RHO-BWI-81-100 4Q

RHO-BWI--81-100-4Q

DE82 012031

MASTER

Basalt Waste Isolation Project Quarterly Report

July 1, 1981 through September 30, 1981

R. A. Deju
Director, Basalt Waste Isolation Project

DO NOT MICROFILM COVER

Prepared for the United States Department of Energy Under Contract DE-AC06-77RL01030

Rockwell International

Rockwell Hanford Operations
Energy Systems Group
Richland, WA 99352

DISCLAIMER

Rockwell International

Rockwell Hanford Operations
Energy Systems Group
Richland, WA 99352

RHO-BWI-81-100 4Q

RHO-BWI--81-100-4Q

DE82 012031

BASALT WASTE ISOLATION PROJECT QUARTERLY REPORT

JULY 1, 1981
THROUGH
SEPTEMBER 30, 1981

R. A. Deju

Director
Basalt Waste Isolation Project

November 1981

Rockwell International

Rockwell Hanford Operations
Energy Systems Group
P O Box 800
Richland, Washington 99352

MGW

ABSTRACT

This document reports progress made in the Basalt Waste Isolation Project during the fourth quarter of fiscal year 1981. Efforts are described for the following programs of the project work breakdown structure:

- Systems
- Waste Package
- Site
- Repository
- Regulatory and Institutional
- Test Facilities
- In Situ Test Facilities.

This project is being conducted for the U.S. Department of Energy under Contract DE-AC06-77RL01030.

SUMMARY

This report addresses the technical progress for the Basalt Waste Isolation Project (BWIP) for the fourth quarter of fiscal year (FY) 1981. The organization of the report follows the work breakdown structure for the technical programs of the project. The major highlights for the quarter are provided below.

SYSTEMS

During this quarter, work in the Systems program progressed in the Program Baseline, Systems Analysis, and Performance Assessment activities. In the Program Baseline activity, the Principal Criteria Document (PCD) was completed and submitted to the U.S. Department of Energy-Richland Operations Office (DOE-RL) and the Office of National Waste Terminal Storage Integration (ONI) on August 31, 1981 for review and comment. The BWIP Missions Document was completed and submitted to DOE-RL and ONI on September 29, 1981. In the Systems Analysis activity, personnel from TRW, Inc., Energy Systems Group, Redondo Beach, California, reviewed the application of systems engineering principles used at the BWIP under a service agreement subcontract administered by Systems Department personnel. A compilation of detailed responses to questions raised at the BWIP third quarter review meeting was prepared by Systems Department and submitted to DOE-RL. In support of the BWIP Performance Assessment, the Systems and Site Departments compiled the site-suitability issues that were identified at the 3-day workshop held during the last quarter. These issues have been analyzed and integrated by Systems and returned to Site for review.

WASTE PACKAGE

The BWIP materials test program was presented to a Peer Review Panel established by the ONI. The review was generally favorable. The Hanford Engineering Development Laboratory (HEDL), Richland, Washington completed the synthesis of 1 kg of simulated spent fuel which will be used in future waste/barrier/rock interaction studies. A report on the characterization of the waste form was also completed by HEDL. Hydrothermal studies of the supercalcine/groundwater/basalt system have continued at Arizona State University, Tempe, Arizona. Temple University, Philadelphia, Pennsylvania and Pennsylvania State University, University Park, Pennsylvania have successfully tested a yttria-doped zirconia pH electrode at 90°C. Continuing sorption experiments conducted at 23° and 60°C on Hanford basalts showed that neptunium is more strongly sorbed under reducing conditions. Higher K_ds under reducing conditions are expected because of the reduction of the neptunium oxidation state from neptunium (V) to neptunium (IV) which leads to lower solubility limits and the formation of neutral or cationic aqueous species. Sorption studies of the potential backfill material, sodium bentonite, were initiated with uranium, neptunium, cesium, strontium, selenium, and iodine. Experiments were run at 65°C under oxic and anoxic conditions. They showed that bentonite has a moderate sorption capacity

for all the radionuclides except for the anionic species, iodine and selenium. Calculations were completed to refine estimates of Eh-pH conditions in the near-field waste package environment. Close agreement in the estimates of Eh values was found using a variety of possible mineral and gas phase assemblages as buffers. Diagrams were constructed depicting stable uranium phases (both solid and aqueous) as a function of temperature, Eh, and pH. The Hanford repository groundwater (Grande Ronde groundwater) and available thermodynamic data provided the data base.

SITE

The Geologic Characterization activity includes nine subactivities which provide geologic data and interpretations significant to the evaluation of candidate repository sites in the basalt beneath the Hanford Site. Work under this activity includes geologic reconnaissance studies conducted throughout the Columbia Plateau and detailed studies conducted within the Pasco Basin, particularly the Umtanum flow (i.e., the candidate host rock) within a reference repository location (RRL) in the west-central portion of the Cold Creek syncline. During this quarter, work under the Surface Geology subactivity included the completion of a reconnaissance geologic map of post Columbia River Basalt Group sediments and volcanics of Oregon, and initiation of a detailed stratigraphic study of the Ringold Formation in the RRL. Results of work carried out under the Resource Potential subactivity showed that the mineral industry within 100 km of, and including the RRL, is a relatively insignificant component of the economy, and likely to remain so; furthermore, the area is relatively unattractive for future subsurface mineral exploration and development in conflict with a potential repository. A study carried out in support of the Volcanic subactivity, indicates that the probability of occurrence of events consequent from renewed igneous activity which pose hazards to a repository sited within the Hanford Site are remote; potential for repository breach as a consequence of renewed igneous activity during the next 1 E-04 yr is calculated as 1 E-04%. Work under the Tectonic subactivity included the continuation of seismic monitoring, geodetic surveys, mechanical analysis of Yakima folds, and analysis of isopach maps of Grande Ronde Basalt. Overall, eastern Washington seismicity during this quarter was low level. Mechanical analysis data indicate that en echelon folds occurring within the Hanford Site are those expected only if basalt is continuous between the Yakima folds and Palouse slope and not disrupted by an as yet undiscovered major structure. Isopach maps indicate that rates of regional tilting occurring during Grande Ronde time were on the order of 3 to 4 m/km/million years; this value is the same order of magnitude as rates of uplift across the Yakima folds during late Wanapum and Saddle Mountains Basalts time. Work under the Structural Geologic Setting subactivity included ground geophysical surveys in the area to the west (Yakima Ridge extension) and northwest (Yakima Barricade) of the RRL. Initial results of a gravity survey in the Yakima Barricade area indicate a north-south trending gravity gradient of 1 milligal which may correspond with a structural feature acting as a hydrologic barrier. Preliminary analysis of gridded ground magnetic data in the Yakima Ridge area suggests that faulting mapped on Yakima Ridge is local and does not continue to the south of the ridge; the data also reveal a set of anomalies coincident with the inferred subsurface extension of Yakima Ridge. During the quarter, revised isopach maps of the flow-top breccia and flow interior of the Umtanum flow were constructed. Work under the Host Rock Lithology activity suggested that silica polymorphs (secondary minerals) are significantly more abundant in the Umtanum and adjacent flows than previously thought and that mordenite, because of its high surface-to-volume ratio, may contribute significantly to radionuclide sorption. Analysis of samples from the Rattlesnake Hills #1 (RSH-1) test well, conducted as part of the Host Rock Stratigraphic Setting subactivity, indicates that the depth of the base of the Columbia River Basalt Group lies at a depth of 4,500 m, not 1,500 m, as interpreted by previous workers. Work under the Data Integration subactivity included completing the report "Subsurface Geology of the Cold Creek Syncline" (RHO-BWI-ST-14) and meeting with staff and consultants of the U.S. Nuclear Regulatory Commission (NRC) for informal technical discussions.

During the fourth quarter in the Hydrologic Characterization activity, nine geologic intervals were tested and transmissivity values were within the range previously reported. A report on Pasco Basin water resources was received forecasting costs, sources, and demand (including a list of the major users). Annual water-demand estimates for the Pasco Basin were 2.467 E+09 m^3 for 1980, increasing to 4.44 E+09 m^3 in 2080. Flash flood analysis of the RRL estimated the probability of flooding at 1 E-05 to 1 E-04. The flood would be of short duration and would not impact underground facilities. A document on modeling of Pasco Basin hydrology, including a simplified description of groundwater flow in the Basin, was completed (RHO-BWI-LD-44). Calculation of water travel time from the hypothetical repository to the model boundary was calculated to be more than 100,000 yr based on the most rapid groundwater flow path. A pattern of near-horizontal movement away from the siting area is developing.

REPOSITORY

Significant progress was achieved in completing development of a Repository Technical Baseline.

Two documents were completed in support of the repository seal development program. The first summarizes laboratory physical test results for candidate seal materials. The second describes a finite element computer code designed to assess borehole plug stability.

Kaiser Engineers/Parsons Brinckerhoff Quade and Douglas, Inc. (KE/PB), Oakland, California completed preparation of a draft conceptual system design description for a nuclear waste repository in basalt. Review by the DOE and Rockwell Hanford Operations is in progress.

In full-scale heater tests, analysis of the temperature and displacement data for the first 270 days of test operation was completed. The results show a good correlation with predicted values for the heating data, good correlation for the displacement data in the vertical plane, but poor correlation for the displacement data in the horizontal plane. The influence of the columnar structure appears to be predominant in the horizontal displacement data.

Block Test Step 1 tests were completed. Predictive analysis for Step 2 tests were completed. Preparations are under way to complete the design modifications for Step 2 tests based on Step 1 data. Thermal conductivity measurements of the block were completed. The block mass conductivity values were determined to be 1.57 W/m·K.

Data verification activities continued during the quarter. Modifications were made to the proposed test plans in Full-Scale Heater Test #2 in order to enhance our understanding of the thermal fracture process for canister heating conditions.

REGULATORY AND INSTITUTIONAL

The major emphasis of the Regulatory and Institutional program during the fourth quarter was coordination of preparation of the Site Characterization Report (SCR). Five chapters have been written and are in various stages of word processing, editing, or undergoing management review. The SCR is scheduled for completion in June of 1982.

A meeting with 27 people from the NRC and its consultants was held to conduct in-depth technical reviews of information to be presented in the SCR.

TEST FACILITIES

The Near-Surface Test Facilities (NSTF) realized several accomplishments during the fourth quarter of FY 1981. Work progressed in all end functions with the exceptions of Decommissioning and Support Facilities.

Progress in the NSTF Phase I end function was highlighted by the completion of Block Test #1 (BT1) Step 1 in its entirety on September 8, 1981. Upon completion, all test instrumentation and associated equipment was removed from the test block and preparations were made to initiate the second step of BT1.

Fabrication began on the Basalt Deformation Measurement System (BDMS) which is designed to measure displacement across the block face during the Step 2 testing cycles. The BDMS is expected to be delivered onsite by mid-January 1982.

The NSTF Phase II facility construction was completed in the fourth quarter with exceptions. These exceptions will be cleared during the first quarter of FY 1982. In the absence of funding in FY 1982 for the NSTF Phase II activities, no additional work will be performed toward completion of the Phase II test implementation.

The Bottom Loading Transporter was assembled in the transfer room at the NSTF and all related construction completed with some minor exceptions. These exceptions will be addressed and cleared during the first quarter of FY 1982.

IN SITU TEST FACILITIES

Exploratory Shaft Phase I (ES-I) conceptual design was initiated by KE/PB on July 15, 1981. A draft ES-I test plan was transmitted to the DOE for review and approval. Requests for directives were transmitted to the DOE for general plant projects to extend utility services to the ES-I site.

CONTENTS

FIGURES (Cont):

TABLES:

INTRODUCTION

The Basalt Waste Isolation Project (BWIP) was initiated in May 1976 to investigate the feasibility of using Columbia Plateau basalt formations as a repository site for deep geologic disposal of high-level radioactive waste. Rockwell Hanford Operations (Rockwell) was selected by the U.S. Department of Energy (DOE) to serve as the prime contractor for performance of the required site exploration and repository design studies. The BWIP is administered by the DOE-Richland Operations Office (DOE-RL).

The BWIP is part of the National Waste Terminal Storage (NWTS) Program, which is the comprehensive DOE program to assess alternate sites and host media for geologic disposal and to evaluate other viable modes for permanent disposal of radioactive waste. The NWTS Program is managed for the DOE by the Office of National Waste Terminal Storage Integration (ONI).

Several key projects within the NWTS Program, including the BWIP, have been organized to share common Work Breakdown Structure (WBS) elements. This approach facilitates communication and coordination of activities between equivalent functional groups at the various organizations participating in the NWTS Program.

Formal Interface Coordination Groups (ICGs), including representatives of the major waste disposal projects, were established for:

- Systems
- Waste Package
- Site
- Repository
- Regulatory and Institutional
- Test Facilities.

The ICG activities are coordinated and controlled by the Isolation-Interface Control Board (I-ICB). Participation in these panels is an essential element of Rockwell's BWIP management effort.

Technical progress in the BWIP for the fourth quarter of fiscal year (FY) 1981 is reported in this document for the programs listed in Figure 1 except for "Land Acquisition," which is not relevant to the BWIP, and "Program Management," which is a nontechnical function. Note that some WBS elements below the program level either have not started or are not applicable to the BWIP and are, therefore, not reported.

PROGRAM	END FUNCTION	ACTIVITY	SUBACTIVITY	WBS NO
SYSTEMS	SYSTEMS	PROGRAM BASELINE	DATA MANAGEMENT	L111
			CONFIGURATION MANAGEMENT	L112
			TECHNICAL BASELINE	L113
		SYSTEMS ANALYSIS	SYSTEMS DEVELOPMENT	L121
			TECHNICAL SERVICES	L122
		SOCIOECONOMIC ASSESSMENT	SOCIOECONOMIC ASSESSMENT	L131
		ALTERNATE DISPOSAL CONCEPTS	ALTERNATE DISPOSAL CONCEPTS	L141
		PERFORMANCE ASSESSMENT	PERFORMANCE ASSESSMENT	L151
WASTE PACKAGE	WASTE PACKAGE	WASTE PACKAGE BASELINE	WASTE PACKAGE BASELINE	L211
		WASTE FORM	INTEGRATION OF WASTE FORM DATA	L221
		BARRIER MATERIALS		L231
			WASTE/BARRIER/ROCK INTERACTIONS	L232
			SORPTION CHEMISTRY	L233
			CANISTER/OVERPACK MATERIALS	L234
			BACKFILL/BUFFER MATERIALS	L235
		DESIGN & DEVELOPMENT	BARRIER SYSTEM DESIGN REQUIREMENTS	L241
		PERFORMANCE EVALUATION	NEAR FIELD RADIONUCLIDE BEHAVIOR	L251
			ENGINEERING EVALUATION	L252
			FIELD AND IN SITU TESTING	L253
SITE	SITE	SITE BASELINE	SITE BASELINE	L311
		EARTH SCIENCES	EARTH SCIENCES	L321
		GEOLOGIC CHARACTERIZATION	SURFACE GEOLOGY	L331
			RESOURCE POTENTIAL	L332
			VOLCANIC ACTIVITY	L333
			TECTONIC SETTING	L334
			STRUCTURAL GEOLOGIC SETTING	L335
			HOST ROCK GEOMETRY	L336
			HOST ROCK LITHOLOGY	L337
			HOST ROCK STRATIGRAPHIC SETTING	L338
			INTEGRATION OF GEOLOGIC DATA	L339
		HYDROLOGIC CHARACTERIZATION	HYDROLOGIC PROPERTIES	L341
			HYDROLOGIC CONCEPTUAL MODEL	L342
			HYDROLOGIC NUMERICAL MODEL	L343
			GROUNDWATER MONITORING	L344
			INTEGRATION OF HYDROLOGIC DATA	L345
		ENVIRONMENTAL CHARACTERIZATION	ENVIRONMENTAL CONDITIONS	L351
			ENVIRONMENTAL IMPACTS	L352
		SOCIOECONOMIC EVALUATION	SOCIOPOLITICAL CONSIDERATIONS	L361
			ECONOMIC CONSIDERATIONS	L362
		PERFORMANCE EVALUATION	HYDROLOGIC MODEL PREDICTIONS	L371
			GROUNDWATER ASSESSMENT	L372
			ENVIRONMENTAL SYSTEMS ASSESSMENT	L373
REPOSITORY	REPOSITORY	REPOSITORY BASELINE	REPOSITORY BASELINE	L411
		REPOSITORY DATA BASE DEVELOPMENT	DATA BASE ANALYSIS	L421
			MODEL DEVELOPMENT	L422
			LABORATORY TESTS	L423
			FIELD TESTS	L424
		EQUIPMENT DEVELOPMENT	SHAFT SINKING	L431
			MINING EXCAVATION	L432
			WASTE HANDLING	L433
			MINE SERVICE SYSTEMS	L434
			REPOSITORY SEALING EQUIPMENT	L435
		INSTRUMENTATION DEVELOPMENT	IN SITU TEST INSTRUMENTATION	L441
			REPOSITORY INSTRUMENTATION	L442
		REPOSITORY SEAL DEVELOPMENT	MATERIAL DEVELOPMENT	L451
			SEAL DESIGN	L452
			TESTING	L453
			SYSTEM ANALYSIS	L454
		GENERIC REPOSITORY ENGINEERING	GENERIC REPOSITORY ENGINEERING	L461
		REPOSITORY CONCEPTUAL DESIGN	TECHNICAL DIRECTION	L471
			PRECONCEPTUAL DESIGN	L472
			AE SELECTION	L473
			CONCEPTUAL DESIGN	L474
			UPDATED CONCEPTUAL DESIGN	L475
			ENGINEERING STUDIES	L476
		REPOSITORY DESIGN AND INSPECTION	TITLE I PRELIMINARY DESIGN	L4U1
			TITLE II FINAL DESIGN	L4U2
			TITLE III INSPECTION SERVICES	L4U3
		REPOSITORY LONG LEAD PROCUREMENT	PROCUREMENT SERVICES	L4V1
			SURFACE FACILITIES PROCUREMENTS	L4V2
			ACESS SHAFTS PROCUREMENTS	L4V3
			SUBSURFACE FACILITIES PROCUREMENTS	L4V4
			WASTE HANDLING SYSTEMS PROCUREMENTS	L4V5
			SERVICE SYSTEMS PROCUREMENTS	L4V6
		REPOSITORY CONSTRUCTION	CM SELECTION	L4W1
			CONSTRUCTION MANAGEMENT	L4W2
			SURFACE FACILITIES CONSTRUCTION	L4W3
			ACCESS SHAFTS CONSTRUCTION	L4W4
			SUBSURFACE FACILITIES CONSTRUCTION	L4W5
			WASTE HANDLING SYSTEMS CONSTRUCTION	L4W6
			SERVICE SYSTEMS CONSTRUCTION	L4W7
		REPOSITORY OPERATION	REPOSITORY OPERATION	L4X1
		REPOSITORY DECOMMISSIONING	REPOSITORY DECOMMISSIONING	L4Y1
		REPOSITORY MONITORING	REPOSITORY MONITORING	L4Z1
		PERFORMANCE EVALUATION	MODEL DEVELOPMENT	L481
			MODEL APPLICATION	L482
REGULATORY AND INSTITUTIONAL	REGULATORY AND INSTITUTIONAL	REGULATORY BASELINE	REGULATORY BASELINE	L511
		LICENSING APLLICATIONS	SITE RELATED DOCUMENTS	L521
			CONSTRUCTION AUTHORIZATION	L522
			OPERATING LICENSE	L523
			DECOMMISSIONING LICENSE	L524
		NEPA DOCUMENTS	ENVIRONMENTAL EVALUATION	L531
			ENVIRONMENTAL ASSESSMENT	L532
			ENVIRONMENTAL IMPACT STATEMENT	L533
			ENVIRONMENTAL REPORT	L534
		COMMUNICATION & INSTITUTIONAL LIAISON	DOE/NWTS LICENSING COMMUNICATIONS	L541
			STATE AND LOCAL GOVERNMENT LIAISON	L542
			INFORMATION SERVICES	L543

FIGURE 1. Basalt Waste Isolation Project Work Breakdown Structure. (Sheet 1 of 2)

PROGRAM	END FUNCTION	ACTIVITY	SUBACTIVITY	WBS NO
TEST FACILITIES (NSTF)	NSTF PHASE I	PHASE I TEST FACILITY BASELINE	PHASE I TEST FACILITY BASELINE	
		DESIGN	ENGINEERING STUDY & CONCEPTUAL DESIGN	LB21
			GEOLOGIC SURVEILLANCE	LB22
			DESIGN TITLE I (VITRO)	LB23
			DESIGN TITLE I (ROCKWELL)	LB24
			DESIGN TITLE II (VITRO)	LB25
			DESIGN TITLE II (ROCKWELL)	LB26
			DESIGN SUPPORT	LB27
			DESIGN MANAGEMENT	LB28
		CONSTRUCTION	PROCUREMENT	LB31
			TUNNELS & EXCAVATION	LB32
			TEST & INSTRUMENT HOLES	LB33
			ELECTRIC DISTRIBUTION LINE (J A JONES)	LB34
			ELECTRIC DISTRIBUTION LINE (ROCKWELL)	LB35
			FACILITY REQUIREMENTS & SITE WORK	LB36
			WATERLINE	LB37
			TITLE III	LB38
			CONSTRUCTION MANAGEMENT	[illegible]
		SAFETY AND ENVIRONMENTAL ANALYSIS	ENVIRONMENTAL REVIEW	LB41
			SAFETY REVIEW	LB42
		TEST IMPLEMENTATION	FULL SCALE TEST NO 1	LB51
			FULL SCALE TEST NO 2	LB52
			BLOCK TEST NO 1	LB53
			BLOCK TEST NO 2	LB54
			ENGINEERING SUPPORT	LB56
			OPERATIONS	LB57
	NSTF PHASE II	PHASE II TEST FACILITY BASELINE	PHASE II TEST FACILITY BASELINE	LC11
		DESIGN	ENGINEERING STUDY & CONCEPTUAL DESIGN	LC21
			GEOLOGIC SURVEILLANCE	LC22
			DESIGN TITLE I (VITRO)	LC23
			DESIGN TITLE I (ROCKWELL)	LC24
			DESIGN TITLE II (VITRO)	LC25
			DESIGN TITLE II (ROCKWELL)	LC26
			DESIGN SUPPORT	LC27
			DESIGN MANAGEMENT	LC28
		CONSTRUCTION	PROCUREMENT	LC31
			TUNNELS & EXCAVATION	LC32
			TEST & INSTRUMENT HOLES	LC33
			FACILITY REQUIREMENTS & SITE WORK	LC34
			BOTTOM LOADING TRANSPORTER (ROCKWELL)	LC35
			BOTTOM LOADING TRANSPORTER (CONTRACT)	LC36
			CONSTRUCTION MANAGEMENT	LC37
			TITLE III	LC38
		SAFETY AND ENVIRONMENTAL ANALYSIS	ENVIRONMENTAL REVIEW	LC41
			SAFETY REVIEW	LC42
		TEST IMPLEMENTATION	ENGINEERING SUPPORT	LC54
			OPERATIONS	LC55
			3 CANISTER NUCLEAR WASTE TEST	LC56
	SUPPORT FACILITIES	SUPPORT FACILITIES	SUPPORT FACILITIES	LD11
	DECOMMISSIONING	DECOMMISSIONING	DECOMMISSIONING	LE11
IN SITU TEST FACILITIES (IN SITU)	EXPLORATORY SHAFT PHASE I (ES 1)	ESTF PHASE I BASELINE	ESTF PHASE I BASELINE	LF11
		CONFIRMATORY BOREHOLE	CONFIRMATORY BOREHOLE	LF21
		DESIGN & INSPECTION	DESIGN MANAGEMENT	LF31
			CONCEPTUAL DESIGN	LF32
			TITLE I DESIGN	LF33
			TITLE II DESIGN	LF34
			TITLE III INSPECTION SERVICES	LF35
		LONG LEAD PROCUREMENT	LONG LEAD PROCUREMENT	LF41
		CONSTRUCTION	CONSTRUCTION MANAGEMENT	LF51
			SITE IMPROVEMENTS	LF52
			SURFACE FACILITIES CONSTRUCTION	LF53
			SHAFT CONSTRUCTION	LF54
		IN SITU SITE CHARACTERIZATION	OPERATIONS	LF61
			TEST EQUIPMENT	LF62
			IN SITU TESTING	LF63
		PERFORMANCE EVALUATION	ENVIRONMENTAL REVIEW	LF71
			SAFETY REVIEW	LF72
			READINESS REVIEWS	LF73
	ES PHASE II	TBD	TBD	LG
	TEST & EVALUATION FACILITY (TEF)	TEF BASELINE	TEF BASELINE	LH11
		CONFIRMATORY BOREHOLE	CONFIRMATORY BOREHOLE	LH21
		DESIGN & INSPECTION	DESIGN MANAGEMENT	LH31
			CONCEPTUAL DESIGN	LH32
			TITLE I DESIGN	LH33
			TITLE II DESIGN	LH34
			TITLE III INSPECTION SERVICES	LH35
		LONG LEAD PROCUREMENT	LONG LEAD PROCUREMENT	LH4
		CONSTRUCTION	TBD	LH5
		OPERATION	TBD	LH6
LAND ACQUISITION	LAND ACQUISITION	LAND ACQUISITION	LAND ACQUISITION	L711
PROGRAM MANAGEMENT	PROGRAM MANAGEMENT	PROJECT MANAGEMENT	PROJECT MANAGEMENT	L811
		PROJECT CONTROL	PROJECT CONTROL	L821
		INTERFACE ACTIVITIES	INTERFACE ACTIVITIES	L831
		QUALITY ASSURANCE	QUALITY ASSURANCE	L841
		SPECIAL SUPPORT	SPECIAL SUPPORT	L851

FIGURE 1. Basalt Waste Isolation Project Work Breakdown Structure. (Sheet 2 of 2)

SYSTEMS

The objective of the Systems program is to integrate the BWIP technology development activities leading to the selection and characterization of a site and to the design and licensing of a repository for nuclear waste within the basalt underlying the Hanford Site. Systems assures that the BWIP work is aimed at resolving key issues as required to meet programmatic criteria.

The Systems program consists of one end function, Systems, which is divided into five activities:

- Program Baseline
- Systems Analysis
- Socioeconomic Assessment
- Alternate Disposal Concepts
- Performance Assessment.

During the fourth quarter of FY 1981, efforts were conducted in the Program Baseline, Systems Analysis, and Performance Assessment activities.

PROGRAM BASELINE

The objective of the Program Baseline activity is to integrate and control the Technical Baseline for the BWIP. The Program Baseline activity provides technical direction to the BWIP staff by identifying, preparing, implementing, and maintaining the BWIP Technical Baseline. In addition, this activity identifies and evaluates all external and internal criteria and requirements which form the basis for the BWIP baseline. The Program Baseline activity includes Data Management and Configuration Management services for the BWIP through a matrix relationship between the BWIP and the Engineering Management Systems Department in the Research and Engineering function of Rockwell.

The Program Baseline activity is divided into three subactivities:

- Data Management
- Configuration Management
- Technical Baseline.

During the fourth quarter of FY 1981, work has progressed in all three subactivities.

Data Management

The objectives of the Data Management subactivity are to ensure that: (1) BWIP design documents are released and controlled by an automated data system and that a current file is maintained of all released items; (2) BWIP records are recorded, filed, and tracked in an automated data system, and placed in a records holding area available for retrieval; (3) all BWIP reference material is located in a central library, catalogued, filed, and tracked by an automated data system; and (4) all borehole core samples are indexed, photographed, catalogued, stored, and controlled by an automated data system.

During the fourth quarter of FY 1981, progress included the following:

- A unit charter was written and approved.
- The 9-mo data backlog in Records Retention was reduced to ~5 mo.
- A "prompt" input system was developed and implemented in the Records Retention area to allow faster data entry.
- Engineering Data Management personnel contributed significantly toward completion of the BWIP Document Control Systems Description Document.

Configuration Management

The objectives of the Configuration Management subactivity are to ensure that the system design is effectively recorded, communicated, and controlled by project and functional managers, and to control the implementation of changes. During the fourth quarter of FY 1981, progress included the following:

- A document was finalized, released, and sent to the DOE-RL which documented the requirements for the BWIP Document Control System.
- A document was prepared and sent to DOE-RL which described the implementation plan for the Document Control System and outlined the framework for completing a sound Document Control System for the BWIP.
- A high level of effort was applied to the analysis of the BWIP Document Control System which resulted not only in finalizing the requirements and implementation plan, but also provided the basis for a system description document now in the final stages of preparation and release.
- Eighteen Basalt Operating Procedures (BOPs) dealing with design were reviewed and revised to assure that all procedures were up to date.

In addition, a total of 15 Engineering Change Proposals (ECPs) were processed through the change control system.

Technical Baseline

The objective of the Technical Baseline subactivity is to identify, prepare, and integrate essential BWIP documents and baseline them into the overall program. Progress of this subactivity during this quarter is described below.

Technical Plans. Effort continued on the revision to the final drafts of all BWIP end function technical plans:

- Regulatory and Institutional
- Waste Package
- Site
- Repository
- Exploratory Shaft
- Test Facilities.

These end function technical plans will ultimately be used in the preparation of the BWIP Plan.

Principal Criteria Document (PCD). The PCD was completed and submitted to DOE and ONI for review and comment on August 31, 1981.

BWIP Missions Document. The BWIP Missions Document was completed and submitted to DOE and ONI on September 29, 1981.

Borehole Assessment Needs Plan (BANP)/Service Agreement, SA-875. The Analytic Sciences Corporation (TASC), Boston, Massachusetts accepted the Service Agreement, SA-875, on August 25, 1981. The BANP is set up to determine further borehole needs for site characterization. The Analytic Sciences Corporation will supply an assessment of the quantity, location, and depth of a multiple-use borehole network. Tasks I and II (Milestone 1) of the Service Agreement, which were to (1) review appropriate criteria and (2) review and develop the technical baseline, were completed on September 30, 1981.

SYSTEMS ANALYSIS

The purpose of the Systems Analysis activity is to assess the relationships of interacting BWIP elements and to identify studies and work necessary to achieve specific program objectives. Progress within this activity during the fourth quarter of FY 1981 proceeded in several different areas.

Personnel from TRW, Inc., Energy Systems Group, Redondo Beach, California reviewed the application of systems engineering principles at the BWIP under a service agreement subcontract administered by Systems Department personnel. Areas covered during this review included functional analyses, trade studies, performance assessment and evaluation, configuration management, data management, baseline identification and control, test planning, organizational interfaces, and other related topics. The TRW, Inc. observations and recommendations resulting from this review were presented in a series of four progress reports and two presentations to key BWIP technical personnel and management staff. TRW, Inc. concluded that the BWIP is progressing well in employing the systems approach and has most essential elements in place. Some specific suggestions were provided regarding methods of implementation and appropriate degrees of emphasis. The two major areas identified as needing the most attention were management and application of technical baseline principles, and effective implementation of the Systems Department integration role.

A compilation of detailed responses to questions raised at the BWIP Third Quarter Review Meeting was prepared by the Systems Department and submitted to the DOE-RL. This meeting, held in Richland, Washington on August 5 and 6, 1981, was attended by DOE-Headquarters and ONI representatives. Most of the questions raised during the meeting were satisfactorily answered during the meeting by the BWIP personnel in attendance. The questions answered in writing, subsequent to the meeting, were those for which BWIP attendees perceived that additional detail and clarification were warranted. The questions and corresponding responses addressed technical issues in the areas of hydrology, rock mechanics, tectonics, repository and exploratory shaft siting, and waste package.

An updated draft of a report on the interim reference repository conditions for a nuclear waste repository in basalt (NWRB) was submitted to the Reference Repository Conditions Interface Working Group (RRC-IWG) chairman and members. Review comments were discussed in extensive detail at an RRC-IWG meeting in Denver, Colorado on July 22 and 23, 1981. One section of the report was redrafted at the meeting; other changes were minor and editorial in nature. The revised report, incorporating these changes, was resubmitted to the RRC-IWG chairman, who has submitted this report, together with corresponding reports for tuff, granite, and salt, for ONI and NWTS Program review.

A BWIP training course on trade study analysis and preparation was prepared and presented on September 17, 1981 by Systems Department personnel. Suggested visual aids were provided by TRW, Inc. personnel working under a related subcontract. The course material included a step-by-step description of a specific BWIP trade study related to waste package design optimization. The presentation was well received by those attending, including DOE-RL representatives.

Application of the functional analysis techniques was demonstrated on the Exploratory Shaft Phase I (ES-I) project. A determination was made of the suitability of the technique on a development test project before it was approved. The TRW, Inc. consultants provided support in the work of assessing the suitability and application of the process to a development testing effort. A status report of FY 1981 results is in preparation and will be issued in early FY 1982. Functional analysis objectives for FY 1981 were threefold:

- Assess and modify the process as required to accommodate a development project
- Demonstrate that the modified process works using ES-I as the test case
- Begin familiarizing BWIP staff members with the functional analysis process.

The report will contain the results of the functional analysis, plans for follow-on work in FY 1982, and a description of functional analysis as an integral part of systems engineering and its application to ES-I.

PERFORMANCE ASSESSMENT

The Systems Department and the Site Department compiled the site suitability issues that were identified at the 3-day workshop held during the last quarter. These issues have been analyzed and integrated by Systems and returned to Site for review. Four key site related issues were identified and transmitted to the DOE-RL. Within each key issue four to eight factors, which require consideration, were also identified.

A report was prepared that describes "The BWIP Performance Evaluation Process: A Criteria Based Method" (RHO-BWI-SA-175). This report will be presented during the first quarter of FY 1982 at the 1981 National Waste Terminal Storage Program Information Meeting. A more detailed edition of this report is being prepared to fully document the entire process.

WASTE PACKAGE

The objective of the Waste Package program is to define site-specific waste package requirements and monitor NWTS Program waste package design to ensure that a waste package emplaced in a repository constructed in basalt meets required regulatory criteria.

The Waste Package program consists of one end function, Waste Package, which is divided into five activities:

- Waste Package Baseline
- Waste Form
- Barrier Materials
- Design and Development
- Performance Evaluation.

During the fourth quarter of FY 1981, work has progressed in all but the Design and Development activity.

WASTE PACKAGE BASELINE

This activity provides project control for the Waste Package end function and includes the preparation, implemention, and control of project plans, schedules, and budgets; the overall direction of technical work; and integration of BWIP waste package studies with the NWTS Program.

During this reporting period, members of the Office of Waste Package Studies (OWPS) staff presented a detailed waste package materials test plan to a Peer Review Panel selected by ONI. The six panel members consisted of scientists and engineers from a variety of disciplines related to materials testing. A 3-day session was held during which members of the OWPS staff made oral presentations of the proposed test plan. In addition, the Peer Review Panel evaluated a test plan report on the BWIP barrier material test program description. The panel's review was generally favorable.

WASTE FORM

Integration of Waste Form Data

The number and types of components required for the design of effective waste packages will be dependent on the chemical and physical properties of the waste form. Consequently, the objectives of this subactivity are to integrate currently available data on the properties of candidate waste forms and to provide this data base and simulated and radioactive waste forms to the Waste/Barrier/Rock Interaction subactivity for testing.

A report on the chemical and physical properties of spent light water reactor fuel and a method for simulation of a nonradioactive analog was completed by subcontractors at Hanford Engineering Development Laboratory (HEDL), Richland, Washington and the staff of the OWPS. The Hanford Engineering Development Laboratory also made their final delivery of simulated spent fuel to Rockwell. The characterization of actual spent fuel and the resulting synthesis of 1 kg of simulated spent fuel is important input to the Waste/Barrier/Rock Interactions subactivity because of the need to perform large numbers of hydrothermal tests in nonradiochemical laboratories.

BARRIER MATERIALS

Waste/Barrier/Rock Interactions

The objective of BWIP hydrothermal chemistry studies is to assess the performance of candidate waste forms and waste package component materials under conditions expected in a repository constructed in basalt at the Hanford Site.

Investigation of the system supercalcine (SPC-4) + groundwater ± basalt under hydrothermal conditions has been completed by Arizona State University (ASU), Tempe, Arizona under contract to the BWIP OWPS. Tests have been performed at 300° and 200°C at 300 bars for durations of approximately 1,000 hr. Routine sampling and analysis of solutions drawn from the autoclaves have been made in order to study the solubility of the chemical components of SPC-4 as a function of time. The solution chemistry from SPC-4 reacted with synthetic Hanford groundwater at 200° and 300°C, 300 bars is shown in Figure 2. Of particular note is the early (first 100 to 200 hr), nonlinear dissolution behavior followed by an approach to steady-state conditions (i.e., unchanging concentration with time) exhibited by all measured solution species.

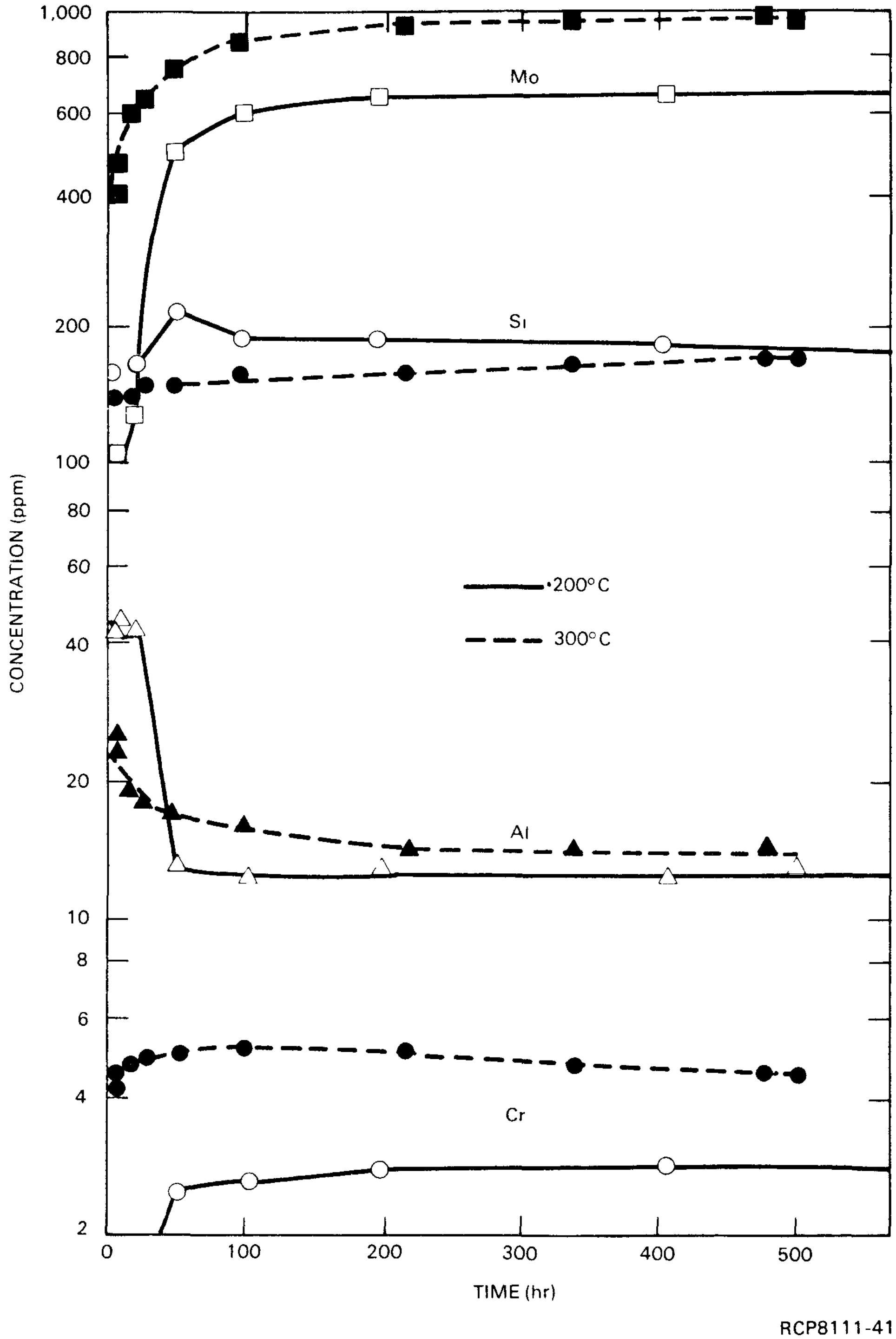


FIGURE 2. Comparison of Selected Cations in Solution Samples from the Interaction of Supercalcine (SPC-4) and Groundwater at 200° and 300°C.

The ASU group also investigated the effects of sample preparation using an acetone wash to remove small, highly reactive particulate material from initial powdered materials, the effect of reinjection of fresh solution into the reaction vessel during testing, and the effect of basalt on hydrothermal reaction between SPC-4 and groundwater. Basalt apparently increases the number of reactive major chemical components, thus greatly increasing the complexity of hydrothermal reactions. This results in a much longer initial period of non-steady-state behavior (up to 2,000 hr for some species, as presented in Fig. 3). Ongoing microcharacterization of solid phases from these studies will greatly aid in the interpretation of explicit hydrothermal reactions in these systems. Solution data on the hydrothermal reactions between borosilicate glass (PNL 76-68) + groundwater $\pm$ basalt at 300°C, 300 bars have also been obtained by ASU. The concentration profiles of solution species from borosilicate glass + groundwater reaction show a regular dissolution behavior with time which is similar to that of SPC-4 + groundwater run under the same experimental conditions. There are, however, several notable differences between the waste form reactions, as summarized in Table 1. For example, the solution concentrations for sodium, molybdenum, and silicon are much higher in the borosilicate glass tests. These differences could be tentatively ascribed to the difference in bulk waste form composition (also shown in Table 1) and perhaps the lower pH in the test with borosilicate glass. Molybdenum may form stable complexes with silicon in solution, based on other literature data. Comparison of the 2-, 24- and 500-hr values confirm that solute concentrations increase much more rapidly in the borosilicate glass tests relative to the SPC-4 tests. This supports the supposition that the glass is less stable (i.e., reacting more rapidly) than SPC-4 under hydrothermal conditions.

Basaltic rock will be the volumetrically dominant reactive solid in a repository at the Hanford Site and thus will buffer the chemical composition of any groundwater reaching the waste package. Studies on the hydrothermal reaction of basalt under repository conditions have been carried out by Temple University, Philadelphia, Pennsylvania through contract to the BWIP OWPS. Tests at 300° and 200°C, 300 bars have monitored the change in solute concentration as a function of time.

Data from runs at both temperatures show initial, rapid changes in concentration (nonlinear dissolution rates). The 300°C solution compositions show an attainment of steady-state conditions within the first several hundred hours, in contrast to the 200°C solutions which show continual solution concentration changes with time up to >750 hr. Calculation of solution-mineral phase equilibria suggests that sampled solutions are saturated with respect to quartz, calcite, and barite among other phases. The potassium/sodium ratio measured for natural hydrothermal groundwaters has been successfully used as a reliable geothermometer in the geochemical literature. A comparison of measured potassium/sodium ratios from the Temple University data with this geothermometer shows agreement within 20°C at 300°C and within 40°C at 250°C. Microcharacterization of solid products of these runs is awaiting run termination after a 4,000-hr duration.

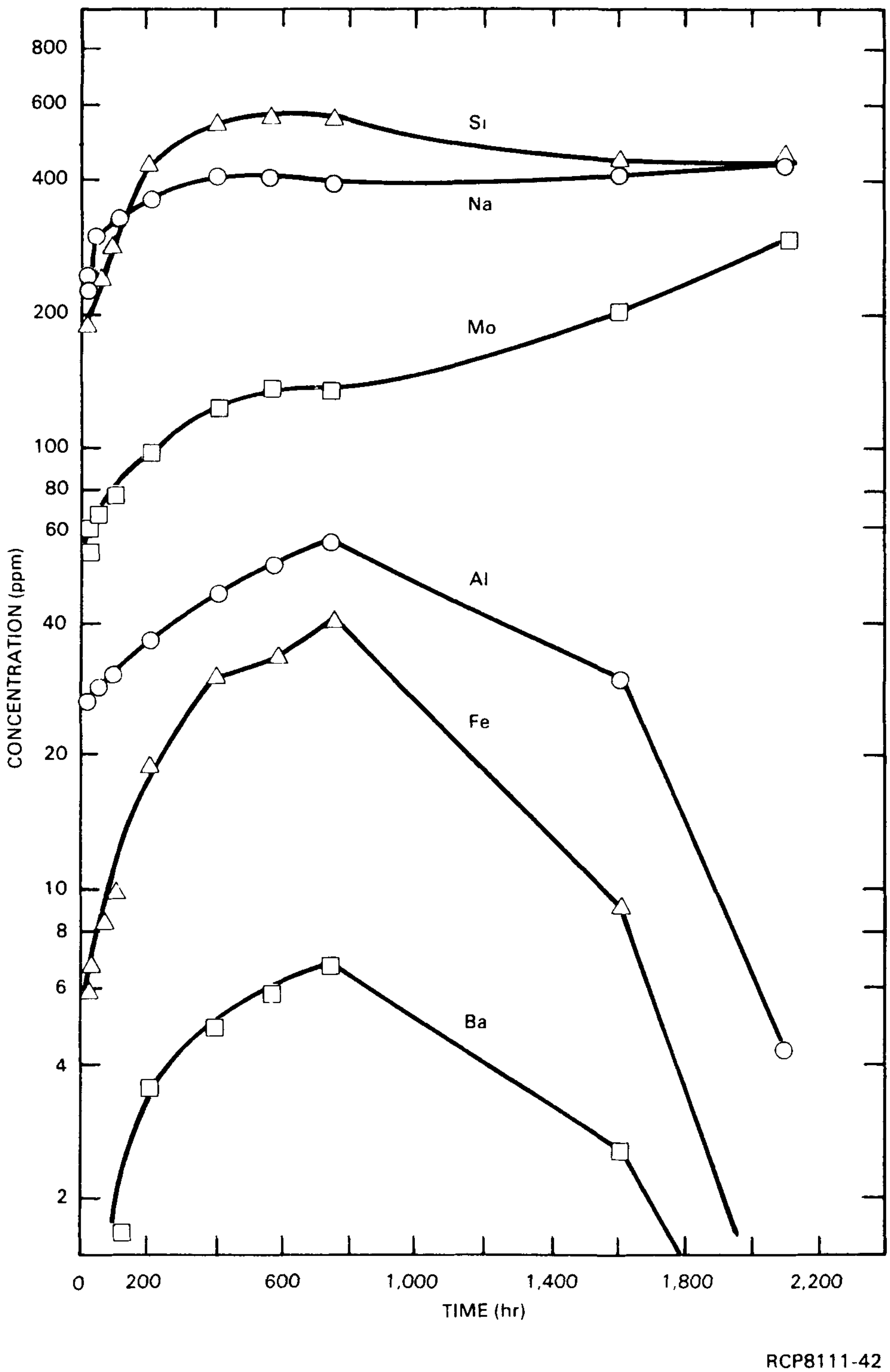


FIGURE 3. Plot of all Cations that are Present above 2 mg/L in Water Samples from Run of Basalt + Supercalcine (SPC-4) + Groundwater at 200°C, 300 Bars. Uncertainty in each value is size of symbol.

TABLE 1. Comparison of Groundwater Solution Compositions in Contact with Borosilicate Glass and Supercalcine (SPC-4) at 300°C and 300 Bars.

Elements	Contact Time of Groundwater Solution Compositions (mg/L)						Wasteform Composition (wt%)	
	2 hr		24 hr		500 hr			
	Glass	SPC-4	Glass	SPC-4	Glass	SPC-4	Glass	SPC-4
Na	3,600	670	3,400	710	3,600	870	12.5	0.2
Mo	1,100	400	1,170	640	1,290	960	1.8	6.8
Si	1,120	140	1,260	150	1,060	170	40	14.5
Al	7.1	24	6.8	18	8.3	13	0	3.7
Fe	5.2	1.6	1.7	1.5	0.62	1.2	9.7	4.0
Cr	43	4.4	44	5.0	3.3	4.5	1.2	0.4
Ca	0.13	0.02	0.08	0.01	0.22	0.02	2.0	1.7
Sr	0.03	0.04	0.02	0.07	0.04	0.07	0.4	3.6
Ba	0.34	0.07	0.12	0.10	0.15	0.17	0.6	2.1
pH	9.56	11.19	9.54	11.22	9.56	10.78	--	--

Arizona State University, Temple University, and Pennsylvania State University, University Park, Pennsylvania geochemical groups under OWPS contract are also continuing an investigation of high-temperature/high-pressure probes for monitoring and controlling solution pH and Eh in Dickson-type rocking autoclaves. A solid-state, yttria-doped zirconia electrode with a Ag/AgCl reference electrode (Fig. 4) has been successfully tested as a pH electrode under a variety of solution compositions at 90°C (Fig. 5). Problems with the intrinsically high impedence of zirconia electrodes, thermal stability of the reference electrode, and zirconia tubes contaminated by iron have been overcome, and full pressure testing of the apparatus in a rocking autoclave is expected early in FY 1982. Shaw-type membranes for controlling H_2 activity (hence Eh) in solution via H_2 diffusion through Teflon or Nafion membranes are also near completion.

Rockwell's Geochemistry Unit (Research and Engineering) has begun hydrothermal testing of bentonite to determine the stability field of this sodium montmorillinite as a function of pressure, temperature, and water content. Microcharacterization of solid run products from outside contractors is being performed on STEM and XRD apparatus by Research and Engineering personnel. Standardized testing procedures for all of the BWIP OWPS hydrothermal studies have also been organized.

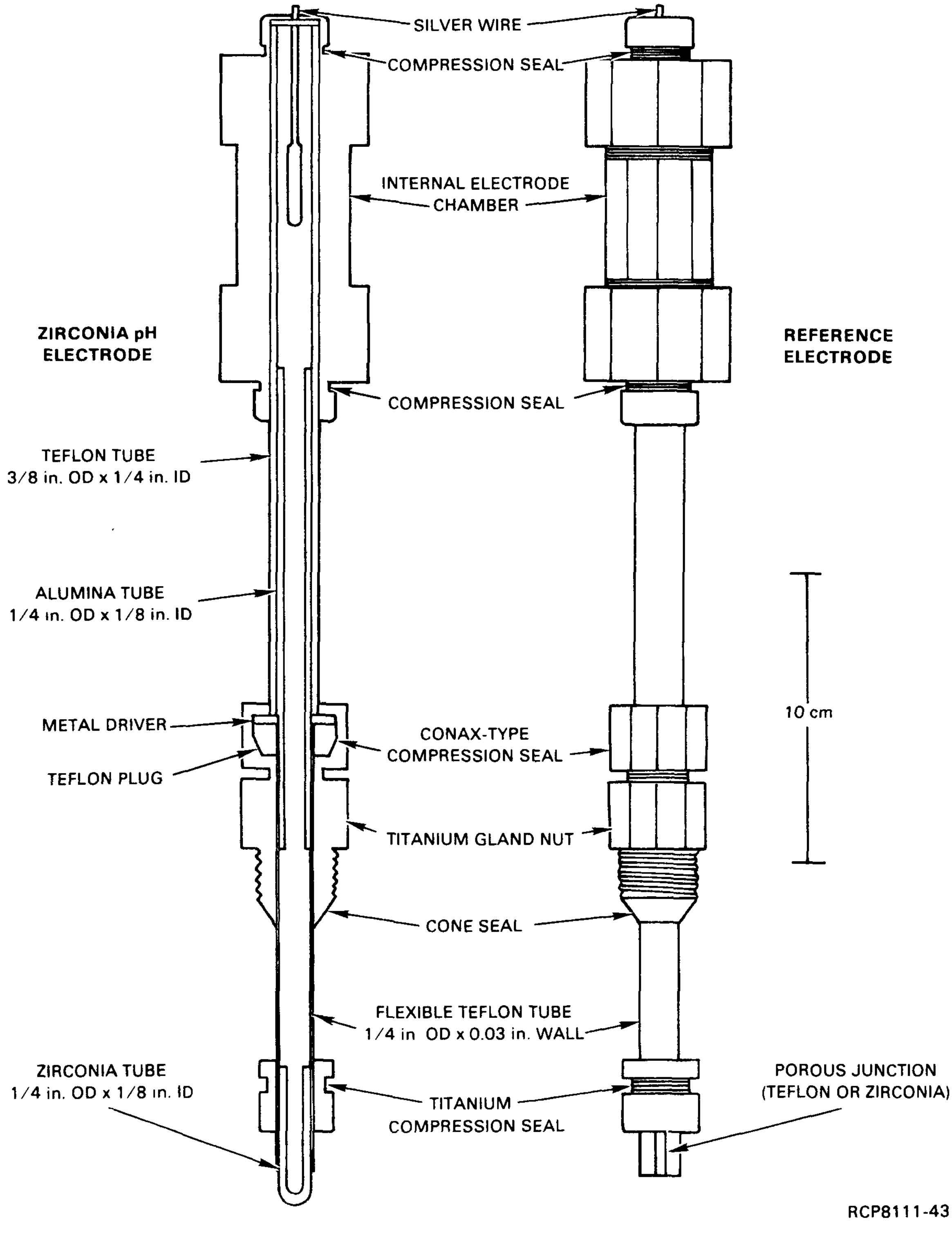


FIGURE 4. Detailed Schematic Diagram Showing Cutaway Section Through Zirconia pH Electrode and Exterior View of Reference Electrode. The two electrodes are identical except for the substitution of a porous salt bridge in the reference electrode for the zirconia tube in the pH electrode.

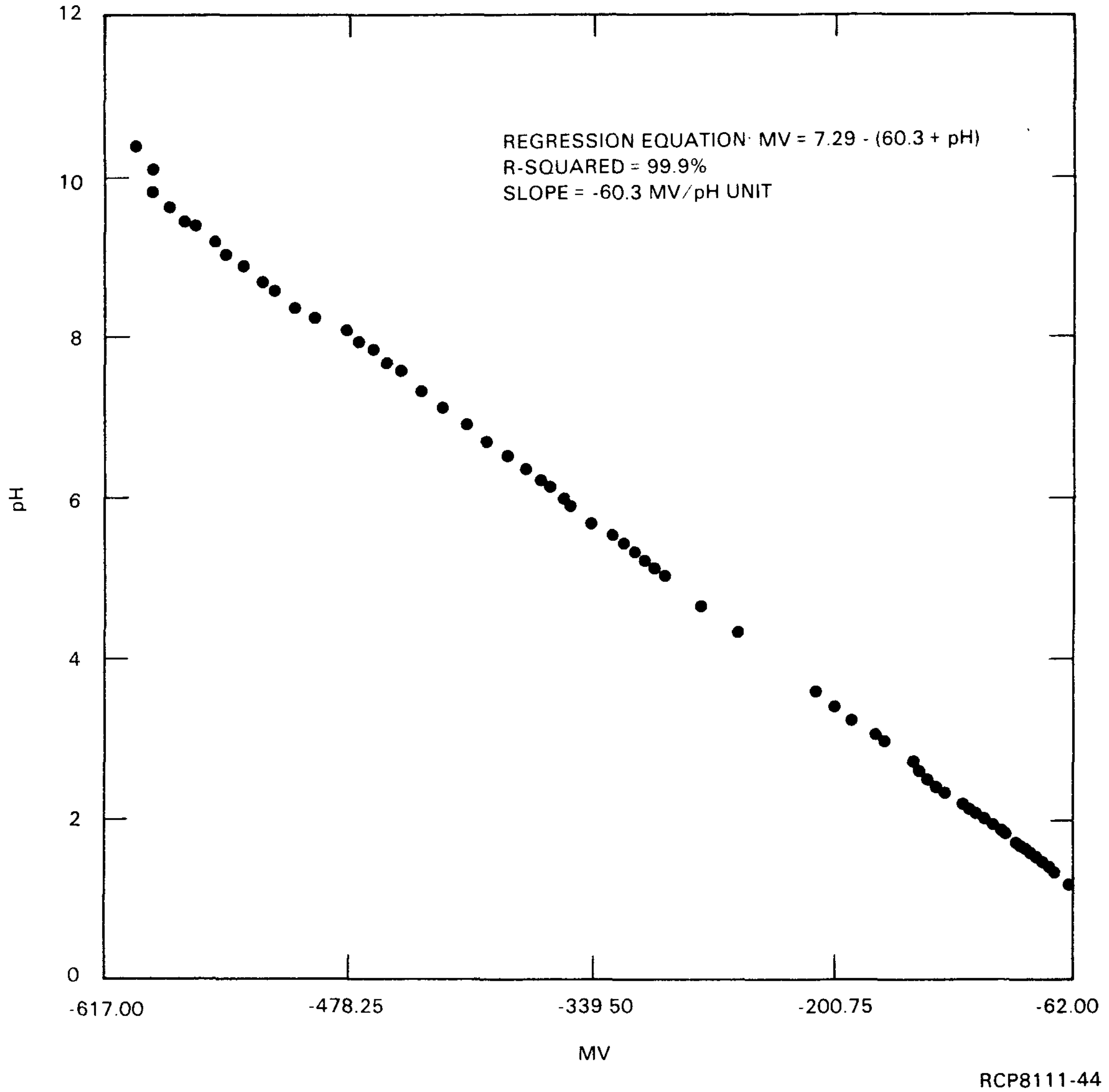


FIGURE 5. Linear Response of Zirconia Electrode in a Single Titration from pH 1.1 to pH 10.5, as Measured by Glass Electrode. Conditions of experiment are: filling solution is pH = 1.0, 2 m KCl, reference electrode is commercial Ag/AgCl type with porous asbestos wick.

Atomics International (AI), Canoga Park, California, has designed, built, and tested a rolling mechanism for aiding remote operation of hydrothermal apparatuses in hot cell facilities. Standardized preparation, loading, operations, and run termination techniques have also been evaluated and documented by AI personnel.

Sorption Chemistry

The objective of the sorption chemistry studies is to obtain distribution coefficients for the key radionuclides under conditions which simulate the groundwater flow path from a repository constructed in basalt to the accessible environment. The distribution coefficient (K_d) is defined as the ratio of the activity sorbed onto the solid phase to the activity in the aqueous phase. These K_ds, along with other relevant chemical and physical data, will be used to evaluate the ability of the geohydrologic system and the candidate engineered barriers materials to prevent the transport of radionuclides to the biosphere.

Radionuclide K_ds between representative Hanford Site geologic materials and simulated Hanford groundwaters have been determined by the Pacific Northwest Laboratory (PNL), Richland, Washington for the BWIP using an equilibrium batch technique as a function of solution composition, solid composition, radionuclide species, pH, temperature, and pressure. The geologic materials included Umtanum, Flow E, and Pomona basalt. The groundwater formulations used in the sorption experiments were presented previously (RHO-BWI-80-100 4Q).

The need for data on radionuclide sorption under the strongly reducing Eh and high pH conditions expected for a repository in basalt prompted the investigation of several Eh-pH control systems. Basalt repository conditions are expected to vary in pH from approximately 6 to 10 and in Eh from approximately -0.4 to +0.5 V. A 0.1$\underline{M}$ hydrazine solution is used to establish a low Eh in the basalt-groundwater system in the sorption experiments. Results of the low Eh sorption (reducing conditions) experiments for neptunium at 23^{o} and 60^{o}C are given in Table 2. Because the repository conditions will be oxidizing during the operating period and immediately after closure, it is also important to investigate radionuclide sorption under oxidizing conditions. Results of the high Eh sorption (oxidizing conditions) experiments for neptunium at 23^{o} and 60^{o}C are given Table 3.

TABLE 2. Neptunium K_d Values for Columbia River Basalts (Reducing Conditions).

Geologic media	Groundwater*	Initial concentration (M)	Temperature (°C)	Equilibrium concentration (M)	Neptunium loading (mol/g)	K_d (mL/g)
Umtanum basalt	GR-1	2.80 E-13	23	7.44 E-15	3.72 E-15	553 ± 216
			60	2.47 E-14	3.55 E-15	150 ± 37
	GR-2	3.91 E-13	23	1.17 E-14	3.79 E-15	352 ± 113
			60	3.81 E-15	3.87 E-15	1,015 ± 164
Flow E basalt	GR-1	3.80 E-13	23	1.28 E-14	3.67 E-15	291 ± 38
			60	2.77 E-14	3.52 E-15	142 ± 57
	GR-2	3.91 E-13	23	1.41 E-14	3.77 E-15	281 ± 79
			60	1.22 E-14	3.79 E-15	426 ± 330
Pomona basalt	GR-1	3.80 E-13	23	1.49 E-14	3.65 E-15	246 ± 15
			60	3.44 E-14	3.45 E-15	100 ± 54
	GR-2	3.91 E-13	23	3.62 E-14	3.55 E-15	105 ± 32
			60	--	--	--

*Composition of groundwaters given in RHO-BWI-80-100 4Q.
NOTE: Errors reported: ±1σ; water to rock ratio: 10 mL to 1 g; contact time: 30 d.

TABLE 3. Neptunium K_d Values for Columbia River Basalts (Oxidizing Conditions).

Geologic media	Groundwater*	Initial concentration (M)	Temperature (°C)	Equilibrium concentration (M)	Neptunium loading (mol/g)	K_d (mL/g)
Umtanum basalt	GR-1	3.99 E-13	23	1.23 E-13	2.96 E-15	24 ± 2
			60	1.65 E-14	3.82 E-15	232 ± 13
	GR-2	4.19 E-13	23	2.19 E-13	1.99 E-15	9 ± 1
			60	8.37 E-14	3.35 E-15	<12 ± 11
Flow E basalt	GR-1	3.99 E-13	23	2.32 E-13	1.87 E-15	8 ± 2
			60	5.34 E-14	3.45 E-15	66 ± 13
	GR-2	4.19 E-13	23	3.67 E-13	5.13 E-16	1 ± 0.3
			60	2.41 E-13	1.77 E-15	7 ± 1
Pomona basalt	GR-1	3.99 E-13	23	1.31 E-13	2.88 E-15	22 ± 3
			60	3.99 E-14	3.59 E-15	117 ± 67
	GR-2	4.19 E-13	23	3.23 E-13	9.60 E-16	3 ± 0.3
			60	1.79 E-13	2.40 E-15	14 ± 3

*Composition of groundwater given in RHO-BWI-80-100 4Q.
NOTE: Errors reported: ±1σ; water to rock ratio: 10 mL to 1 g; contact time: 30 d.

Neptunium K_d values for basalt increase by up to two orders of magnitude under the reducing conditions established by the presence of 0.1M hydrazine in the groundwater. Hydrazine should reduce neptunium (V), the predominant oxidation state in oxidizing environments, to neptunium (IV). Under oxidizing conditions, neptunium is fairly soluble (~1 E-05M) and dominant solution specie at pH 10 are probably $NpO_2HCO_3^0$, NpO_2OH^{0-}, and $NpO_2OH_2^-$. These neutral/anionic species are poorly sorbed by the basalt. However, under reducing conditions, neptunium (IV) is dominant and its solubility is very low (at repository conditions, 1 E-18 to 1 E-20M). The estimated solubility of NpO_2 is ~1 E-12 to 1 E-14M for the measured experimental Eh and pH conditions (0.0V and 10, respectively; the reason for the unusually high Eh value for the hydrazine-groundwater system is not known at this time). The initial concentration of neptunium was 3.9 E-13M, near the upper estimate of the neptunium solubility and the equilibrium neptunium concentration was 3.8 E-15M, near the lower neptunium solubility estimate. Therefore, until a more precise value for the neptunium solubility is obtained, precipitation of neptunium as NpO_2 is possible under the experimental conditions. The dominant neptunium solution species under alkaline reducing conditions is not known at this time. Possibilities are $Np(OH)_4^0$, $Np(OH)_5^-$, or $NpCO_3^{2+}$ (by analogy to uranium (IV)) and plutonium (IV). Unless the possible cationic carbonate species or some other cationic neptunium (V) species predominates in the groundwater, it is not expected that neptunium (IV) sorption (reducing conditions) will be significantly different from neptunium (V) sorption (oxidizing conditions) on basalt. Solubility should be the dominant control on neptunium concentration and, therefore, the potential mobility of neptunium in the basalt geohydrologic system.

The presence of complexing ligands ($CO_3^=$, HCO_3^-, $PO_4^{\equiv}$, $SO_4^=$, F^-, etc.) and the pH of the groundwater can significantly affect the sorption behavior of radionuclides by controlling the dominant solution species present in the groundwater. Temperature also can affect the speciation and solubility of radionuclides in the groundwater. The effect of two groundwater compositions (GR-1, pH 8; GR-2, pH 10) at two temperatures (23° and 60°C) on radionuclide sorption under reducing and oxidizing conditions is shown in Tables 2 and 3. Neptunium sorption generally appears to increase with increasing temperature, possibly reflecting a change to a more easily sorbed species and/or an increase in the sorption reaction rate. Increasing pH and ionic strength appear to decrease the sorption of neptunium under oxidizing conditions, again probably reflecting a shift in the neptunium speciation to a less-easily sorbed species. Further information is needed on neptunium speciation in basalt groundwaters before the effects of temperature, pH, and complexing ligands on neptunium sorption on basalt can be adequately evaluated.

Radionuclide K_d values have been shown to be sensitive to changes in the initial concentration of radionuclides present. The concentrations of the radionuclides in groundwater can be expected to vary with time because of changes in the thermal and physiochemical conditions in and near the repository.

Sorption isotherms describe dependence of radionuclide sorption on the radionuclide concentration. Neptunium sorption, over the concentration range investigated, can be described by the Freundlich isotherm equation:

$$S = KC^N$$

where

S = amount of solute sorbed by the basalt

K = "affinity" constant

C = equilibrium solute concentration

N = constant related to energy of sorption.

The Freundlich isotherm is followed under both reducing and oxidizing conditions. Figure 6 shows the Freundlich isotherm and gives the linearized Freundlich equation describing neptunium sorption onto Umtanum basalt. These isotherm equations are used in calculating radionuclide retardation factors, a term used in modeling radionuclide transport.

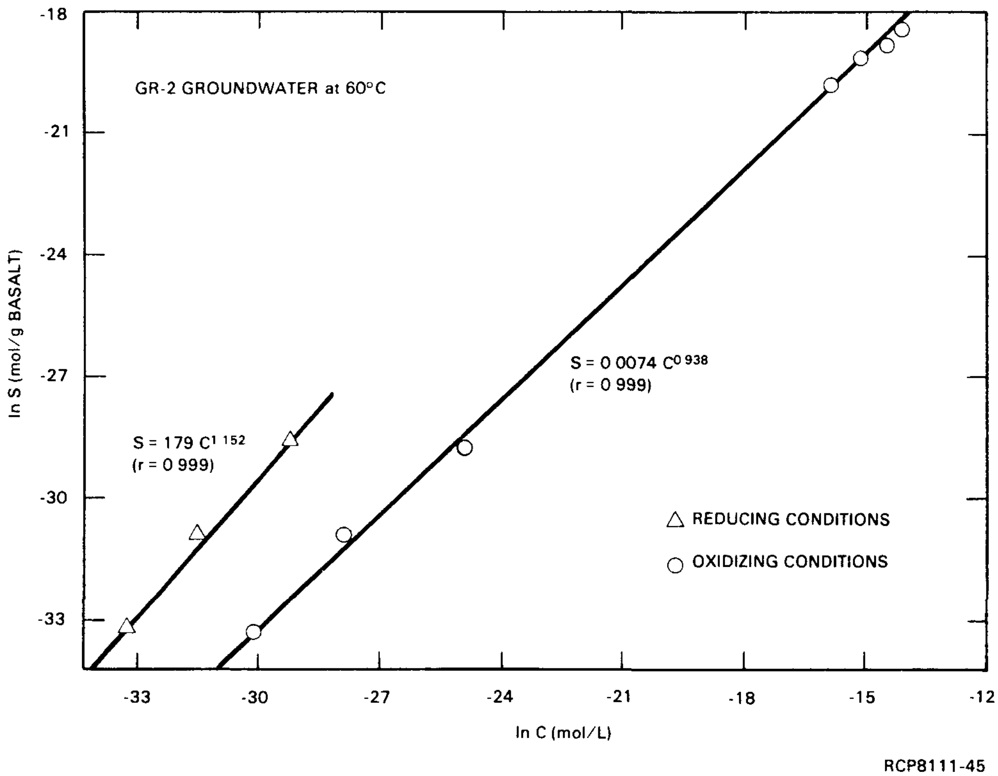


FIGURE 6. Freundlich Isotherm, Neptunium Sorption on Umtanum Basalt.

Backfill/Buffer Materials

The objective of the backfill/buffer studies is to determine the suitability of various materials for use in a waste package backfill/buffer component. One function of the backfill component is to retard the transport of key (hazardous) radionuclides through the backfill to the host environment. In order to predict radionuclide rates of transport through the backfill, experiments are being conducted to determine the sorptive capacity of potential backfill materials for important radionuclides.

Radionuclide K_ds were determined between sodium bentonite and simulated Hanford groundwater (Grande Ronde groundwater) which represents groundwater found in the near field environment of the proposed repository site. The data have been generated by PNL for the BWIP using an equilibrium batch technique. Experiments were completed to determine the sorption capacity of sodium bentonite for uranium, neptunium, cesium, strontium, iodine, and selenium. All experiments were conducted at 65°C, the ambient temperature at repository depth. Oxic and anoxic conditions were imposed on the experimental system in order to simulate the range of Eh conditions expected to occur in the near-field waste package environment. A 0.1<u>M</u> solution of hydrazine was added to achieve the anoxic state. In order to remove organic components in the bentonite, it was heated to 450°C for 18 hr prior to the experiments.

The experimental results indicated that neither iodine nor selenium, the anionic species, sorbed on to the bentonite. However, measurable K_d's were observed for uranium, neptunium, cesium, and strontium. Sorption data for uranium and neptunium under oxic and anoxic conditions and as a function of time are listed in Table 4. The K_d's versus time relationships are plotted in Figure 7. These data show that uranium and neptunium are sorbed more strongly under anoxic conditions. One explanation for this behavior is that uranium and neptunium are in the reduced +4 oxidation state where solubility limits are low enough to result in precipitation of UO_2 and NpO_2. However, if this is the case, uranium K_d's should be higher. The high neptunium K_d after 144 hr does suggest that precipitation may be occurring. However, steady state has not been achieved and NpO_2 solubilities are not well known.

Uranium, cesium, and strontium isotherms were also completed on the sodium bentonite at 65°C. The results are given in Table 5. The fact that uranium, cesium, and strontium sorption data can fit to a Freundlich equation is illustrated in Figures 8, 9, and 10. This empirical relationship takes the form:

$$S = KC^N$$

which is described in the previous section (Sorption Chemistry). These relationships are useful for calculating retardation factors and modeling radionuclide transport.

TABLE 4. Sorption of Radionuclides as a Function of Time by the 450°C-Treated Sodium Bentonite in Simulated Grande Ronde Groundwater at 65°C.

Radio-nuclide	Contact time (hr)	Initial concentration (M)	Equilibrium concentration (M)	Bentonite loading (mol/g)	K_d (mL/g)
Uranium (oxic)	0.25	3.592 E-07	3.097 E-07	2.187 E-09	17.0 ± 0.2
	0.50	3.592 E-07	2.720 E-07	3.532 E-09	13.0 ± 0.6
	1.0	3.592 E-07	2.192 E-07	5.373 E-09	25.0 ± 1.0
	4.0	3.592 E-07	2.126 E-07	6.377 E-09	30.0 ± 0.5
	24	3.592 E-07	1.398 E-07	7.954 E-09	57.0 ± 0.03
	48	3.592 E-07	1.109 E-07	9.529 E-09	86.0 ± 1.1
	144	3.582 E-07	7.596 E-08	9.027 E-09	119.0 ± 5.7
Uranium (anoxic)	0.25	3.592 E-07	2.484 E-07	4.724 E-09	19.0 ± 0.04
	0.50	3.592 E-07	1.910 E-07	6.812 E-09	36.0 ± 1.1
	1.0	3.592 E-07	1.377 E-07	8.499 E-09	62.0 ± 0.9
	4.0	3.592 E-07	6.154 E-07	5.206 E-08	85.0 ± 2.6
	24	3.592 E-07	7.275 E-08	1.038 E-08	143.0 ± 0.8
	48	3.592 E-07	7.143 E-08	1.104 E-08	155.0 ± 5.8
	144	3.582 E-07	6.141 E-08	9.492 E-09	165.0 ± 3.6
Neptunium (oxic)	0.25	3.787 E-12	2.476 E-12	5.590 E-14	23.0 ± 0.1
	0.50	3.787 E-12	1.807 E-12	8.023 E-14	44.0 ± 0.1
	1.0	3.787 E-12	1.487 E-12	8.827 E-14	59.0 ± 0.7
	4.0	3.787 E-12	1.013 E-12	1.124 E-13	111.0 ± 0.5
	24	3.787 E-12	8.105 E-13	1.079 E-13	133.0 ± 1.6
	48	3.787 E-12	6.248 E-13	1.079 E-13	173.0 ± 13.5
	144	3.876 E-12	5.245 E-13	1.043 E-13	199.0 ± 4.0
Neptunium (anoxic)	0.25	3.787 E-12	1.750 E-12	8.686 E-14	50 ± 0
	0.50	3.787 E-12	1.235 E-12	1.034 E-13	84 ± 6
	1.0	3.787 E-12	1.106 E-12	1.029 E-13	93 ± 4
	4.0	3.787 E-12	5.810 E-13	1.300 E-13	224 ± 1
	24	3.787 E-12	4.399 E-13	1.513 E-13	344 ± 8
	48	3.787 E-12	2.447 E-13	1.208 E-13	494 ± 17
	144	3.786 E-12	1.204 E-13	1.172 E-13	976 ± 66

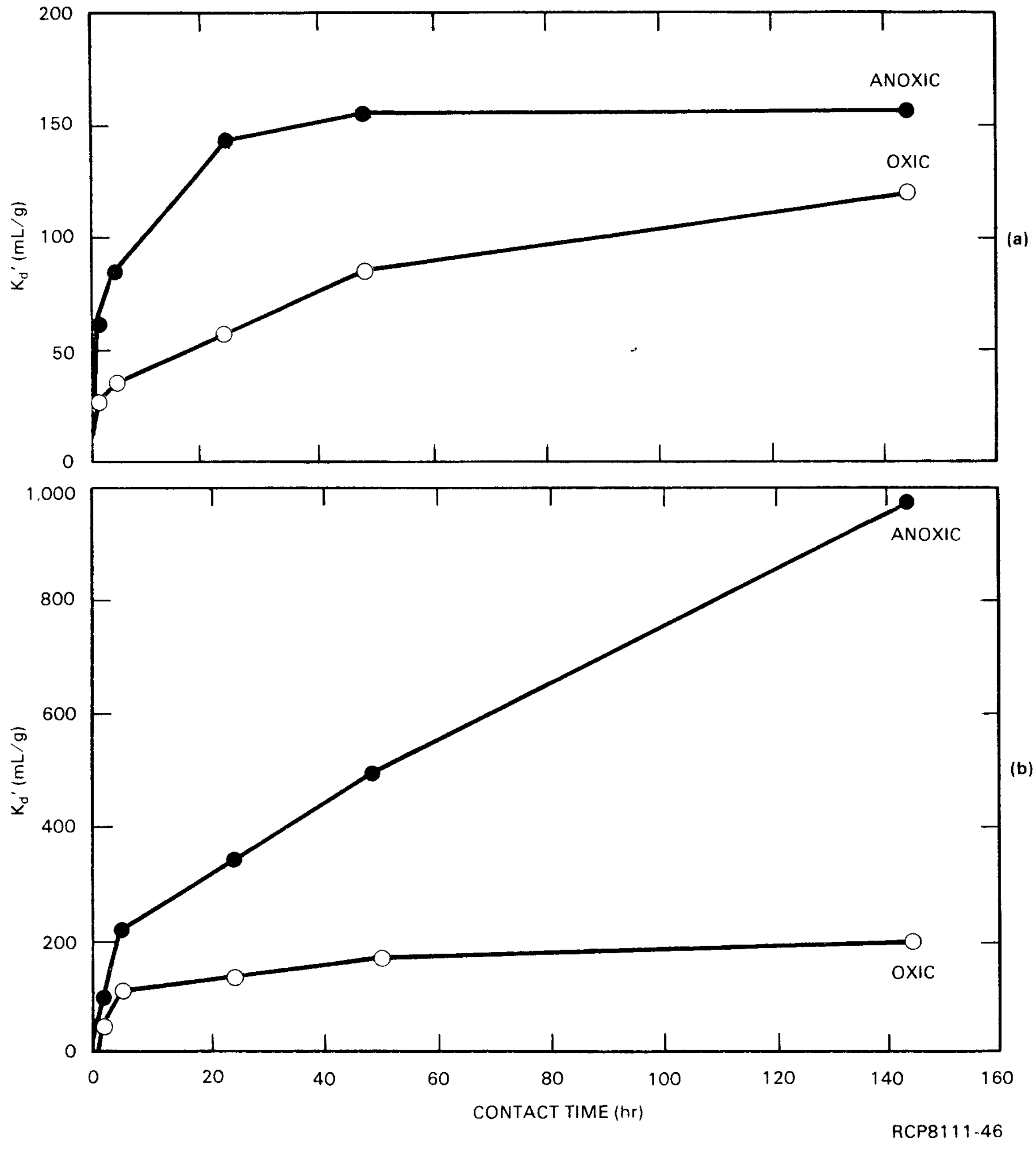


FIGURE 7. Loading of (a) Uranium and (b) Neptunium onto 450°C-Treated Bentonite from Simulated Grande Ronde Groundwater at 65°C.

TABLE 5. Sorption of Radionuclides on 450°C-Treated Sodium Bentonite in Simulated Grande Ronde Groundwater at 65°C.

Radionuclide	Initial concentration (M)	Equilibrium concentration (M)	Bentonite loading (mol/g)	K_d (mL/g)
Uranium* (oxic)	1.006 E-04	4.601 E-05	1.092 E-06	24 ± 3
	1.056 E-05	3.107 E-06	1.491 E-07	48 ± 3
	1.547 E-06	3.553 E-07	2.383 E-08	67 ± 2
	5.409 E-07	1.173 E-07	8.472 E-09	72 ± 3
Uranium* (anoxic)	1.005 E-04	1.644 E-05	1.681 E-06	103 ± 8
	1.055 E-05	1.417 E-06	1.827 E-07	129 ± 6
	1.544 E-06	1.668 E-07	2.754 E-08	167 ± 20
	5.434 E-07	5.294 E-08	9.809 E-09	186 ± 17
Cesium** (oxic)	1.000 E-04	9.700 E-06	1.806 E-06	186 ± 9
	1.000 E-06	8.839 E-08	1.823 E-08	206 ± 5
	1.016 E-08	8.176 E-10	1.868 E-10	229 ± 16
	1.519 E-10	1.109 E-11	2.816 E-12	254 ± 5
Cesium** (anoxic)	1.000 E-04	4.422 E-06	1.912 E-06	423
	1.000 E-06	4.436 E-08	1.911 E-08	431
	1.015 E-08	4.335 E-10	1.943 E-10	448
	1.491 E-10	6.113 E-12	2.860 E-12	468
Strontium** (oxic)	5.000 E-05	1.834 E-06	9.633 E-07	526 ± 22
	5.000 E-07	1.903 E-08	9.619 E-09	508 ± 41
	5.000 E-09	1.970 E-10	9.606 E-11	491 ± 52
	5.011 E-11	1.922 E-12	9.638 E-13	502 ± 14
Strontium** (anoxic)	5.000 E-05	1.351 E-06	9.730 E-07	720
	5.000 E-07	1.283 E-08	9.743 E-09	759
	5.000 E-09	1.363 E-10	9.727 E-11	713
	5.011 E-11	1.391 E-12	9.744 E-13	700

*Solution-clay contact time = 30 d; solution volume to clay weight = 10 mL/1 g.

**Solution-clay contact time = 7 d; solution volume to clay weight = 20 mL/1 g.

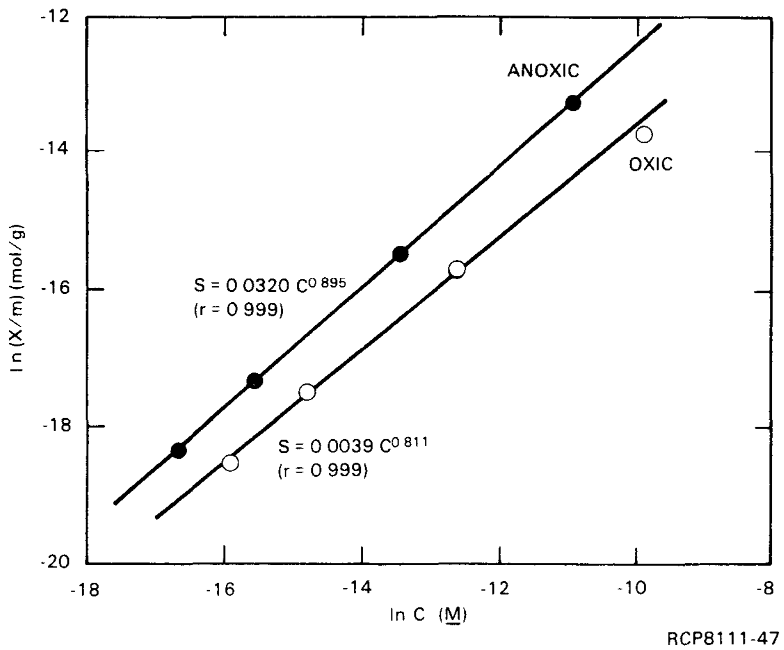


FIGURE 8. Sorption of Uranium by 450°C-Treated Rockwell-Standard Bentonite from Simulated Grande Ronde Groundwater at 65°C. Clay weight to solution volume was 1 g/20 mL.

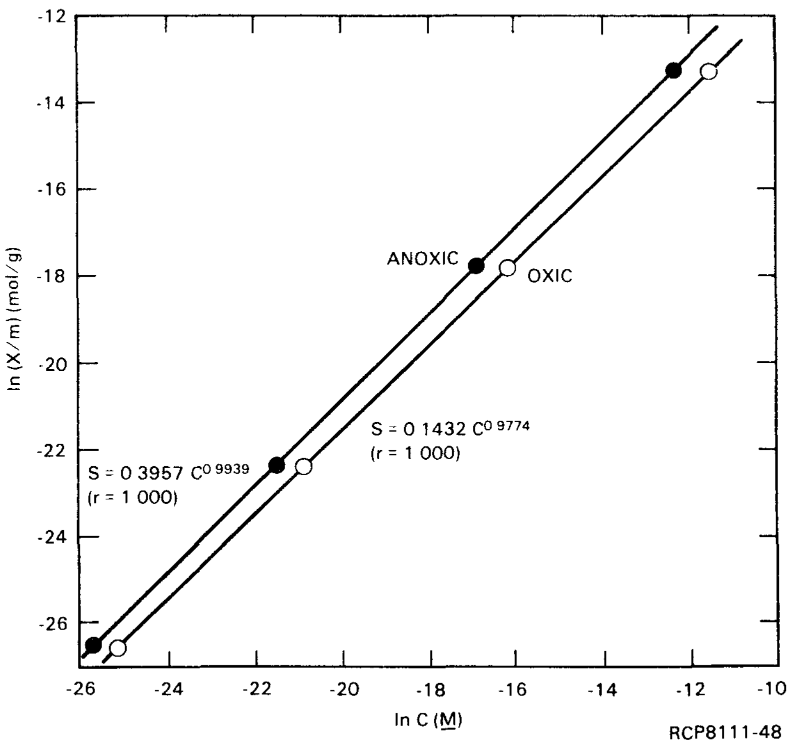


FIGURE 9. Equilibrium Cesium Sorption on 450°C-Treated Rockwell-Standard Bentonite from Oxic and Anoxic Simulated Grande Ronde Groundwater at 65°C.

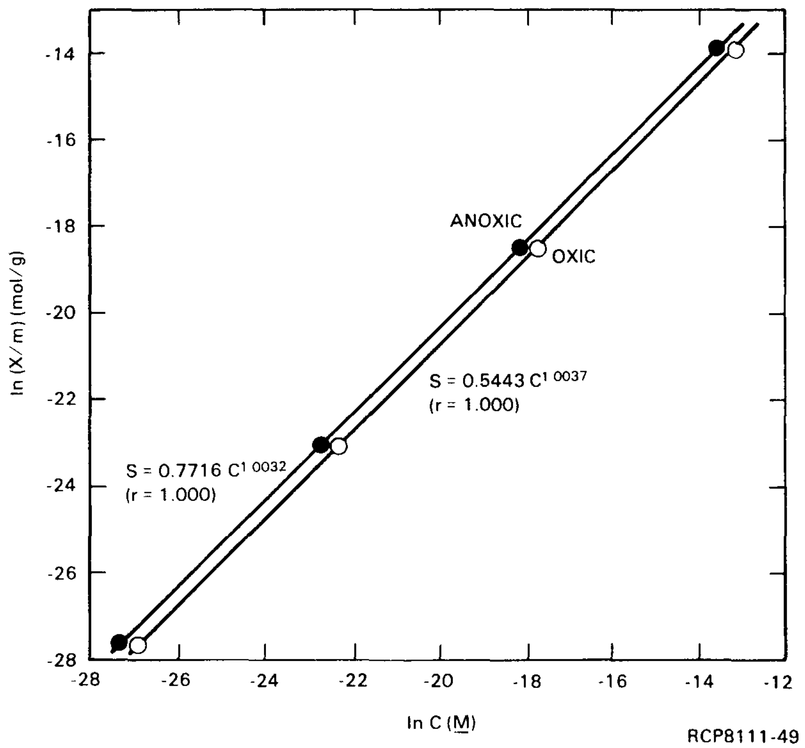


FIGURE 10. Equilibrium Strontium Sorption on 450°C-Treated Rockwell-Standard Bentonite from Oxic and Anoxic Simulated Grande Ronde Groundwater at 65°C.

PERFORMANCE EVALUATION

Near-Field Radionuclide Behavior

Solubilities of nuclides, important input to performance and risk assessment models, are strong functions of temperature, Eh, pH, and water chemistry. It is, therefore, important to determine actinide solubilities for a variety of temperature, pH, and Eh conditions in Grande Ronde groundwater, in addition to determining solubilities under anticipated repository conditions. The distribution of aqueous species for nuclides, both complexed and uncomplexed, is also very important information for geochemical modeling efforts and for interpretation of sorption experimental results. Because experimental determination of solubilities and the aqueous speciation of several nuclides under a variety of conditions is very time consuming, estimates from thermodynamic calculations must be used until such experiments can be completed. In addressing these needs, preliminary results are reported in the following areas:

- Estimating the Eh-pH conditions and buffer controls on the groundwater within the Grande Ronde Basalt

- Developing a computer code to calculate Eh-pH diagrams which include stable solid fields, dominant aqueous species fields, and solubility contours for a variety of radionuclides

- Developing a computer code to calculate the distribution of aqueous species in Grande Ronde groundwater for a variety of radionuclides.

A preliminary analysis of mineral assemblage and water chemistry data from drill holes in the Grande Ronde Basalt suggests that at 338 K (ambient temperature at 1,000 m depth) Eh-pH conditions will be approximately:

$$pH = 9.5 \pm 0.5$$
$$Eh = -0.45 \pm 0.05 \text{ V}$$

The pH value was estimated on the basis of measured data. The Eh values were estimated on the mineral assemblages present in the basalt: (magnetite $\pm$ pyrite, no hematite), CO_2/CH_4 ratios of ~0.2, and no detectable (~1 E-09 mol/L) HS^- present in the groundwater.

It is anticipated that dissolution of glass (i.e., the most reactive phase in the basalt) will actually control solution Eh-pH values at all temperatures. One model for the Eh buffer is the dissolution of iron (II)-bearing glass (expressed as a pyroxene component) to form silica (amorphous) and secondary magnetite. At 338 K, Eh values calculated with this buffer are in close agreement with Eh values indicated by the water chemistry and mineral assemblage data above. In situ measurements of pH and experimental data also indicate that pH is buffered by silicic acid dissociation arising from glass dissolution-controlled buffering, Eh-pH conditions for water in equilibrium with Grande Ronde Basalt can be calculated at elevated temperatures.

A computer code, EHPH, has been developed (though not finalized as yet) which enables the calculation of Eh-pH diagrams for any cationic species of interest at any temperature of interest (providing, of course, the necessary thermodynamic data is available). Output from the program includes diagrams illustrating stable solid and dominant aqueous species fields and activity contours (solubility) for the element of interest.

Preliminary results for uranium from 298 to 523 K are illustrated in Figures 11 through 14. It is interesting to note that as the minimum solubility for uranium shifts to low pH values, repository conditions (indicated by the hatchured rectangle) also shift to low pH values. Thus, the solubility of uranium under repository Eh-pH conditions at temperatures from 298 to 523 K should remain ~1 E-08 mol/L. In addition, the dominant aqueous species for these conditions is $U(OH)_5^-$. These results are supported by measurements of low uranium solubility under reducing conditions. Sorption experiments under reducing conditions suggest low K_d values for uranium--in agreement with the dominant species being anionic $U(OH)_5^-$.

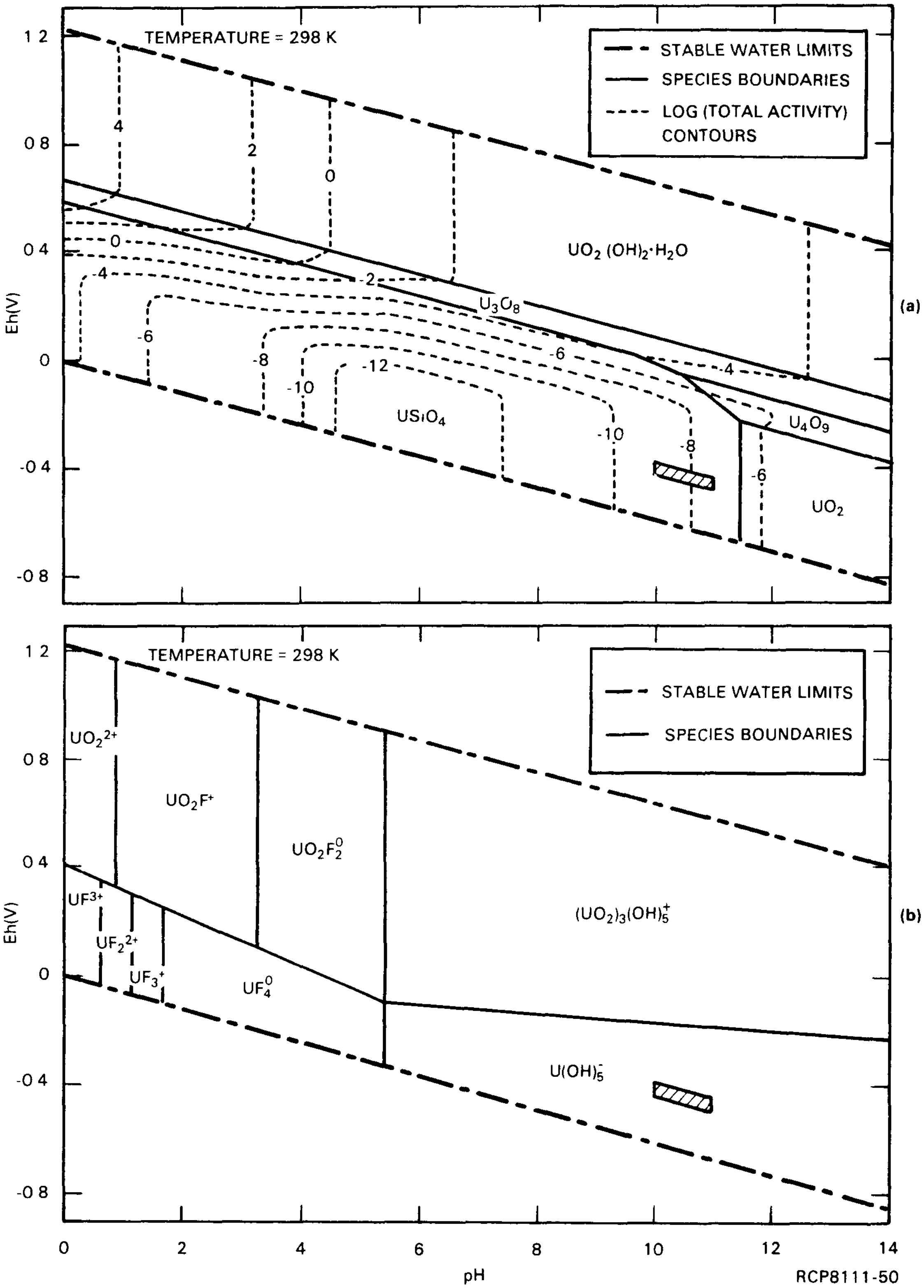


FIGURE 11. Eh-pH Diagrams for Uranium at 298 K for (a) Stable Solid Fields and Solubility Contours and (b) Dominant Aqueous Species Fields. Repository conditions were represented by the hatchured rectangle.

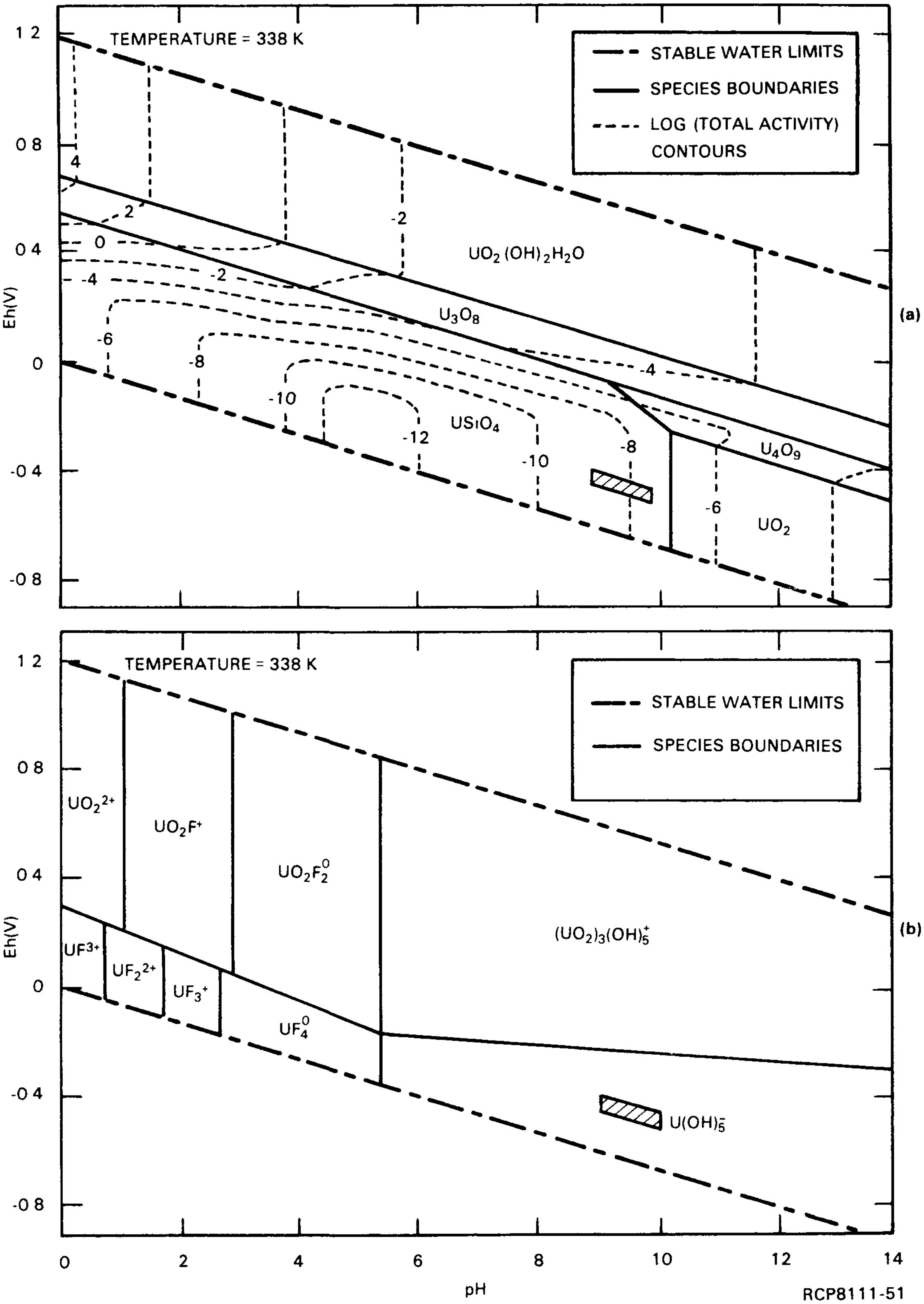


FIGURE 12. Eh-ph Diagrams for Uranium at 338 K for (a) Stable Solid Fields and Solubility Contours and (b) Dominant Aqueous Species Fields. Repository conditions were represented by the hatchured rectangle.

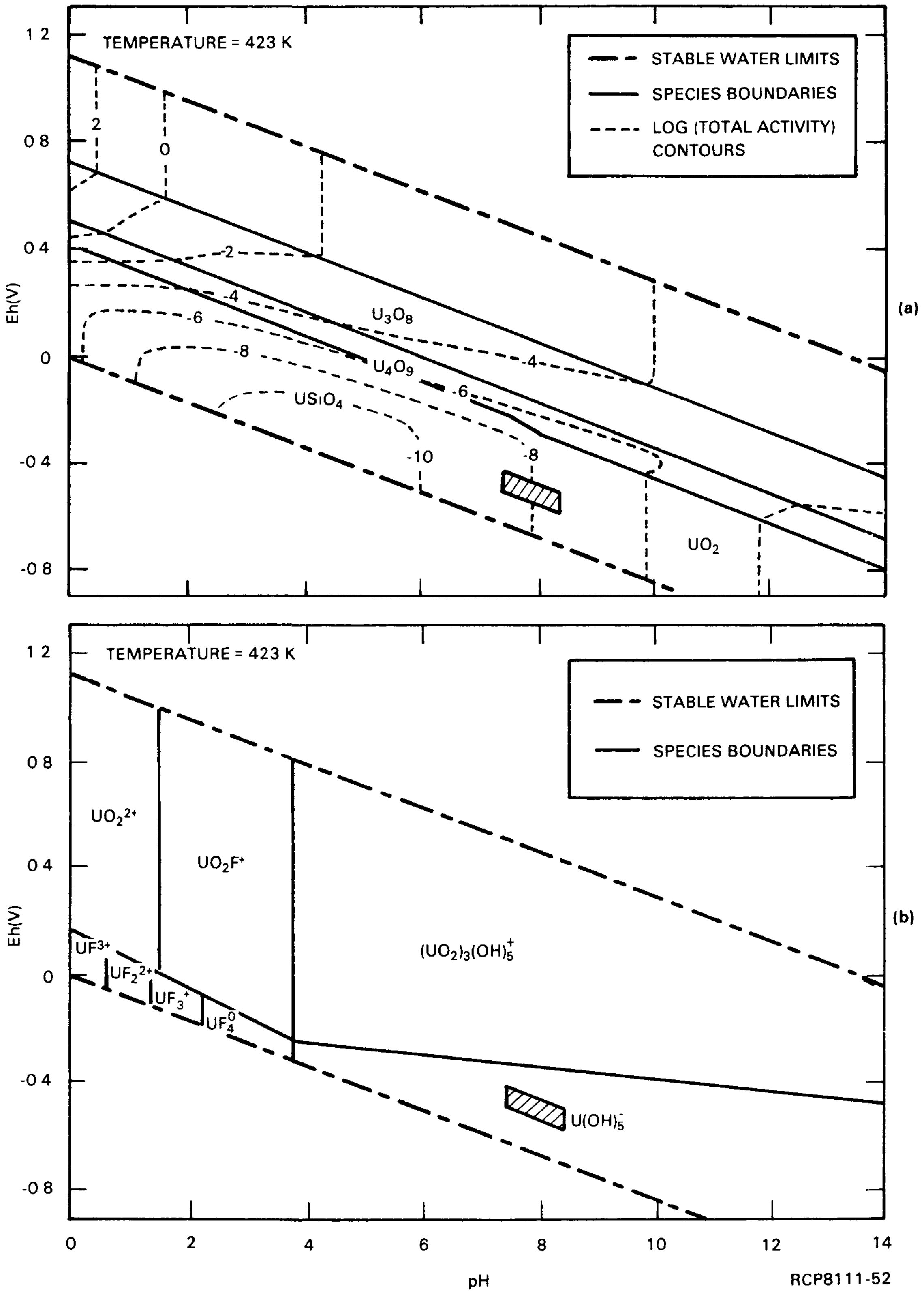


FIGURE 13. Eh-ph Diagrams for Uranium at 423 K for (a) Stable Solid Fields and Solubility Contours and (b) Dominant Aqueous Species Fields. Repository conditions were represented by the hatchured rectangle.

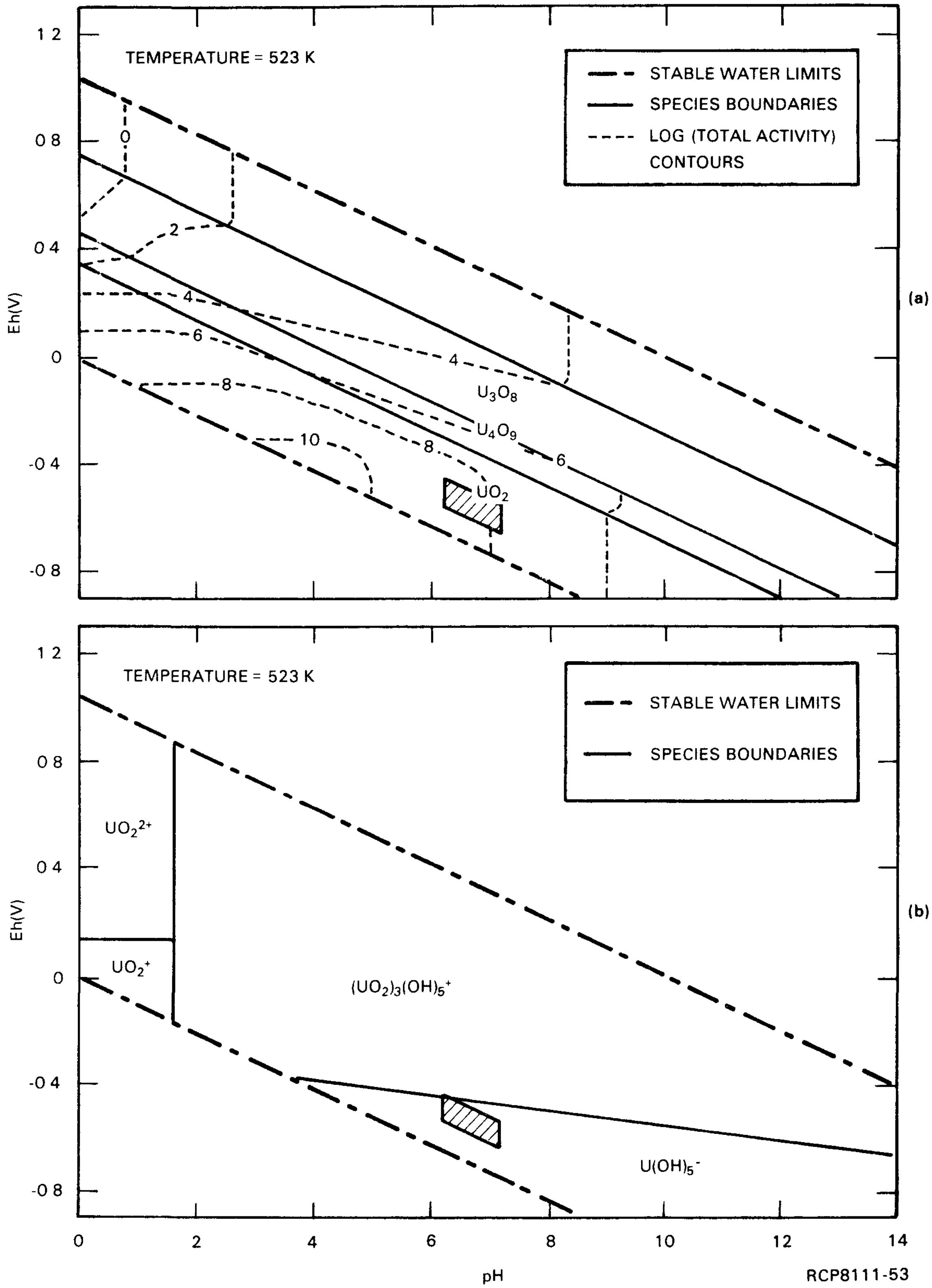


FIGURE 14. Eh-ph Diagrams for Uranium at 523 K for (a) Stable Solid Fields and Solubility Contours and (b) Dominant Aqueous Species Fields. Repository conditions were represented by the hatchured rectangle.

Code development will continue in FY 1982, with particular emphasis on data evaluation, calculations at elevated temperatures, and deriving diagrams for other important radionuclides.

Work was initiated this past summer on developing a computer code to calculate the distribution of aqueous species of nuclides in Hanford groundwater. A preliminary code was completed for calculations with the neptunium-Hanford groundwater system at 298 K. Table 6 lists the results of these calculations for the conditions:

Neptunium = 1 E-20 mol/L, fO_2 = 1 E-60 atm
Temperature = 298 K, activity coefficients (γ) = 1.0.

It is important to note that with the exception of NpO, the other aqueous Np^- species are uncharged and will tend not to be sorbed.

Work will continue in FY 1982 on code development with a contract to Washington State University, Pullman, Washington. In particular, the capability to perform calculations at elevated temperatures will be developed, and the speciation of uranium and plutonium in Grande Ronde groundwater will be calculated.

TABLE 6. Aqueous Np^- Speciation in Grande Ronde Reference Groundwater with 1 E-20M Neptunium Added; fO_2 = 10 E-60 atm, Temperature = 298 K, Activity Coefficients (γ) = 1.0.

Species	Equilibrium concentrations (gmol/kg)	Species	Equilibrium concentrations (gmol/kg)
HCO_3^-	5.521 E-04	MgF^+	8.885 E-08
CO_3^{2-}	2.618 E-04	$Mg_4(OH)_4^{4+}$	8.761 E-25
$SiO(OH)_3^-$	7.390 E-04	$Mg(SiO(OH)_3)_2^0$	2.884 E-09
$SiO(OH)_2^{2-}$	5.938 E-07	$(SiO(OH)_3)_4^{4-}$	9.431 E-10
$(SiO(OH)_3)_2^{2-}$	4.979 E-07	$(SiO(OH)_3)_6^{6-}$	6.484 E-20
$Si(OH)_4$	5.292 E-04	K^+	1.130 E-04
OH^-	1.019 E-04	KSO_4^-	1.328 E-06
H^+	9.885 E-11	$MgHCO_3^+$	3.932 E-09
Ca^{2+}	3.966 E-05	Na^+	1.571 E-02
$CaCO_3^0$	1.467 E-05	$NaSO_4^-$	1.307 E-04
SO_4^{2-}	1.660 E-03	$MgSiO(OH)_3^+$	2.578 E-09
$CaSO_4^0$	1.344 E-05	HF_2^-	1.435 E-12
$CaSiO_2(OH)_2^0$	2.896 E-08	$CaSiO(OH)_3^+$	7.195 E-08
$Ca(SiO(OH)_3)_2^0$	1.681 E-08	$NaOH^0$	1.010 E-06
F^-	1.762 E-03	KOH^0	3.639 E-09
HF^0	2.576 E-10	Cl^-	8.770 E-03
HSO_4^-	1.604 E-11	$MgCl^+$	7.008 E-10
$CaOH^+$	8.060 E-08	Np^{3+}	3.288 E-39
CaF^+	8.797 E-07	Np^{4+}	6.268 E-46
$CaHCO_3^+$	2.189 E-07	NpO_2^+	5.177 E-21
Mg^{2+}	7.991 E-07	NpO_2^{2+}	3.843 E-46
$MgCO_3^0$	1.587 E-07	NpO_2OH^0	4.098 E-21
$MgOH^+$	3.095 E-08	NpO_2Cl^0	2.206 E-23
$MgSO_4^0$	2.253 E-07	$NpO_2HCO_3^0$	7.031 E-22
$MgSiO_2(OH)_2^0$	7.018 E-09	NpO_2^{3+}	3.083 E-59

SITE

The Site program includes the activities required to identify and characterize a suitable site for a repository of nuclear wastes in basalt rock underlying the Hanford Site.

The Site program consists of one function, Site, which consists of seven activities:

- Site Baseline
- Earth Sciences
- Geologic Characterization
- Hydrologic Characterization
- Environmental Characterization
- Socioeconomic Evaluation
- Performance Evaluation.

Efforts during this quarter focused on the Geologic Characterization and Hydrologic Characterization activities.

GEOLOGIC CHARACTERIZATION

The Geologic Characterization activity provides geologic data and interpretations significant to the evaluation of candidate repository sites in the basalt beneath the Hanford Site. Geologic investigations include reconnaissance studies of the Columbia Plateau and detailed studies within the Pasco Basin where the Hanford Site is located (Fig. 15). Previously completed site identification work (see RHO-BWI-80-100 4Q and RHO-BWI-LD-24) resulted in the selection of a reference repository location (RRL) in the Cold Creek syncline (Fig. 16). The Geologic Characterization activity presently includes work to refine interpretations of the geology within the RRL.

The Geologic Characterization activity is subdivided into the following nine subactivities:

- Surface Geology
- Resource Potential
- Volcanic Activity
- Tectonic Setting

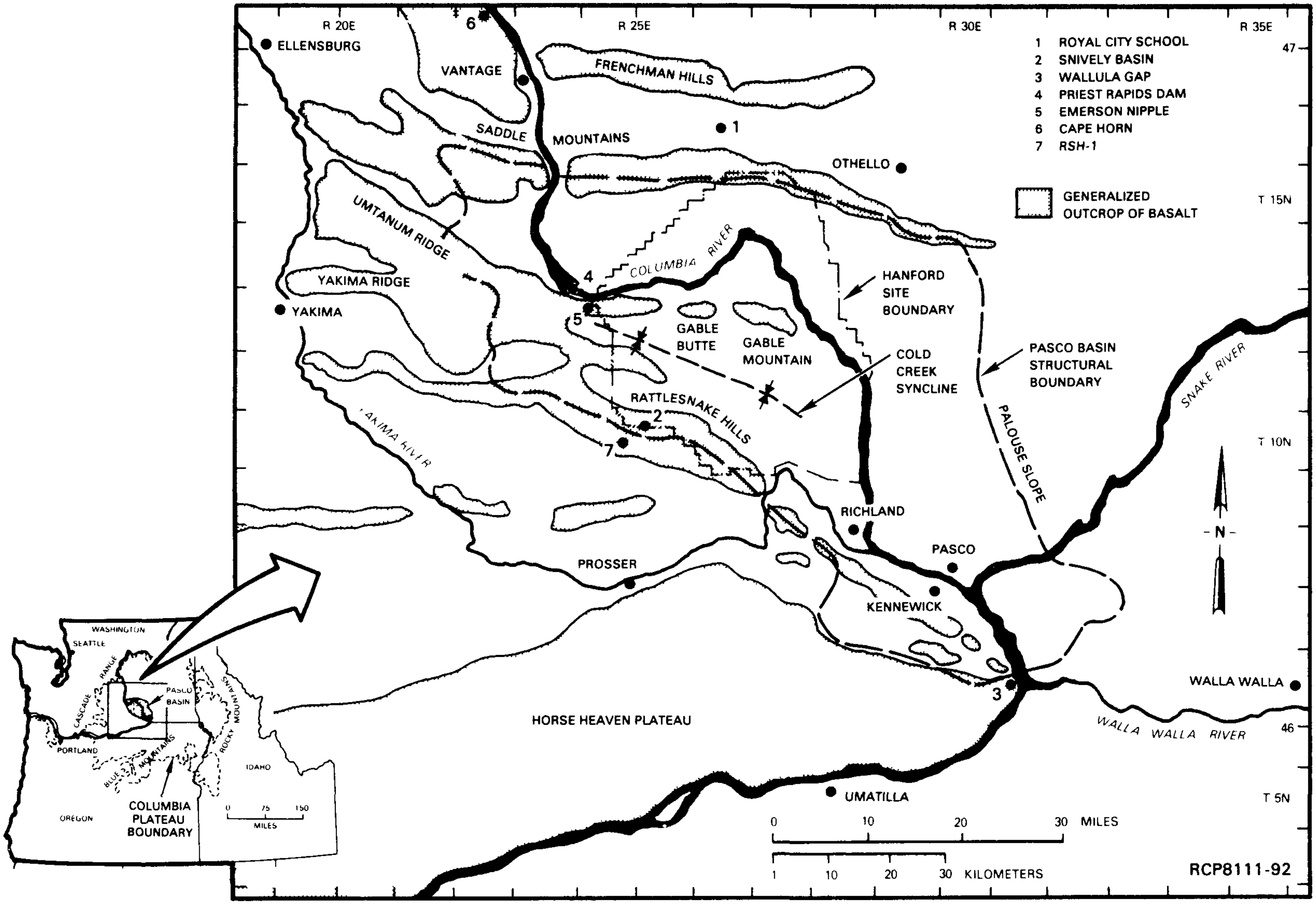


FIGURE 15. Location Map--Columbia Plateau, Pasco Basin, and Hanford Site.

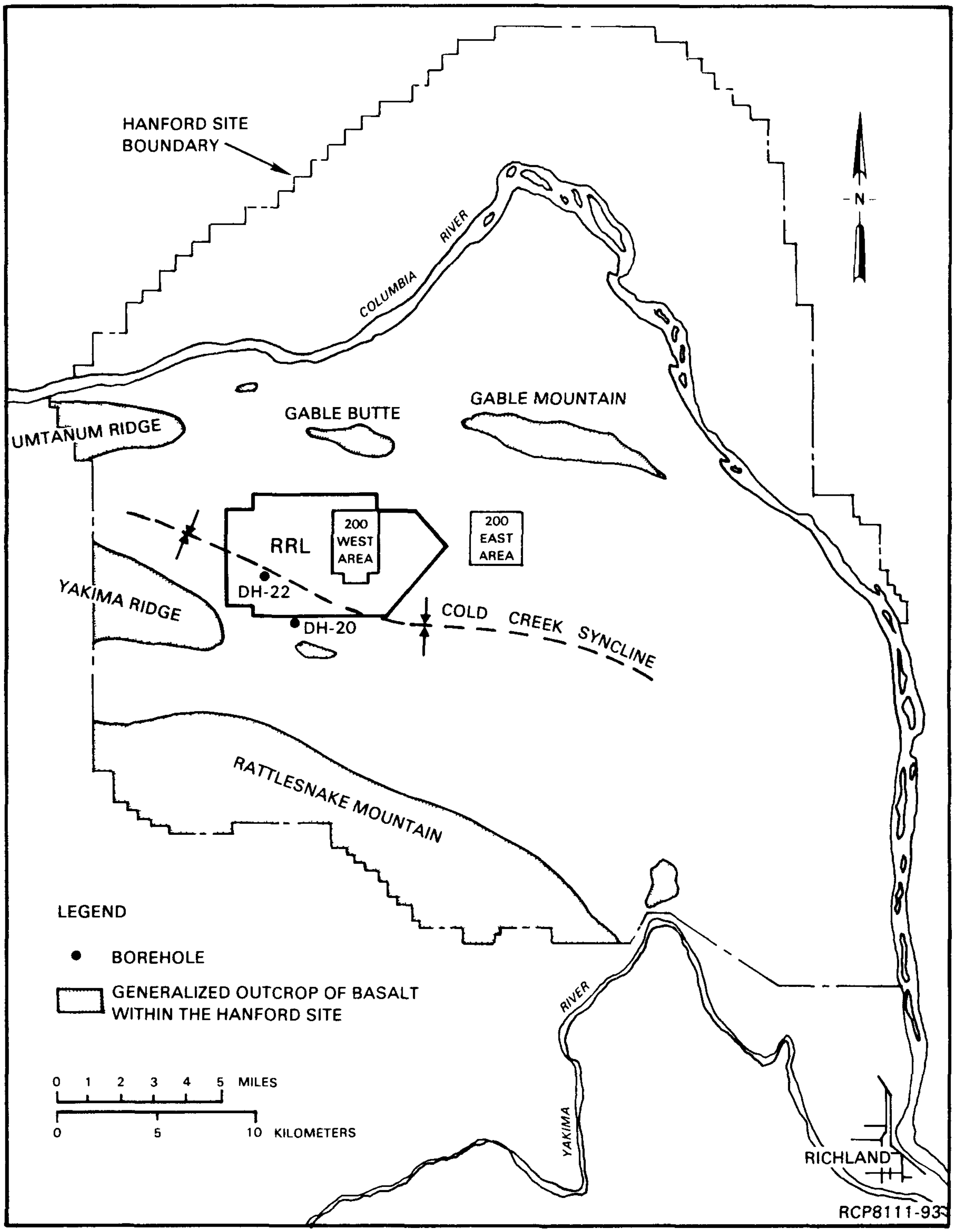


FIGURE 16. Reference Repository Location (RRL) Within the Cold Creek Syncline.

- Structural Geologic Setting
- Host Rock Geometry
- Host Rock Lithology
- Host Rock Stratigraphic Setting
- Integration of Geologic Data

A discussion of work conducted under each of these subactivities during the fourth quarter follows.

Surface Geology

The objective of the Surface Geology subactivity is to: (1) collect and interpret surface geologic data (surface geologic mapping) as needed for input to the Tectonic Setting and Structural Geologic Setting subactivities, (2) determine the net effect of surficial processes at or near the repository site to aid in an assessment of long-term repository stability, and (3) collect and interpret data of the suprabasalt sediments (Miocene to present) of the Cold Creek syncline in order to refine the sedimentary stratigraphy of the area.

Reconnaissance geologic mapping of post-Columbia River Basalt Group sediments and volcanics was completed by the Oregon Department of Geology and Mineral Industries (DOGAMI) (Fig. 17). The final report, "Post-Columbia River Basalt Group Stratigraphy and Map Compilation of the Columbia Plateau, Oregon,"* was submitted along with six Army Map Service (AMS) 1- by 2-degree quadrangle geologic maps. This work is based on field studies, compilation of previous geologic maps, and aerial photo mapping.

Newly defined Neogene deposits in the Oregon map area include the Dalles Group and the Baker, Unity, Ironside, and LeRoux deposits. The Dalles Group includes five formations in five discrete synclinal basins (Fig. 18). These are: (1) the Tygh Valley Formation of the Tygh Valley Basin, (2) the Chenoweth Formation of the Dalles Basin, (3) the Deschutes Formation of the Madras Basin, (4) the Alkali Canyon Formation of the Arlington-Boardman Basin, and (5) the McKay Formation of the Agency Basin.

In the Hanford Site, two Ringold boreholes, DH-20 and DH-22, were completed during this quarter (Fig. 16). Borehole DH-20 hit basalt at 169.47 m (556 ft) and was cored to a total depth of 173.43 m (569 ft); DH-22 hit basalt at 205.74 m (675 ft) and was cored to a total depth of 209.70 m (688 ft). Samples were collected from the sand and finer facies of both cores for paleomagnetic analyses; DH-20 and DH-22 are the first of a series of Ringold core holes to support detailed stratigraphic studies of the Ringold Formation in the RRL (Fig. 16).

---

*Oregon Department of Geology and Mineral Industries, 1981, Oregon DOGAMI Open-File Report O-81-10, Portland, Oregon.

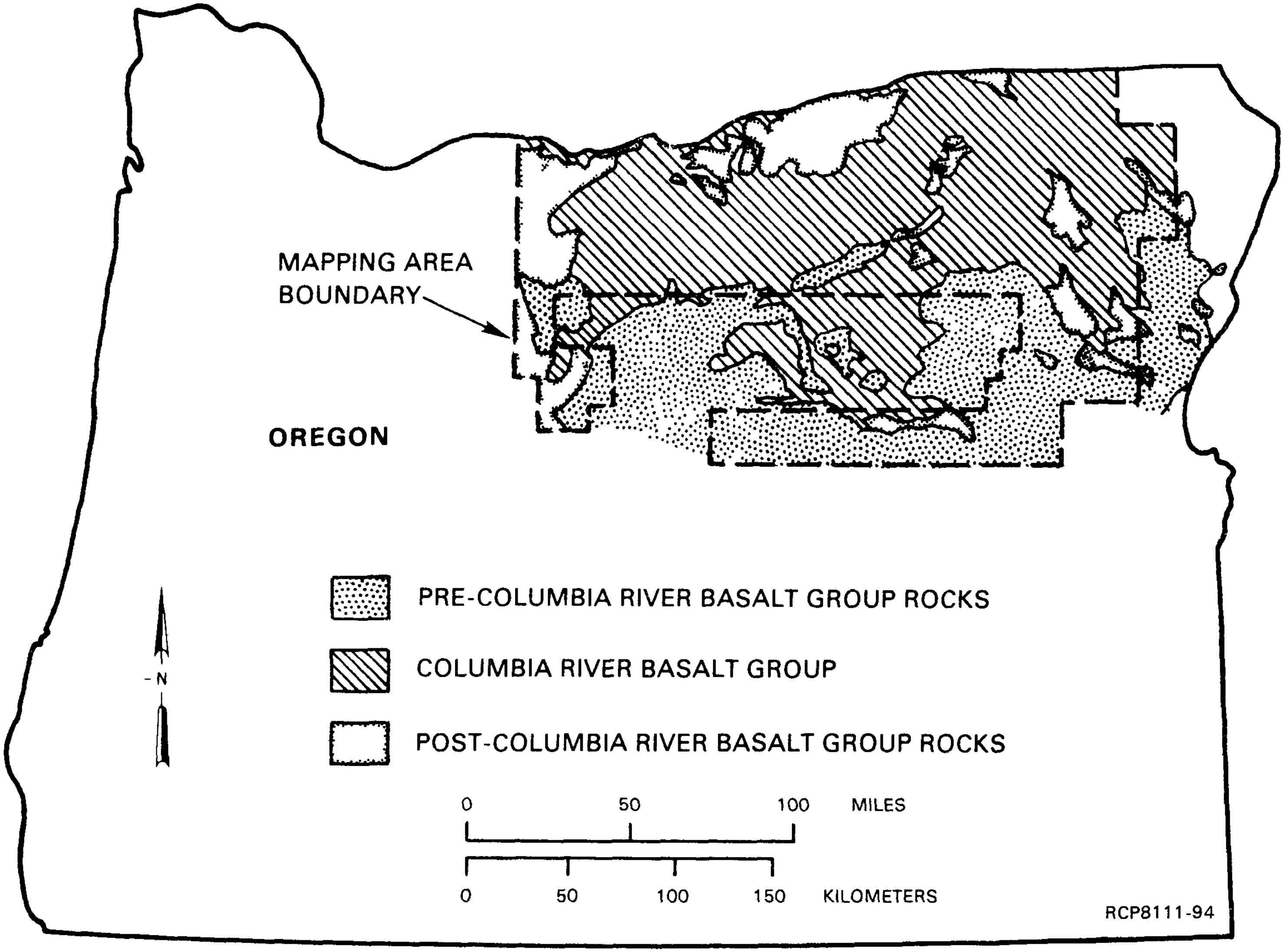


FIGURE 17. Map Area--Oregon Department of Geology and Mineral Industries.

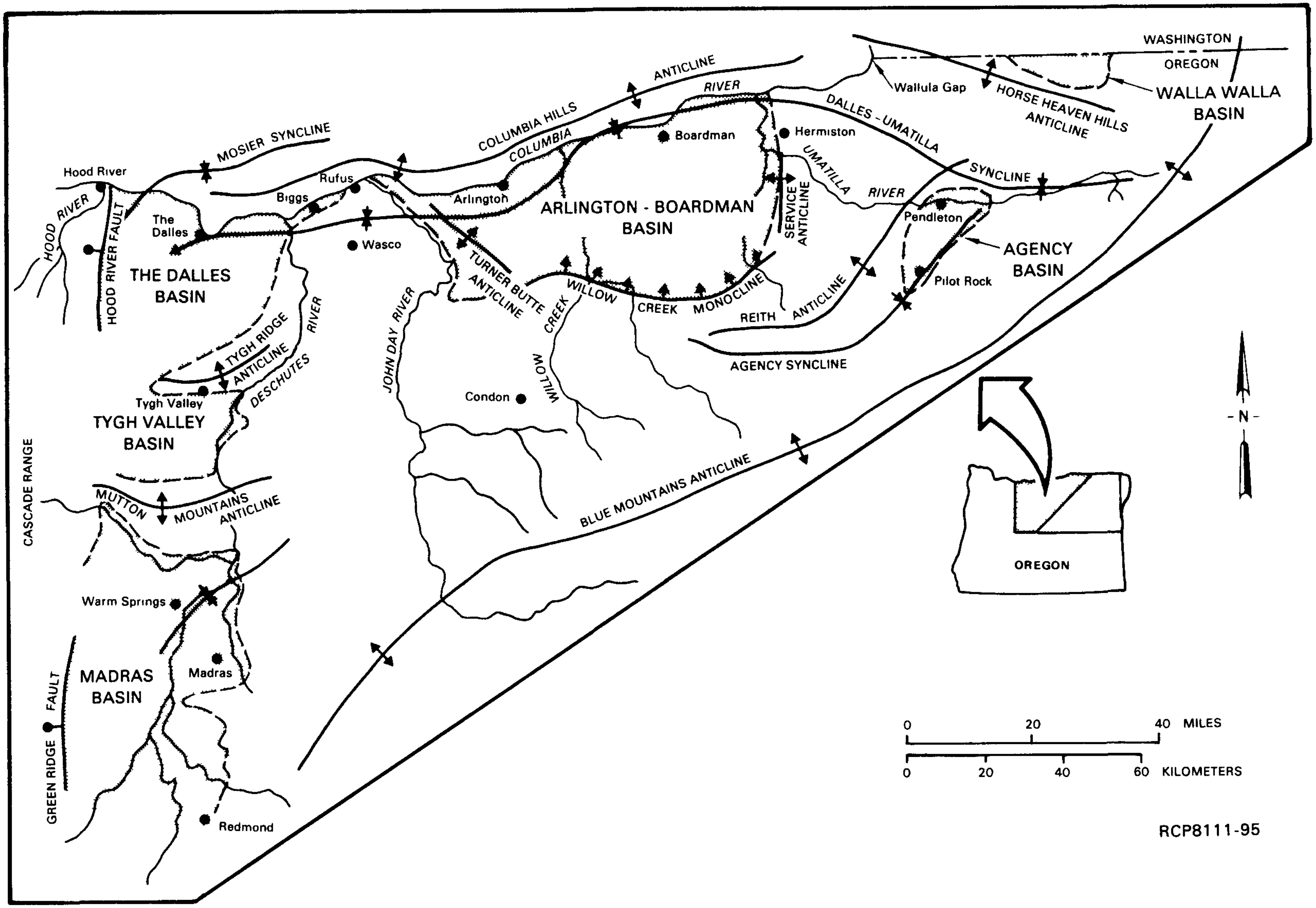


FIGURE 18. Location Map--The Dalles Group Basins.

Resource Potential

The objective of the Geologic Resource Potential Assessment subactivity is to evaluate potential risk for disruption of a high-level nuclear waste repository in the Hanford Site resulting from future resource exploration and development. Such assessment includes: (1) inventory of conventional or in situ mining or drilling for geologic resources in the potential site area, (2) geologic evaluation of resource occurrence potential, (3) economic valuation of resources in the candidate site area and in the remainder of the Columbia Plateau, and (4) comparison of the relative attractiveness to human incursion of the potential site with the remainder of the Columbia Plateau, as a result of the presence of geologic resources.

During this quarter, economic evaluation of geologic resources within the Columbia River Basalt Group and overlying or interbedded sediments in the candidate site area and the remainder of the Columbia Plateau was completed by economists George Leaming and Associates, Marana, Arizona, under subcontract to Rockwell.

The economic evaluation of resources was made in terms of gross value (market price times total quantity available at that price), net value (gross value minus cost of exploration, development, production and wholesale marketing), and present net value (net value at the beginning of a series of periodic payments). Comparisons of the relative economic contribution of mining and minerals processing in the candidate site area with the remainder of the Columbia Plateau study area were made in terms of projected net values (25-yr basis) and personal income (per capita and per km^2/yr basis), employment, and tax revenues derived from such activities.

Results of the economic analysis are given in Table 7. It is concluded that the mineral industry within 100 km of, and including, the potential site is a relatively insignificant component of employment, personal income, and governmental revenue derived from all economic sources, and it is likely to remain so. Geologic assessment of the site area and vicinity suggests that the area is relatively unattractive for future subsurface mineral exploration and development in conflict with a potential high-level nuclear waste repository. Resource potential of subbasalt lithologies cannot currently be assessed, due to the absence of available information.

Volcanic Activity

One objective of this subactivity is to determine probability of occurrence of future igneous events and events consequent from such igneous activity, which may affect proposed high-level nuclear waste repository facilities within the Hanford Site. A second objective is to gather geothermal gradient and heat flow data. These data are necessary to assess whether anomalous heat flow is present within the proposed site

TABLE 7. Economic Comparisons of Geologic Resource Values--the Candidate Site Area Versus the Remainder of the Columbia Plateau.

Variable factor	Candidate Site Area[a]	Remainder of Columbia Plateau[b]
Area (km^2)	58,500	97,830
Population (1980)	533,241	478,793
Total employment (1980)	231,050	189,180
Net resource value ($)[c]	33,300,000	47,000,000
Per square kilometer	569	1,195
Per inhabitant	62	98
Mining personal income ($)[d]	4,479,000	4,945,000
Per square kilometer	77	126
Per inhabitant	8.40	10.33
Jobs in mining (1980)	280	340
Per thousand square kilometer	4.8	8.6
Per thousand inhabitants	0.5	0.7
Government revenues ($)[e]	192,400	77,000
Per square kilometer	3.29	1.96
Per inhabitant	0.36	0.16

[a]Closest approximation of a 100-km radius from the RRL achievable on the basis of county-line boundaries.

[b]Closest approximation of main area of Columbia River Basalt Group outcrop achievable on the basis of county boundaries.

[c]Net resource value is the projected value, in 1980 dollars, of minerals that could be produced from 1981 and 2005. In each of the two areas considered, net values are only for those minerals found within 100 km of the potential site and exclude values for other minerals, even though they may be found and produced elsewhere on the Columbia Plateau.

[d]Mining personal income is personal income derived directly from mining in 1978 as reported by the U.S. Department of Commerce, Bureau of Economic Analysis.

[e]Government revenues are defined as state and local tax revenues contributed by mining enterprises.

area and vicinity, which may adversely affect siting of a repository because of enhanced potential for human incursion due to the presence of geothermal energy resources or low-heat dispersal characteristics of the proposed site.

Ertec Western, Long Beach, California, subcontractor to Rockwell for igneous activity risk probability and geothermal energy resource potential evaluation, completed contractural work during this quarter to refine and revise preliminary event/consequence probability calculations and geothermal energy resource potential evaluation. Revision and refinement of preliminary work was based on additional data acquired by Rockwell and the Washington Department of Natural Resources, Division of Geology and Earth Resources.

Results of the revised probability calculations indicate that the probability of occurrence of events consequent from renewed igneous activity which pose hazards to a repository sited within the Hanford Site are remote. Potential for repository breach as a consequence of renewed igneous activity during the next 1 E+04 yr is calculated by Ertec Western as 5.3 E-04%. Analysis of calculated and observed thermal gradients and heat flow from measurements of groundwater temperatures in confined aquifers in the Pasco Basin suggests no anomalous geologic heat source is present in the Pasco Basin. Potential for occurrence of high- and intermediate temperature geothermal resources within the Pasco Basin is judged to be insignificant because neither localized heat sources, nor high-heat flow, nor favorable geologic setting are present.

Tectonic Setting

The objective of this subactivity is to characterize the tectonic setting of a potential repository site in the Cold Creek syncline area. Studies under the Tectonic Setting subactivity are aimed at defining the past, present, and projected rate (over an anticipated 10,000-yr time frame) of repository host rock deformation by using geologic, geophysical, historical, and instrumental monitoring data. Tectonic Setting subactivity work carried out during the quarter included: (1) seismic monitoring, (2) geodetic surveys, (3) mechanical analysis of Yakima folds, and (4) an analysis of isopach maps of Grande Ronde Basalt units with regards to an assessment of structural development of the central Columbia Plateau during the Miocene.

On September 23, 1981, regional monitoring by the University of Washington, Seattle, Washington recorded a magnitude 2.4 earthquake at a depth of 17 km in the Cold Creek syncline (Fig. 16) (46^{o}31.5' N., 119^{o}39.4' W.). Two smaller events in the same area occurred on July 13 and September 24, 1981 at a depth of 15 km. These events occurred well below the basalt. Overall, eastern Washington seismicity during the quarter has been low level, with two magnitude 2.6 events being the largest earthquakes.

Site-specific monitoring by Rockwell continued using the single component vertical seismometers of the baseline array and the three component portable array. Several stations have been moved and others added to improve the quality of signal or to improve the geometry of the network. Other improvements include installation and implementation of a satellite synchronized clock and time code generator as the primary timing system and installation of filters to improve the radio transmission signals from the portable array. A radio telemetry receiving station will be established at the Royal City School (Fig. 15) to facilitate monitoring areas north of the Saddle Mountains. Sites for boreholes to house the shallow vertical component seismometers for the expanding baseline array have been selected for drilling.

Geodetic surveys were performed in September by Walters Flying Service, Ridgecrest, California, subcontractor to the U.S. Geological Survey, for single-color-laser distance surveying. Funding for the surveys was provided by Rockwell through an interagency agreement between the DOE and the U.S. Geological Survey. A single-color, first-order trilateration laser survey was completed for the 19-station Hanford trilateration network, for two stations newly added to the existing network at the bend in the Horse Heaven Hills structure near Prosser, Washington (Fig. 15), and for eight newly established stations in Snively Basin (Fig. 15) and the RRL.

The surveys conducted during the quarter were performed to establish baseline conditions for long-term monitoring of potential aseismic movement on known geologic structures in the vicinity of the potential site. Newly established stations in the Snively Basin area were emplaced by Rockwell to provide movement data in an area of possible surface rupture of recent age. Planninq progressed during this quarter for the performance of leveling surveys across the RRL and for first-order laser distance surveys of the Wallula fault system from Wallula Gap (Fig. 15) to the Milton-Freewater area (located ~80 km to the southwest), where geodetic monuments were established by Rockwell in the prior fiscal year.

A regional mechanical analysis of the eastern terminations of Yakima folds (i.e., Frenchman Hills, Saddle Mountains, Umtanum Ridge-Gable Mountain, Yakima Ridge, and Rattlesnake Hills) (Fig. 15) was conducted. Individual folds decrease in amplitude and trend more southeasterly as they terminate eastward into the Palouse slope (Fig. 15). This termination style was examined in the Umtanum Ridge-Gable Mountain anticline in particular and compared in general with other folds. The analysis shows that the 1-km horizontal crustal shortening in Umtanum Ridge at Priest Rapids Dam (Fig. 15) dies out eastward into the undeformed Palouse slope with components of dextral shear and rotation between the folds and the Palouse slope. The dextral shear is interpreted to have produced the characteristic en echelon folds of Gable Butte and Gable Mountain (Fig. 15). Such folds are expected only if the basalt is continuous between the Yakima folds and Palouse slope and not disrupted by an, as yet, undiscovered major structure.

Work to develop a detailed flow-by-flow stratigraphy of the upper 500 m of Grande Ronde Basalt in the Pasco Basin (see Host Rock Stratigraphic Setting subactivity) has been used to formulate isopach maps of individual flows or groups of flows and to infer structural development of the central Columbia Plateau (i.e., Pasco Basin). Rates of regional tilting were determined and are on the order of 3 to 4 m/km/million years. This value is the same order of magnitude as the rates of uplift across the Yakima folds during late Wanapum and Saddle Mountains Basalts time. The style of deformation during Grande Ronde Basalt time is uncertain and may be the same as that of the large amplitude folding of Wanapum and Saddle Mountains Basalts time, but because of the rapid rate of eruption of Grande Ronde Basalt, the only deformation which is observed is that of broad southwest regional tilting. The general rate of differential uplift, however, appears to have changed little from Grande Ronde to Saddle Mountains Basalts time.

Structural Geologic Setting

The objective of this subactivity is to characterize the structural setting of the Cold Creek syncline and surrounding area. Work carried out this quarter includes ground geophysical surveys conducted in the area to the west and northwest of the RRL.

A geophysical survey in the Yakima Barricade Study area (Fig. 19) was initiated to locate a suspected structure which could be responsible for a hydrologic barrier located between boreholes DB-11 and DC-4/5. Boreholes west and northwest of DB-11 (Fig. 19), including DB-11, exhibit artisian conditions from the Priest Rapids aquifer, while wells east of DB-11 show appreciably less hydrologic heads from the same horizon. Data from the geophysical survey, consisting of 383 gravity stations, will be used to locate borehole DC-17 for purposes of hydrologic testing.

Approximately 45% of the gravity stations have been occupied, yielding preliminary Bouguer and Residual anomaly maps. These initial results reveal a north-south trending gradient of 1 milligal, spanning ~900 m, with the center of the gradient passing ~0.5 km east of borehole DB-11. The gradient is traceable from ~1.5 km northeast of DB-11 to ~0.5 km southeast of the borehole (Fig. 19). The contact between the upper Priest Rapids flow and the Mabton interbed is ~300 m below ground surface at DB-11. The half width of the gravity gradient is thus sufficient to enable the detection of a source at this depth.

Data collection is continuing to trace this gradiant further and to incorporate other wells and outcrops into the coverage area for control purposes. Geophysical modeling, using present geologic, geophysical, and hydrologic knowledge of the area, is also continuing.

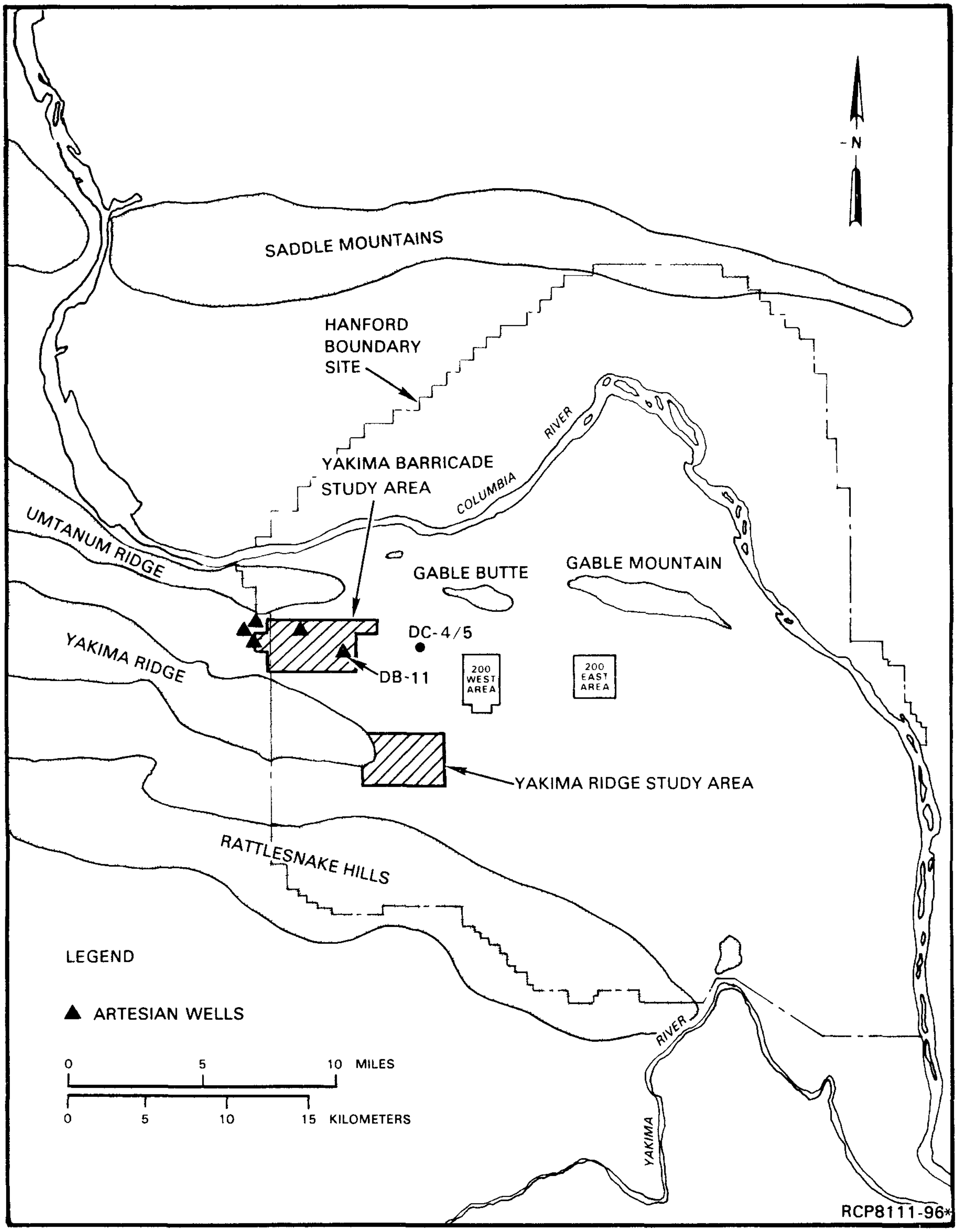


FIGURE 19. Geophysical Study Areas.

The objective of the ongoing Yakima Ridge geophysical survey is to define the structural relationship between the eastern termination of the ridge and the subsurface bedrock high to the east. This buried extension of the ridge is defined by several nearby boreholes and scattered surface outcrops of the Elephant Mountain flow (Tem). The Yakima Ridge structure is considered to either plunge abruptly eastward or to be truncated along a northwest trending fault.

A total of 823 ground magnetic stations were occupied at established surveyed grid points. An additional 357 ground magnetic stations were collected along three traverses oriented perpendicular to anomalous trends revealed by the gridded data. Two-dimensional magnetic modeling of the magnetic data collected along these traverses is in progress. Collection of gravity data across anomalous features revealed by the magnetics is planned.

Contour maps of the gridded magnetic data indicate significant magnetic anomalies related to the eastern termination of the Yakima Ridge and its buried eastern extension. Preliminary analysis of the gridded data suggests that faulting mapped on Yakima Ridge, along the boundary of sections 19 and 20, T12N, R25E, is a local feature which does not continue to the south of the ridge. The gridded data also revealed a complex set of anomalies which transect the survey area along an eastwest trend coincident with the inferred Yakima Ridge extension. This east-west belt of anomalies is complicated by north-south deviations in the field, which may represent structural features cross cutting the buried ridge. In several cases, these north-south trends are seen to continue to the north and south of their intersection with the east-west extension, anomalies. Additional geologic and geophysical data will be required to define potential source geometries for these anomalies.

Host Rock Geometry

The objective of the Host Rock Geometry subactivity is to determine the variations in thickness and attitudes of the interior of the Umtanum flow in the Cold Creek syncline area. This is to ensure that the volume of relatively impermeable rock in the flow is adequate for siting and constructing a repository. During this quarter, revised isopach maps of the flow-top breccia and flow interior were constructed (Fig. 20 and 21). These isopachs are consistent with previous depictions of flow top and flow interior of the Umtanum flow. The isopachs are necessarily generalized, due to borehole spacing, and cannot be used to identify local perturbations in the flow-top, flow-interior contact (see RHO-BWI-81-100 3Q).

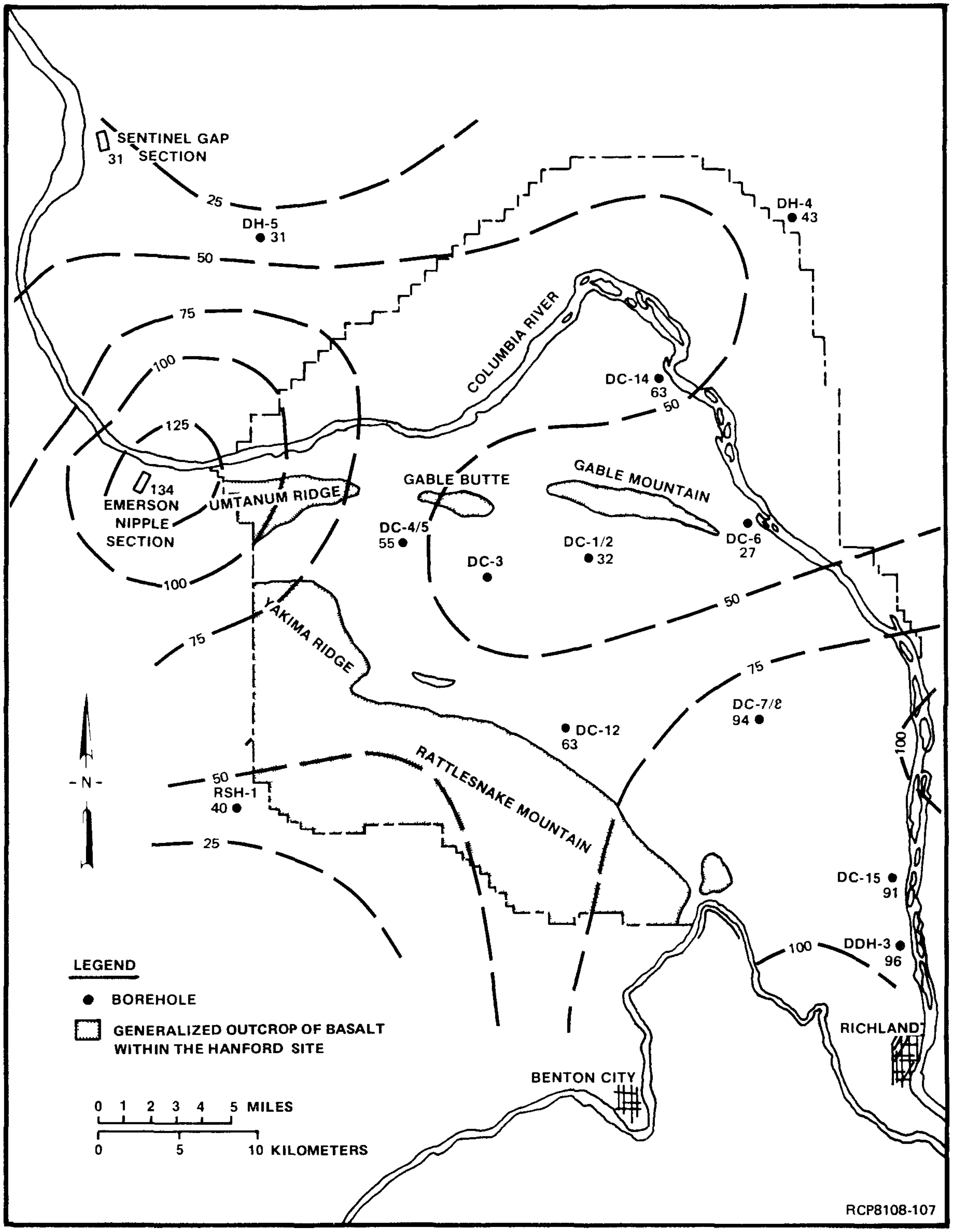


FIGURE 20. Isopach of Umtanum Flow-Top Breccia.

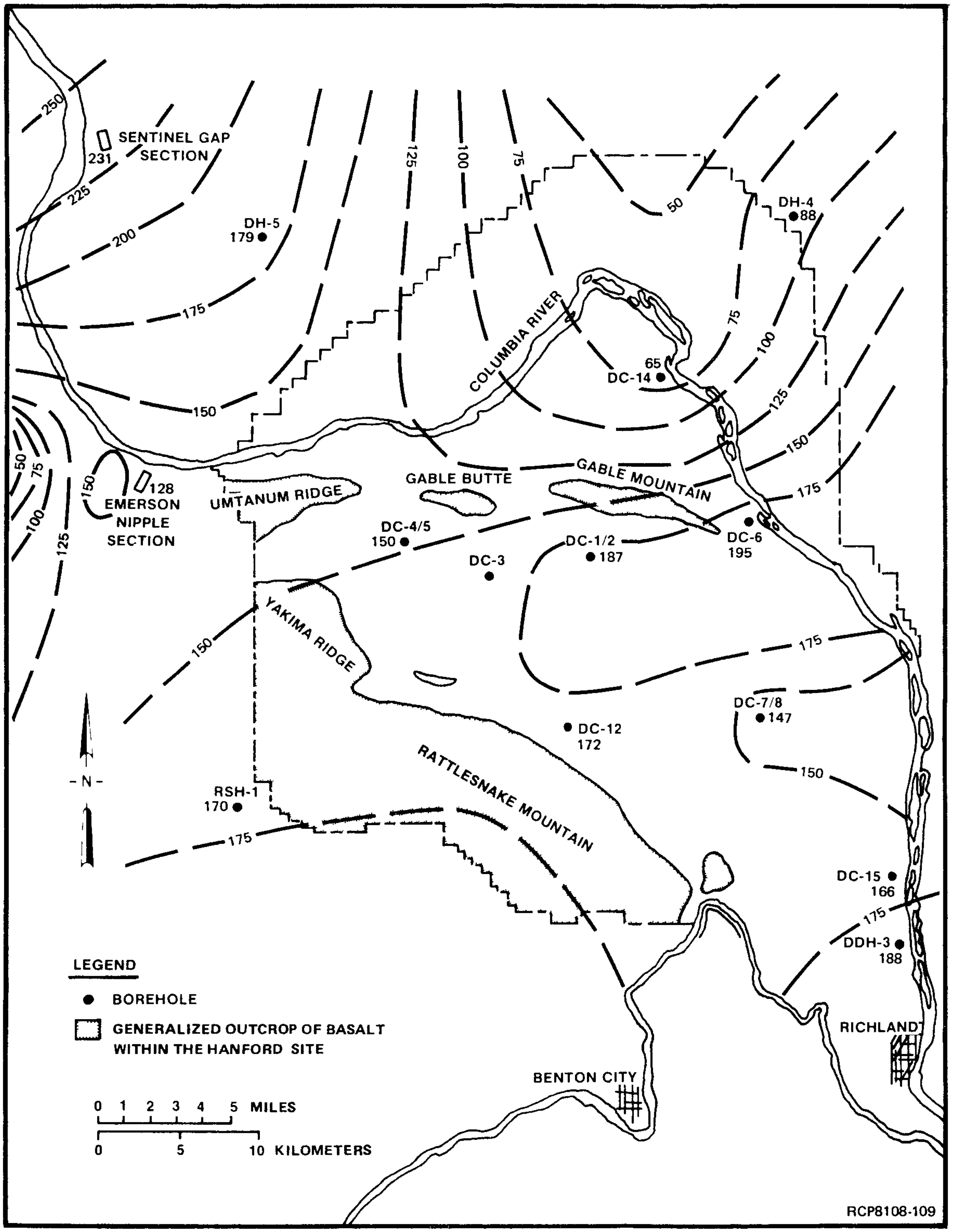


FIGURE 21. Isopach of Umtanum Flow Interior.

Host Rock Lithology

The objective of the Host Rock Lithology subactivity is to characterize Grande Ronde Basalt with emphasis on the Umtanum flow. Characterization includes determining the petrography, phase chemistry, and internal structures (fracture patterns) of these flows. Understanding these features of the host rock is important in assessing isolation of waste from hydrologic flow systems and in predicting long-term behavior of waste-rock interactions.

During this quarter, approximately 500 electron microprobe analyses of pyroxene were completed on samples from the Umtanum flow at Emerson Nipple (Fig. 15). These analyses show that the ratio of pigeonite (low-calcium pyroxene) to augite is highly variable and ranges from 0.2 or less to as high as 0.67. In part, differences are associated with entablature and colonnade, but there are also major differences between samples as little as 5 m apart within the entablature. More study is required to determine the cause of these variations, but correlation between rock textures and pigeonite abundance suggests that the cooling rate of a given part of the flow may play an important role.

Characterization of secondary minerals in the Umtanum and adjacent flows also continued during this quarter. Results obtained to date show that the relative abundances of secondary minerals estimated by Benson and Teague* may require revision. Examination of drill core with identifications of secondary minerals firmly established suggests that silica polymorphs are significantly more abundant than previously thought.

It has also been determined, with a scanning transmission electron microscope, that mordenite, a zeolite which occurs in a fibrous form, consists of hollow fibers with wall thicknesses on the order of 50 Å. In contrast, the tube or fiber diameters are commonly 2,000 Å. Consequently, the surface-to-volume ratio for this mineral is extremely high compared, for instance, to the equant crystals of clinoptilolite. It is tentatively concluded that, in spite of its low abundance and limited occurrence, mordenite may contribute significantly to radionuclide sorption.

Host Rock Stratigraphic Setting

The objective of the Host Rock Stratigraphic Setting subactivity is to determine the stratigraphy of individual flows and sequences of flows above and below the Umtanum flow in the RRL. During this quarter, additional data was obtained on major element, trace element, and magnetostratigraphic correlations of flows. A new Grande Ronde Basalt stratigraphic section was taken at Cape Horn, Washington, west of Crescent Bar (Fig. 15). In this section, three paleomagnetically reversed flows (R_2) underlie a sequence of 12 magnetically normal flows (N_2). The

*Benson, L. V. and L. S. Teague, 1979, A Study of Rock-Water Nuclear Waste Interactions in the Pasco Basin, Washington, LBL-9677, Lawrence Berkeley Laboratory, Berkeley, California.

contact between the N_2 and R_2 flows is well exposed. It is typical contact between basalt flows, marked by a vesicular flow top and minor siliceous material. No evidence for anomalous permeability compared with other flow tops was found.

Rattlesnake Hills #1 (RSH-1), a test well emplaced to determine the oil and gas potential of Rattlesnake Mountain, was drilled to a total depth of 3,247 m in 1957 and 1958 (Fig. 15). The well encountered volcanic rocks throughout its entire depth except for relatively minor interbedded sediments. Previous interpretations (by Raymond and Tillson[a]; Swanson et al.[b]) estimated 1,523 m of Columbia River basalt, the base of which was marked by a thick zone of altered basalt from a depth of 1,504 to 2,053 m. Flows within the altered zone, and those below, were thought to be chemically distinct from and significantly older[c] than Columbia River basalt.

Chip samples from 165 intervals below the Vantage horizon and extending to the total depth of the well have been reanalyzed for major and minor elements by X-ray fluorescence. Strontium-87/strontium-86 analyses have been obtained for four samples. In addition, 20 samples were analyzed for trace elements using instrumental neutron activation techniques. These new analyses show that the flows beneath the Vantage horizon (i.e., Grande Ronde Basalt), including those in the altered zone and below, are indistinguishable from Grande Ronde Basalt.

Lack of repetition of compositional differences within the sequence suggests that the stratigraphic section has not been greatly thickened by faulting. Thickness of flows encountered are typical for the Columbia Plateau making it unlikely that the steeply dipping limb of a fold was drilled.

Magnetotelluric data indicate that the base of the volcanic sequence at RSH-1 lies at a depth of $\sim$4,500 m; the new data suggests that this coincides with the base of the Grande Ronde Basalt. By assuming that the magnetotelluric data accurately reflects the thickness of the Columbia River basalt, Grande Ronde Basalt is calculated to have a total volume of 274,000 km^3 and to comprise 85% by volume of Columbia River basalt. This raises the total estimated volume of the Columbia River Basalt Group to 325,000 km^3 and changes the relative volume percentages of the formations to those listed in Table 8.

---

[a]Raymond, J. R. and D. D. Tillson, 1968, Evaluation of a Thick Basalt Sequence in South-Central Washington, Geophysical and Hydrological Exploration of Rattlesnake Hills Deep Stratigraphic Test Well, BNWL-776, Battelle, Pacific Northwest Laboratories, Richland, Washington.

[b]Swanson, D. D., T. L. Wright, P. R. Hooper, and R. D. Bentley, 1979, "Revisions in Stratigraphic Nomenclature of the Columbia River Basalt Group," U.S. Geological Survey Bulletin 1457-H.

[c]Newman, K. R., 1969, "Pylanology of Interflow Sediments from the Standard Oil Company of California Rattlesnake Hills Number 1 Well, Benton County, Washington," paper presented at the Second Columbia River Basalt Symposium, March 1969, Cheney, Washington.

TABLE 8. Relative Volume Percent of Formations of the Columbia River Basalt Group.

Formation	Volume (km^3)	Relative %
Imnaha Basalt	20,000	6.15
Picture Gorge Basalt	17,500	5.38
Grande Ronde Basalt	275,000	85.00
Wanapum Basalt	10,000	5.00
Saddle Mountains Basalt	2,500	0.80

It is suggested that the great thickness of Grande Ronde Basalt in the Pasco Basin is probably due to crustal extension that resulted in subsidence. The resulting subsidence was slow as evidenced by the subaerial nature of the flows and was accommodated by the great volume of basalt magma.

Integration of Geologic Data

The objective of this subactivity is to integrate the results from the other eight subactivites within the Geologic Characterization activity into the required technical presentations and technical documents, journal manuscripts, and licensing documents.

During this quarter, a report entitled "Subsurface Geology of the Cold Creek Syncline" (RHO-BWI-ST-14) was finalized and prepared for printing. The specific purpose of this report is to review current knowledge of stratigraphic, lithologic, and structural factors that directly relate to the suitability of the Umtanum flow within the Cold Creek syncline for use as a nuclear waste repository host rock. The contents of the report are described in more detail in the previous quarterly report (RHO-BWI-81-100 3Q).

Work toward establishing a Geographic Information System (GIS), under a subcontract with Woodward-Clyde Consultants, San Francisco, California continued. The GIS is a data-base oriented system for storing geologic data in a common file structure and outputting these data in geographic form. Data entered under the FY 1981 subcontract (which also included time-sharing support) included multi-level aeromagnetic information, gravity station readings, geochemical analysis and corresponding locations, and borehole data. Also entered for map annotation and field reference were political, cultural, physical, and cartographic information for the Pasco Basin. The Pasco Basin topography was entered on a 200-m grid using U.S. Geological Survey Digital Elevation Model (DEM) tapes. All data entered is geographically referenced in meters from a universal transverse Mercator projection. Part of the subcontract included training of Rockwell personnel with regards to in-house use of the GIS.

A meeting with staff and consultants of the NRC was held the week of September 21, 1981. Presentations to NRC personnel and their consultants included an overview of geologic investigations and small group presentations and discussion sessions on regional tectonics, geophysical investigations, remote sensing data, and petrology.

During the quarter, work continued on Chapter 3 of the Site Characterization Report (SCR). This chapter is concerned with a geologic description of the candidate area and site (i.e., the Columbia Plateau and RRL, respectively).

HYDROLOGIC CHARACTERIZATION

The Hydrologic Characterization activity provides criteria and evaluation techniques for the hydrologic assessment of the rate and direction of groundwater movement to the biosphere from a potential repository site. Study of the groundwater regime within the Columbia River basalt is important since the groundwater pathway affords the most likely avenue of contact between repository-stored wastes and the biosphere and is the basis for evaluating isolation potential. Hydrologic studies have emphasized the development of a data base to characterize the groundwater system and modeling of the flow system to evaluate the potential for radionuclide transport to the biosphere. The hydrologic studies include reconnaissance regional studies over the Columbia Plateau and intensive local studies within the Pasco Basin where the Hanford Site is located.

The Hydrologic Characterization activity is divided into five subactivities:

- Hydrologic Properties
- Hydrologic Conceptual Model
- Hydrologic Numerical Model
- Groundwater Monitoring
- Integration of Hydrologic Data.

Progress was made in the first four of these subactivities during this quarter.

Hydrologic Properties

During this quarter emphasis was focused on the acquisition of new downhole hydrologic parameters and hydrochemical data for groundwater horizons within new and existing boreholes in the Hanford Site. Electronic malfunctions in some of the leased hydrologic test equipment reduced the number of geologic intervals successfully tested during this quarter.

Stratigraphic intervals and transmissivity values determined during this quarter for selected interbed and flow tops are listed in Table 9. Nine geologic intervals were hydrologically tested in boreholes under construction during FY 1981, i.e., BH-17, DB-14, DC-12, DC-14, DC-15, and DC-16 (see Figure 22 for locations). Two additional horizons were tested at existing borehole DC-7. Transmissivity values shown in Table 9 fall within the range previously reported for these type of geologic intervals.

TABLE 9. Preliminary Transmissivity Values for Selected Flow Tops and Sedimentary Interbeds Tested Between July 1, 1981 and September 30, 1981.

Borehole number	Stratigraphic formation	Test interval (m BGS)	Transmissivity (m^2/s)
BH-17	Saddle Mountains	312.4 - 334.1	1 E-07 to 1 E-06
DB-14	Wanapum	356.6 - 371.2	*
DC-7	Grande Ronde	1,354.6 - 1,406.6	*
		1,298.8 - 1,351.4	1 E-09 to 1 E-08
DC-12	Grande Ronde	1,244.8 - 1,357.9	1 E-04
		1,324.1 - 1,357.9	1 E-04
		1,347.2 - 1,357.9	*
DC-14	Grande Ronde	973.2 - 981.5	1 E-06 to 1 E-05
DC-15	Grande Ronde	1,140.3 - 1,172.0	1 E-08
		1,261.3 - 1,293.3	1 E-06 to 1 E-05
DC-16	Saddle Mountains	203.6 - 254.5	1 E-04 to 1 E-03

*Results not available. Test data currently being analyzed.

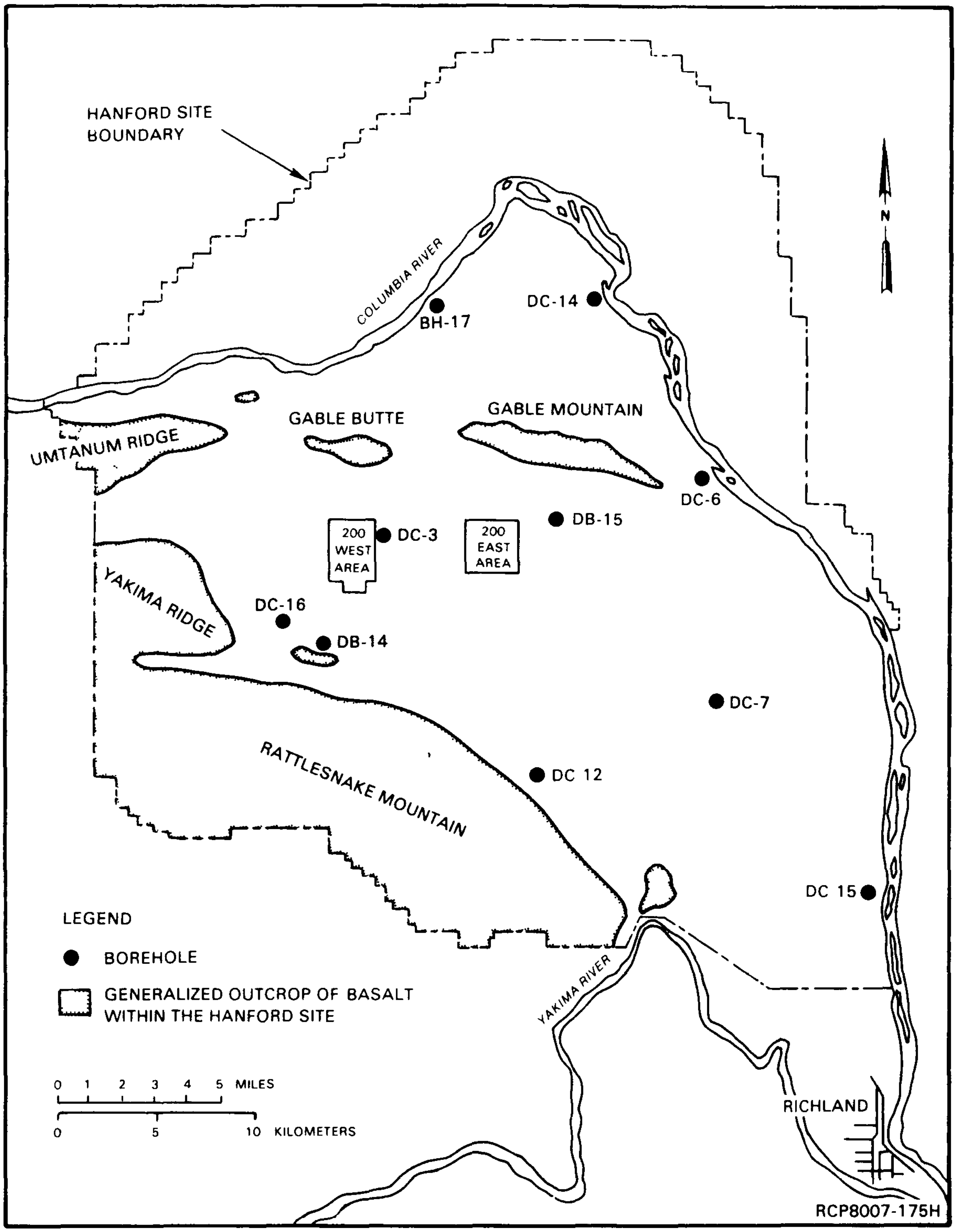


FIGURE 22. Location of Selected Boreholes on the Hanford Site.

Low permeability testing was conducted on three selected colonnade/entablature zones within the Wanapum and Grande Ronde Basalts at existing boreholes: DB-15, DC-3, and DC-6. Transmissivity values listed in Table 10 for colonnade/entablature zones tested during this quarter, fall within and/or slightly below the range previously reported for these types of geologic intervals.

TABLE 10. Transmissivity Values for Selected Colonnade/Entablature Zones Tested Between July 1, 1981 and September 30, 1981.

Borehole number	Stratigraphic formation	Test interval (m BGS)	Transmissivity (m^2/s)
DB-15	Wanapum	338.3 - 349.6	1 E-13 to 1 E-12
DC-3	Grande Ronde	1,093.6 - 1,107.9	<1 E-14 to 1 E-12
DC-6	Grande Ronde	1,165.6 - 1,270.7	1 E-12 to 1 E-11

Preparation for tracer studies was also undertaken during this quarter. The purpose of these tracer tests is to determine in situ effective porosities and dispersivities within selected flow tops of the Grande Ronde Basalt. The work conducted included interfacing with BWIP consultants (G. M. Thompson and L. W. Gelhar), purchase of analytical and field support equipment, and the initial writing of test procedures.

Hydrologic Conceptual Model

During this quarter several reports were received regarding aspects of the hydrologic conceptual model. George Leaming Associates, Marana, Arizona completed a report assessing the present value of water resources within the Pasco Basin, forecasting water demand, sources and costs. The study reveals that groundwater use accounts for ~3% of the present demand for all consumptive water use in the Pasco Basin.

The major consumptive users of water (both groundwater and surface waters) are agriculture (69%), industry (28%), and residential (3%). During 1980, the estimated total water demand within the Pasco Basin was 2.467 E+09 m^3. The most likely projected water demand by the year 2080 is 4.44 E+09 m^3 per year.

A study was completed by PNL to evaluate possible flash flooding of the RRL and to provide a preliminary basis for designing flood protection measures for surface facilities and access roads. The main conclusion of this report was that under probable maximum flood conditions, the southwest third of the RRL would be inundated by a flash flood from the Cold Creek. Maximum water depth would be ~1.53 m (~5 ft). Such a flood would be of short duration and would not impact the underground facilities. The probability of such an event was estimated at 1 E-04 to 1 E-05.

In addition to the above reports, aerial photographs of the Cold Creek syncline area were taken at a 1:27,000 scale. The purpose of this study was to provide detailed surficial geologic maps to verify land-use classifications identified with LANDSAT data.

Hydrologic Numerical Model

The hydrology modeling efforts currently under way are being conducted to estimate pathlines, travel times, and potential nuclide migration rates. The work completed this quarter on these modeling studies is summarized in the following paragraphs.

Pasco Basin Modeling (Far-Field). The Pasco Basin modeling studies consist of three efforts:

- Verification of the far-field numerical models
- Calibration of the flow model with existing borehole data
- Parametric and sensitivity analysis.

During this quarter a far-field modeling study was completed and the results documented. The outline of the Pasco Basin, together with some hydrologic features, are shown in Figure 23. A simplified description of the present groundwater flow within the Pasco Basin is presented in Figure 24.

A three-layer geometry (Saddle Mountains, Wanapum, and Grande Ronde Basalts), boundary conditions set, and material property set were developed from available information and input into the MAGNUM-3D finite element groundwater flow model. MAGNUM-3D was used to calculate the steady-state hydraulic head distribution throughout the Pasco Basin.

Subsequent to the MANGUM-3D model simulation, an auxiliary streamline code was used to predict the path of a particle of groundwater released at a hypothetical repository location. Because composite values were used for the hydraulic conductivities of each of the three model layers, use of these values for travel-time calculations were considered to be nonconservative. The most rapid groundwater flow paths away from a hypothetical repository lying within a sequence of flow tops and dense basalt would likely be the flow tops (ignoring thermal effects in the near field). Consequently, it was assumed, for the purpose of travel-time calculations, that particles moved away from the repository exclusively in the flow tops and flow-top material properties were used. Under such circumstances the travel time from the repository to the model boundary was calculated to be >100,000 yr.

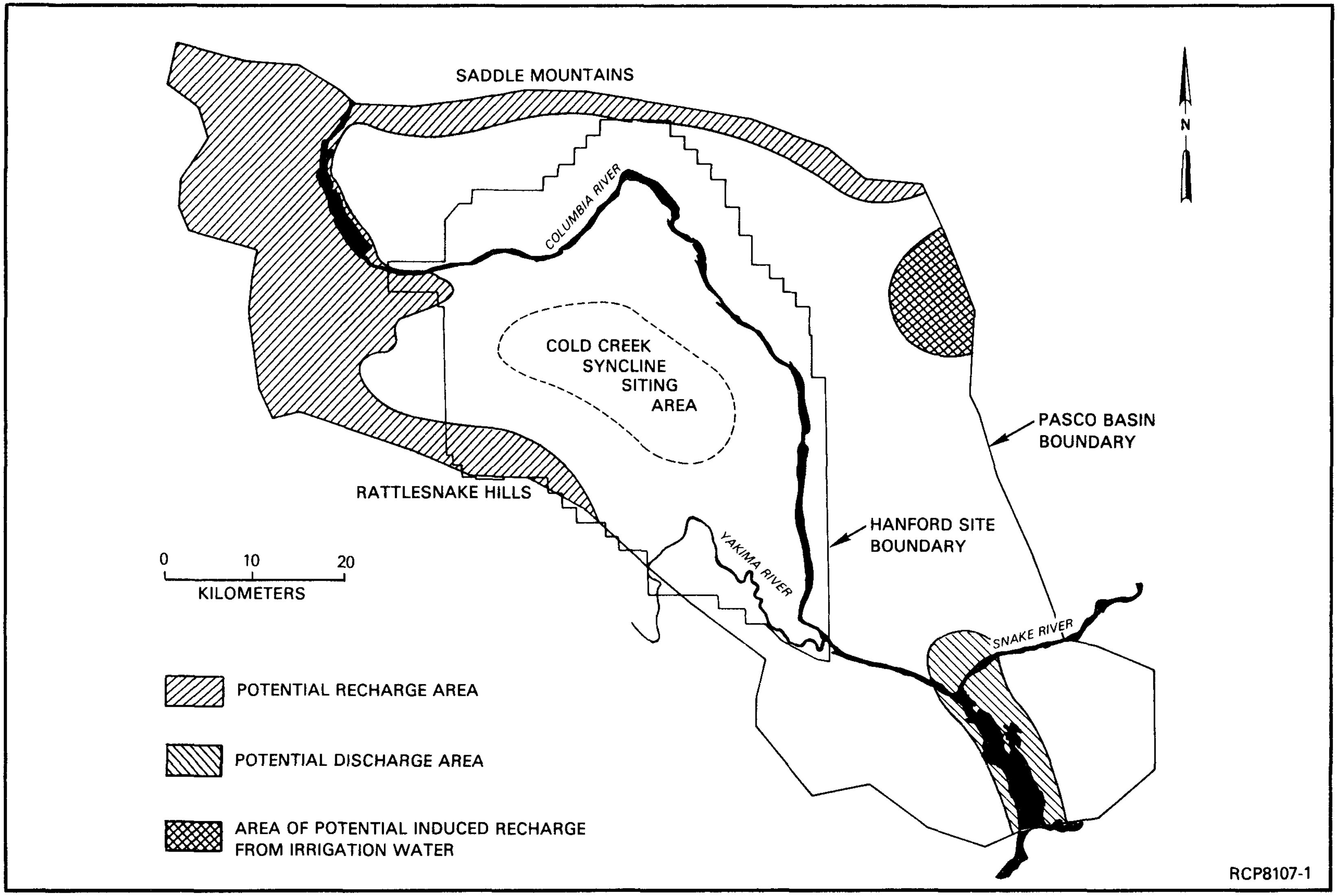


FIGURE 23. Location of Basalt Recharge and Deep Discharge Zones.

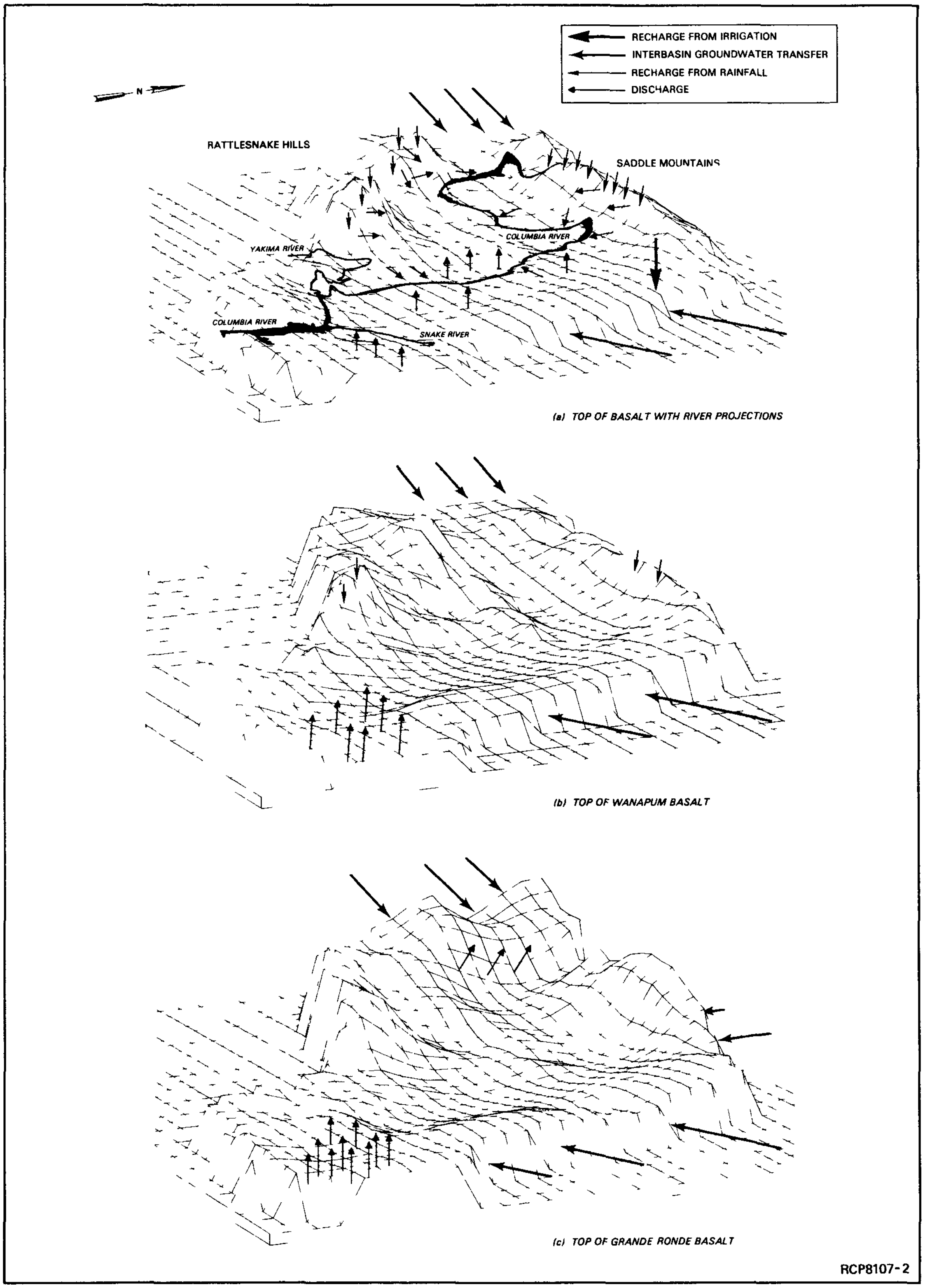


FIGURE 24. Pasco Basin Conceptual Groundwater Flow.

Although uncertainties and limitations of the conceptual model remain, a pattern of near-horizontal groundwater movement away from the siting area is emerging. This is due to the low to nonexistant upward head gradient as measured in the field, together with the concept of a layered system of more permeable flow tops alternating with less permeable dense basalts. In the analyses, the groundwater was calculated to move away from the siting area in a southeasterly direction, beneath the Columbia River, toward the area near Wallula Gap. The streamlines are shown in Figures 25 and 26. Both the streamline orientation and the travel-time estimates are subject to change as further information is gathered and the conceptual models are improved. A parametric and sensitivity analysis is planned to evaluate the impact of possible variations or uncertainties in parameters, boundary conditions, and geometry.

Groundwater Monitoring

Baseline groundwater monitoring was conducted in a network of eleven basalt wells. Three wells monitor the Mabton interbed, six wells monitor a Priest Rapids flow top, and two wells are open to flow tops in the Grande Ronde Basalt. Groundwater monitoring data files are being maintained both in hard copy form and on magnetic tape. In addition to periodic monitoring of groundwater levels, continuous water level recordings are maintained at three of the well sites by use of Stevens recorders.

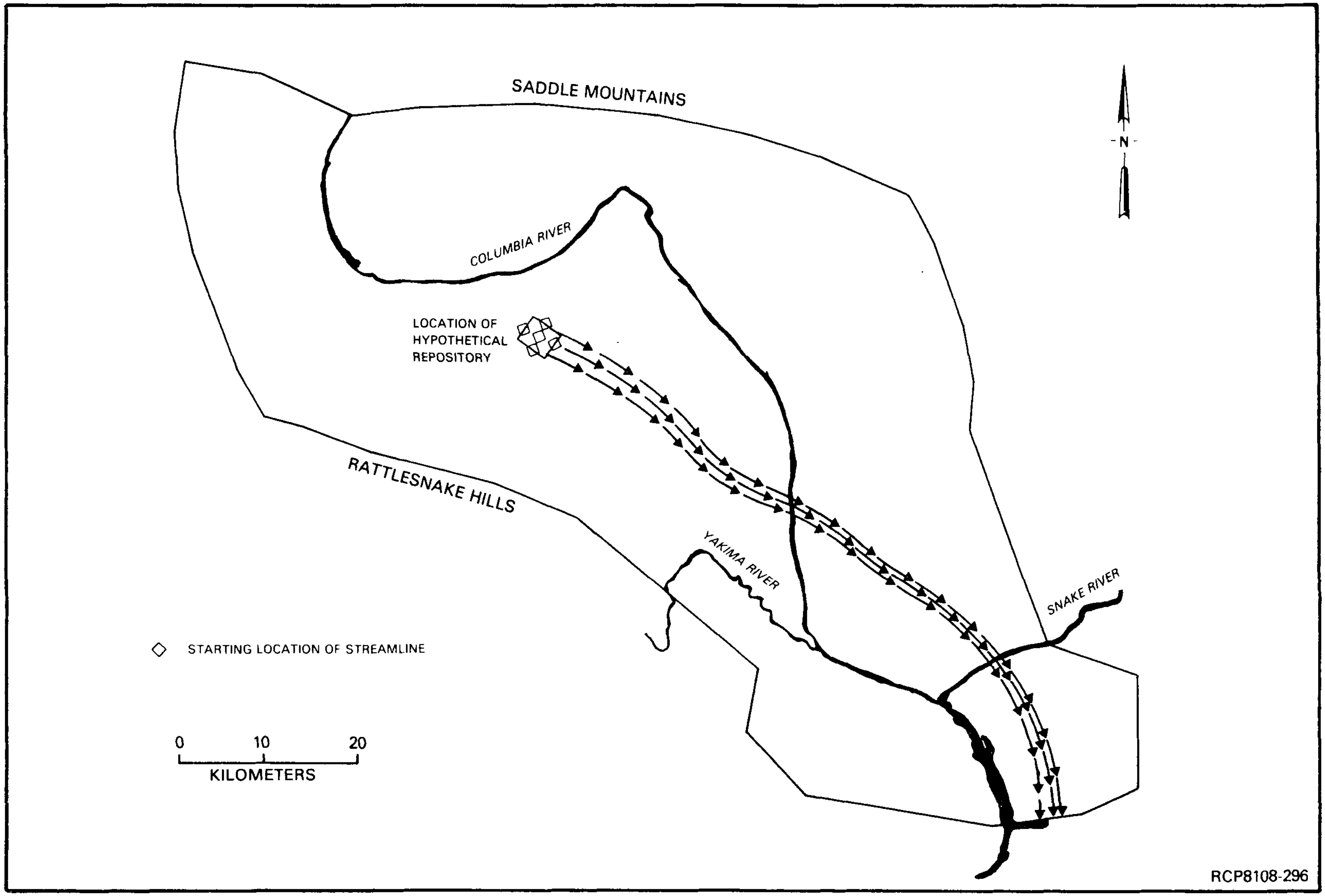


FIGURE 25. X-Y Projection of Streamlines from Hypothetical Repository to Model Boundary.

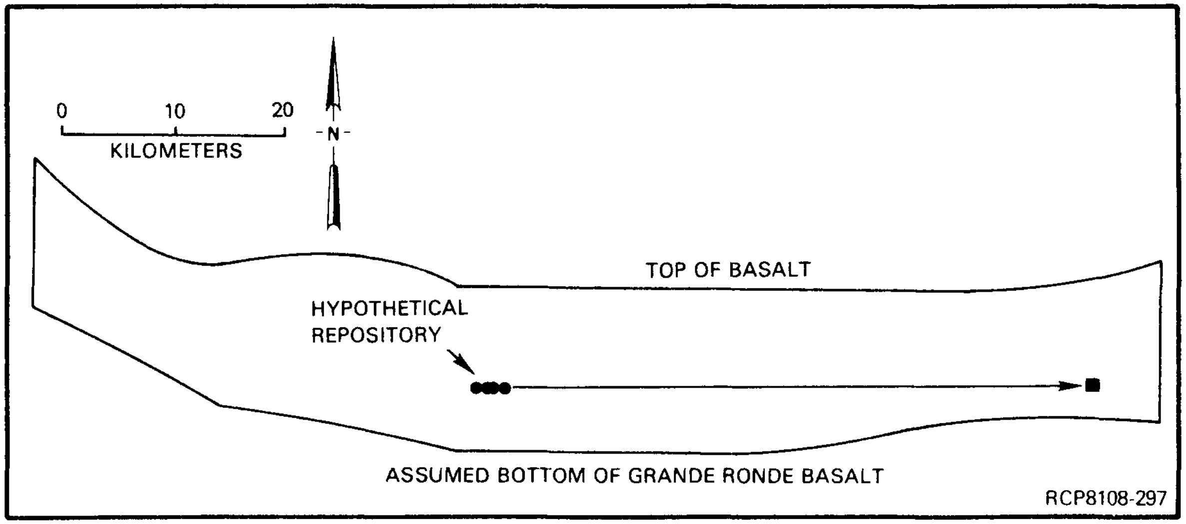


FIGURE 26. X-Z Projection of Model Calculated Streamline.

REPOSITORY

The objectives of the Repository program are to develop the technology required for the design, construction, operation, and decommissioning of an NWRB underlying the Hanford Site and to complete the conceptual design of an NWRB.

The Repository program consists of one end function, Repository, which is divided into the following activities:

- Repository Baseline
- Repository Data Base Development
- Equipment Development
- Instrumentation Development
- Repository Seal Development
- Generic Repository Engineering
- Repository Conceptual Design
- Repository Design and Inspection
- Repository Long-Lead Procurement
- Repository Construction
- Repository Operation
- Repository Decommissioning
- Repository Monitoring
- Performance Evaluation.

During the fourth quarter of FY 1981, work progressed in four of these activities: Repository Baseline, Repository Data Base Development, Repository Seal Development, and Repository Conceptual Design.

REPOSITORY BASELINE

The repository baseline activity is responsible for the management of the Repository end function, specifically, the preparation and control of plans and schedules, preparation of budgets and work packages, control of program costs, and overall direction of the technical activities. During this quarter, monthly repository conceptual design review meetings were conducted among the DOE, Kaiser Engineers/Parsons Brinckerhoff Quade and Douglas, Inc. (KE/PB) of Oakland, California, and Rockwell. Significant progress was achieved in completing development of a Repository technical baseline.

REPOSITORY DATA BASE DEVELOPMENT

The Repository Data Base Development activity is responsible for providing technical assistance, conducting rock mechanics test data and analysis of the Near-Surface Test Facility's (NSTF's) full-scale heater tests, block tests, and tests in preparation for an exploratory shaft facility, developing and verifying numerical models for application to repository design, develop methods and procedures for in situ stress measurements, and establish laboratory and procedures for rock testing.

Data Base Analysis

Full-Scale Heater Tests #1 and #2 Analysis. An analysis of the Full-Scale Heater Tests #1 and #2 (FS1 and FS2) thermal and displacement data in comparison to predicted data after 270 d of operation was conducted by the Dames & Moore's Advanced Technology Group, Burlington, Massachusetts. The evaluation indicates that meaningful data are being obtained with respect to thermal properties and induced displacements.

Specific conclusions of the analysis are:

- The thermal data and the derived properties provide an improved understanding of the rock mass thermal response that could be used in a refined predictive model.

- The thermal modeling data would be improved by using thermal conductivity data from the specific test site as opposed to taking somewhat generalized data from nearby locations. Actual conductivity (as determined by laboratory tests on test site core samples) was $\sim$30% higher than values used in the modeling.

- The influence of the limited amount of water in the test zone on the overall thermal response of the tests is not considered to be significant. This is based on observations and analytical studies involving energy considerations. The major influence of water on the tests appears to be its localized and variable influence on instrument response.

- The coefficient of thermal expansion of the rock mass was not evaluated because of the variability of laboratory test results and the potential influence of the basalt structure. Data from other tests under controlled conditions, e.g., the Jointed Block Test (JBT), is needed in order to evaluate this parameter.

- The displacement behavior induced in the heater tests is in accordance with the geological structure and expected deformability characteristics of the rock mass.

Analysis of the test data from FS1 and FS2 is scheduled to continue during FY 1982. Updated predictive modeling studies are to be undertaken incorporating site-specific laboratory properties and model adjustments based on actual test conditions.

Model Development

Pre-Test Analysis of the Jointed Block Test. A pre-test analysis of Step 2 of the JBT was conducted by the Department of Civil and Mineral Resources Engineering, University of Minnesota, Minneapolis, Minnesota. The objective of the pre-test analysis was to define the factors which needed to be considered in the design of an acceptable load path for Step 2 (full four-sided test) of the JBT and to define the loading conditions which would preclude any specimen disturbance to determine the modulus of elasticity or the coefficient of thermal expansion of the basalt block. It also was intended to provide some indication of the stress distribution for the active test domain of the jointed block for the particular conditions of the applied loads.

The analysis concluded that in a JBT, in which large mechanical biaxial loads are imposed on the basalt block, irreversible deformation or failure can occur by inducing tension in the block or slippage along basalt joints. In order to prevent tension or joint slippage failure, it is necessary to impose a compressive load on the front of the block. This can generate an admissible state of triaxial compression in the block.

Specific conclusions of the analysis are:

- Calculations established the combination of forces needed to produce the triaxial loads required to ensure no slippage failure and elimination of tensile stresses in the block. These are within the expected performance range of the JBT system.

- The conditions under which tensile stresses were prevented in the three-dimensional model coincide with the approximations developed to prevent nonlinear (slippage) effects.

- The three-dimensional analysis suggests a strong effect of the base boundary condition of the block specimen and the areal extent of the flat jack loading on the development and distribution of stresses in the rock parallel to the long dimension of the block.

- The three-dimensional analysis indicates that measurements taken in the test plane are not appreciably affected by nonuniform stress conditions normal to the plane assuming nonlinear effects are avoided. Therefore, two-dimensional analysis for the test plane should be appropriate.

Laboratory Tests

All laboratory testing by contractors scheduled for FY 1981 has been completed and statements of work and purchase requisitions have been prepared for FY 1982 contracts. These include contracts to examine joint creep in basalt, the simulation of core discing, and the acquisition of a test apparatus for determining the gas permeability of jointed rock masses. All of these contracts will be placed and in operation during the first quarter of FY 1982.

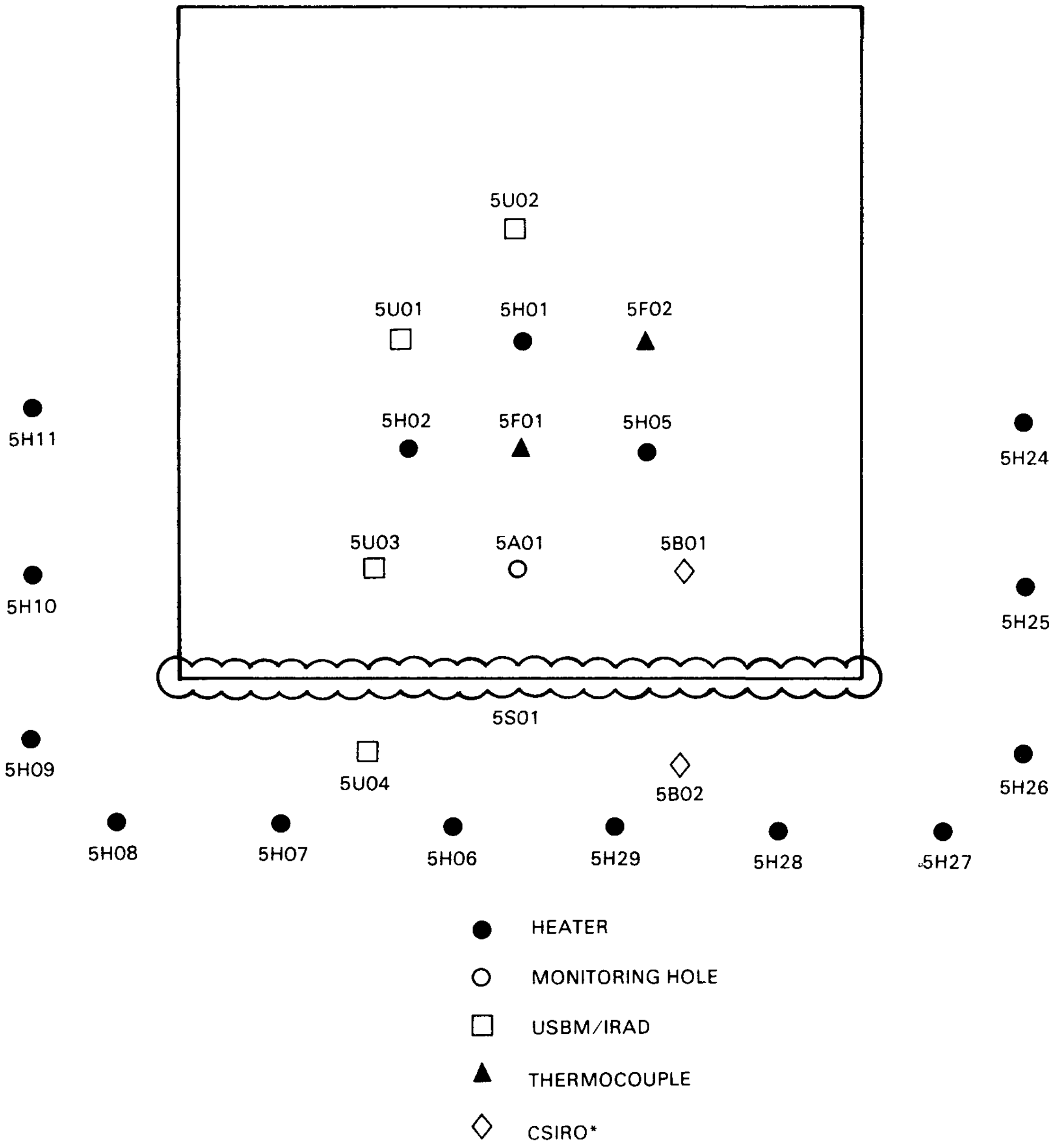
The Rock Mechanics Laboratory facility is complete. The contract for the compression testing machine was awarded to MTS Systems Corporation, Minneapolis, Minnesota. Delivery of major portions of the laboratory system is expected by the end of January 1982 with the balance by April 1, 1982. Miscellaneous pieces of equipment have been ordered and should be received during the the first quarter of FY 1982.

Field Tests

Block Test. Block Test #1 consists of a cube of basalt (~2 m on a side) located in a tunnel wall. It will be heated by electric heaters and confined by hydraulic flat jacks which will exert pressures simulating a deep underground repository environment. Testing will be conducted in two steps: In the first step, only one of the four slots surrounding the test cube is excavated. Heaters, rock instruments, and flat jacks are installed in the configuration shown in Figure 27 for Step 1. A series of temperature and pressurization cycles were conducted to determine the rock response to uniaxial pressures up 7.5 MPa and temperatures up to 100°C.

Step 2 commences with the completion of the remaining three slots and installation of the flat jacks and rock instruments. Pressure cycles up to 20 MPa and temperature cycles up to 200°C will be conducted in order to determine biaxial rock deformation, thermal expansion coefficient, and stress distribution and magnitude.

During this quarter, the Block Test Step 1 was completed and analysis and report preparation was initiated.



*COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANIZATION

NOTE EACH INSTRUMENT AND HEATER SHOWN CONTAINS A THERMOCOUPLE

RCP8105-159

FIGURE 27. Step-1--Slot and Instrument Locations.

A thermal conductivity test was completed the first week in July 1981. This test consisted of energizing the center heater 5H01 and monitoring block temperature with thermocouples in 5F01 and 5F02. The thermal conductivity was determined to be 1.57 W/m·K which compares with the predicted value of 1.61 W/m·K.

After completion of the thermal conductivity test the block was heated to 50° and 100°C in steps. At each of these temperatures, pressure cycling was conducted to a total pressure of 7.5 MPa. After the 100°C cycle, the block was cooled to 50°C and another pressure cycle was performed to the 7.5-MPa level. The block was then cooled to near ambient temperature and a final pressure cycle of 7.5 MPa was performed on September 8, 1981. This last cycle, conducted at ~36°C, was the final pressure cycle for Step 1 and marked the completion of Step 1 testing.

Preparation of a Step 1 report was initiated in August 1981 and is continuing at this time. Current activities include data verification and analyses for determining the elastic modulus from Step 1 tests.

Data Verification (FS1 and FS2)

Validation and verification of data received from the full-scale heater tests continued in accordance with the Data Verification Plan. This effort includes evaluation of instrument performance and conversion algorithms and compilation of data for test analyses. Preparation of a comprehensive report describing the performance, calibration, and operation of the rock instrumentation was continued.

The following rock instrumentation is installed to monitor rock response to thermomechanical loading during the tests:

- Thermocouples - temperature
- U.S. Bureau of Mines' (USBM) Borehole Deformation Gauges (BDGs) - stress
- Vibration Wire Stressmeters (VWSs) - stress
- Multiple-Position Borehole Extensometers (MPBXs) - displacement.

Temperature Measurements. The maximum scheduled heater power levels, achieved on Febuary 12, 1981, have been maintained throughout the quarter (Fig. 28). A change to the heater power program was approved this quarter. The FS1 peripheral heaters were not reduced in power on August 25, 1981 as originally scheduled but will remain at their present levels (8-kW total) until the end of the test. The FS2 heater will remain at 5 kW until November 23, 1981 at which time it will be turned off for a 2- to 3-mo cooling period.

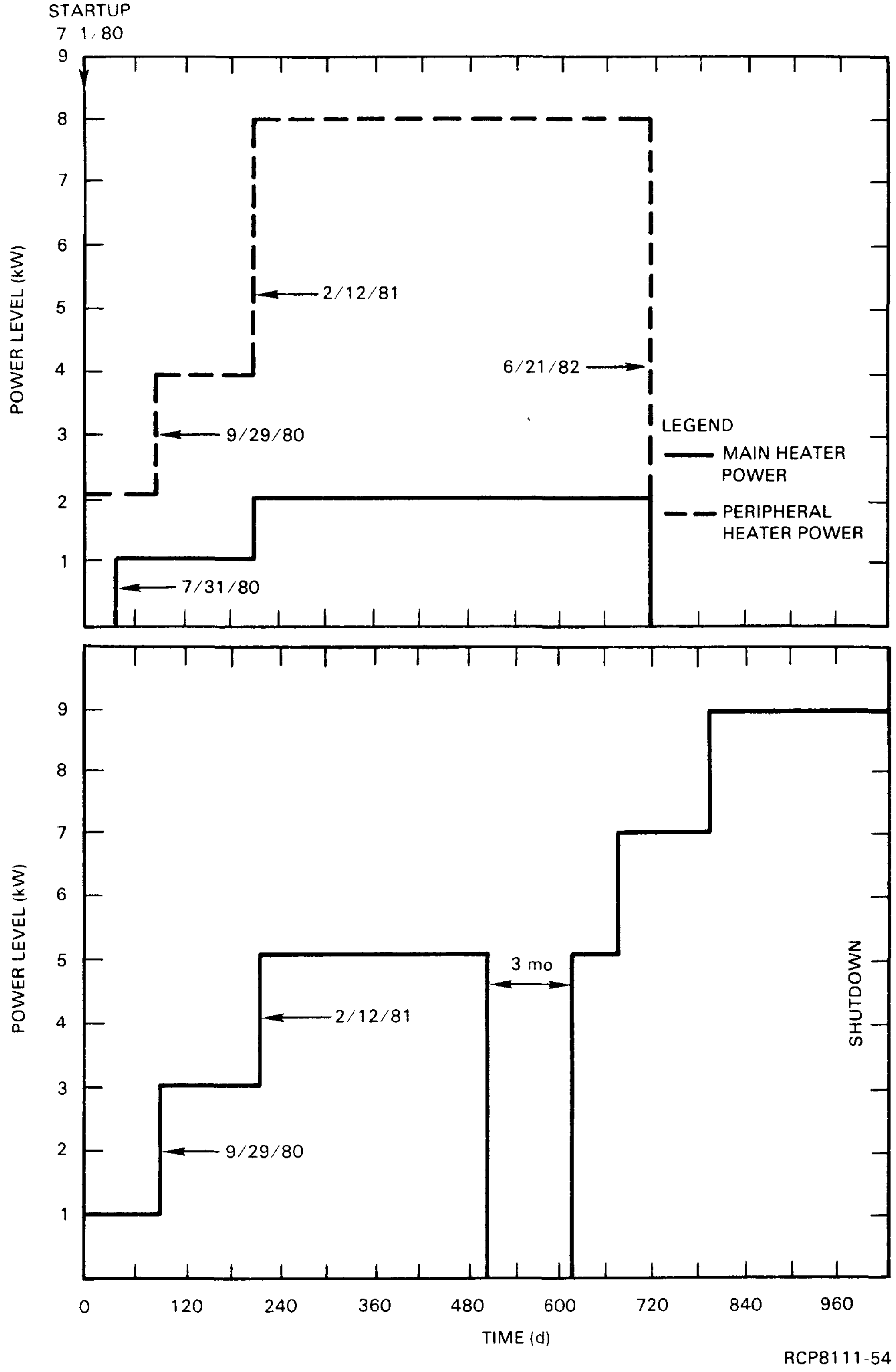


FIGURE 28. Planned Heater Power Levels Full-Scale Heater Test #1.

The basalt rock surrounding the heaters continues to increase in temperature at a constant rate. Temperature histories for the heater liner, 0.5, 1.5, and 2.5 m in the rock on the horizontal midplane are presented in Figure 29 for FS1 and Figure 30 for FS2. Based on observations of rock temperatures, there has been no evidence to date that severe decrepitation of the heater borehole has occurred.

Borehole Deformation Gauge. The performance status of USBM gauges in FS1 and FS2 is presented in Table 11. During the reporting period a total of 14 malfunctioning USBM gauges were removed from the heater tests (Table 11) and two from the block test. Current plans are to replace some of these gauges with the Phase II instruments prior to the scheduled cooldown in November 1981.

Vibrating Wire Stressmeter Performance. The performance status of the VWS in FS1 and 2 is presented in Table 12. When a valid algorithm for conversion of the raw data to stress is available, all test data will be reworked.

Multiple-Position Borehole Extensometer Performance. The status of the MPBX instruments remains essentially unchanged from the previous report. The total of failed anchor systems is currently 75% for FS1 and 31% for FS2. No slippage of the anchors has been detected to date.

Two factors which affect the extensometer results are stick slip and wall movement. Additional tests were conducted this quarter on these parameters as reported below.

The stick slip phenomenon is restricted movement due to frictional interference in the extensometer assembly or in the fractures and joints in the rock mass. Interferences with rod movement can be detected and relieved by tapping the head with a mallet (dithering). Dithering was performed on all horizontal extensometers in FS1 and FS2 this quarter. Results of previous testing indicated that the effect on the vertical extensometers was negligible. Weekly dithering of the horizontal extensometers will continue.

Extensometer displacements are anchor movements measured with respect to the instrument head which is mounted on the borehole collar. If the wall or floor moves, then appropriate corrections need to be applied to the reported data. To determine the stability of the test room surfaces a precision survey is conducted weekly of targets located throughout the test tunnel and extensometer room.

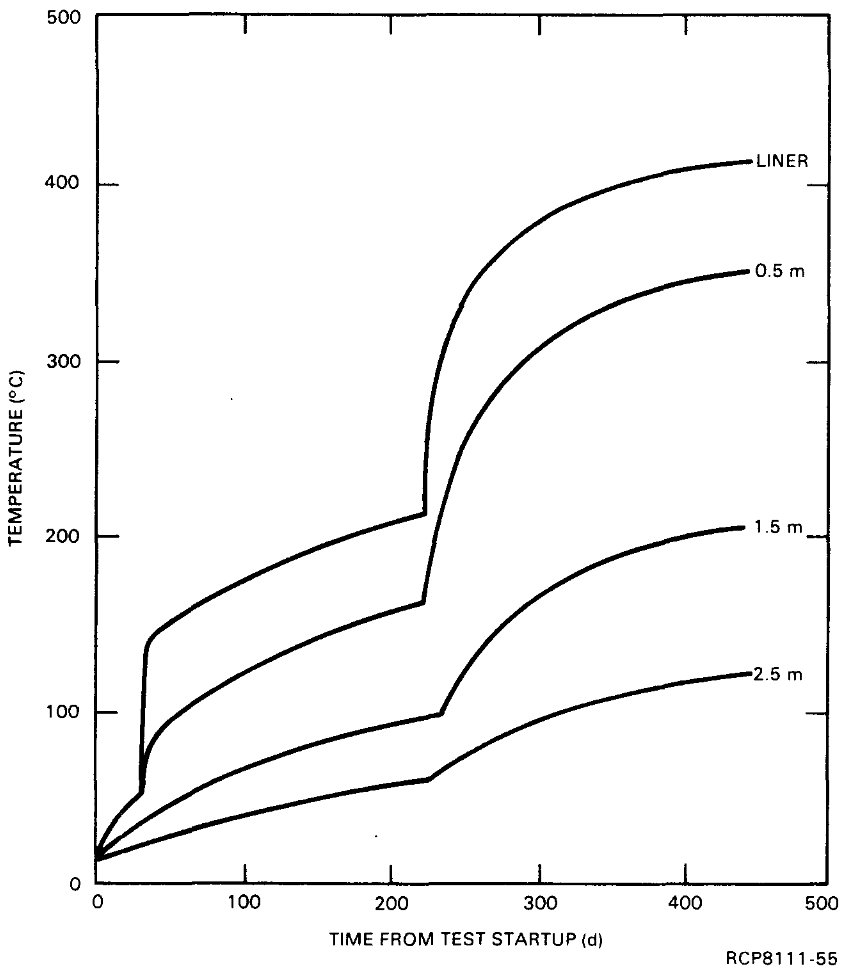


FIGURE 29. Full-Scale Heater Test #1 Temperature Histories.

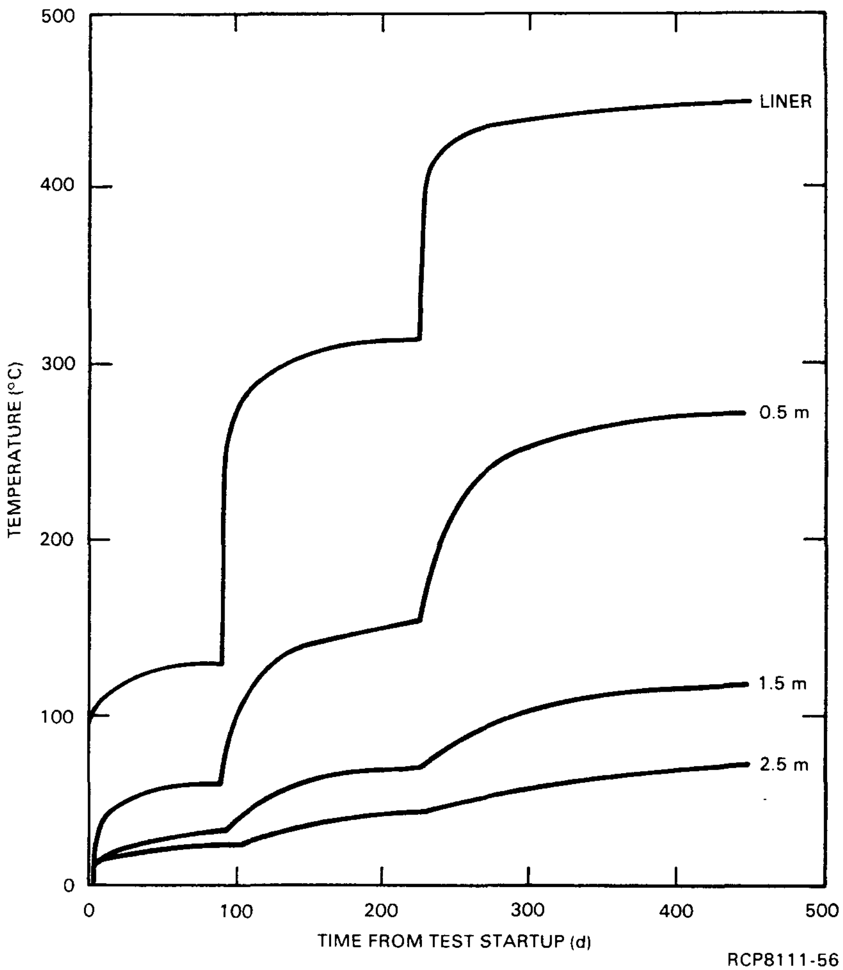


FIGURE 30. Full-Scale Heater Test #2 Temperature Histories.

TABLE 11. USBM Gauge Performance Status (September 30, 1981).

Performance status	FS1	FS2	Combined	
	Number		Number	Percent
Acceptable[a]	4	5	9	32
Suspect[b]	4	1	5	18
Replacement required[c]	4	10	14	50
Total	12	16	28	100

[a]Performing satisfactorily.
[b]Erractic behavior, large change in output, or trend reversal.
[c]Out-of-limits or extreme values, long-term erractic behavior.

TABLE 12. VWS Gauge Performance Status (September 30, 1981).

Performance status	FS1	FS2	Combined	
	Number		Number	Percent
Acceptable[a]	2	7	9	22
Suspect[b]	1	8	9	22
Replacement required[c]	15	7	22	56
Total	18	22	40	100

[a]Performing satisfactorily.
[b]Erractic behavior, large change in output, or trend reversal.
[c]Out-of-limits or extreme values, long-term erractic behavior.

REPOSITORY SEAL DEVELOPMENT

The NWTS Program draft criteria identify the repository seal system as a significant component of the waste isolation system. The basic objective is to develop materials and designs which will provide a repository seal system which acts in concert with the natural geologic barriers to limit release of radionuclides from the repository during operation period and subsequent decommissioning.

Internal documents were prepared which present recent laboratory materials testing results and results of a seal configuration computer modeling study.

The physical testing document summarizes preliminary repository seal material data for materials identified in previous preconceptual studies. The information will be useful in assessing potential physical stability of candidate plug materials.

The computer modeling document is a presentation of developmental effort to date with a finite-element computer code designed to solve borehole plugging stability problems. The document includes the theory incorporated in the code development. It discusses practical use and program limitations and a program listing and contains a user guide. Additional work is required to verify its usefulness as a seal criteria developmental aid.

REPOSITORY CONCEPTUAL DESIGN

Preparation of a conceptual system design description for an NWRB was completed by KE/PB during this quarter. The first drafts of two documents were transmitted to the DOE-RL and Rockwell for review on September 30, 1981. Work on the NWRB conceptual design to be completed during FY 1982 includes:

- Completion of a draft project schedule and planning cost estimate by April 1, 1982
- Peer review by the NWTS Program of the completed NWRB conceptual design report.

REGULATORY AND INSTITUTIONAL

The objectives of the Regulatory and Institutional (R&I) program are to establish requirements for all BWIP work as needed to comply with the requirements identified in regulations and laws pertaining to all aspects of siting, construction, operation, and decommissioning of an NWRB; monitor the development of regulations that apply to the licensing of a nuclear waste repository; and coordinate the BWIP licensing documentation.

The R&I program is composed of one end function, R&I, which is divided into four activities:

- Regulatory Baseline
- Licensing Applications
- National Environmental Policy Act (NEPA) Documents
- Communications and Institutional Liaison.

During the fourth quarter of FY 1981, work progressed in all of these areas.

REGULATORY BASELINE

The Regulatory Baseline activity covers the development of the regulatory data and planning baseline and the constant updating required to ensure authenticity, traceability, and consistency of requirements, and to provide appropriate confidence that the BWIP meet all pertinent legal requirements for an NWRB. The R&I end function technical plan was updated during this quarter to include the most current requirements of the NRC, the Environmental Protection Agency (EPA), and the NWTS Program. Also, the consolidated BWIP review comments on the proposed technical rule for 10 CFR 60, "Disposal of High-Level Radioactive Wastes in Geologic Repositories," were transmitted to the DOE-RL.

LICENSING APPLICATIONS

Licensing activities involve compliance with the permit and licensing procedures of the NRC and other agencies with jurisdiction over radioactive waste disposal. Activities during this quarter consisted of the following:

- Five chapters of the SCR were written and are being prepared for word processing or have already started the management review cycle. These chapters are:
  - Chapter 2.0, Decision Process for Choosing an Area and a Site
  - Chapter 4.0, Geomechanical Engineering

- Chapter 8.0, Climatology, Meteorology, and Air Quality
- Chapter 10.0, Repository Design
- Chapter 11.0, Waste Form, Waste Packaging, and Environment

- A 4-day meeting consisting of 27 people from the NRC and its consultants was conducted by the BWIP between September 22 and 25, 1981. The meeting represents the first of several in-depth technical meetings to allow the NRC to understand what will be included in the SCR.

NEPA DOCUMENTS

This activity presents BWIP data and information related to compliance with the NEPA by documenting the decision-making process and the potential impacts of major program activities in the BWIP. During this quarter, three activities were conducted:

- An Action Description Memorandum (ADM) was submitted to the DOE-RL to discuss plans and possible impacts that could result from an exploratory shaft (ES) at Hanford. Comments from Department of Energy-Headquarters (DOE-HQ) have been incorporated into the most recent draft of the ADM.

- Environmental Evaluations (EEs) for the deepening of existing borehole RRL-2 and for drilling borehole DC-21 were prepared and submitted to the DOE-RL. In addition, NWTS Program checklists for environmental evaluation of borehole drilling activities to cover both proposed activities were prepared.

- The introductory chapter of the Environmental Assessment (EA) to support the SCR was prepared and is undergoing internal review. The EA will be submitted to the DOE-RL with the SCR.

COMMUNICATIONS AND INSTITUTIONAL LIAISON

This activity encompasses the day-to-day coordination with the DOE/NWTS Program on licensing matters, the planning and implementation of state and local government coordination plans, as well as day-to-day and periodic public information services. A contract was let for preparation of models of the stratigraphy beneath the Hanford Site and of a big-hole drilling machine. These models will be used to aid the public to understand these aspects of the BWIP.

TEST FACILITIES

The objective of the Test Facilities program is to provide for the design, construction, and operation of test facilities in support of the technology development needs of the BWIP. The Test Facilities program is divided into four end functions:

- Near-Surface Test Facility Phase I (NSTF Phase I)
- Near-Surface Test Facility Phase II (NSTF Phase II)
- Support Facilities
- Decommissioning.

During the fourth quarter of FY 1981, work progressed in NSTF Phase I and NSTF Phase II.

NEAR-SURFACE TEST FACILITY PHASE I

The NSTF Phase I end function is divided into five activities:

- Phase I Test Facility Baseline
- Design
- Construction
- Safety and Environmental Analysis
- Test Implementation.

Design and construction activities for the Phase I test area tunnels and facilities were completed to the point of beneficial occupancy in January 1979. An environmental analysis was prepared prior to tunnel and facility construction. Continuing safety reviews are conducted to ensure the NSTF integrity.

During the fourth quarter of FY 1981, work has progressed in two activities: Phase I Test Facility Baseline and Test Implementation.

Phase I Test Facility Baseline

This activity is responsible for the program management of the NSTF Phase I end function, specifically, the preparation and control of schedules, preparation of budgets and work packages, control of program costs, and overall guidance of technical activities.

Test Implementation

The Phase I Test Implementation activity includes six subactivities:

- Full-Scale Heater Test #1
- Full-Scale Heater Test #2
- Block Test #1
- Block Test #2
- Engineering Support
- Operations.

During the fourth quarter of FY 1981, work continued in Block Test #1 (BT1), Engineering Support, and Operations subactivities. Drilling is scheduled to start on BT1, Step 2 by November 1981. Block Test #2 is not funded at this time.

Block Test #1. Fabrication of the Basalt Deformation Measurement System (BDMS) began during the fourth quarter. The BDMS is an optical system designed to measure displacement across BT1 to an accuracy never attempted previously in rock. The design parameter of the system measures a dynamic range of rock movement of ±2 mm to an accuracy of 10 μm. The distance between measurement points is ~1.2 m. This measurement will be used in the calculation of the in situ rock-mass modulus and Poisson's ratio. Fabrication will continue through the next quarter with anticipated delivery of the BDMS base and system by mid-January 1982.

The L slot demonstration of flat-jack installation and operations techniques was removed, and a failure analysis conducted. The jack had a split along the mild steel tubing forming the edge of the flat jack. The split is indicative of a burst failure of the type experienced. The cause of the failure was a void in the grout around the steel receiver allowing the jack to over extend well past design limits. The over extension was estimated at 64.77 mm during the failure analysis while the designed maximum extension was 19.05 mm. The weld joining the tubing to the plates of the flat jack was not found to be a contributing factor in the failure.

Engineering Support. This subactivity includes geologic characterization of the test areas and automatic data acquisition, data processing, and software maintenance.

Geologic characterization was accomplished by detailed geologic mapping, instrument borehole core logging, and borehole mapping of selected holes, and was reported on in previous quarterly reports.

Data Acquisition System (DAS). The DAS, which records and processes NSTF test instrument responses and theoretical data, has been modified by the incorporation of 37 system change requests this quarter. With 151 system change requests having been applied to date, and no additional system changes outstanding, the DAS is a completely functional and enhanced system with additional capabilities and features to aid system analysts, and comply with user demands.

These major enhancements were incorporated this quarter:

- All data under new algorithms
- New graphics package
- New batch reports
- All data on-line
- Temperature versus radial distance plots
- Raw data plots.

Data Collection and Retrieval System (DCARS). The DCARS is that set of computer software and hardware designed and configured to support BT1. To date 55 system change requests have been written by analysts and users, and 15 have been completed and included into the system this quarter.

Step 1 of BT1 was completed on September 8, 1981. Over 2,000 instrument scans were taken between April 23, 1981 and September 8, 1981. One hundred and ninety-nine channels were read during each scan, so the BT1 Step 1 data base consists of approximately 400,000 data points. The DCARS, data base reports, graphics and statistical modules will remain on the system indefinitely to support Rock Mechanic's data analysis and validation efforts.

Operations. Step 1 of BT1 was completed in its entirety on September 8, 1981. During the last testing cycle, pressures were varied from 2.24 to 7.4 MPa, while thermal conductivity testing was performed. In preparation for Step 2 of the block test, the heaters and instrumentation were removed so that the remaining sides of the block along with the additional heater and instrument holes may be drilled. One of the two hydraulic flat jacks was removed to repair a leak in the jack.

Dewatering activities continued on FS1 and FS2 instrument, heater, and time-scale test boreholes. Quantities of water removed from the full-scale heater test areas were minimal. The water level in the time scale area was maintained at ~7 m below the tunnel floor.

The Waste Technology Safety Committee was briefed on the safety aspects of the NSTF. Based on the examination of evidence presented, the committee determined that construction and inspection procedures were adequate to maintain the facility in a safe condition.

The NSTF Emergency Plan was revised and reissued. A simulated rockfall emergency drill was conducted at the NSTF on September 2, 1981 in compliance with the DOE manual chapter requirements. Rockwell's Fire Department, Patrol, medical staff, and the NSTF Operations staff participated.

Recalibrations were performed on 12 full-scale test USBM gauges. The data from these gauges was questionable so they were removed and sent to the Rock Mechanics and Mining Technology Group for failure analysis. These gauges will be replaced with superior Phase II design instrumentation.

Calibrations were performed on eight FS1 and four FS2 extensometers for data validation purposes.

All Phase I NSTF operating procedures were revised and reissued to upgrade auditability and control. Procedures are now controlled by Operating Document Control.

NEAR-SURFACE TEST FACILITY PHASE II

The NSTF Phase II end function is divided into five activities:

- Phase II Test Facility Baseline
- Design
- Construction
- Safety and Environmental Analysis
- Test Implementation.

Design activities covering the Phase II test area tunnels, facilities, and the Bottom Loading Transporter (BLT) were completed by August 1980. Construction of the test area tunnels was completed, and construction of the facilities is in progress.

During the fourth quarter of FY 1981, work progressed in four activities: Phase II Test Facility Baseline, Construction, Safety and Environmental Analysis, and Test Implementation.

Although work continued in the fourth quarter of FY 1981 toward final completion of the NSTF Phase II construction program, utilization of the Phase II facilities has not been fully determined at this time. There is no operational funding for Phase II activities as originally conceived in FY 1982. Viable alternatives for utilization of the NSTF are currently being discussed between Rockwell and the DOE-RL.

Phase II Test Facility Baseline

This activity is responsible for program management of the NSTF Phase II end function--specifically, the preparation and control of schedules, preparation of budgets and work packages, control of program costs, and overall guidance of technical activities.

Construction

This activity is divided into eight subactivities:

- Procurement
- Tunnels and Excavation
- Test and Instrument Holes
- Facility Requirements and Site Work
- Bottom Loading Transporter (Rockwell)
- Bottom Loading Transporter (Contract)
- Construction Management
- Title III.

Tunnel and excavation work was completed in FY 1979, and test and instrument holes were completed in the first quarter of FY 1981. The contract work on the BLT was completed in FY 1979.

During the fourth quarter, work has progressed in five subactivities: Procurement, Facility Requirements and Site Work, Bottom Loading Transporter, Construction Management, and Title III.

Procurement. The procurement of gamma radiation monitoring equipment was completed with the exception of the ion chambers which are scheduled for delivery November 1981.

Facility Requirements and Site Work. The facility construction continued, and the major activities were as follows:

- The test hole liner installation drawings were completed. Liner installation has begun with projected completion during the first quarter of FY 1982.
- All instrument test holes were cleaned and capped.

- All required test holes were reamed and recessed.
- Approximately 25% of the instrument base plates were installed.
- The drawings for the data collection and retrieval system were completed.
- The installation and wiring of the DCARS is ~70% complete.

Bottom Loading Transporter. The BLT was disassembled in the West Area, transported and reassembled in the transfer room. The transducer converter was installed, and operational checks were performed on all installed components.

Construction Management. This is a continuous activity which is performed essentially as a level of effort. The effort is concerned with all activities under the Construction heading.

Title III. The Title III inspection effort is an ongoing activity. There has been a high level of activity this quarter as the construction work has been progressing rapidly in all areas.

Safety and Environmental Analysis

This activity is concerned with an ongoing effort in environment and safety analysis.

Environmental Review. The effort this quarter has been a continuation of the effort to establish the baseline for air and surface quality at the NSTF.

Safety Review. The NSTF Phase II Safety Analysis Report was approved by the DOE-RL.

Test Implementation

Phase II Test Implementation includes five subactivities:

- Spent Fuel Test #1
- Spent Fuel Test #2
- Vitrified Waste Form Test
- Engineering Support
- Operations.

During the fourth quarter of FY 1981, work was performed in all subactivities.

Spent Fuel Tests #1 and #2 and the Vitrified Waste Form Test. The Spent Fuel Test #1 (SF1) test article is a canisterized pressurized water reactor fuel element which was cycled out of a reactor 5 yr ago and is estimated to have a residual thermal output of ~0.7 kW.

The Spent Fuel Test #2 (SF2) test article is a second canisterized pressurized water reactor fuel element, 2 yr out of a reactor with an estimated thermal output at installation of 2.5 kW.

The third test article, the vitrified waste form (VWF) test, is canisterized nuclear waste generated during the processing of irradiated Point Beach Reactor spent fuel with a residual thermal output of ~500 W.

The rock instruments obtained for the SF1, SF2, and VWF test completed calibration and environmental testing this quarter and were received by Rockwell. This testing program included the test listed below:

- BDG Sensitivity Testing
- BDG Submergence Testing
- BDG Offset Testing
- BDG Offset with Temperature Testing
- BDG Stress Agreement Testing
- VWS Design Screening
- VWS Isobaric Testing
- VWS Isothermal Testing
- VWS Analytical Study
- VWS Combination Testing.

The Test Automated Support System (TASS), the third generation data collection system designed to support Phase II activities, is 95% complete as to software implementation. Overall documentation and approval was 70% complete at the end of the quarter.

The TASS consists of three major modules:

- Scan control for "n" test
- Data by day (smoothed)
- Data by scan.

These major features are included:

- Interactive graphics/reports
- All data on-line
- Hard copy reports/graphics
- Variable scan rates.

Engineering Support. This subactivity includes the geologic characterization of the structural and physcial composition of the rock mass in the Phase II test area.

Characterization provides baseline data so that changes resulting from testing can be identified and NSTF geologic conditions can be compared to those which prevail at a site selected for the repository. Characterization was accomplished by detail-line-map instrument borehole core logging and geologic mapping.

All data to complete the Phase II characterization report have been collected and the report preparation is well under way. The report will contain a complete characterization of the Phase II test area.

Operations. The BLT was installed in the transfer room. Final assembly is nearing completion and acceptance testing is scheduled for the first quarter of FY 1982.

The NSTF Phase II MORT Analysis Report was submitted by the Health, Safety, and Environment Function.

The Readiness Review documentation outline items were examined by the NSTF Phase II startup team for applicability to startup. Documentation for most applicable construction items was submitted with the Quality Information Center and placed on file. Estimates-to-complete dates were determined for all other items.

The NSTF Phase II Fire Detection, Facility Function Alarm, and Safeguard Security System acceptance test procedures were completed.

Drafts for most new and revised Phase II operating Procedures and nuclear waste transfer operations were reviewed.

IN SITU TEST FACILITIES

The objectives of the In Situ Test Facilities program is to provide for the design, construction, and operation of test facilities in support of the technology development needs of the BWIP. The In Situ Test Facilities program is divided into three end functions:

- Exploratory Shaft Phase I (ES-I)
- Exploratory Shaft Phase II (ES-II)
- Test and Evaluation Facility (TEF).

During this quarter, work progressed in the ES-I end function.

EXPLORATORY SHAFT PHASE I (ES-I)

The conceptual design for ES-I was initiated on July 15, 1981 by KE/PB. Two design reviews were conducted during this quarter. The KE/PB conceptual design will include all the facilities to be located at the ES-I site; however, water and power utilities will be extended to the ES-I site from the 200 West Area by independent projects. The draft test plan for ES-I was transmitted to the DOE for review and approval during September 1981. The technical objectives of ES-I are to:

- Provide the design information required for shaft design and selection of porthole locations and ascertain the overall suitability of the proposed location for an exploratory shaft (ES) at the RRL
- Demonstrate that an ES can be sunk at the RRL and assess the construction method
- Verify that an ES can successfully seal off the groundwater system and evaluate the effects of shaft construction on the surrounding rock at the RRL
- Measure the hydraulic properties (e.g., hydraulic conductivity) of the reference repository horizon to provide input to a preliminary estimate of its isolation capability in the vicinity of the ES
- Conduct geomechanical tests (e.g., in situ stress) and provide a preliminary rock mass characterization of the reference repository horizon.

The proposed location of the ES is ~2.4 km west of the 200 West Area, within a few hundred kilometers of existing borehole RRL-2. Prior to drilling the shaft, a small test borehole will be core drilled to at least 1,280 m in order to confirm the suitability of the proposed site. Surface facilities and services will be constructed to support the shaft drilling and follow-on testing operations. A large-diameter shaft borehole will be drilled adjacent to the test borehole. The planned depth is ~1,280 m, which will traverse the entire Umtanum flow (reference repository horizon) and penetrate the flow beneath the Umtanum. The inside diameter of the finished shaft (with a seal-grouted, welded steel liner) will be 1.8 m, unless it is established during conceptual design that a larger diameter liner is mandatory. A head frame and hoist will be installed to permit installation and use of portholes for testing selected downhole horizons and for transporting men and materials during ES-II mining and exploration. The porthole tests will determine the degree of success achieved in grout sealing the annulus between the borehole and the shaft liner. In addition, the porthole tests will provide important in situ geologic and hydrologic data which cannot be obtained from the surface and which will be used to confirm selection of the horizon favored for a repository. Shaft breakout will be completed and a mined bell test chamber provided at ~1,130 m to furnish access to the Umtanum entablature and to permit additional testing of the shaft grout seal and in situ rock testing.

A draft functional design criteria (FDC) for ES-I was prepared, and a design review of the FDC has been scheduled during the first quarter of FY 1982. A draft end function technical plan and schedule for ES-I was prepared and internal review initiated at the end of the reporting period.

Requests for directives were prepared and transmitted to the DOE-RL September 29, 1981 for Project B-415, ES Water Line ($226,000); Project B-416, ES Power Line ($480,000); and Project B-417, ES Substation ($200,000)--all of which are to be funded from General Plant Projects (GPP). Functional design criteria documents also were prepared, and conceptual designs by Braun Hanford Co, Richland, Washington were nearly complete at the end of the reporting period.

DOCUMENTS ISSUED
(DURING THE QUARTER)

RHO-BWI-C-89 (unclassified), October 1980, F. S. Shuri, D. J. Dodds (FSI), and K. Kim, "Measurement of Rock-Mass Deforation Properties by the Borehole Jacking Method at the Near-Surface Test Facility"

RHO-BWI-C-97 (unclassified), September 1980, H. P. Foote, S. C. Blair, W. E. Wukelic, and V. L. Coburn, "Evaluation of Growth in Irrigated Agriculture in the Columbia Plateau, 1975-1979"

RHO-BWI-SA-81 (unclassified), March 1981, R. G. Baca and R. C. Arnett, "Analysis of Fracture Flow and Transport in the Near-Field of a Nuclear Waste Repository"

RHO-BWI-SA-113 (unclassified), June 1981, R. G. Baca, R. C. Arnett, and I. P. King, "Numerical Modeling of Flow and Transport Processes in a Fractured-Porous Rock System"

RHO-BWI-ST-15 (unclassified), May 1981, W. J. Anderson, "Corrosion Tests of Canister and Overpack Materials in Simulated Basalt Groundwater"