**Basalt Waste Isolation Program
Quarterly Report**

January 1, 1979

through

March 31, 1979

MASTER

**R. A. Deju
Director, Basalt Waste
Isolation Program**

April 1979

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Rockwell International

**Rockwell Hanford Operations
Energy Systems Group
Richland, WA 99352**

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ABSTRACT

During the quarter, progress was made in all areas of the Basalt Waste Isolation Program. In the Geosciences, Hydrology, and Engineered Barriers areas, work continued on schedule aimed at being able to make a site selection decision in 1981, as scheduled. Emphasis continued to be placed on geologic mapping studies, on hydrologic data gathering, and on definitions of waste/basalt interactions and needed engineered barriers. Construction of the Near-Surface Test Facility was rescheduled to reflect tunnel design changes and previous quarter work delays. Progress at the end of the quarter was approximately on schedule and the rate of work was accelerating to better than scheduled due to some equipment improvements and tunnel design modifications. In the Engineering Testing area, design work, test planning, and fabrication of heaters and auxiliary equipment continued on schedule.

In the Repository area, an Architect/Engineer Evaluation Board was formally designated by the U. S. Department of Energy-Headquarters during October 1978. The evaluation board will select an architect/engineer for repository conceptual design with an option for follow-on Title I, Title II, and Title III engineering services. Selection will be completed by October 1979. Questionnaire information was received from a number of interested architect/engineer firms by the U. S. Department of Energy-Richland Operations Office and has been evaluated. Onsite visits with the qualified firms are scheduled during April 1979. In addition, repository preconceptual design studies continued on schedule with emphasis on compilation of repository functional design criteria by July 1979, and the repository preconceptual design report in August 1979.

Twenty-nine documents were issued during the quarter. These documents are listed at the end of this report.

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INTRODUCTION

In February 1976, the U. S. Energy Research and Development Administration (currently the U. S. Department of Energy) expanded the commercial radioactive waste management programs and established the National Waste Terminal Storage Program. Its mission was to provide multiple facilities in various deep geologic formations within the United States. The Office of Waste Isolation was established within the Union Carbide Corporation-Nuclear Division to provide program management of the National Waste Terminal Storage Program. The overall program consisted of investigating a number of geologic rock types to determine their suitability for terminal storage of radioactive waste. Basalts, such as the Columbia Plateau basalts, which underlie a large portion of the Pacific Northwest and the Hanford Site, were selected for initial geologic reconnaissance. Atlantic Richfield Hanford Company was asked in May 1976, by the Office of Waste Isolation, to plan and execute a geologic exploration of Columbia Plateau basalts to determine the feasibility of utilizing those formations as a site for terminal storage of commercial nuclear waste.

In September 1977, the National Waste Terminal Storage Program was restructured. While emphasis was still on a salt repository, additional funds were given to support investigations of two U. S. Department of Energy sites--Hanford and Nevada. The Hanford program is presently the responsibility of the U. S. Department of Energy-Richland Operations Office. Rockwell Hanford Operations (successor to Atlantic Richfield Hanford Company) is the prime contractor responsible for this work. The Basalt Waste Isolation Program within Rockwell Hanford Operations has been chartered with the responsibility of conducting these investigations. The investigations are presently aimed at assessing the feasibility of utilizing basalts as a possible rock type for nuclear waste storage. As recently noted in a report by the Interagency Review Group (Report to the President by the Interagency Review Group on Nuclear Waste Management, October 1978, TID-28817 Draft), once feasibility is established at various sites, the U. S. Department of Energy will select a site for construction of a repository. The present basalt studies are not to imply that a commitment has been made to select a basalt site as a repository location.

The overall program is divided into the following areas:

- Systems Integration;
- Geosciences
- Hydrology;
- Engineered Barriers;
- Near-Surface Test Facility;
- Engineering Testing;
- Repository.

A summary of major program accomplishments during the reporting period follows.

SYSTEMS INTEGRATION

The objective of Systems Integration is to integrate all activities leading to the identification, qualification, and licensing of a site and a repository for nuclear waste within Columbia River Basalt. The scope of work includes reviewing of research test and design activities, providing computer models, trade studies, data analyses and interpretation, and establishing the technical bases and criteria for site selection, licensing, and the design of the repository and ancillary facilities and functions. The Systems Integration Program is divided into three major activities: (1) Project Management; (2) Systems Integration; and (3) Safety and Environmental Documentation. During this second quarter of fiscal year 1979, work has progressed in all three activities.

PROJECT MANAGEMENT

The Project Management activity is concerned with the management of the Systems Integration end function; specifically in the preparation and control of schedules, preparation of budgets and work packages, control of program costs, and overall guidance of the technical activities.

SYSTEMS INTEGRATION

Technical Criteria

A brief study was performed to: (1) identify potential causes of radiological release from waste drums and canisters in a potential repository; and (2) determine the relative amounts and types of radioisotopes that might leave a waste container. The data have been useful in scoping heating, ventilating, and air conditioning systems for the repository preconceptual design.

The preliminary technical criteria for evaluating site suitability (i.e., basis for qualification of a site) have been drafted.

A Basalt Waste Isolation Program glossary comprised of geologic, mining, and nuclear terminology using Office of Nuclear Waste Isolation developed definitions has been prepared.

The natural conditions for a reference repository were developed as a basis for the preconceptual design studies.

Systems and Test Analysis

Planning is under way on the development of a test program for assessing underground conditions in a deep horizon selected as a repository site. The purpose of such testing is two-fold. First, the penetration of the candidate horizon would allow actual verification of the geologic, hydrologic, and thermal properties as previously determined by deep core holes in the surrounding medium and testing at the Near-Surface Test Facility. This may be the first penetration of the candidate horizon because of a need to maintain the integrity of the repository horizon. The second purpose would be to verify repository construction and operations activities such as shaft sinking and grouting techniques, remote handling systems, tunnel boring equipment, and emplacement and retrievability equipment.

Site Evaluation

The draft screening and ranking guidelines for the repository siting study have been prepared. The guidelines will be used in defining the parameters to be used in the preparation of screening maps and in the decision analysis process when ranking of candidate sites occurs. Work has also been directed at gathering base data information about the Columbia Plateau to be used in siting evaluation. Candidate areas are being identified as a first mapping step in the screening process.

Three major subtasks of the repository siting study have been proposed: (1) identify and develop the base line information for siting guidelines; (2) develop the siting guidelines; and (3) develop a framework for sensitivity analysis.

1. Information that establishes base line conditions, provides quantitative and qualitative physical and facility performance factors has been identified. The primary categories of the base line information to be used in establishing numerical screening guidelines are: facility description; waste description; repository host rock characteristics; performance characteristics; legal and licensing issues; safety systems economics; environmental and socioeconomic conditions; and national defense and security considerations.
2. Siting guidelines are being developed with the overall goals in mind of identifying a suitable site meeting the objectives of maximizing public health and safety, minimizing environmental impacts, and minimizing systems costs. The results of this process are one set of guidelines for identifying sites during screening and another set for ranking sites. The first set will be used during screening to identify sites meeting a minimum level of achievement of the siting objectives. The second set will be used during ranking to compare differential achievement of the siting objectives.
3. Changes can be expected to occur in the numerical values of the siting guidelines depending on the relationships used in siting evaluation. Effects of these changes can be assessed through sensitivity analysis. Impacts will be evaluated for changes in base line conditions, regulatory framework, screening and ranking guidelines, and the acquisition of additional data.

Draft regional screening maps and descriptions of the application of the guidelines have been used to develop screening maps. These maps indicate the candidate areas which will be evaluated in subsequent steps. These maps include:

1. Base map of study area;
2. Composite overlay map showing candidate areas;
3. Ground motion map;
4. Volcanic effects map;
5. Stratigraphic characteristics map showing total basalt thickness;

6. Aircraft impact map;
7. Hazardous facilities map;
8. Operational radiation release map;
9. Protected ecological areas map;
10. Culturally important areas map.

Engineering Model Development

Investigations were made into conceptual repository design, predictions of the Near-Surface Test Facility response, and development of numerical codes used for modeling a hypothetical repository. The analysis of the Near-Surface Test Facility response and code development has been the primary focus of work thus far. Conceptual repository design work is closely related to the other tasks, with work on these tasks being directly applicable to repository design activities.

The objectives of engineering model development, as it relates to the Near-Surface Test Facility, are two-fold. One is to analyze and predict the response of the basalt environment to thermal and mechanical loading. This is done to ensure that the Near-Surface Test Facility will be capable of producing the results expected as identified in the test plan. The other consideration is to ensure that the test plan will provide information that can be used to simulate actual repository conditions. The following work has been accomplished toward these objectives.

1. Finite element models of the Near-Surface Test Facility - Phase II were constructed to model different boundary conditions; e.g., ventilated cavern, insulated cavern, cavern with region of blast-damaged rock. Results were produced for time periods up to three years.
2. The boundary integral technique was used to model the Near-Surface Test Facility - Phase II. Different cavern geometries were investigated.
3. A model based on analytical solutions for heat sources was used to simulate the emplacement of spent fuel canisters and electric heaters in the Near-Surface Test Facility - Phase II. Heat location and strength were adjusted to best match conditions anticipated in an operational repository at 3,000 feet.
4. Sample calculations were completed for the Near-Surface Test Facility. These will provide a basis for discussion of the scope and level of effort required for the proposed detailed analysis of the Near-Surface Test Facility tests.
5. Problem breakdown of Near-Surface Test Facility - Phase I test into components for one-, two-, and three-dimensional analysis has been completed. This includes initiation of the setup of the data axisymmetric analyses of the Full-Scale Heater Test Number 1 and setup of the three-dimensional problem for the Full-Scale Heater Test Number 1.

6. Organization and setup of the DAMSEL code to solve stress and thermal conduction problems for the Near-Surface Test Facility studies.
7. Determination of the temperature in the floor of the Near-Surface Test Facility using finite element analysis with a reduced convective heat transfer coefficient. The results of these preliminary analyses indicate a maximum 5°C change in the floor temperature from the initial temperature of 27°C to 32°C.
8. Further comparisons of temperature histories in the Near-Surface Test Facility and temperature histories in a working repository have been made using a semi-analytical approach. Analyses of the working repository have been executed assuming five-year old waste canisters. Material properties from Borehole DC-10, sited near the test facility, have been used for the test facility analysis, while estimated material properties have been retained for the repository at depth.
9. The Phase I field instrumentation design is being reviewed to determine if a large number of instrumentation holes may affect the results of the test.
10. Preliminary experimental work concerning spalling of basalt around small heater holes in the Near-Surface Test Facility has been initiated.
11. Further work is being done on the heater layout for the Near-Surface Test Facility; for example, the impact of an extra heater at each end of the row of final canisters will be assessed and closer attention will be paid to floor temperatures likely to be achieved.

Additional work has been done regarding the development of codes that will be used to model the repository. These codes will be tested at the Near-Surface Test Facility and refined or modified as comparison between actual field observations and the predictions indicates. These codes will then be utilized to simulate the response to thermal and mechanical loading in the repository. Work accomplished in this quarter includes the following.

1. DAMSSWEL, the Dames & Moore/Swansea finite element code has been modified to include convective heat transfer boundary conditions and up to three different time-dependent heat sources, each with up to three different decay constants.
2. Work has been continuing on the three-dimensional boundary integral code DAMBIT.
3. Work on methods of incorporating the Drucker-Prager yield criteria, with associated and non-associated flow rules, in STEALTH and a special purpose one-dimensional explicit finite difference model has progressed and earlier difficulties have been resolved.

4. A computer model based on analytical solutions for temperature distributions around a heat source has been developed for use on a desk-top computer to facilitate rapid analysis of alternative canister and heater arrangements.
5. Drucker-Prager and Mohr-Coulomb yield criteria have been incorporated into a one-dimensional explicit finite difference code. Extensive testing of these codes against analytical solutions and results of other reports has been completed.
6. The development of a semi-analytical solution for use in the Near-Surface Test Facility - Phase II analysis is continuing.
7. Work on a finite element code for the fracture mechanics analysis is continuing.

SAFETY AND ENVIRONMENTAL DOCUMENTATION

The objective of this activity is to provide licensing documentation (preapplication site review report, environmental report, and a license application) for site selection and construction of a repository.

The proposed formats for environmental reports and license applications for a potential deep geologic terminal repository in basalt have been concurred in the U. S. Department of Energy.

Schedules which detail the preparation sequence and responsibilities of the various contributors to the preapplication site review report have been prepared and approved. The schedules for the environmental report and license application are under revision to incorporate the preapplication site review report data input.

GEOSCIENCES

This program includes geologic and geophysical studies that aid in the identification of criteria and development techniques for use in selecting preliminary repository sites. The studies emphasize reconnaissance field work in both the portion of the Columbia Plateau underlain by Columbia River Basalt and within the Pasco Basin where the Hanford Site is located.

The Geosciences Program is divided into four major activities: (1) Project Management; (2) Geology; (3) Geophysics; and (4) Seismic Monitoring. During this second quarter of fiscal year 1979, work has progressed in all four activities.

PROJECT MANAGEMENT

The Project Management activity is concerned with the management of the Geosciences end function; specifically in the preparation and control of schedules, preparation of budgets and work packages, control of program cost, and overall guidance of the technical activities.

GEOLOGY

Geologic studies for the Basalt Waste Isolation Program are designed to gather the data required for selection and evaluation of potential repository sites in basalt. Work during fiscal year 1979 includes reconnaissance work in the region and detailed work in the Pasco Basin.

Integration of results of geologic activities to date for preliminary site characterization is planned for completion by September 1979 and is the primary goal of present work. This integration is necessary for preliminary site characterization by the Basalt Waste Isolation Program and is also necessary for planning future work. The outline of the report and a schedule for its completion have been prepared and both have been approved by the Basalt Waste Isolation Program Office. The report is tentatively titled "Summary of Geologic Studies in the Columbia Plateau" and is to emphasize geologic and geophysical findings regarding the structure and stratigraphy of the Columbia River Basalt in the Pasco Basin subsurface. In addition, the report is to contain sections on regional geology and on seismicity and tectonics. Draft versions of selected sections of the report have been started.

Regional geologic mapping is being conducted to provide information necessary to develop an understanding of the stratigraphic, structural, and tectonic setting of the Columbia Plateau (Figure 1). The U. S. Geological Survey has completed approximately 25,000 square miles of reconnaissance geologic mapping of basalt at a scale of 1:250,000. Geologic maps of the Columbia River Basalt within Washington State have been published as U. S. Geological Survey Open-File Report 79-534.

The Washington State Department of Natural Resources, Division of Geology and Earth Resources, has completed approximately 26,000 square miles of reconnaissance mapping of Late Cenozoic sediments in the Columbia Plateau (Washington State) at a scale of 1:250,000 (Figure 1). Approximately 80 percent of the compilation of the maps has been completed.

The regional geologic mapping effort is supported by remote sensing studies being conducted by Pacific Northwest Laboratory personnel. Pacific Northwest Laboratory has completed a preliminary lineament map (scale 1:250,000) based upon an interpretation of enhanced Landsat imagery and upon input provided by regional field mappers. The data set of high-quality U-2 photography (flown during fiscal year 1978 and received during the first quarter of fiscal year 1979) has been used to refine approximately 25 percent of the preliminary Landsat photo-lineament map of the Columbia Plateau.

A report has been completed by the Idaho Bureau of Mines and Geology, entitled "Bibliography of Geologic Studies of the Columbia Plateau (Columbia River Basalt) and Adjacent Areas in Idaho," and is available as RHO-BWI-C-44.

FIGURE 1
THE COLUMBIA PLATEAU

Surface geologic mapping of the Pasco Basin is being conducted to provide information that can be combined with results from borehole studies and geophysical surveys to improve our understanding of the stratigraphic, structural, and tectonic details of the Pasco Basin subsurface. Surface geologic mapping activities during the second quarter of fiscal year 1979 were concentrated in two main areas: (1) completion of basalt and sediment mapping; and (2) compilation of the mapping results at a scale of 1:62,500. The compilation geologic map is to be printed as a colored, multi-sheet set and is proposed to be issued by August 1979. Work to date on the compilation map has included printing service procurement, sheet layout, and index map preparation.

The final phase of basalt and sediment mapping was delayed from mid-December until mid-January by heavy snow cover. Mapping activities are now fully under way, however, and have been accelerated to compensate for the delay. The actual mapping of outcrop (basalt and sediment) is 80 percent complete in both the eastern and western parts of the basin. Much effort is now concentrated on field checking and compilation of results at a scale of 1:62,500. "Deliverables" from this surface mapping effort include 10 reports by Rockwell Hanford Operations and subcontractor geologists on geologic mapping results. These reports cover separate subbasins of the Pasco Basin; 5 reports of the 10 have been received and 5 are outstanding and in various stages of completion. Field check reports of the mapped area are also scheduled. Overall, the mapping, field checking, and compilation are on schedule.

Borehole studies and subsurface mapping by Rockwell Hanford Operations' geologists are continuing. Lithologic logs were completed this quarter for all deep cores drilled to date by the Basalt Waste Isolation Program. In addition, lithologic summary charts are in preparation for the intermediate depth "DB" core holes drilled for the Offsite Migration Program. These DB core holes provide supplemental information on geologic structures in the Pasco Basin subsurface. Seven tables that summarize geologic data from Pasco Basin boreholes are in various stages of completion.

Visual examination of small fractures and fissures in basalt core has revealed additional associated mineralization, which is interpreted to have occurred contemporaneously with basalt flow emplacement.

The following modifications have been recommended for future basalt coring operations: a triple tube, split innertube core barrel with five-foot runs should be required; rock quality designation determinations should become routine, standard operating procedure during logging; wireline geophysical logging should be by the same contractor, should be completed in every borehole before casing, and should be run immediately after hole completion; and borehole surveys should be run routinely without delay. These recommendations are being incorporated in all new coring contracts.

Paleomagnetic analyses of basalt samples have been completed and a report on magnetostratigraphic relationships of Grande Ronde Basalt, Pasco Basin has been received from Woodward-Clyde Consultants. This work

identified four magnetic correlation lines based on inclination variations and two magnetic polarity boundaries in the Grande Ronde Basalt; the report also demonstrated the potential for magnetostratigraphic correlation in the Wanapum and Saddle Mountains basalts should the need arise. The Grande Ronde Basalt magnetostratigraphic correlations have been combined with correlations derived through wireline geophysical log character, whole-rock major element-chemistry, and microscopic lithologic features. These revised correlations are generally consistent with earlier correlations, but have provided much greater stratigraphic detail.

Locations have been selected for basin-wide cross sections that are to be prepared through the Pasco Basin. These cross sections are to be along geophysical survey lines and are to link key surface outcrops and basalts.

Field work is approximately one-third complete in the Crescent Bar area, which is located about 40 miles north of the Pasco Basin. Here, Grande Ronde Basalt flows exposed in the Columbia River cliffs can be traced, studied, and sampled over a distance of many miles. This work is providing information on the lateral variability in chemistry, petrology, and intraflow structures. Field work to date indicates that, in this area, some Grande Ronde flows are generally of uniform thickness for many miles, but exhibit considerable variability in their intraflow structures.

GEOPHYSICS

Investigations by the Basalt Waste Isolation Program geophysical staff are continuing on several selected sites throughout the Pasco Basin. The surveys are utilizing magnetic, gravimetric, seismic, electrical, and electromagnetic techniques to help delineate the subsurface structures being mapped by the Geosciences staff. Areas currently being investigated are: Rattlesnake Mountain; Gable Mountain; Gable Butte; and specific small sites along the seismic surveying lines being conducted by Seismograph Service Corporation. The results of these surveys and the survey conducted in the Saddle Mountains are showing that the magnetic, gravimeter, and Turam electromagnetic techniques may be valuable for rapid definition of subsurface structures.

Seismic surveying of approximately 50 line miles has been completed. Figure 2 shows the current survey routes, percent completed, and suggested additional coverage. Onsite analysis performed by Seismograph Service Corporation has shown that the method provides very valuable data on subsurface structure in the Pasco Basin. Several new processing programs have been developed beyond last year's test surveys. The new processing elements are responsible for increased value of the seismic data. The work is currently on schedule and the final results are anticipated for July 1979.

Magnetotelluric surveys conducted during the first quarter are undergoing final processing and modeling. Preliminary interpretations are basically the same as produced during the 1978 surveys. Deviations

FIGURE 2

SEISMIC SURVEYING MAP

from the originally mapped structures are occurring along the western and eastern edges of the Hanford Site. These changes in the mapped structure are due to the increased number of data stations, which has allowed for better "sampling" of the subsurface. The project is on schedule.

Planning for this year's aeromagnetic surveying is still not under way. The delay in the start has been due to weather conditions and scheduling of the "field" surveying crew.

SEISMIC MONITORING

Seismic monitoring in eastern Washington continues by the University of Washington. No major events occurred in eastern Washington during the quarter, but two recent events of Richter Scale magnitude 3.5 and 3.8 in western Washington were recorded. Downhole monitoring has begun. Data from a single-component vertical seismometer in Borehole DC-3, as well as other seismometers installed in the vicinity of DC-3, are being telemetered by low-wattage direct radio to a central recording trailer where events are recorded on magnetic tape. This preliminary array is to be expanded with the installation of a three-orthogonal-component seismometer in DC-3 later this year. A capital request for such an instrument has been submitted, approved, and is presently being processed. A six-station portable microearthquake detection array is being assembled. A report detailing the history and status of seismic monitoring in the Columbia Plateau has been prepared in draft form.

HYDROLOGY

The Hydrology Program provides hydrologic criteria and evaluation techniques by which potential repository sites can be identified and evaluated. Study of the ground water regime underlying the Columbia Plateau is important, since the ground water pathway probably affords the fastest avenue of contact between repository wastes and the biosphere. Thus, hydrologic studies have emphasized the development of a data base in order to characterize the ground water system underlying the plateau, and modeling of the flow system needed to evaluate the potential for radiocontaminant transport to the biosphere. The hydrologic studies include reconnaissance regional studies over the Columbia Plateau and intensive local studies within the Pasco Basin. The Pasco Basin was selected for detailed study because of its unique structural significance in the region. The Pasco Basin also contains the greatest accumulation of basalt rock found on the Columbia Plateau. The Hydrology Program is divided into four major activities: (1) Project Management; (2) Hydrology; (3) Testing Support; and (4) Drilling Support. During the second quarter of fiscal year 1979, work has progressed in the first three of these activities.

PROJECT MANAGEMENT

The Project Management Activity is concerned with the management of the Hydrology end function; specifically in the preparation and control of schedules, preparation of budgets and work packages, control of program costs, and overall guidance of the technical activities.

HYDROLOGY

Regional hydrologic studies during the second quarter included a continued update of the ground water data base for the Columbia Plateau. The Washington State Department of Ecology, Washington State University, and Pacific Northwest Laboratory have assisted in this area.

A preliminary synthesis and interpretation of the ground water data base available for the Columbia Plateau within the State of Washington has been completed. Those portions of the data base significant to the regional hydrologic studies are:

1. Basic well identification data for approximately 4,440 wells drilled deeper than 250 feet in the Columbia Plateau portion of Washington State were input to the data base;
2. Approximately 350 wells that have been geophysically logged were identified and located on base maps;
3. Hydraulic head maps and transmissivity maps were prepared for the Saddle Mountains, Saddle Mountains/Wanapum, Wanapum, and Wanapum/Grande Ronde basalts, and composite Saddle Mountains, Wanapum/Grande Ronde basalts;
4. Sixteen cross sections showing hydrogeologic features across the Columbia Plateau were prepared;
5. Basic hydrologic subbasins in the Washington State portion of the Columbia Plateau were delineated.

Surface water studies are being conducted for both the Columbia Plateau and the Pasco Basin due to the importance of surface water in the overall water balance of the plateau. A substantial surface water data base has been compiled in the form of available reports, maps, and records relating to stream flow, hydrometeorological conditions, water quality, and water-use parameters. This base is being supplemented and updated through visits to and conversations with various agencies such as the U. S. Bureau of Reclamation, U. S. Environmental Protection Agency, Soil Conservation Service, individual county extension services, and Washington State University. Worthy of note is the acquisition of a STORET compilation from the U. S. Environmental Protection Agency which lists water quality records for the Pasco Basin area, water distribution summaries for the Columbia Basin and Yakima irrigation projects, estimates of deep percolation from irrigation, and data on surface water bodies for the 15 Washington State counties within the Columbia Plateau. Also included are maps showing irrigated lands for certain counties and statistics on flood risk within the Pasco Basin.

A hydrometeorological data base consisting of about 72 stations across the Columbia Plateau has been entered into an onsite UNIVAC computer file for eventual modeling. Statistics for evaporation, precipitation, and runoff within each hydrologic subbasin of the Columbia Plateau are being generated as a spinoff from mapping. Irrigated lands

are also being classified through machine processing of remote, multi-spectral imagery. Apparent water gains or losses along selected reaches of the Columbia, Snake, and Yakima rivers are being estimated on the basis of differences in long-term averages between successive stream flow gauges.

The Rattlesnake Hills area forming the western boundary of the Pasco Basin was surveyed to identify and sample springs. Ninety-five springs or features characteristic of springs were located and mapped; 22 were dry at the time of location and 63 showed either ground dampness or flowing water of up to 40 gallons per minute. For each of the 63 confirmed springs, a land layout and rock profile was drafted. Water samples were taken of selected springs and were submitted for chemical analyses. Routine field analysis indicated increased calcium, bicarbonate, and total dissolved solids in springs at successively lower elevations. Neither structure nor stratigraphy appears to control spring location. A spring is formed whenever a localized impermeable rock layer interrupts the downward percolation.

A preliminary simplified model description of the hydrogeological systems in the Pasco Basin has been developed. The Pasco Basin was conceptualized as a sequence of three flow systems: (1) local; (2) intermediate; and (3) regional. The local system appears to correspond to the unconfined aquifer lying within the post-basalt sediments. These waters are relatively young (less than 2,500 years) generally containing low (less than 500 parts per million) concentrations of total dissolved solids. Ground water flow paths are relatively short and are closely related to local topography and surface water drainage. The intermediate system is comprised of the confined aquifers existing along flow contacts, interflows, and interbeds in the upper basalts. This water is older and contains more dissolved solids than the local flow system. The deepest flow system is regional in extent containing very old waters (greater than 25,000 years) and is characterized by very slow ground water velocities. Ground water recharge to the regional system may occur as far away as the Okanogan Highlands to the north and the Rocky Mountains to the east. Flow system boundaries are probably stratigraphically related.

The ultimate objective of the research and development effort in the Basalt Waste Isolation Program is to assess the risk of siting a repository in a given subsurface stratum. Certain basic input parameters are required for ground water flow and solute transport models that serve as the basis for risk assessment. The data requirements for these models have been determined and are illustrated in Table I.

As part of other Hanford programs, models describing ground water contaminant movement in the unsaturated zone and the unconfined aquifer beneath the Hanford Site have been developed and tested against analytical solutions and field data. The RHAFE three-dimensional finite element numerical model was successfully compared to the accepted Hantush analytical model of well drawdown in a leaky artesian aquifer with storage. The maximum difference between the numerical and analytical models was 1.8 percent.

TABLE I

GENERAL DATA REQUIREMENTS

<u>DATA/PARAMETER TYPES</u>	<u>DATA SOURCES</u>
<u>FLOW MODEL REQUIREMENTS</u>	
Hydraulic conductivity of basalt and interbeds	Lithologic data, pump test, laboratory measurements
Effective porosity	Laboratory measurements, lithologic data, electrical conductivity of fluid filling the void spaces
Vertical compressibility of the solid skeleton	Lithologic data, laboratory measurements, existing data
Leakage	Geologic and lithologic data, potential measurements, pump tests, tracer movement, water mass balance
Fluid density, compressibility, and viscosity	Existing data in literature
Recharge and discharge locations and rates	Pump tests, geologic studies, flow measurements for man-made recharge/discharge, potential measurements
Time-varying potentials along the boundaries	Potential measurements, measurements of surface water elevations along the boundaries
Geometric description of aquifer boundaries	Lithologic data, geologic data, potential measurements
Initial potential distribution	Field measurements at wells or piezometers
<u>TRANSPORT-REACTION MODEL REQUIREMENTS</u>	
Dispersion coefficients	Laboratory measurements, correlations with lithologic data, existing literature
Sorption coefficients	Laboratory measurements, correlations with lithologic data
Compile radioactive decay rates	The half-lives of all radionuclides at Hanford have been determined
Chemical reaction constants	Laboratory measurements, correlations with lithologic data
Contaminant initial concentration	Pre-defined by the waste composition

This comparison gives us confidence that the RHAFÉ model can compute the ground water head distribution in a leaky aquifer with storage. Verification with field data showed areas where data coverage was inadequate and pointed out the need for the development of a technique to compute the impact of uncertainties in the model input data.

The model development effort has been separated into three major categories: (1) data models; (2) hydraulic models; and (3) contaminant transport models. Data models are being used to calculate the input characteristics required for the operation of the hydraulic and transport models.

TESTING SUPPORT

Geophysical logging services were initiated this quarter by Birdwell Division, Seismograph Service Corporation. Velocity surveys were run in Boreholes DC-2-A-2, DC-4, DC-6, and DC-7 to assist in seismic interpretation (see Figure 3 for locations). Cement bond logs were run in DC-2-A-2, DC-4, DC-6, DC-7, and DC-8 to evaluate the casing cementation program. Neutron-thermal neutron logs were run in DC-4 and DC-6 as part of the standard logging suite. Spinner surveys were run in DC-6 and DC-7 to measure fluid movement from zones of higher pressure to zones of lower pressure. These surveys were inconclusive due to the inability of the tool to accurately measure flow rates less than 20 feet per minute. Flow rates were found to be much less than this value.

The fiscal year 1979 downhole hydrologic testing and sampling program will be initiated early next quarter. The rig contract in support of this testing has been awarded and proposals for hydrologic testing services are in final evaluation.

ENGINEERED BARRIERS

The primary goal of the Engineered Barriers Program is to specify a set of multiple barriers--engineered and natural--that will ensure that nuclear materials emplaced in a basalt repository do not exceed acceptable rates of release to the biosphere. Key activities are the definition of repository conditions under planned operating and potential accident scenarios, review and development of information relevant to radionuclide transport, and the development of data necessary to define safe disposal of wastes in a basalt repository. The key activities of the program are concerned with definition of the need for and specification and testing of natural and man-made materials which can be used to plug boreholes in basalt and which can be used as an overpack to surround nuclear waste forms and containers. The Engineered Barriers Program is divided into three major activities: (1) Project Management; (2) Multiple Barrier Studies; and (3) Borehole Plugging. During the second quarter of fiscal year 1979, work has progressed in all three activities.

FIGURE 3
SELECTED DRILL HOLES

PROJECT MANAGEMENT

The Project Management activity is concerned with the management of the Engineered Barriers end function; specifically in the preparation and control of schedules, preparation of budgets and work packages, control of program costs, and overall guidance of the technical activities.

MULTIPLE BARRIER STUDIES

The emplacement of nuclear waste in a deep geologic repository may cause both physical and chemical changes to the existing environment. This activity examines the nature of these changes and attempts to identify the chemical and physical stability of natural and engineered barriers to the transport of radioactive contaminants. The activity includes the study of four potential barriers: (1) the waste forms; (2) the basalt rock; (3) the container; and (4) the overpack. To evaluate this multiple barrier system, one examines the possibility of chemical reactions which can occur near the canister (phase transformations, dissolution) and away from the canister (solution/precipitation and sorption/desorption).

Characterization of the secondary minerals in core sections from drill holes DH-4, DH-5, and DC-6 has continued. Secondary minerals are those minerals formed as a result of the reactions between basalt and ground water over geologic time. The types of secondary minerals observed in vesicles and fissures of the basalt in the Columbia Plateau and the sequence of crystallization of mineral phases determined allow prediction of what chemical reactions have taken place. These data also provide insight into what the historic compositions of ground water have been. The data also provide information which indicates the basalt has been stable over a long period of time (millions of years).

Samples from DH-4 (2,438 to 4,362 feet), DH-5 (2,616 to 2,831 feet), and DC-6 (1,978 to 4,323 feet) are being examined by petrographic microscopy, electron microprobe, X-ray diffraction, scanning and transmission electron microscopy, and energy dispersive X-ray spectroscopy. Data from these examinations are used as input to the thermodynamic modeling of the chemical reactions of basalts in the Columbia Plateau.

Continued characterization of core samples has shown that a majority of the vesicles sampled contains an initial layer of clay and, in some cases, multiple layers. Clay is also present in the vast majority of vesicles as spheres, cylinders, or irregularly shaped particles. Roughly one-third of the vesicles examined in DC-6 do not possess an initial clay layer. In these cases, silica and two zeolites (clinoptilolite and mordenite) are the first alteration phase which were formed in the vesicle. One vesicle was found to be completely filled with illite (a clay).

The chemical composition and X-ray diffraction data are being tabulated for additional analysis and correlation. Unusual minor-phase minerals continued to be observed such as pyrite, calcium/magnesium/iron/

sodium aluminosilicate, and a calcium phosphate. Further characterizations, focusing on alteration products filling fissures, are continuing. Such secondary mineralization will act as sorptive substrates for waste ions should any radionuclides enter the ground water flow system.

Updates of the input formats of the Wolery mass transfer code have been completed, and the updated code is being tested with information supplied by T. Wolery. Schemes for the estimation of the Gibbs free energies of formation of 2:1 clay minerals and zeolites are also being examined. The free energy information is used to calculate mineral solubilities, which further augments the data base for thermodynamic modeling.

Research aimed at understanding radionuclide sorption on basalt and basalt secondary minerals has continued. Colloidal solids generated during batch K_d (radionuclide distribution ratio) experiments appear to lead to misleading results in such experiments. Colloidal particulates generated during agitation (required to achieve timely equilibrium) remain in solution during the usual solid-solution separation procedures and, hence, yield much lower K_d value than is actually the case. Given a proper solids-solution separation, the cesium K_d value for 20- to 50-mesh Umtanum basalt is 3,100 milliliters per gram. Experimental techniques to prevent the problem of colloidal solids generation have been investigated and are under development. In light of these findings, previously reported K_d values for cesium sorption on Umtanum basalt are lower than the true values.

Collection of reference experimental materials mined from the Near-Surface Test Facility has begun. To date, many kilograms of arkosic sand of several varieties, tuffaceous rock, vesicular basalt, and quantities of clay-like material have been collected from the Pomona flow and overlying interbeds. These samples have been collected immediately after the mining rubble is removed from the tunnel. In this way, the approximate location of the origin of the sample may be determined from mining records.

In further hydrothermal interactions of basalt with simulated nuclear waste forms, new mineral-like phases of fission product elements have been identified. The formation of these mineral-like phases from reactions with basalt provides additional barriers to the transport of the radionuclides from the canister to the biosphere.

In the hydrothermal interactions of basalt and spent unprocessed fuel at 300°C and 300 bars, powellite (CaMoO_4) has been identified as an interaction product. Reaction of basalt and supercalcline under these conditions has produced a phase similar to $\text{Na}_2\text{Al}_2(\text{MoO}_4)_2$. In 6-month long glass-basalt hydrothermal reactions at this temperature and pressure, weeksite has not been found. However, a grey crusty material structurally similar to pumpellyite and HoVWO_6 has been isolated. Its chemistry is yet to be determined.

The studies of the hydrothermal interactions of postulated cesium and strontium phases from spent unprocessed fuel with basalt and basalt

phases has been completed. Mixtures of labradorite and Cs_2MoO_4 yield mixtures of pollucite ($\text{CsAlSi}_2\text{O}_6$) and powellite (CaMoO_4) when reacted at 200°C and 300 bars. At 100°C (4 months), 200°C (12 months), and 300°C (1 month), little temperature dependence was observed in the reactions of labradorite and Cs_2MoO_4 . Reactions with diopside produce only small amounts of pollucite and powellite at all temperatures. Glass does not react with Cs_2MoO_4 below 300°C, while reactions with basalt show temperature dependence with very strong reaction occurring at 300°C, 300 bars. Pollucite was the cesium reaction product in all cases.

Reaction of CsOH with basalt and basalt phases at 200°C, 300 bars for 2 months is very strong. Pollucite is formed in all cases with a slight amount of CsAlSiO_4 forming in reactions with labradorite. When $\text{Cs}_2\text{U}_2\text{O}_7$ is substituted as the cesium host phase from spent unprocessed fuel, similar behavior is observed. Pollucite forms easily at 300°C, 300 bars, and 1 month time for every basalt phase except diopside. The reaction is strong only with labradorite at 200°C. Uranium dioxide, uranium trioxide dihydrate, and/or one or more unknown phases form in addition to pollucite in these reactions.

The percentage of strontium which enters solution is small when SrZrO_3 is reacted at 200°C to 500°C, 300 bars for 28 days. The amount of strontium in solution is maximum (2.5 percent) at the lowest reaction temperature. The percent of strontium remaining in solution decreased by at least a factor of 2 when SrZrO_3 was reacted in the presence of basalt phases or basalt compared to SrZrO_3 plus water alone.

BOREHOLE PLUGGING

The objective of the borehole plugging activity is to devise a plugging system to seal boreholes, shafts, and tunnels leading to a radioactive waste repository in basalt. The plugging system consists of materials, machines, placement techniques, and instrumentation. The work which has been completed thus far has been in the characterization of the system components.

Tunnels and shafts drilled during the construction of a repository will cross a variety of basalt flows and interbeds. The concept of multiple barriers, which includes a series of engineered plugs and/or backfill in a tunnel, shaft, or borehole, must be considered for plugging man-made openings, since any single plug may not meet all performance required. To simplify the activity, the types of required plugs are classified into three categories. These are:

1. Category One Plugs--these would be plugs where direct failure may allow radioactivity to reach the licensed perimeter of a repository;
2. Category Two Plugs--failure of a Category Two Plug may allow material to move about the repository or may impact a Category One Plug;
3. Category Three Plugs--the Category Three Plugs would be materials that were mainly void fillers.

Category One Plugs would be placed at the interface of the repository zone and geologic environment surrounding the repository zone. This category would be the primary licensed plug, constructed to maintain high design integrity and prevent transport of unacceptable amounts of radionuclides along the tunnel, shaft, or borehole. Category Two Plugs would be placed in less critical locations within the repository, but would also have design requirements for containing and isolating radioactive waste. Category Three Plugs would be used to fill space and to provide long-term structural needs.

The repository will be a dynamic system where heat is produced and dissipated. Changing thermal, hydrostatic, and ion concentration gradients can be anticipated in the plug system, repository rock, and surrounding backfill and certain chemical and physical changes must be anticipated. Therefore, the behavior of candidate plug materials depends on their reaction to the repository rock and surrounding expansion and chemical reaction parameters.

The testing program for characterizing the plug materials will be of a geochemical and physical nature. The geochemical testing program will define the behavior of plug materials and systems and match materials with desired behavioral characteristics. The physical testing program will evaluate three general categories of materials: (1) cohesive materials; (2) non-cohesive materials; and (3) grouts; however, this study will not be limited to only these. Some physical test methods are common to all the categories, but other tests are unique to only one category.

A final characterization will be the evaluation of plug stability. The preliminary evaluation will employ a numerical and probabilistic analysis following the characterization of candidate materials and machine, preliminary but definitive test results, and a comparative rating of candidate materials, machines, and combinations thereof. As soon as the preconceptual design of a borehole plugging system is recommended, unified plug placement systems have been completed, and test data have confirmed properties of the components, a numerical and probabilistic analysis of the overall stability of the preconceptual design will be carried out.

NEAR-SURFACE TEST FACILITY

The Near-Surface Test Facility is a multipurpose test facility for in situ testing in basalt. The Phase I (Electric Heater) and Phase II (Radioactive Material) tests to be conducted in the facility are designed to:

1. Assess the feasibility of basalt as a repository medium;
2. Provide the basis of design for key repository elements;
3. Demonstrate placement, storage, and retrieval of spent fuel canisters in an underground basalt environment;
4. Demonstrate spent fuel monitoring capability in an underground basalt environment.

The Near-Surface Test Facility is located on the west end of Gable Mountain on the Hanford Site near Richland, Washington. When completed, the facility will consist of approximately 3,300 feet of underground workings including access tunnels, test rooms, and a computer room. Phase I is to develop the electric heater test portion of the facility so that testing may begin in 1980. Work on Phase II is scheduled for completion in 1981.

The program is divided into five major activities: (1) Project Management; (2) Facility Design; (3) Construction; (4) Safety and Environmental Analysis; and (5) Decommissioning. During the second quarter of fiscal year 1979, work has progressed in the first four activities.

PROJECT MANAGEMENT

The Project Management activity is concerned with the management of the Near-Surface Test Facility design and construction end function; specifically in the preparation and control of schedules, preparation of budgets and work packages, control of program costs, and overall guidance of the technical activities.

FACILITY DESIGN

With the completion of Title I and Title II design for Phase I in prior quarters, the Near-Surface Test Facility design effort is now concentrated on Phase II. Phase I Title III support continues for Phase I construction activities.

As a result of a study of the Phase I computer facility, a decision was made to change the computer from its initial location in the Phase I tunnel to an area outside the tunnels between tunnel entrances 1 and 2. The new location provides a number of advantages:

1. Computer installation and enclosure fabrication is less complicated;
2. Heat load in the tunnel is significantly reduced;
3. Power loading on the main transformer is reduced;
4. Tape storage restrictions are eliminated;
5. The excavation cost for the computer room drift is eliminated;
6. Hydrogen production in the tunnel from uninterrupted power system operation is eliminated.

In summary, the cost of computer relocation design will be offset by reduced construction costs so that additional funds are not required. Interference with tunnel construction is eliminated. Release of drawings is scheduled so that maximum schedule benefit is realized by J. A. Jones Construction Services Company in accomplishment of facility construction work. Design will be completed before July 27, 1979.

A significant improvement was realized in tunnel construction progress, when rock quality analysis by Rockwell Hanford Operations tunnel construction consultants revealed that use of mesh and rock bolts would not be required in the Pomona Member of the Saddle Mountains Basalt. A design change was processed substituting a roof-stabilizing coat of shotcrete immediately after blasting, and a second coat of shotcrete within 50 feet of the advancing face.

Another design change which improved operating conditions was the installation of 12 inches of concrete in the interbed inverts of tunnels 1 and 2. Tunnel 3 concrete work, which was delayed until completion of the extensometer room, will be completed in April 1979.

The Atomics International conceptual design effort for the Phase II remote handling equipment was completed. The design concept remains substantially the same as that reported in the first quarter 1979 report. The Title I design effort for the bottom loading transporter was initiated on March 5, 1979 at Atomics International, with Title II design initiated at Rockwell Hanford Operations on March 19, 1979. The design effort at Rockwell Hanford Operations also includes the liner and plug design for the Phase II test holes. The start of the remote handling design effort was later than originally planned. However, integration of this design with facility design is expected to be achieved with no significant problems, since facility conceptual design is phased properly with respect to the remote handling equipment design schedule. Plans now call for use of the National Lead Industries (NLI-1/2) highway cask in place of the Nuclear Assurance Corporation (NAC-1) highway cask specified earlier.

The Phase II facility conceptual design effort for structural, electrical, mechanical, security, safety, site, and remote handling support items is on schedule for completion of conceptual design before June 29, 1979. The facility conceptual design will cover the following:

1. Phase II project total estimated cost;
2. Project justification;
3. Functions and design requirements;
4. Systems design descriptions;
5. Summary description;
6. Quality assurance codes, and standards;
7. Schedule and methods of performance;
8. Special requirements, safety, safeguards, energy conservation, and environmental assessment;
9. Drawings and outline specifications;
10. Cost estimate;

11. Remote handling system trade studies;
12. Tunnel heat transfer analyses and alternate studies.

CONSTRUCTION

Tunneling is 64 percent complete against a projected schedule of 66 percent. Tunnel and room advances are shown in Figure 4. Tunnel 2 was completed on March 30, 1979 and tunnel 3 was completed on March 12, 1979. The top heading of the extensometer room is complete, which includes all rock support required for the room.

Shotcrete has been used extensively for rock support, as opposed to rock bolts and mesh required by the original design. As a result, advance rates have improved considerably and the mining subcontractor has acquired additional equipment and personnel to improve advance rates as well.

Concrete was poured on the invert of tunnels 1 and 2 in the interbed portion. The concreted invert will stabilize the shotcrete arch against movement and provide a suitable "roadway" over the soft interbed material. A concreted invert will be provided in the interbed portion of tunnel 3 as soon as practicable.

A Design Review Committee, consisting of prominent mining consultants and Jenny Geotechnical Corporation, has reviewed construction progress and the tunnel and room rock support. Their recommendations have been incorporated in the present design.

SAFETY AND ENVIRONMENTAL ANALYSIS

Training of the first Rockwell Hanford Operations' mine rescue team has been completed. As a result of the ongoing training, Rockwell Hanford Operations plans to be self-sufficient in mine rescue operations with at least two teams onsite.

ENGINEERING TESTING

The objectives of the Engineering Testing Program are to fabricate, procure, and install equipment and instrumentation to obtain test data during subsequent Near-Surface Test Facility operations. The test data will be used to establish engineering feasibility of constructing a repository in basalt and repository design.

Rock testing and other miscellaneous special studies are also included as part of this program to assist in meeting the Near-Surface Test Facility objectives. Test articles will include both electric heaters, spent fuel, and other waste forms. The Engineering Testing Program is divided into five major activities: (1) Project Management; (2) Engineering Studies; (3) Phase I; (4) Phase II; and (5) Operation. During this second quarter of fiscal year 1979, work has progressed in all five activities.

FIGURE 4
NEAR-SURFACE TEST FACILITY

PROJECT MANAGEMENT

The Project Management activity is responsible for the management of the Engineering Testing end function; specifically in the preparation and control of schedules, preparation of budgets and work packages, control of program costs, and overall guidance of the technical activities.

ENGINEERING STUDIES

Testing of the basalt samples is continuing at the Colorado School of Mines' Earth Mechanics Institute. The fiscal year 1979 effort is aimed at gathering material property data of deep underground basalt flows. The Umtanum flow, which exists at a depth of between 3,560 feet and 3,800 feet, was selected for testing this year. Within the Umtanum flow, samples were taken from three different test holes (DC-4, DC-6, and DC-8, see Figure 3).

The properties that are being measured include:

1. Uniaxial and triaxial compressive strength under various conditions of temperature, confining pressure, and moisture contents;
2. Young's modulus and Poisson's ratio;
3. Strength properties of joints under various conditions of temperature, confining pressure, and moisture contents;
4. Thermal conductivity and specific heat;
5. Thermal expansion;
6. Time-dependent deformation under various conditions of load and temperature;
7. Rock hardness;
8. Thermal and mechanical anisotropy;
9. Post-failure behavior;
10. Density.

Some of the results to date can be summarized as follows.

1. Essentially isotropic elastic conditions exist within the Umtanum flow. Isotropic conditions are defined as less than a 10 percent variance between properties measured in the axial and radial direction. These data contrast the data obtained from samples taken near the Near-Surface Test Facility which revealed anisotropic behavior.
2. The thermal expansion results were consistent over the central portion of the basalt flow, averaging 9.9×10^{-6} inch per degree Celsius.

3. Rock hardness was lowest near the top of the flow, reaching a peak value of 69.8 (scleroscope hardness scale), and then decreased near the bottom of the flow.

PHASE I

Phase I provides the design, procurement, fabrication, calibration, installation, checkout, and analysis of the heater test engineered equipment in the Near-Surface Test Facility. Phase I is subdivided into the following subactivities: (1) Heaters and Controllers; (2) Rock Instrumentation; (3) Data Acquisition System; (4) Site Characterization; (5) Test Engineering Support; and (6) Equipment Installation. During this quarter, work has progressed in the first five subactivities.

Heaters and Controllers

The heating elements for the Full-Scale Heater Test Number 1 main heater were received, inspected, and are ready for assembly. Matching of the main heaters for both full-scale tests and the peripheral heaters is complete, while assembly is about 60 percent completed.

Seattle Electronic Corporation of Seattle, Washington was the successful bidder on the main and peripheral heater controller fabrication and assembly contract. Fabrication of these controllers is expected to be completed in April 1979. A preliminary functional power-on test of the first heater controller has been completed. Acceptance test procedures for calibration and testing of the heater/controllers and testing of voltage regulators were prepared.

Preliminary design criteria were established for a dewatering and desteaming system to service the heater and rock instrumentation holes, if required.

The time-scaled heater design was reviewed and comments are being resolved. Procurement has been initiated for the time-scaled heater controller parts.

Rock Instrumentation

Foundation Sciences, Inc., the contractor for the design, fabrication, and delivery of the rock instrumentation system for Full-Scale Heater Test Number 1, has completed their design effort.

Thermocouple calibration tests have started. The purpose of these tests is to ensure each thermocouple used is within the National Bureau of Standards Type E temperature curve (American National Standards Institute MC96.1--1975 Table VIII, Special Limits of Error). The thermocouples will also be subjected to an X-ray examination to verify the integrity of the weld, and to determine if gas bubbles, cracking, or undercutting are present; if so they will be rejected.

Extensometer test procedures for the anchor system and long-term electronic stability test of the direct current linear variable differential transformer have been reviewed and comments submitted to Foundation Sciences, Inc. for incorporation.

Seven basalt samples from the Near-Surface Test Facility have been shipped to Foundation Sciences, Inc. for use in their instrument test program.

Eight additional tests are planned to evaluate the following parameters.

1. Long-term electronic stability of the extensometer direct current linear variable differential transformer will be tested at various fixed output readings while held at the expected operating temperature ($40^{\circ}\text{C} \pm 1^{\circ}\text{C}$) for a continuous 30-day period. The information obtained shall be used as an input to the calibration of the extensometers.
2. Extensometer anchor subsystem inertia testing is planned to evaluate the influence that the inertia of each anchor subsystem and attached anchor rod has on the measured extensometer output reading. In addition, the manufacturer's field calibration procedure will be tested and the results of the inertia test will be included in the procedure, if required.
3. U. S. Bureau of Mines borehole deformation gauges will be tested to determine long-term electronic stability. The gauges shall be held at fixed output readings, at a temperature of $200^{\circ}\text{C} \pm 2^{\circ}\text{C}$ for 30 days. The results of these tests will be used as part of the U. S. Bureau of Mines gauge calibration procedure.
4. U. S. Bureau of Mines gauge sensitivity testing will be conducted to determine temperature sensitivity and calibration factors. Each gauge will have each of the three measuring diameters calibrated over the full deflection range. A number of selected gauges will have this test repeated at temperatures of $100^{\circ}\text{C} \pm 2^{\circ}\text{C}$ and $200^{\circ}\text{C} \pm 2^{\circ}\text{C}$. The results of all tests will be plotted and used as an input to the U. S. Bureau of Mines gauge calibration procedure.
5. Five basalt cores from the Pomona flow at Gable Mountain will be instrumented and tested over the temperature range of 25°C to 200°C to determine the coefficient of thermal expansion for use in the algorithm for the U. S. Bureau of Mines gauge.
6. Vibrating wire stress meters (IRAD gauge) shall be tested with the measuring axis loaded to a predetermined level, while at a temperature of $200^{\circ}\text{C} \pm 2^{\circ}\text{C}$ for a minimum of 30 consecutive days. This approach will determine the long-term electronic stability and become an input into the IRAD gauge calibration procedure.
7. One IRAD gauge will be tested at various controlled thermal and mechanical states to determine gauge calibration constants. The tests will check the gauge in various materials including steel, aluminum, brass, and basalt from the Pomona flow at Gable Mountain at pressures over the range of 0 to 2,000 pounds per square inch and at temperatures of 50°C , 100°C , 150°C , and 200°C . The data will be analyzed and reduced to become an input into the IRAD gauge algorithm.

8. Six basalt cores from the Pomona flow at Gable Mountain shall be tested at various controlled thermal and mechanical states to determine the modulus of elasticity of the basalt as a function of temperature. The information will be used as an input into the IRAD gauge algorithm.

Data Acquisition System

The Data Acquisition System for Phase I has been divided into five major tasks:

1. Acquire and direct installation of the automatic data processing equipment;
2. Develop, program, and test the graphics computer programs;
3. Collect and process data from the rock and heater instrumentation for the data analyses;
4. Provide support for operations and maintenance related to the Data Acquisition System;
5. Provide Data Acquisition System personnel and resource management.

Pertinent accomplishments in each of these areas are outlined below. The first Data Acquisition System task included obtaining an interim facility at the Richland Airport (Skypark Terminal). The interim facility will be used to check out hardware and to develop software before the computer is moved to the Near-Surface Test Facility.

The automatic data processing equipment for Phase I was acquired and delivered to the Rockwell Hanford Operations' interim location. The equipment consisted of one Data General M/600 minicomputer, one Data General 6061H disk unit, two Data General 6026 tape drives, three Data General 6053 video terminals, three DI/AN 60 terminals, and a VARIAN 9211 electrostatic printer/plotter (see Figure 5).

Two Tektronix 4014 graphics terminals and one 4631 hard copy unit have been acquired. Data Acquisition System personnel have begun providing detailed specifications necessary to design graphics software and the top-level graphics design has been started. The Tektronix software acquired included the Terminal Control System and Advanced Graphics.

Equipment acquisition and program development are subtasks for the data collection and processing task. Two Fluke data loggers with Columbia Model 300 C tape cartridge units were purchased to provide for data collection and storage for Full-Scale Heater Test Number 1.

Design was started to provide for remote control of the data loggers by the Data General M/600 computer. Other accomplishments were: (1) review of Foundation Sciences, Inc. engineering units conversion algorithms by Data Acquisition System personnel; and (2) definition by Data Acquisition System personnel and the University of Minnesota of the predicted data format.

FIGURE 5

DATA ACQUISITION SYSTEM LAYOUT

Two major accomplishments were realized by Data Acquisition System personnel for support of operations and maintenance. First, Data Acquisition System hardware was identified and the associated preventive and failure maintenance requirements were specified for Rockwell Hanford Operations Production Support use. Second, recommendations for Data Acquisition System operations were made.

Site Characterization

Geologic mapping remained current with excavation and consists of maps at a scale of 1:20 and detailed line maps. The 1:20-scale maps describe the rock mass mineralogy, fabric, and structure in detail. The detailed line maps are taken at frequent intervals and provide statistical data for analysis of local joint patterns, joint aperture, and infilling materials.

Borehole logging with closed circuit television was deemed neither practical nor feasible for this project and an alternate method (impression packers) was chosen as the best means to obtain borehole wall jointing data. A 360° wall impression will be taken in the heater holes and monitor holes to provide permanent records to be used for comparison in post-test characterization.

Test Engineering Support

The Phase I instrument layouts for Full-Scale Heater Tests Numbers 1 and 2, and the Time-Scaled Heater Test have been modified. These modifications consisted of:

1. Increasing the hole diameter for the U. S. Bureau of Mines and IRAD stress gauges in the tests from 1.5 inches to 1.89 inches at the request of the instrumentation contractor to facilitate instrument dewatering tube placement;
2. Deleting one thermocouple hole and moving six other instrument holes in the Time-Scaled Heater Test;
3. Deleting two monitoring holes and two thermocouples and relocating four other instrument holes in the Full-Scale Heater Test Number 1;
4. Deleting two monitoring holes and a thermocouple and moving five other instrument holes in the Full-Scale Heater Test Number 2.

The purpose of deleting instrumentation holes and moving other hole locations was to prevent hole interferences. Because of the extremely hard, brittle nature and fracture pattern of the Pomona basalt, the tolerances that the drillers will be able to maintain were less than earlier predicted. The small reduction of instrumentation is not expected to influence the test data adversely.

PHASE II

Phase II testing, as currently defined, will involve three specific tests: (1) the single canister test; (2) the unheated array; and (3) the heated array. The purposes of Phase II testing include:

1. Demonstration of the capability to safely handle and store nuclear wastes;
2. Near-term validation of long-term predictive models;
3. Examine the heating of a significant volume of basalt;
4. Examine hydrogen generation from any radiolytic decomposition of moisture in the basalt;
5. Assess moisture changes in the basalt;
6. Examine the impact of radiation on the geochemistry of the basalt;
7. Measure the influence of gamma heating on heat transfer and temperature distribution;
8. Serve as a comparison between test results obtained with electric heaters and results observed with nuclear wastes.

Preliminary planning and design efforts are under way in several different areas. The number of rock instruments defined for each test in Phase II has been tentatively reduced to lower the overall cost of the tests, reduce the influence of the instrument holes on the test data, but not impact the tests. A detailed analysis regarding these reductions will be conducted during the design of the Phase II instrumentation layout during the first quarter of fiscal year 1980.

The reference spent fuel shipping cask for the delivery of encapsulated spent fuel to the Near-Surface Test Facility was changed from Nuclear Assurance Corporation's (NAC-1) cask to National Lead Industries' (NLI-1/2) cask. This change was necessary, since all existing NAC-1 casks would be contaminated for use at the Near-Surface Test Facility and a "clean" shipping cask is a prerequisite. The cost of manufacturing a new NAC-1 cask was considerably more expensive than modifications associated with the NLI-1/2 cask.

The Office of Nuclear Waste Isolation experimental demonstration canister is currently in the design phase. This basic canister design will be used for all the demonstrations (Near-Surface Test Facility and subsequent waste isolation programs). However, this canister will be modified, as required, by each program to incorporate site-specific design changes. Since the Basalt Waste Isolation Program may be the first program to use the Office of Nuclear Waste Isolation canister, current planning calls for the Office of Nuclear Waste Isolation canister to match the needs of the Basalt Waste Isolation Program.

A spent fuel preparation plan was prepared. An implementation plan will be formulated for use in acquiring, transporting, characterizing, and encapsulating pressurized water reactor spent fuel assemblies for use at the Near-Surface Test Facility. Fuel acquisition is scheduled to start in the first quarter of fiscal year 1980.

OPERATION

Operation supports Phases I and II testing by providing planning input for the facility and operating schedule information. Preliminary manpower requirements for operation of the Near-Surface Test Facility have been defined, job descriptions prepared, and personnel are being acquired. Procedure preparation for operation of the data acquisition system is in progress.

REPOSITORY

The objective of the Repository Program is the design and construction of a repository in Columbia River Basalt for the storage and eventual disposal of nuclear waste and spent fuel. The Repository Program is divided into seven major activities: (1) Project Management; (2) Engineering Support; (3) Repository Design; (4) Long-Lead Procurement Support; (5) Construction-Manager Selection Support; (6) Construction; and (7) Site-Specific Tests. During the second quarter of fiscal year 1979, work was conducted only on the first two activities.

PROJECT MANAGEMENT

The Project Management activity is concerned with the management of the Repository end function; specifically in the preparation and control of schedules, preparation of budgets and work packages, control of program costs, and overall guidance of the technical activities.

ENGINEERING SUPPORT

An Architect-Engineer Evaluation Board was formally designated by the U. S. Department of Energy-Headquarters during October 1978. The evaluation board will select an architect-engineer for repository conceptual design, with an option for follow-on Title I (preliminary) design, Title II (detailed) design, and Title III engineering services by October 1979.

During the reporting period, Standard Form 254 (Architect-Engineer and Related Services Questionnaire) and Standard Form 255 (Architect-Engineer and Related Services Questionnaire for Specific Project) submittals were received by the U. S. Department of Energy-Richland Operations Office from interested architect-engineer firms. Additional information was subsequently received from a selected number of firms via a request for supplemental information. All information received has been evaluated, and onsite visits with the qualified firms are scheduled during the last half of April 1979.

Repository preconceptual design studies are being conducted by Vitro Engineering, J. F. T. Agapito and Associates, and Rockwell Hanford Operations. The design studies have been divided into the following seven tasks:

1. Task I - Overall Repository Preconceptual Design (Rockwell Hanford Operations);
2. Task II - Surface Facilities (Vitro Engineering);
3. Task III - Shafts (J. F. T. Agapito and Associates);
4. Task IV - Subsurface Facilities (J. F. T. Agapito and Associates);
5. Task V - Waste Handling System (Rockwell Hanford Operations);
6. Task VI-A - Surface System (Vitro Engineering);
7. Task VI-B - Subsurface Systems (J. F. T. Agapito and Associates).

During the report period, significant progress was achieved in the repository preconceptual design studies. At the present time, approximately 30 percent of the work scheduled has been completed. Engineering trade studies have been completed, concepts have been selected for each task, and preparation of system design descriptions is in progress. The repository preconceptual design report, to be issued by August 31, 1979, will consist of three parts:

1. Part I - System Design Description (RDT Standard F1-2T format)
Technical description,
Drawings and sketches,
Trade studies;
2. Part II - Integrated Schedule for Repository Design and Construction
Engineering for conceptual, Title I, Title II, and Title III design,
Major advance procurements,
Construction of major elements;

3. Part III - Preliminary Repository Cost Estimate

The cost estimate will be summarized in the same work breakdown used in the design description and in the schedule. Backup data will be submitted to justify the estimated costs.

Preparation of repository functional design criteria was initiated on March 9, 1979. This work is being conducted by Richland Engineering in parallel with the repository preconceptual design studies. At the present time, approximately 30 percent of the work scheduled has been completed. Repository functional design criteria are to be submitted to the U. S. Department of Energy-Richland Operations Office for review and approval in June 1979.

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