site is required to develop a high level of confidence in predicting the isolation potential of a repository.

In FY 1978, initial studies were performed with tuff samples taken from hole J-13 in Jackass Flats. The results indicated very good sorptive properties

with average distribution coefficients as high as or higher than those of other rock types considered for waste isolation. However, distribution coefficients varied significantly with the lithologic varieties of tuff.

In FY 1979, the studies were extended to include tuff samples obtained from hole UE25a-1 on Yucca Mountain. Distribution ratios have been obtained by the batch method for a number of nuclides, including those of strontium, cesium, technetium, barium, cerium, europium, uranium (VI), americium, and plutonium. The batch sorption method allows for the investigation of the effects of varying many parameters. Those investigated so far include: temperature (22^{o} C and 70^{o} C), atmosphere (air and nitrogen), concentration (americium and technetium), time, water composition, particle size, and mineralogy of the tuff. Migration rate studies are being performed on samples of crushed core which include determining the flow rate.

Methods of studying sorption on whole core samples for either fracture flow or porous flow are being developed. A microautoradiographic method is used to determine sorption sites of alpha-emitters on thin sections of tuff and microstructural distribution in whole cores which have been infiltrated and sectioned.

During FY 1980, batch aerobic sorption measurements will be performed at LASL on selected tuff samples recovered as part of Task 2. Core samples from the G-1 drill hole, particularly from below 2,500 feet, will be studied to establish their sorptive properties. Samples with different lithologies will also be investigated.

During FY 1980, the dependence of the sorption ratio on the following additional variables will be determined: (1) the concentration of the element in the reactant solution, (2) the ratio of the weight of solid to volume of solution, and (3) the absence of oxygen while maintaining carbon dioxide pressure. The latter is particularly important since anoxic measurements in the absence of carbon dioxide can lead to unrealistic pH values. Furthermore, carbonates are present in some tuffs and in the groundwater; the carbonate ion is a good complexing agent for some elements.

Migration rate studies will be continued during FY 1980 using three different types of laboratory-size columns: (1) crushed rock; (2) intact, unfractured cores; and (3) cores containing natural fractures. Rock-treated waters prepared from naturally occurring groundwaters or having a similar composition will be used. Results from the crushed-rock column studies will be compared to the results from earlier batch sorption studies performed on the same geologic materials. The effects of atmospheric composition (i.e., oxygen and carbon dioxide concentration) on the behavior of selected elements will be assessed, as will the effect of flow rate. Migration rate experiments through consolidated rocks and through cores containing a natural fracture will be continued using high-pressure rock-column systems incorporating constant-flow liquid-metering pumps. This should provide information on the proper method of predicting migration rates in consolidated materials from those obtained in columns prepared from granular materials. LASL will also investigate methods of obtaining dispersion information.

During FY 1980, the batch sorption behavior of carbonate rocks and of the three-component system, calcite, dolomite, and siderite, will be determined under anoxic conditions in the presence of carbon dioxide. The most probable potential pathway for radionuclides to reach the biosphere from a repository at the NTS is through the carbonate aquifer in the Paleozoic strata. Carbonates may also play a significant role in controlling pH and Eh. The presence of siderite should create reducing conditions which will probably influence those elements that are multivalent.

Radionuclide migration to the biosphere in the NTS area would generally involve transport through alluvium. Selected measurements will be made on alluvium samples from Jackass Flats. The results will be compared with those made on alluvium from Frenchman Flat in earlier studies.

Detailed chemical, mineralogical, and geochemical analyses will be performed to characterize sorption behavior of a nuclide in any geologic material and type of water. LASL will analyze these materials by a variety of techniques to determine such parameters as the major, minor, and trace-element composition; mineralogy/petrology; pH/Eh; carbonate/bicarbonate ratio; and ions/anions.

LASL will continue to study nuclide sorption on naturally existing surfaces by infiltrating consolidated rock columns, sectioning the rock afterwards, and determining the microdistribution of nuclides. This work will be an important step in delineating, for a given tuff, what the absorbing surface material is and where in the rock structure nuclide sorption takes place. In addition to work with alpha-emitters, LASL will also explore the possibility of extending the microautoradiographic technique to include beta-emitting radionuclides.

During FY 1980, LASL will continue studies of the behavior of actinides in the water found in most of the NTS environments and the studies involving technetium. Experiments with iodine and selenium will begin. The possibility of using electrophoresis to determine the nature of the chemical species present in water will be studied using either iodine or plutonium.

The sorption capacities of many geologic media are frequently governed by the presence of alteration phases (for example, zeolites) which may not be present in great abundance. LASL will use equipment to hydrothermally alter tuffs in an agitated pressure vessel. This equipment is capable of operating up to 300^{o} C and 1 kbar. The batch technique will then be used under anoxic conditions to measure the sorption behavior. Detailed characterizations of changes in the mineralogy/petrology will be done. These measurements should have some applicability to sorption behavior in the near-field environment as well as in the far field.

During FY 1981, it will be necessary to scale up the small column experiments for measurements of large cores or blocks brought into the laboratory. This will be an intermediate study between those with small samples and in situ field experiments. Large-scale laboratory experiments and in situ field tests are necessary to demonstrate that the results from laboratory studies apply to natural systems and that models of nuclide transport derived from the laboratory results correctly model nuclide movement in intact geological strata.

Yucca Mountain core samples recovered from the geologic exploration program and existing core samples at the USGS Mercury Core Library have been and will continue to be studied in FY 1980 to determine the major mineral

phases present and their chemical composition, relative abundance, and textural relationships in individual rock specimens. Particular attention is being focused on determining the rock characteristics that directly control physical and thermomechanical properties. These include: degree of welding, presence and textural variation of devitrification products, presence and textural variation of vapor-phase minerals, and secondary alteration products including primarily zeolite and clay minerals. The mineralogical/petrological studies involve specialized sample preparation, optical microscopy, electron probe microanalyses, and X-ray diffraction.

In FY 1979, tuff samples from the exploratory drill hole UE25a-1 and drill hole J-13 (Test Well 6) were studied. The mineralogy and petrology of densely welded units consist principally of quartz and feldspar. Above the water table, the secondary mineralogy consists of minor cristobolite and alkali feldspar, while below the water table the secondary mineralogy of the densely welded units consists of very minor amounts of clays and zeolites. The nonwelded and partially welded units below the water table are extensively altered to various zeolite phases, principally clinoptilolite.

During FY 1980, the mineralogic and petrologic work on drill hole G-1 will include modal analyses, phase identification, and mineral chemistry of selected samples from the drill hole. Physical and mechanical property determinations and correlations will also be made.

Zeolite minerals are known to undergo reversible and nonreversible dehydration reactions in the temperature range 200° to 500° C. To evaluate the possible impact of such reactions on a repository in tuffaceous media, several exploratory investigations will be carried out. These will include dry heating experiments and careful monitoring of X-ray diffraction patterns. They will also include the measurement and analysis of evolved fluids and evaluation of other techniques as deemed appropriate.

FY 1981 activities will include drill core characterization. Samples from the hydrothermal soak tests shall be characterized and reported with the results of those experiments. Zeolite property investigations will include exploratory $^{18}O/^{16}O$ ratio measurements to determine the feasibility of applying oxygen isotope geothermometry to zeolite analyses.

Funding was received in late FY 1979 to start instrumentation development of exploratory tests to measure the effects of exposure ot tuff over an extended time period to the simulated conditions of a waste repository. Prototype hydrothermal soak vessels, pressure systems, and electronics systems have been assembled and tested in preparation to begin the experimental runs in FY 1980. The hydrothermal soaking tests will be started in FY 1980. Two lithologic types of tuff, core specimens from the exploratory drill hole UE25a-1, will be subjected to temperatures of 50, 150, and 250^{o} C and confining pressures of 0.5 and 5 MPa for periods of up to six months. The samples will be characterized petrologically and a series of thermomechanical properties will be determined prior to the experimental runs. Following exposure, the thermomechanical measurements will be repeated and petrologic examinations undertaken for samples showing significant property changes. Attention will be focused on the presence or absence and mechanisms of mineral alterations.

Pending the results of exploratory drilling in the Yucca Mountain block during FY 1980, the experimental matrix of lithologic types of tuff may be extended during FY 1981 with new runs for G-1 core samples. The results of the FY 1980 experiments will be analyzed. In addition, laboratory and possibly in situ field experiments will be conducted to extend the data base concerning the thermomechanical and mineralogical response of tuffs to elevated pressure/temperature conditions.

SUBTASK 3.3 GRANITIC MEDIA INVESTIGATIONS

Objective: To characterize and determine the suitability of granitic and other relatively impermeable media as host rock for the permanent isolation of nuclear wastes.

Descriptive Summary

In prior fiscal years (1977, 1978, 1979), funding was devoted to the design, construction, and operation of a heater test in the Climax granite, to laboratory measurements of Climax granite, and to modeling activities to support the Climax granite studies. Test plans for granitic investigations have also been prepared. Permeability studies were carried out in prior years as a part of Task 2.

Climax Granite Field Testing--The Climax granite in situ heater test was designed and constructed in FY 1977 and operated in FY 1978. These data have been used in designing the Spent Fuel Test-Climax, but have not been formally documented in topical reports. Efforts in this activity during FY 1980 will be restricted to documenting test results from the heater test. No activity is planned for FY 1981.

Permeability Studies--The permeability studies will design and construct a multisample apparatus for the measurement of water permeability through various types of relatively impermeable generic repository rocks. The permeability studies will also determine the behavior of the Climax Stock quartz monzonite and Westerly granite at high temperatures and pressures.

To assess the transport of radionuclides by groundwater, it is important to have accurate input to the calculations. Part of this input is the spatial and temporal variation of permeability, including the effects of temperature and pressure on permeability. Tests of the permeability of Eleana argillite were carried out as a function of pressure for FY 1978. At that time, it was recognized that in order to more completely evaluate the material behavior, additional testing would have to be carried out at elevated temperatures. Also, rock permeabilities were so low (approaching 10^{-12} darcy) and test durations so long that more production capability was needed.

In FY 1979, a new multiple high-temperature permeability apparatus was designed by LLL and construction was begun. Four samples can be run simultaneously in each of the two test cylinders. The purpose of the improved apparatus is to conduct tests under temperature conditions more nearly representative of an actual repository. Characteristics of the unit were as outlined above, with test control and data acquisition possible by either manual control or by automatic means using an LSI-11 minicomputer. This unit is expected to become operational for tests at 20^{o} C late in the first quarter of FY 1980. The elevated temperature capability will be added by late in the second quarter of FY 1980.

Samples to be measured in FY 1980 will include Climax Stock quartz monzonite, Westerly granite, and Eleana argillite (to extend FY 1978 measurements to include the effects of temperature). In FY 1981, these tests will continue and other rock types of interest to the NTS program will be added. These may include several types of tuff or other rocks as specified.

TASK 4. ENGINEERING AND TECHNICAL SUPPORT

This task provides for the separation of Project costs for drilling, the core library, and general engineering support from the NTS contractors.

SUBTASK 4.1 DRILLING PLANS AND ENGINEERING

Objective: To provide Project participants with technical support from the NTS contractors.

Descriptive Summary

The NTS contractors will provide general technical engineering support on drilling, mining, construction, and studies related to the NNWSI Project as requested by the DOE/NV. This general support will involve (1) participation at certain Project meetings where engineering, logistical, or estimating expertise is required for planning, review, and/or recommendation purposes; (2) preparation of planning data, estimates, and evaluation of various proposals developed by the Technical Project Officers; and (3) other requested miscellaneous technical services or support work. Additionally, this subtask was established to provide the NNWSI Project Office and the USGS with engineering and drilling services from the NTS contractors.

SUBTASK 4.2 FIELD GEOLOGY AND CORE LIBRARY SUPPORT

Objective: To provide and maintain a cadre of Fenix & Scisson geologists to support Project participants, provide and maintain a Core Library at Mercury for handling and storing rock samples, and provide general NNWSI Project support to the U.S. Geological Survey.

Descriptive Summary

USGS will provide technical coordination and instruction to the Fenix & Scisson (F&S) geologists. Activities at the Mercury Core Library include the storage, handling, labeling, retrieval, and shipping of rock samples and documenting distribution of samples obtained from field operations in support of the Project.

The principal duties of the F&S geologists are drill hole monitoring in support of the NNWSI Project and procuring, identifying, describing, and distributing rock samples from the NNWSI drill holes. Other activities include reporting on current progress of drilling operations, preparing reports upon completing drill holes, geologic mapping of Quaternary deposits, sampling and measuring of magnetic properties of surface and subsurface rock samples, surveying and metering gravity stations, assisting in surface electrical surveys, and ad hoc activities in support of the USGS and other appropriate Project participants.

REECo will provide general support, office space, clerical assistance, vehicle procurement and maintenance, radio support, and other logistic operations as required in support of the USGS.

TASK 5. QUALITY ASSURANCE

This task will provide the overall quality assurance program plan and procedures needed to assure the quality and accountability of the data obtained by NNWSI participants.

SUBTASK 5.1 QUALITY ASSURANCE OVERVIEW

Objective: To develop and implement the Project Quality Assurance Program and to guide and assess participant Quality Assurance Programs.

Descriptive Summary

SL will continue activities emphasizing implementation of requirements contained in the NNWSI Quality Assurance Program Plan. Quality Assurance Overview completed the draft Quality Assurance Program Plan at the end of FY 1979. The Quality Assurance Program Plan contains the Quality Assurance Program Plans of participating organizations for the complete description of quality assurance activities supporting Project activities. The Project Office is scheduled to review and approve the NNWSI Quality Assurance Program Plan during the second quarter of FY 1980. Any new regulatory guidance specific to waste repositories will be incorporated into the Quality Assurance Program Plan as it becomes available.

Procedures implementing NNWSI Quality Assurance Program Plan requirements for Project Office, Technical Overview, and Quality Assurance Overview activities will be completed and/or approved for use during FY 1980. These procedures include existing DOE and Sandia Laboratories procedures plus special procedures developed to cover Project activities. Priority will be given to completion of a procedure that documents the Quality Assurance Program requirements used for Project activities. This procedure will consolidate and amplify previous quality assurance guidance developed by Quality Assurance Overview and released by the Project Office. After completion of the procedure and approval by the Project Office, it will be distributed to Project participants. Quality Assurance Overview will review and approve participant Quality Assurance Program Plans, including revisions due to this Quality Assurance Program requirements document.

Work will begin on incorporating quality assurance activities into the NNWSI network charts. Quality Assurance Overview will work with Project participants to update the network charts to identify quality-related milestones on existing networks and add networks as necessary to define quality assurance activities and milestones not directly affecting scientific investigations. The emphasis of FY 1980 network chart efforts will be to chart quality assurance activities associated with the G-1 hole to be drilled into the base of Yucca Mountain. In addition, the remainder of FY 1980 activities will be incorporated into the network charts.

A records library will be established at the NTS Engineering Records Center for the collection and permanent storage of records generated during Project activities. Quality Assurance Overview will provide requirements for the NNWSI records collection system and oversee its establishment. The records collection system requirements will include records library operating criteria and guidance to Project participants concerning the types of records that should be retained and how and when to transmit copies of them to the records library.

Quality Assurance Overview will provide quality control support for the Project Office and Technical Overview. This is a general and continuing activity including, but not limited to, the development and implementation of quality assurance procedures, document reviews, and follow-up on quality problems brought to the attention of the Project Office.

Quality Assurance Overview will continue to schedule and conduct Project audits. Six audits are planned for FY 1980.

FY 1981 activities will be a continuation of the Quality Assurance Program activities implemented during FY 1980. Nuclear Regulatory Commission (NRC) guidance which is specific to waste repositories is anticipated by FY 1981 and Project quality requirements will need updating to address this new guidance. There will have to be some additional stress placed on activities not completely covered during FY 1980 due to funding limitations, especially in the areas of surveillance and Project audits.

SUBTASK 5.2 PARTICIPANT QUALITY ASSURANCE

Objective: To internally develop, implement, and audit participant Quality Assurance Programs.

Descriptive Summary

During FY 1980, LASL, LLL, SL, USGS, and DOE/NV contractors will finalize the development of their Quality Assurance Programs for activities which control or affect the acquisition of data from which conclusions and decisions will be reached concerning the site/media selection for the repository. Participant Quality Assurance Programs will be administered by qualified individuals who are responsible to the Technical Project Officer for maintaining an independent assessment of Quality Assurance Program effectiveness. Implementation of Quality Assurance Programs by all participating organizations will continue during FY 1980 with ongoing Program assessment through audits by participant quality assurance organizations and Quality Assurance Overview.

Each participant will identify all organizations and activities that the Quality Assurance Program is written to cover, including other participant quality assurance organizations. Each participant quality assurance organization will interface with all other organizations within that program to assure proper implementation and compliance with the defined Quality Assurance Program. Additionally, each participant quality assurance organization will interface with Quality Assurance Overview (Subtask 5.1).

During FY 1980, Project participants will develop and implement quality assurance procedures for their newly assigned subtasks. Participant Quality Assurance Programs will document their surveillance and auditing activities and evaluations for each subtask on a periodic basis.

In FY 1981, participant Quality Assurance Programs will continue to develop quality assurance procedures for newly assigned subtasks and will complete the implementation of their Quality Assurance programs and procedures. Surveillance and auditing activities and evaluations will continue.

TASK 6. TECHNICAL OVERVIEW

This task has the lead responsibility for the technical planning, integration, implementation, coordination, and documentation of the NNWSI and for developing site evaluation criteria for screening potential repository sites on or in the vicinity of the NTS.

SUBTASK 6.1 TECHNICAL OVERVIEW CONTRACTOR

Objective: To provide technical support to the DOE/NV Project Manager for the Nevada Nuclear Waste Storage Investigations Project.

Descriptive Summary

The Technical Overview contractor, Sandia Laboratories, will work with the DOE/NV Project Manager, participating laboratories, agencies, and subcontractors to plan, coordinate, review, document, and implement a balanced technical Project to determine the feasibility of using the NTS for the geologic isolation of nuclear wastes. This will be accomplished by: (1) developing both short- and long-range plans, including evaluating proposed portions of the plans; (2) reviewing the progress of and recommending means to improve the technical performance of existing subtasks; (3) preparing or coordinating the preparation of the overall Project documentation, including an annual Project Plan and other Project documents; (4) assisting DOE/NV with DOE/ONWM, ONWI, NWTS, and NRC interfaces on technical matters; and (5) conducting in-depth technical studies which cut broadly across the NNWSI. A complete description of the responsibilities of the Technical Overview contractor is provided in the Management Structure section of this document.

The first subtask function, assistance with planning, is guided by the technical approach described earlier in this Project Plan and is characterized by the milestone logic network presented in Appendix A. The milestone logic network, developed in coordination with other Project participants, will be periodically updated, modified, and extended as circumstances require. Assisting the DOE/NV with the evaluation of future revisions to the plan, as

required by possible Project redirection at significant decision points, is a responsibility of this subtask.

The second subtask function, evaluation of the progress of existing subtasks, is a Project requirement. SL will assist the DOE/NV in these evaluations by the use of appropriately trained SL personnel and qualified consultants. Technical evaluations will be accomplished by formal periodic technical reviews, visits to field and laboratory projects, and meetings with Project participants. Major technical recommendations and position papers will be prepared and provided to the DOE/NV as appropriate.

The third subtask function is assisting the DOE/NV with the preparation of Project documentation. This documentation includes an annual Project Plan and periodic technical status reports. Technical assistance will also be provided on technical matters as required.

The fourth subtask function involves assessing the technical objectives of the NNWSI through interaction with national waste management and regulatory bodies. SL will participate in formulating the interfaces and assist the DOE/NV in evaluating technical requirements resulting from potential future redirections of national waste management policy and/or regulatory criteria.

The fifth subtask function consists of two technical studies which were conducted in FY 1979. The first study involved a sensitivity analysis of the regional groundwater flow model. This study was carried out in close cooperation with the USGS (Subtask 2.4). The SL-developed statistical sensitivity analysis techniques were applied to the USGS-developed, regional-scale hydraulic model to indicate geographical areas where additional data would be most beneficial and to identify the hydrologic parameters which will have the greatest impact on long-term safety analyses. This work will be documented during FY 1980 and a decision will be made concerning the use of these techniques to support the development of the regional drilling plan. The second study involved an age-dating study with basalts from the NTS region. The results of this study will also be documented during FY 1980.

SUBTASK 6.2 SITE EVALUATION ACTIVITY

Objective: To develop and exercise the site evaluation criteria and screening methodology needed for evaluating potential high-level nuclear waste repository sites on the NTS or contiguous areas.

Descriptive Summary

In FY 1979, the Site Evaluation Activity was initiated to ensure that the evaluation of potential repository sites on the NTS occurs on a timely basis and is coordinated with the National Waste Management Program schedule. The organizational structure for this activity consists of three tiers: Management, Site Evaluation Steering Committee, and Site Evaluation Working Group. (See the Management Structure section for a description of the organization and the responsibilities.) During FY 1979, the Site Evaluation Steering Committee was organized and charters for the Site Evaluation Steering Committee and the Site Evaluation Working Group were written. During FY 1980, the Site Evaluation Working Group will be impaneled by the Site Evaluation Steering Committee to start developing repository site evaluation criteria for the NTS area and a methodology for the evaluation of potential sites in terms of the criteria developed.

The first task of the Site Evaluation Working Group is to devise a detailed plan for criteria and methodology development. This is expected to require about three months of effort. After approval by the Site Evaluation Steering Committee, this plan will be incorporated into the NNWSI Project network charts. The subsequent criteria and methodology development activities of the Site Evaluation Working Group for FY 1980 and beyond will be guided by this plan.

TASK 7. SPENT FUEL TEST--CLIMAX

This task will test the feasibility of storing spent reactor fuel in an underground granitic rock mass and evaluate the effects of thermal and radiation loadings on the host rock.

SUBTASK 7.1 SPENT FUEL TEST MANAGEMENT, DESIGN, AND PROCUREMENT

Objective: To accomplish the technical direction, design, and procurement activities required to conduct the Spent Fuel Test--Climax.

Descriptive Summary

The Spent Fuel Test--Climax was originally proposed by LLL in January 1978 as a generic test of the geologic storage of spent reactor fuel assemblies in granite. The test was authorized in June 1978 and initial site confirmation and facility rehabilitation work was initiated in the balance of FY 1978.

During FY 1979, the detailed design, procurement, and construction activities proceeded in parallel to expedite preparation for the emplacement of spent fuel into storage during the first half of FY 1980. Significant milestones which were achieved by the end of FY 1979 included:

1. Completion of the technical concept and definition of the instrumentation and data acquisition systems.

2. Completion of the development of construction and support criteria and review and approval of all construction designs for the test.

3. Completion of the detailed designs for all components of the fuel canister handling system.

4. Initiation of procurement of all canister handling and instrumentation components. About 75 percent of these procurement actions were completed and assembly activities on all subsystems were in progress at the end of FY 1979.

5. All scoping calculations to support the test design and safety-related construction were completed or were being documented during FY 1979.

6. All significant elements of the Safety Assessment Document for the test were drafted and reviewed internally by LLL and Westinghouse.

7. Characteristics of fuel assemblies to be stored were specified, fuel assemblies were selected, and fuel shipments to the NTS were initiated in FY 1979.

8. Designs for fuel canisters and all related hardware were reviewed and approved and all hardware was completed during FY 1979.

At the end of FY 1979, all test-related activities were on schedule to meet the FY 1980 milestones of completion of test construction by the end of the first quarter and completion of initial fuel canister loading by the end of the second quarter.

LLL will provide the overall technical management functions for the Spent Fuel Test--Climax. This will include responsibility for preparation of the required documentation for the test, including test plans, a Safety Assessment Document, and operating procedures. LLL will, in coordination with other test participants, maintain current estimates of cost and schedule for the test. LLL will be the principal NV technical contact for considerations relating to the interaction with other elements of the Project and other NTS program activities. LLL will provide technical support to the NV Public Affairs Office as requested.

LLL will develop the technical plan for the test, including detailed calculations of the anticipated effects, and documentation of the test geometry. LLL will provide the technical criteria for the support to be furnished by other Project participants.

LLL will be responsible for installation and maintenance of the test instrumentation and data acquisition system appropriate to satisfy the technical concept objectives, safety considerations, and documentation. This includes

assembly and installation of test components, preparation of operating procedures, dry runs, and checkouts, and certification of the test facilities as ready for operation.

LLL will provide the major elements of the canister-handling system required to transport the fuel canister assemblies from the E-MAD encapsulation facility to the test storage area and retrieve them in a safe and reliable manner. These elements will include a shielded cask surface transporter for use on the NTS road system which will interface with the E-MAD remote handling equipment and with the canister access hole, an access hole lowering hoist system, and a rail-mounted transfer cask which will move the assemblies between the bottom of the access hole and the storage holes in the canister storage drift. LLL will be responsible for the operation of the canister-handling system and the data acquisition system.

FY 1981 will be the first full year of operation of the Spent Fuel Test. During the first half of the year, the thermal maxima in the near field (the region around the canister storage holes) will be reached and the temperature will begin to slowly decline. The principal geotechnical activity will be data reduction and calculations to model the thermomechanical response of the rock mass in a manner consistent with the observed behavior.

In the operational and engineering area, two fuel assembly exchanges are planned during the year--eight months after initial loading, and then eight months later. In view of the length of this test (three to five years), it is essential that a demonstrated capability be maintained to perform fuel canister retrieval operations. These two exchanges will exercise that capability and maintain personnel proficiency. The exchanges are scheduled to occur prior to and after the near-field thermal maxima to confirm that no unanticipated problems are associated with the maxima.

Routine maintenance of both the instrumentation and canister-handling equipment will be required during the year. We have assumed that a manned entry to the subsurface test area will be required once per month to perform these activities.

A continuation of the FY 1980 effort in support of the national program, i.e., primarily informational and technical reporting activities, is anticipated through FY 1981.

SUBTASK 7.2 SPENT FUEL TEST CANISTER ENGINEERING AND SUPPORT

Objective: To accomplish the necessary engineering design, procurement, and operations to provide the packaged fuel assemblies to support the Spent Fuel Test--Climax.

Descriptive Summary

Westinghouse Advanced Energy Systems Division is responsible for the engineering design and manufacturing operations required for the spent fuel storage canisters. The activities completed during FY 1979 included the design and procurement of canisters, canister closures, shield plugs, and storage hole liners. Other activities included the design and procurement of E-MAD handling tools and fixtures, assistance in the arrangement for the acquisition of spent fuel assemblies, and support in the management functions involved in the direction and coordination of the design, procurement, manufacturing, and technical support operations.

The assembly and installation of the electrically heated simulators will be completed during the first quarter of FY 1980. During the second quarter, Westinghouse will support LLL during the assembly and delivery of the surface transporter cask and trailer system.

During FY 1980, the remaining 10 of 13 spent fuel assemblies will be received and encapsulated at the E-MAD facility. Complete calorimeter installation, checkout, and fuel assembly characterization will be carried out as directed. Eleven of the canisters containing spent fuel assemblies will be loaded into the LLL transporter and delivered to the Climax site for emplacement.

During FY 1981, two canisters from the Climax test will be removed and replaced with two units from the E-MAD Lag Storage Pit; one replacement at 8 months and the second at 16 months after initial emplacement in the Climax granite.

SUBTASK 7.3 SPENT FUEL TEST FACILITIES CONSTRUCTION AND SUPPORT

Objective: To accomplish test facility design, construction, and support activities required for the Spent Fuel Test.

Descriptive Summary

This effort will include architectural engineering services by Fenix & Scisson, Inc. (F&S) and Holmes & Narver, Inc. (H&N) and construction and support services by Reynolds Electrical & Engineering Co., Inc. (REECo).

F&S will provide architectural engineering services for all mining- and drilling-related operations. Services will include preparation of detailed plans, estimates and specifications, and field engineering and inspection services.

H&N will provide architectural engineering services for all other facilities which support the test and provide all survey support to establish and document the orientation and location of all test installations.

REECo will provide mining, drilling, and other construction operations and will provide operations and maintenance support, including the procurement of materials and subcontract services as required.

By the end of FY 1979, almost all of the design responsibilities of F&S and H&N had been completed and major REECo construction requirements (canister access hole, mining of the experiment drifts, canister emplacement holes, instrumentation holes, and floor and rail) were completed. Construction of various other elements of the test were in progress.

The remaining construction work for FY 1980 includes completion of various surface and underground facilities for the test and field engineering services. Remaining elements of work include: electrical power distribution, instrumentation cabling, HEPA ventilation system, headframe, miscellaneous underground and surface facilities, concrete collar at the access hole, site paving, fire suppression systems, emplacement cable and hoist installation, and other items

in support of fuel transport/dry runs and facility operations support and maintenance.

All construction work is scheduled for completion prior to dry runs of the fuel emplacement operations. Subsequent to fuel emplacement, test operations support will include maintaining an underground access capability for the inspection and maintenance of test facilities and for tours of the underground facilities by various interested organizations and the public. The facilities and operational capabilities will be maintained to remove the fuel assemblies at any time during the life of the test.

Support of test operations will include the planned exchange of two fuel assemblies in FY 1981 (the first in November 1980 and the second in July 1981). No fuel exchange operations are planned for FY 1980.

The basis for all activities of the architectural engineering and operating contractors will be the submission of specific criteria by LLL to NTSSO with a copy to the Project Manager, NV, and will conform to the procedures as specified in the NTSSO-SOP 6001.

TASK 8. NATIONAL WASTE TERMINAL STORAGE PROGRAM SUPPORT

This task provides support to the National Waste Terminal Storage Program on technical matters.

SUBTASK 8.1 NATIONAL WASTE TERMINAL STORAGE PROGRAM TECHNICAL SUPPORT

Objective: To provide technical support to the National Waste Terminal Storage Program as requested or approved by the NNWSI Project Manager.

Descriptive Summary

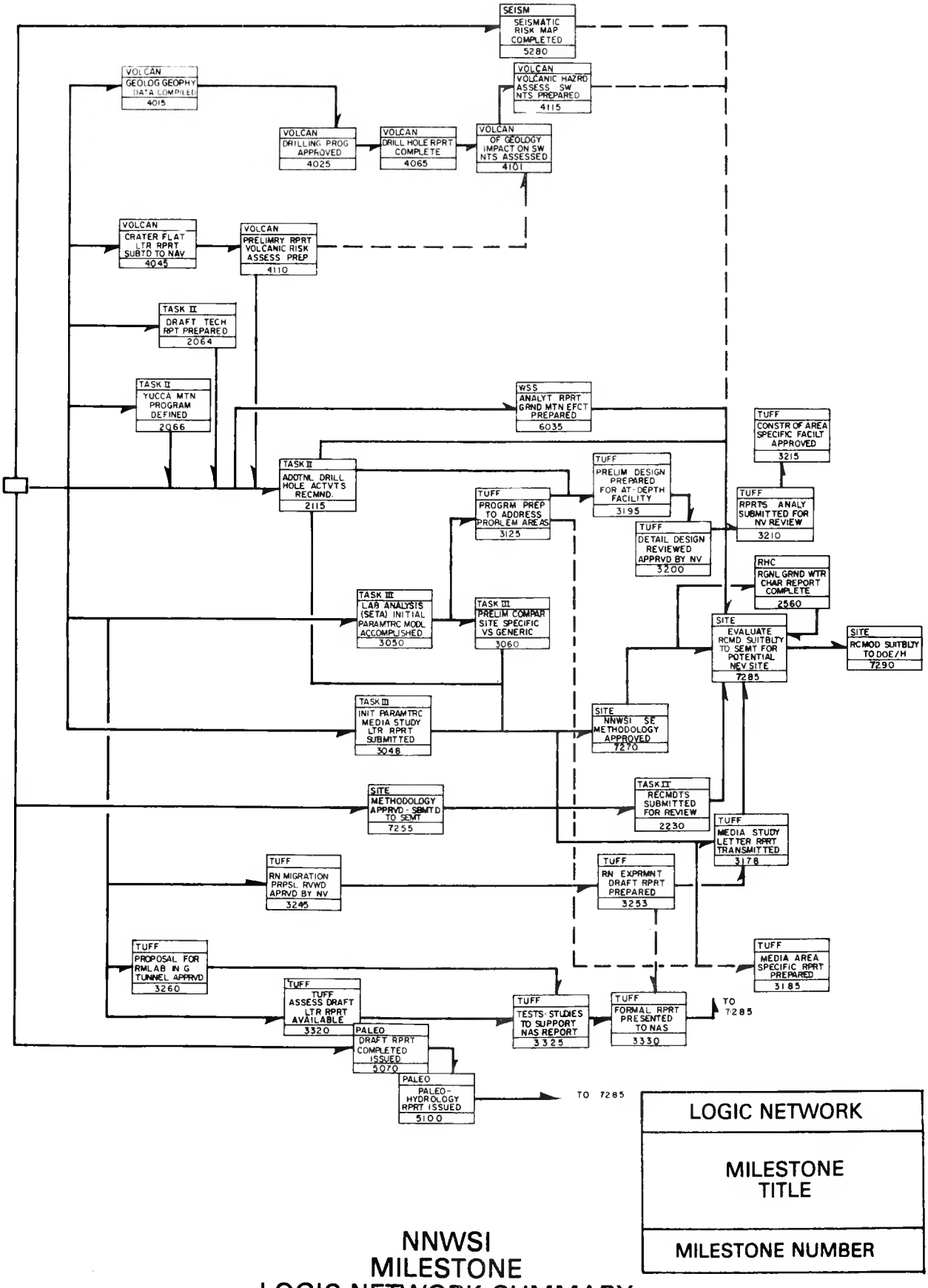
NNWSI Project participants will, as requested or approved by the DOE/NV: (1) work with other national program participants and/or contractors preparing or reviewing documents such as the Earth Science Technical Plan, the National Program Site Evaluation Criteria, and other documents requested by DOE/ONWM; (2) review major documents, plans, or criteria prepared by other projects within the national program; and (3) attend and participate in national program meetings and discussions, including meetings between DOE and other federal agencies.

APPENDIX A

MILESTONE LOGIC NETWORK

During FY 1979, the NNWSI Project Officers developed logic networks for all the work activities of the Project leading to the recommendation to DOE/HQ on the suitability of a site on the NTS for a commercial spent fuel or high-level waste repository. The logic networks were prepared to allocate resources and to assure that all activities were completed in a timely manner for a recommendation of site suitability to DOE/HQ. During FY 1980, additional work is required to refine the detailed working tools to reflect ongoing Project developments and budget allocations.

A summary of the logic network development is included in this appendix. It is first shown in chart form (Figure A-1) with the major identifiable milestones leading to Milestone 2290, Recommendation of Suitability to DOE/HQ. As noted in the legend, reference is made to the logic network from which the milestone is obtained and the numerical mode of the milestone. The key activities leading to the logic network milestones are shown in Table A-1.



NNWSI MILESTONE LOGIC NETWORK SUMMARY

Figure A-1

TABLE A-1

KEY ACTIVITIES LEADING TO
LOGIC NETWORK MILESTONES

Milestone Number	Reference Task	Activities
2066	2	• Perform surface geological, hydrologic, and geophysical evaluations of Yucca Mountain.
2064	2	• Evaluate conductor zone on the east side of Yucca Mountain using shallow-hole drilling and geophysics.
2115	2, 4	• Drill G-1 stratigraphic exploratory hole in Yucca Mountain. • Evaluate data.
2230	2, 4	• Drill G-2, G-3 stratigraphic exploratory holes in Yucca Mountain. • Drill H-1, H-2, H-3 holes to define in detail the hydrologic environment of Yucca Mountain. • Analyze data.
2560	2	• Drill regional hydrology holes to determine the hydrologic pathways from Yucca Mountain. • Update the solute transport model.
3048	2, 3	• Determine the thermal/mechanical properties using cores from the shallow drill holes and the deep stratigraphic drill hole, G-1. • Parametric modeling to assess the feasibility of repository siting.

3050	2, 3	• Determine the geochemical properties of cores from shallow drill holes and the deep stratigraphic drill hole, G-1. • Develop parametric models to assess the feasibility of repository siting.
3060	3	• Compare the core property data from Yucca Mountain to earlier generic core studies.
3125	3	• Define problem areas of tuff. • Prepare program for further evaluation of tuff.
3178	3	• Perform laboratory thermal/mechanical studies of G-2, G-3 cores.
3185	3	• Perform laboratory geochemical studies of G-2, G-3 cores.
3195	3	• Prepare preliminary design of at-depth test facility.
3200	3	• Review design of at-depth test facility.
3210	3	• Design detailed "area-specific" test facility using data from the G-1, G-2, and G-3 material properties and stratigraphic studies.
3215	3	• Obtain construction approval for the at-depth test facility.
3245	3	• Prepare radionuclide migration in tuff test plan proposal.
3253	Unassigned	• Perform radionuclide migration in tuff test.
3260	Unassigned	• Prepare tuff rock mechanics proposal.

3320	3	• Perform field test to study the response of tuff to a thermal load. • Prepare preliminary assessment of tuff using the test and other available data.
3325	Unassigned	• Perform rock mechanics, geochemical, and thermal experiments in tuff.
3330	3	• Prepare formal tuff assessment report for presentation to the National Academy of Sciences.
4015	2	• Compile geologic and geophysical data from field investigations in Crater Flat. • Recommend drill sites to provide subsurface data for the volcanism study of the Crater Flat area.
4025	2	• Develop criteria for drilling the V-1 hole into Crater Flat.
4045	2	• Determine the chronologic succession of basalts in Crater Flat.
4065	2, 4	• Drill the V-1 stratigraphic hole. • Analyze data.
4101	2	• Assess impact of Crater Flat geology on siting a repository in Yucca Mountain.
4110	2	• Perform laboratory studies on the basalts of Crater Flat.
		• Prepare a preliminary volcanic risk assessment using the chronologic and laboratory data.

4115	2	• Prepare volcanic hazard assessment on siting a repository at Yucca Mountain.
5070	2	• Perform ancient spring deposit analysis. • Prepare criteria for and drill the paleohydrologic hole to study clay mineralogy. • Collect, examine, and analyze rat middens. • Prepare draft paleohydrology report for the NTS region.
5100	2	• Develop conceptual models of paleoclimate and paleohydrology and future climate and hydrology for the NTS region. • Prepare final paleohydrology report for the NTS region.
5280	2	• Perform earthquake monitoring in the southern Great Basin. • Analyze and interpret the earthquake monitoring data. • Prepare a seismic risk map of the southern Great Basin.
6035	1	• Deploy weapons test seismic net at Yucca Mountain. • Prepare an analytical report on the ground motion effects studies regarding the siting of a repository at Yucca Mountain.
7255	6	• Develop a repository site evaluation methodology and site-screening criteria. • Study the repository licensing process.

7270	6	• Management review of repository site evaluation criteria and site-screening methodology.
7285	6	• Evaluate all potential repository site data against the site evaluation critera.
7290	6	• Present findings to DOE/HQ.

APPENDIX B

FY 1980 MILESTONES AND DELIVERABLES

Tables B-1 and B-2 are lists of the milestones and reports scheduled for completion in FY 1980 for the subtask activities described in the main text of this Project Plan. The governing assumption for all milestones and reports listed is that the principal area of investigation, Yucca Mountain, remains suitable for continued study. Should it not, a redirection of the Project will necessarily require changes to this appendix.

TABLE B-1

FY 1980 MILESTONES

Milestone Description	Responsible Participant	Scheduled Date	Reference Subtask
• Complete construction for SFT-C.	LLL	12/79	7.3
• Begin two-dimensional radionuclide transport model.	USGS	1/80	2.4
• Complete permeability apparatus with 20° C capability.	LLL	1/80	3.3
• Begin drilling the G-1 exploratory hole at Yucca Mountain.	NV	3/80	4.1
• Complete installation of downhole seismographs at UE25a-3 and Piledriver.	USGS	3/80	2.5
• Perform hydrologic testing of G-1 exploratory hole at Yucca Mountain.	USGS	3/80	2.4
• Complete collection of rat midden samples.	USGS	3/80	2.4
• Initiate emplacing spent fuel into SFT-C.*	LLL	3/80	7.1

*Major project milestone.

• Complete 500° C capability for permeability apparatus.	LLL	4/80	3.3
• Complete inverse modeling and sensitivity analysis for regional two-dimensional model.	USGS	5/80	2.4
• Start permeability testing.	LLL	5/80	3.3
• Quality assurance records library established.	SL	6/80	5.1
• Complete field investigations and preliminary maps of Quaternary stratigraphy and structure of southwestern NTS area.	USGS	8/80	2.2
• Review of Quality Assurance Programs for participating organizations complete.	SL	8/80	5.1
• Evaluate age of groundwater in Pahute Mesa flow system.	USGS	9/80	2.4
• Complete preliminary geologic-tectonic map of NTS region.	USGS	9/80	2.5

TABLE B-2

FY 1980 DELIVERABLES

Report Subject	Responsible Participant	Scheduled Date	Reference Subtask
• Major Impediments on NTS*	SL	11/79	6.1
• FY 1979 Fourth Quarter Progress	NV	12/79	6.1
• Preliminary Assessment of Volcanic Hazards, NTS Region	USGS	12/79	2.5
• FY 1980 Project Plan	NV	12/79	6.1
• FY 1980 First Quarter Progress	NV	2/80	6.1
• Geologic Appraisal of the Syncline Ridge Area	USGS	3/80	2.2
• Reconnaissance Evaluation of Shale/Argillite Sites in Southern Nevada	USGS	3/80	2.7
• Geologic Evaluation of the Twin-ridge Granitic Pluton, Incorporating Magnetic Data	USGS	3/80	2.2
• Quality Assurance Program Plan	SL	3/80	5.1
• Heat-Flow Investigations at NTS	USGS	4/80	2.3

*Major project deliverable.

• Physical Property Measurements from UE25a-1 and UE25a-3	USGS	4/80	2.3
• Geology of Conductor Drill Holes at Yucca Mountain	USGS	4/80	2.2
• Seismicity Data Report from FY 1979	USGS	4/80	2.5
• Assessment of Mineral-Resource Potential of the Lone Mountain Pluton in Southern Nevada	USGS/NBM*	4/80	2.7
• Results of Two-Dimensional Hydrologic Regional Modeling	USGS	4/80	2.4
• FY 1980 Second Quarter Progress	NV	5/80	6.1
• Borehole Geophysics on UE25a-4 through UE25a-7	USGS	6/80	2.3
• Geophysical Studies Conducted in Support of Hydrologic Studies	USGS	6/80	2.3
• Analysis of Existing Tuff Heater Experiment Data	SL	6/80	3.2
• Eleana Heater Experiment Final Report	SL	6/80	3.1
• Letter Report of Tuff Heater Experiment Results	SL	6/80	3.2

*Nevada Bureau of Mines

• Status of Tuff Joint/Water Interactions	SL	6/80	3.2
• Description and Evaluation of FY 1979 Tuff Data Obtained	LASL	6/80	3.2
• Interim Report on Suitability of Tuff*	SL	6/80	3.2
• Interpretation of Calico Hills/ Topopah Wash Gravity and Magnetic Surveys	USGS	7/80	2.3
• Refined Locations of Nevada Earthquakes	USGS	7/80	2.5
• Status of Yucca Mountain Analysis	SL	7/80	3.2
• Geophysical Summary of Syncline Ridge	USGS	8/80	2.3
• FY 1980 Third Quarter Progress	NV	8/80	6.1
• Geologic Characterization of the Southwest Quadrant of the NTS	USGS	9/80	2.2
• Interpretation of Wahmonie Gravitational Intensity and Magnetic Surveys	USGS	9/80	2.3
• Electrical Studies at Calico Hills and Wahmonie Areas	USGS	9/80	2.3

*Major project deliverable.

• Clay Mineralogy of Existing Drill Cuttings	USGS	9/80	2.4
• Downhole Experiments at UE25a-3 and Piledriver	USGS	9/80	2.5
• Status of Tuff Mine Design Activities	SL	9/80	3.2
• Data Report on Tuff to NAS	SL	9/80	3.2
• Preliminary Petrographic and Mineralogic Results from G-1	LASL	9/80	3.2
• SFT-C Documentation	LLL	9/80	7.1
• Regional Geologic Drilling Plan*	USGS	9/80	2.2
• Petrology of Crater Flat Volcanic Rocks	USGS/LASL	9/80	2.5

*Major project deliverable.

APPENDIX C

FY 1981 FORECAST OF MILESTONES AND DELIVERABLES

The projected milestones and reports schedules for FY 1981 are presented in Tables C-1 and C-2. Should Yucca Mountain not remain suitable for continued study, a redirection of the Project will necessarily require changes to this appendix. Further, since funding allocations for FY 1981 (see Appendix D) have not been authorized, some modifications may be required should allocations be different than those forecast herein.

TABLE C-1

FY 1981 MILESTONES

Milestone Description	Responsible Participant	Scheduled Date	Reference Subtask
• Complete first spent fuel exchange in SFT-C.	LLL	11/80	7.1
• Begin three-dimensional site-specific solute transport modeling.	USGS	1/81	2.4
• Site evaluation methodology and criteria established.	NNWSI	6/81	6.2
• Drilling of volcanism hole in Crater Flat.	USGS	6/81	2.5
• Complete histogram of volcanism for the NTS region.	USGS	7/81	2.5
• Complete second spent fuel exchange in SFT-C.	LLL	7/81	7.1
• Drilling and testing of a hydrologic test hole in the Yucca Mountain area.	USGS	9/81	2.4

TABLE C-2

FY 1981 DELIVERABLES

Report Subject	Responsible Participant	Scheduled Date	Reference Subtask
• Physical Property Measurements From UE25a-4, -5, -6, and -7	USGS	12/80	2.3
• Analysis of Rat Midden Data	USGS	12/80	2.4
• FY 1980 Project Plan	NV	12/80	6.1
• FY 1980 Fourth Quarter Progress	NV	12/80	6.1
• FY 1981 First Quarter Progress	NV	2/81	6.1
• Solute Transport Two-Dimensional Model	USGS	3/81	2.4
• Seismicity Data Report for FY 1980	USGS	3/81	2.5
• Electrical Studies at Yucca Mountain	USGS	4/81	2.3
• FY 1981 Second Quarter Progress	NV	5/81	6.1
• Permeability Studies Conducted During FY 1980	LLL	6/81	3.3
• Revised Probability Calculations and Volcanic Risk, NTS Region	USGS/LASL	7/81	2.5
• FY 1981 Third Quarter Progress	NV	8/81	6.1

• Geologic Evaluation of One or More Shale/Argillite Sites in Southern Nevada	USGS	9/81	2.7
• Summary Report on Geological Evaluation of Yucca Mountain	USGS	9/81	2.2
• Geologic Evaluation of One or More Granitic Sites in Southern Nevada	USGS	9/81	2.7
• Appraisal of Mineral-Resource Potential of Additional Selected Granitic Sites in Southern Nevada	USGS/NBM	9/81	2.7
• Basaltic Volcanic Cycles of the Southern Great Basin	LASL/USGS	9/81	2.5
• Interim SFT-C Data and Analysis	LLL	9/81	7.1

APPENDIX D

BUDGET SUMMARY
(Thousands of Dollars)

Task		FY 1980	FY 1981 Forecast
1		$ 278	$ 495
2		2,836	3,350
3		2,803	3,840
4		2,329	9,544
5		685	880
6		861	1,350
7		5,973	1,620
8		405	430
	TOTALS	$16,170	$21,500

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