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CNWRA PROGRAM MANAGER'S PERIODIC REPORT ON ACTIVITIES OF THE CENTER FOR NUCLEAR WASTE REGULATORY ANALYSES

For the Fiscal Reporting Period

February 18–March 17, 1995

PMPR No. 95-06

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LIST OF ABBREVIATIONS

1D, 2D, 3D	1-Dimensional, 2-Dimensional, 3-Dimensional
AA	Atomic Absorption
ACD	Advanced Conceptual Design
ACF	Alumina (in excess of alkali feldspar), Calcium oxide, Ferromagnesianoxide
ACNW	Advisory Committee on Nuclear Waste
ACRS	Advanced Computer Review System
AI	Administrative Item
AECL	Atomic Energy Canada Limited
AES	Atomic Emission Spectrometry
AGU	American Geophysical Union
AML	Arc Macro Language
AP	Administrative Procedure
ASCE	American Society of Civil Engineers
ASCII	American Standard Code for Information Interchange
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
ASU	Arizona State University
ATDTS	Automated Technical Data Tracking System
BFD	Basis for Design
CAI	Color Alteration Index
CAR	Corrective Action Request
CCDF	Complementary Cumulative Distribution Function
CCL	Commitment Control Log
CCM	Constant Capacitance Model
CD-R	CDROM Recordable
CDM	Compliance Determination Method
CDROM	Compact Disk Read Only Memory
CDS	Compliance Determination Strategy
CDTS	Commission Decision Tracking System
CEB	Center for Environmental Biotechnology
CEC NAWG	European Community Natural Analog Working Group
CFD	Computational Fluid Dynamics
CM	Configuration Management
CNWRA	Center for Nuclear Waste Regulatory Analyses
COI	Conflict of Interest
COPS	CNWRA Operations
CQAM	CNWRA Quality Assurance Manual
CRG	Center Review Group
CRWMS	Civilian Radioactive Waste Management System
CSCS	Constrained Stochastic Climate Simulator
DAS	Data Acquisition System
DBE	Design Basis Event
DC	Division of Contracts
DCAA	Defense Contract Audit Agency
DECOVALEX	Development of Coupled Models and Their Validation Against Experiments in Nuclear Waste Isolation
DEM	Digital Elevation Model
DFCSS	Division of Fuel Cycle Safety & Safeguards
DIE	Determination of Importance Evaluation
DIMNS	Division of Industrial & Medical Nuclear Safety
DLG	Digital Line Graph
DLM	Diffuse Layer Model
DNAG	Decade of North American Geology
DNFSB	Defense Nuclear Facilities Safety Board
DOE	U.S. Department of Energy
DRA	Division of Regulatory Applications
DTED	Digital Terrain Elevation Data
DWM	Division of Waste Management
EBS	Engineered Barrier System
EBSPAC	Engineered Barrier System Performance Assessment Code
EDO	Office of the Executive Director for Operations
EDS	Energy-Dispersive Spectrometry
EDX	Energy-Dispersive X-Ray Spectroscopy
EIS	Environmental Impact Statement
EM	Element Manager
EMPA	Electron Microprobe Analysis
EPA	U.S. Environmental Protection Agency
EPR	Electrochemical Potentiokinetic Reactivation
EPRI	Electric Power Research Institute
EQA	External Quality Assurance
EROS	Earth Resource Observation System
ESF	Exploratory Studies Facility
EXAFS	Extended X-Ray Absorption Fine Structure
FAC	Favorable Condition
FCRG	Format and Content Regulatory Guide
FD&SHA	Fault Displacement and Seismic Hazard Analysis
FEM	Finite Element Method
FFT	Fast Fourier Transform
FIN	Financial Identification Number
FTE	Full Time Equivalent
FTP	File Transfer Protocol
FY	Fiscal Year
GEM	General Electrochemical Migration
GEOTRAP	GEOlogic Transport of RAdionuclides Predictions

LIST OF ABBREVIATIONS (cont'd)

GERT	General Employee Radiological Training
GET	General Employee Training
GHGC	Geohydrology and Geochemistry
GIS	Geographic Information System
GLGP	Geology and Geophysics
GPS	Global Positioning Satellite
GROA	Geologic Repository Operations Area
GS	Geologic Setting
GSA	Geologic Society of America
GUI	Graphics User Interface
GWSI	Groundwater System Integration
GWTT	Groundwater Travel Time
HLUR	HLW and Uranium Recovery Projects Branch
HLW	High-Level Waste
HRTEM	High-Resolution Transmission Electron Microscopy
ICP-AES	Inductively Coupled Plasma-Atomic Emission Spectrometry
IHLRWM	International High-Level Radioactive Waste Management Conference and Exposition
IM	Intermediate Milestone
IMS	Information Management Systems
INEL	Idaho National Engineering Laboratory
INTRAVAL	International Code Validation
I/O	Input/Output
IPA	Iterative Performance Assessment
IRM	Office of Information Resources Management
IVM	Interactive Volume Modeling
IWPE	Integrated Waste Package Experiments
JC	Job Code
JPL	Jet Propulsion Laboratory
JRC	Joint Roughness Coefficient
KTU	Key Technical Uncertainty
LAN	Local Area Network
LANL	Los Alamos National Laboratories
LARP	License Application Review Plan
LBL	Lawrence Berkeley Laboratory
LHS	Latin Hypercube Sampling
LITC	Lockheed Information Technology Company
LLNL	Lawrence Livermore National Laboratory
LWR	Light Water Reactor
MGDS	Mined Geologic Disposal System
MH	Mechanical-Hydrological
MIT	Massachusetts Institute of Technology
MM	Major Milestone
M&O	Management and Operations
MPC	Multi-Purpose Canister
MRS	Monitored Retrievable Storage
MSS	Multispectral Scanner
NAS	National Academy of Science
NAWG	Natural Analogs Working Group
NCR	Nonconformance Reports
NFS	Network File Server
NMSS	Office of Nuclear Material Safety & Safeguards
NOAA	National Oceanographic and Atmospheric Administration
NRC	U.S. Nuclear Regulatory Commission
NSRRC	Nuclear Safety Research Review Committee
NTS	Nevada Test Site
NWPA	Nuclear Waste Policy Act, as amended
NWTRB	Nuclear Waste Technical Review Board
OBES	Office of Basic Energy Sciences
OCRWM	Office of Civilian Radioactive Waste Management
OGC	Office of General Counsel
OITS	Open Item Tracking System
OPS	Operations Plans
ORS	Overall Review Strategy
OWFN	One White Flint North
PA	Performance Assessment
PAAG	Performance Assessment Advisory Group
PAC	Potentially Adverse Condition
PAC/FAC	Potentially Adverse Condition/ Favorable Condition
PA&HT	Performance Assessment and Hydrologic Transport
PASP	Performance Assessment Strategic Plan
PC	Personal Computer
PC/TCP	Personal Computer/Transmission Control Protocol
PCT	Product Consistency Test
PEM	Program Element Manager
PFD	Probabilistic Fault Displacement
PI	Principal Investigator
PMDA	Program Management Decision Analysis Staff
PMPR	Program Manager's Periodic Report
PNL	Pacific Northwest Laboratory
PO	Project Officer
PPA	Proposed Program Approach
PRA	Probabilistic Risk Assessment
PSAG	Probabilistic System Assessment Group
PSHA	Probabilistic Seismic Hazard Analysis
PTFE	Polytetrafluoroethylene
PVM	Parallel Virtual Machine
QA	Quality Assurance
QAP	Quality Assurance Procedure
RASA	Regional Aquifer-System Analysis

LIST OF ABBREVIATIONS (cont'd)

RDCO	Repository Design, Construction, and Operations
REE	Rare Earth Element
REECO	Reynolds Electrical & Engineering Company, Inc.
RES	Office of Nuclear Regulatory Research
RFA-ROC	Repository Functional Analysis—Repository Operations Criteria
RIC	Repository Isolation Criteria
ROC	Repository Operations Criteria
RPD	Regulatory Program Database
RRT	Regulatory Requirement Topic
RSRG	Real Space Renormalization Group
SAIC	Science Applications International Corporation
SAR	Safety Analysis Report
SCA	Site Characterization Analysis
SCC	Substantially Complete Containment
SCCEX	Substantially Complete Containment Example
SCM	Surface Complexation Models
SCP	Site Characterization Plan
SELM	Spectral Element Method
SEM	Scanning Electron Microscopy
SER	Safety Evaluation Report
SGML	Standard Generalized Markup Language
SHE	Standard Hydrogen Electrodes
SKI	Swedish Nuclear Power Inspectorate
SLAR	Side Looking Airborne Radar
SNL	Sandia National Laboratories
SOW	Statement of Work
SRA	Systematic Regulatory Analysis
SRB	Sulfate-Reducing Bacteria
SRBS	Shafts, Ramps, Boreholes, and their Seals
SS	Stainless Steel
STEM	Scanning Transmission Electron Microscopy
STP	Staff Technical Position
SUFLAT	Stochastic Analyses of Unsaturated Flow and Transport
SVF	Springerville Volcanic Field
SwRI	Southwest Research Institute
TBD	To Be Determined
TBM	Tunnel Boring Machine
TDAS	Technical Database Access System
TDI	Technical Document Index
TDOCS	Technical Document Reference Database System
TEM	Transmission Electron Microscopy
THMC	Thermal-Hydrologic-Mechanical-Chemical
TLM	Triple Layer Model
TM	Thematic Mapper
TMH	Thermal-Mechanical-Hydrologic
TMS	The Minerals, Metals, and Materials Society
TOP	Technical Operating Procedure
TP	Technical Position
TPA	Total Performance Assessment
TRP	Technical Review Group
TSPA	Total System Performance Assessment
TSw-Chnv	Topopah Spring-Calico Hills
TWFN	Two White Flint North
UA	University of Arizona
UDEC	Universal Distinct Element Code
UNM	University of New Mexico
U.S.	United States
USDA	U.S. Department of Agriculture
USGS	U.S. Geologic Survey
UTM	Universal Transverse Mercator
VCS	Version Control System
VF	Vitrification Facility
WAN	Wide Area Network
WBS	Work Breakdown Structure
WGB	Western Great Basin
WIPP	Waste Isolation Pilot Plant
WMB	Waste Management Branch
WP	Waste Package
WSE&I	Waste Systems Engineering and Integration
WSS	Waste Solidification Systems
WTSO	Washington Technical Support Office
WVDP	West Valley Demonstration Project
WVNS	West Valley Nuclear Services
XPS	X-ray Photoelectron Spectroscopy
XRD	X-ray Diffractometry
YM	Yucca Mountain
YMP	Yucca Mountain Project
YMSCO	Yucca Mountain Site Characterization Office
YMR	Yucca Mountain Region

EXECUTIVE SUMMARY — PERIOD 6

In the Division of Waste Management (DWM) Job Code (JC), the following outlines the Center for Nuclear Waste Regulatory Analyses (CNWRA) key activities and accomplishments:

- The Quality Assurance (QA) staff, together with DWM staff participated in the second phase of the Management & Operations (M&O) Baseline QA Audit in Las Vegas, Nevada and the Lawrence Livermore National Laboratory QA Audit in Livermore, California.
- The Geology/Geophysics staff augmented the capability of the CNWRA Geographic Information System.
- The Geohydrology/Geochemistry staff completed the KTU integration reports for issues related to Geochemical Retardation and Groundwater.
- The Repository Design, Construction, and Operations staff completed review of the Study Plan on Laboratory Determination of Mechanical Properties of Fractures and two reports: (i) Initial Summary Report for Repository/ Waste Package Advanced Conceptual Design, and (ii) Exploratory Studies Facility Title II Design Package 2C.
- The Performance Assessment staff submitted a report entitled Input to the Draft Staff Technical Position on Elicitation of Expert Judgment.

The DWM JC year-to-date cost variance is 13.7 percent. This variance reflects a small reduction from last period. Reactive work has been limited in several elements, but activities related to site characterization reviews increased slightly. The greatest underspending, about 45 percent of the total, is in Regulatory Requirements and Technical Guidance (Task 1).

In the Office of Nuclear Regulatory Research (RES) JC, the following outlines the CNWRA key activities and accomplishments:

- The CNWRA submitted its Semi-Annual Research Report.
- Staff presented the final results from the Thermohydrology Research Project. Recommendations regarding future work were included as part of this presentation.
- The Rock Mechanics Research Project staff completed preparation of Chapter 18 (Dynamic Behavior of Rock Joints) for a DECOVALEX book and submitted same to the DECOVALEX Secretariat.
- The IWPE Research Project staff submitted a report entitled Effects of Surface Chromium Depletion on Localized Corrosion of Alloy 825 as a High-Level Waste Container Material.
- The Volcanic Systems of the Basin and Range Research Project staff completed a paper titled Three Nonhomogeneous Poisson Models for the Probability of Basaltic Volcanism: Application to the Yucca Mountain Region, Nevada, USA, which has been accepted for publication in the Journal of Geophysical Research.
- The Tectonic Processes in the Central Basin and Range Research Project staff made a poster presentation entitled Digital Elevation Models Applied to Basin and Range Tectonics Research at the annual meeting of the American Association of Geographers.
- The Performance Assessment Research staff submitted a paper entitled Mixed Transform Finite Element Method for Solving the Equation for Variably Saturated Flow.

The RES JC year-to-date cost variance is 14.4 percent. This variance remained essentially the same as last period even though there was underspending and overspending in some of the research projects.

In the Division of Industrial & Medical Nuclear Safety (DIMNS) JC, CNWRA staff submitted a document entitled Comment Resolution with West Valley Demonstration Project (WVDP).

The DIMNS JC year-to-date cost variance of −21.1 percent.

CNWRA PROGRAM MANAGER'S PERIODIC REPORT ON ACTIVITIES OF THE CENTER FOR NUCLEAR WASTE REGULATORY ANALYSES

TITLE: Center for Nuclear Waste Regulatory Analyses

CONTRACTOR: Southwest Research Institute
6220 Culebra Road, San Antonio, Texas 78238-5166

CONTRACT NO: NRC-02-93-005

JOB CODES: D1035, L1793, B6666

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ESTIMATED BUDGET: $89,898,141

PERIOD OF PERFORMANCE: 10/15/92-9/26/97

PERIOD OF THIS REPORT: 2/18/95-3/17/95

1. TECHNICAL

1.1 *CNWRA Operations (COPS)*

The NRC and CNWRA management actively coordinated meetings and telephone conferences to address a wide range of important day-to-day programmatic issues as well as long-term management topics. CNWRA management staff continued its coordination with specific personnel from the PMDA, DWM, RES/DRA, and DC, responding to *ad hoc* requests for information addressing management issues affecting the conduct of CNWRA work. Both formal and informal NRC DWM budget (C-3) development meetings, recommending resource allocation for FY96-97, continued during this period. CNWRA senior management continued further discussions with various NRC staff relative to: (i) current status of the DOE Program Approach, (ii) implementation of the CNWRA Network Security, (iii) status of identifying a single point of contact for RPD/TDOCS, (iv) CNWRA/SwRI capabilities to perform possible MPC work related to storage and transport, (v) status of an SOW on materials research and proposal for follow-on work in hydrology, and (vi) schedule for NRC/CNWRA staff exchanges.

The current status of CNWRA staffing is indicated in Table 1. Recruitment efforts and interviews continued for open positions. Offers were made for a structural geologist and a performance assessment professional. Drs. E. Pearcy and N. Sridhar were appointed

to Element Manager of the Geohydrology and Geochemistry Element, and the Engineered Barrier Systems Element, respectively.

The CNWRA conveyed change pages to its Operations Plans for the DWM in response to the NRC letter of February 24, 1995. Item one of that letter received an approved extension for its delivery date until resolution of the addition of a milestone in the PA Element is resolved.

Following the last NRC/CNWRA meeting, when agreement was reached on revisions to software QA procedures at the CNWRA, progress has been made to complete minor changes to the QA Manual and finish the revision to TOP-018 dealing with software QA. Comments provided by NRC staff were incorporated into TOP-018 and, during this period, CNWRA Element Managers had an opportunity to make their final comments on the procedure. Other internal QA activities included: (i) QAP-002 verification of review of outgoing CNWRA products, (ii) participation by QA staff in COI Management Committee meetings, (iii) review of SwRI Requests for Proposal to verify no organizational COI, and (iv) indoctrination of new staff members to the CNWRA QA program.

TDOCS development continued during this period. The TDOCS Design Report is expected to be completed and submitted in the next period. Work will begin on the TDOCS Database Synchronization Design Report, and other work continued on the migration of TDOCS to the Solaris operating system and the Oracle V7.0 database software. Cognizant CNWRA staff continue to participate in discussions with appropriate NRC staff concerning the timing and approach for completing the TDOCS Initial Data Loading Plan (IM 5702-156-540).

The CNWRA received comments from the NRC DWM and IRM staff on the FY95 CNWRA Computer Security Plans (IM 5702-157-510). The comments on both plans will be discussed with the appropriate NRC contacts to resolve them and change the plan accordingly. Implementation of the CNWRA Firewall System (IM 5702-157-550) remains on schedule. A brief test plan that includes the performance of tests by the CNWRA, NRC IRM, and an independent contractor is being discussed. The NFS Mass Storage System is functioning in a pilot test mode pending installation of the Tape Cartridge Backup System. Partial migration and testing of cc:Mail and shared disk drive applications to this system continued. Negotiations by the NRC with LITC for use of their CRAY systems are nearing completion and should provide both the NRC and CNWRA with the same rate under separate contracts to be established with LITC. Benchmark tests on the LITC CRAY for PVM executions indicated about a four to one improvement in throughput performance as compared to the INEL CRAY XMP. CNWRA/NRC communication continues to improve each month in the teleconference calls to coordinate work on the new LAN Security system and resolution of problems on other LAN systems, such as e-Mail.

The following activities are expected to occur during the next period.

The CNWRA will pursue resolution of outstanding management issues and continue responding to *ad hoc* requests for information on CNWRA operations. A visit by the

Office Director for NMSS along with other NRC staff is planned for next period. In addition, an NRC/CNWRA Management Meeting will be held at San Antonio along with the visit by newly appointed NMSS senior management from NMSS/DWM and RES/DRA.

Recruitment and interviews will continue for the CNWRA core and limited-term staff. At least two additional offers are expected to be made, one in geohydrology and one in engineering geology.

Changes to certain project plans will be sent to the NRC. Further, necessary modifications will be made to the Revision 5 Change 1 pages in the FY95 Operations Plans for the DWM.

CNWRA QA staff will: (i) complete the change to the CNWRA QA Manual and the revision to the computer software TOP-018 procedure, and distribute both as controlled documents to designated recipients at the CNWRA and the NRC; (ii) participate in the regular COI Management Committee Meetings; (iii) conduct QA indoctrinations for new staff; (iv) continue CNWRA QA Records processing and maintenance; and (v) perform appropriate surveillances on project and task work.

The CNWRA will install the TDOCS Prototype (IM 5702-156-520) when the necessary NRC-provided software becomes available, and provide the TDOCS User Guide with installation of the prototype server with Windows and UNIX clients.

The CNWRA will complete the installation, configuration, and preoperational testing of the CNWRA Firewall System by April 7, 1995, and resolve the NRC DWM and IRM comments on the FY95 Computer Security Plans for the LAN and RPD/TDOCS. Further migration of applications to the NFS Mass Storage will be accomplished. It is expected that a subcontract will be finalized with LITC for use of CRAY services by CNWRA users. The CNWRA will continue to support its LAN and provide design consultation on the DWM ACRS, as necessary.

1.2 *Waste Systems Engineering and Integration (WSE&I)*

No tasking was received for support on NWPA-mandated actions. The CNWRA expects to be tasked later in the FY as the DOE revised program evolves.

In the LARP Development subtask, KTU integration continued with working groups completing their draft reports and starting technical reviews. The results of this effort will be submitted as a Letter Report on Recommended NRC Actions to Address KTUs (IM 5702-221-511) on March 31, 1995. Work on an agenda for a LARP development workshop to be conducted for DWM and CNWRA staffs was delayed pending completion of the LARP Roadmap which is being developed jointly with the NRC. The date for this workshop has not been determined. A number of CDM development activities have started recently, with WSE&I providing guidance to aid in integrating these efforts.

No tasking for WSE&I special projects was received this period.

RPD and OITS operation and maintenance efforts continued. Significant progress was made on the MacIntosh port of RPD during this period, but additional effort is needed to complete this platform porting. The installation of RPD/OITS at the NRC is being delayed until network security upgrades have been installed. Work on updating the SCA open items continued this period. Updating of the SCA open items should be finished by the end of Period 7. The open items are being completed based on a prioritization of: (i) SCA open items, (ii) study plan open items, and (iii) other open items. Following NRC approval, the completed open items will be loaded into RPD/OITS. Work will begin in Period 7 on developing and formatting study plan open items. WSE&I staff assisted the NRC in long-range planning for general computer needs as well as for the specific needs of the RPD/OITS system.

In the next period, the WSE&I staff will focus on the following areas: (i) producing CDMs; (ii) developing porting software to support the installation of the RPD on the MacIntosh computer platform; (iii) coordinating LARP development activities throughout the CNWRA, including conducting training necessary to support CDM preparation; (iv) revising the list of CDMs for development in FY95 to address DOE high-level findings for surface processes; (v) delivering the KTU recommendations report (IM 5702-221-511); (vi) continuing preparation of SCA open items and beginning work on the study plan open items; (vii) finalizing the LARP roadmap; and (viii) continuing work on plans for accelerated CDM development and a LARP workshop.

1.3 *External Quality Assurance (EQA)*

During this period, CNWRA QA staff members participated with NRC staff in the second phase of the M&O Baseline QA Audit in Las Vegas, Nevada (IM 5702-331-504) and in the LLNL QA Audit in Livermore, California (IM 5702-331-505). The observation audit reports which form the basis for the final NRC report were initiated and will be completed during the next period.

The CNWRA and NRC QA staffs held numerous discussions during the period concerning the observation audit, meeting, and field verification schedule for the remainder of FY95. These discussions focused on the planned NRC field verification activity of the M&O in Nevada and the availability of CNWRA QA staff to support such work.

The NRC field verification of the M&O operations in Nevada (IM 5702-332-501), with CNWRA QA and technical staff participation, will be conducted next period. CNWRA QA staff has also been discussing with NRC QA staff the best approach to construct a short but effective performance based field verification/inspection course for NRC staff.

1.4 *Geology and Geophysics (GLGP)*

During Period 6, work has focused on writing the major milestone on normal fault hangingwall deformation that is due on April 24, 1995. This milestone is entitled Computer Simulation of Fault-Block Scale Tectonic Deformation (MM 5702-425-503).

Work continued on the KTU integration report for volcanism and tectonics/seismicity with CNWRA review of completed drafts begun. The Evidence of Extreme Erosion CDM (3.2.1.10) was commented upon by NRC staff and some issues remain to be settled on the appropriate language for the document. Draft CDMs on Evidence of Dissolution (3.2.1.4), Minimum Waste Emplacement Depth (3.2.1.2), and Historical Earthquakes (3.2.1.6) were begun.

The GLGP Element also contributed to CDM 6.1, Assessment of Compliance with the Requirement for Cumulative Release of Radioactive Materials. A revision of the Testing of SEISM 1.1: Sensitivity Analysis report was prepared.

During this period, the YM PSHA calculation reported in CNWRA Report 94-013 was disaggregated and a draft internal report on the topic was prepared. This is a joint effort of the GLGP, PA, and RDCO staffs. The disaggregation provides a basis for selection of initial time functions for methodology development and calculations to determine the dynamic response of YM facilities by the CNWRA RDCO Element.

GLGP staff attended a week-long USGS/DOE meeting held to determine YM PSHA data needs for the DOE. This meeting, one of several to be held, concentrated on the development of faulting scenarios at YM based on available field mapping and interpretation.

Preparation for a presentation on PSHA efforts at CNWRA to an ACNW meeting to be held about April 12, 1995 was begun.

Refinement of the 3D geological framework model is continuing. Three new geological cross sections have been located and are being constructed for providing additional subsurface control on positions of stratigraphic horizons and faults. At least one of these cross sections will be balanced.

The following aspects have been improved or added in the 3D model: (i) eight stratigraphic units are now in the model, including CFUn (nonwelded, undifferentiated Crater Flat) and BFw (welded Bullfrog Hills) as the two newly-added units; (ii) Surface geology has been refined to illustrate units which should be reflected on a surficial geologic map; (iii) Stratigraphic horizon-fault intersections have been refined so that the horizons now show more realistic geometry on both sides of the faults; and (iv) The water table surface has been added to the model. In addition, data have been catalogued to make it possible to add alluvium to the model in an upcoming iteration.

Selected static and near-static GIS coverages of general interest have been archived to CD-R media. Version 0.12 of the CD-R has been delivered to NRC staff as previously agreed. Telephone assistance has been given to an NRC contractor to achieve successful startup of GIS from CD-R.

The GIS library and geospatial database support software, ARC/Info, has been upgraded from version 6.1 to 7.0 on the CNWRA SGI ONYX workstation.

A commercial *point and click* access interface to the GIS library, ARCVIEW2, has been installed on the SGI ONYX workstation. ARCVIEW2 is being explored as a tool to assist nonexpert access to the GIS library. It is being tested with library coverages stored in the GIS library. ARCVIEW2 is designed to promote general access.

Effort to establish a card catalog index to the GIS library has begun. Vector coverages are being rasterized to browse images. This will allow non-ARC/Info users to use their file managers (on SUN and OS/2) and their finders (on MacIntosh) to preview GIS library contents via NFS. Individuals wishing to browse may double-click on image rasterizations of vector coverages to view contents before integrating map coverages into their related reports.

Work will continue on CDM development and KTU integration. CNWRA staff will support the NRC during a telephonic meeting on the talking points generated from the review of the Dorn and Krinsley (1994) report entitled New Perspectives on Colluvial Boulder Deposits in the Southwestern Great Basin, USA. Fault-dike interaction modeling is anticipated to begin next period.

Completion of the major milestone on normal fault hangingwall deformation entitled Computer Simulation of Fault-Block Scale Tectonic Deformation (MM 5702-425-503) is anticipated during the next period.

During Period 7, the GLGP Element will prepare for and participate in the semiannual program review at White Flint. A presentation on PSHA will be given to the ACNW.

1.5 *Geohydrology and Geochemistry (GHGC)*

CDM development continued, with increasing interaction between CNWRA and NRC staffs. A first draft was prepared for CDM for RRT 3.2.3.4 PAC—Groundwater and the EBS (IM 5702-423-503) and circulated to NRC/CNWRA staff. Detailed outlines were also developed for CDMs for RRT 3.2.2.10 PAC—Complex Engineering Measures (IM 5702-423-506) and RRT 3.2.2.12 PAC—Perched Water Bodies (IM 5702-423-505). The CDM for RRT 3.2.2.5 PAC—Flooding (IM 5702-423-501) is largely complete, but the NRC/OGC has not completed its review, and technical review at the CNWRA cannot yet be initiated.

KTU integration reports for issues related to Geochemical Retardation and Groundwater have been completed and are currently in the CNWRA review cycle in preparation for a March 31, 1995 deliverable (IM 5702-221-511).

Work continued on modifications to the 3D hydrologic framework model, including borehole data on porosity and hydraulic conductivity. CNWRA staff have prepared proposals for initiating technical assistance efforts in geochemistry. These efforts are designed to focus on geochemical retardation using mechanistic models developed in the Sorption Research Project, and a limited-scale study of thermodynamic data for solids and aqueous species involving key radionuclides.

CNWRA staff participated in the preparation and the dry run rehearsals for the NRC staff presentations that were made to the ACNW on March 16, 1995.

Outlines for Appendices C (General Approach to Assessing Uncertainty) and D (Repository Induced Conditions that Could Affect GWTT) have been prepared for inclusion into the draft Staff Technical Position on GWTT (IM 5702-412-502).

An invited abstract entitled Uncertainty Reduction in the Implementation of a Geologic HLW Repository Performance Regulation Using Subsurface Flow Models was submitted to AGU for presentation at the spring meeting.

Effort will continue in the development of CDMs RRT 3.2.3.4—Groundwater Conditions and the EBS, RRT 3.2.2.10—Complex Engineering Measures, and RRT 3.2.2.12—Perched Water. Technical reviews of the CDM for RRT 3.2.2.5 PAC—Flooding (IM 5702-423-501) will be initiated after comments from the NRC OGC are received and resolved. Assessment of the computer code FEHM will continue under GWTT.

1.6 *Engineered Barrier Systems (EBS)*

Integration activities for the KTUs in the EBS area continued in conjunction with the WSE&I Element. Comments on the three consolidated KTUs: (i) Uncertainty in Prediction of the Environment Near and Within the EBS, (ii) Uncertainty in Prediction of Effects on the Waste Package During the Containment Period, and (iii) Uncertainty in Prediction of the Effects on the EBS During the Post-Containment Period, received from the NRC and from CNWRA team members, were addressed in revised versions. The three KTUs have been reviewed technically in the CNWRA and the technical reviewer comments have been addressed. Work on CDM for review plan 3.2.3.4 on the interaction between groundwater conditions and the EBS was continued. Technical support, in the form of bullet items for an annotated outline, is being provided to the PA Element in the preparation of CDM 6.1 related to assessment of compliance with requirement for cumulative releases of radioactive materials. Technical support is also being provided for CDMs 6.2 and 6.3 related to assessment of compliance with individual and groundwater protection requirements, respectively.

Technical support was provided to the WSE&I element in reviewing entries related to the EBS including waste package, spent fuel, and vitrified waste forms, for the Open Item Standard Reports. These reports document the status of resolved and unresolved items from the DOE responses to the NRC-SCA (NUREG-1347) along with citations of the supporting documents or basis.

The modification of the GEM code to incorporate the Butler-Volmer equation for the rate of electrochemical interfacial reactions was continued during this period. A draft version of the requirements document for MULTIFLO was written and will be sent for review during the next period. Discussions were held with PA staff, CNWRA management, and, later, with NRC staff on the connection between the models and codes developed for detailed analyses and simpler codes that will be used in CDMs and IPA.

Revision of the colloids report is in progress. Revision from one coauthor have been received. The contributions of the other coauthors are expected before the March 31, 1995 deadline. A working group meeting of all the coauthors will be held in San Antonio during the week of May 15, 1995.

Work on revising and extending CDM 5.2 will begin with the gathering of appropriate technical staff. The requirements document for MULTIFLO will be completed for technical review.

1.7 *Repository Design, Construction, and Operations (RDCO)*

The RDCO Element concentrated on the following activities: (i) developing CDMs and integrating KTUs; (ii) evaluating computer codes for compliance determination, rock joint model development, and developing a rock properties database; (iii) reviewing prelicensing reports and conducting prelicensing interactions; (iv) field verification and analysis; and (v) performing ESF design review and ACD review work.

The development of the CDM for RRT 4.3—Shafts and Ramps Design continued during this period. This included CDM development activities on Section 3.2.2—10 CFR 60.130 and Section 3.26—10 CFR 60.131(b)(9) of this RRT. The full CDM development on Shafts and Ramps Design will be documented in a report that will be submitted to the NRC to fulfill milestone CDM for RRT 4.3—Shafts and Ramps Design (IM 5702-621-501). The integration of THMC, retrievability, and seals KTUs continued during this period. This work was conducted under the scope of RDCO Element Subtask 2.1 of the FY95 OPS.

Computational testing of two problems for the evaluation of the finite element code ABAQUS continued. The objectives of this testing activity are to identify and document the simulation capabilities of the ABAQUS code, with particular attention to problems involving coupled thermal, mechanical, and hydrological processes. This information will be used to formulate code refinements and improvements. The testing of ABAQUS will be documented in a report that will be submitted to the NRC to fulfill the milestone ABAQUS Code Evaluation Final Report (MM 5702-623-503). This work was conducted under the scope of RDCO Element Subtask 2.3 of the FY95 OPS.

Development of a rock joint constitutive model continued. The establishment of a correlation between the fractal properties of Apache Leap tuff joints and joint roughness coefficient is in progress. The objective of this activity is to develop a model for the rock joint responses under cyclic pseudostatic and dynamic loads which can be incorporated in UDEC, 3DEC, and ABAQUS codes. A report detailing the progress of this model development activity has been completed and was submitted to the NRC on January 31, 1995 to fulfill the milestone Seismic Rock Joint Model Development Preliminary Report (IM 5702-623-501). The final report will document the model and the associated development processes and will be submitted to the NRC to fulfill the milestone Seismic Rock Joint Model Development Final Report (IM 5702-623-504). This work was conducted under the scope of RDCO Element Subtask 2.3 of the FY95 OPS.

Evaluation of Type 3 CDM codes continued. Three draft chapters on Radiation Shielding, Underground Ventilation, and Radiation Dose Calculation have been prepared. The preparation of the chapter on Criticality Calculation is in progress. The objective of this activity is to assess the capabilities of several codes, based on reported information, to evaluate their suitability for use during CDM Type 3 reviews. This activity will be documented in a report that will be submitted to the NRC to fulfill the milestone report on CDM Codes for Type 3 Assessment (IM 5702-623-502). This work was conducted under the scope of RDCO Element Subtask 2.3 of the FY95 OPS.

The preparation of In-Field Verification Checklist for NRC's independent verification of the DOE/M&O ESF activities was initiated during this period. S. Hsiung of the CNWRA RDCO element will participate in this independent verification activity to be held in Las Vegas on April 3-6, 1995.

Review of the Study Plan 8.3.1.15.1.4—Laboratory Determination of the Mechanical Properties of Fractures has been completed and submitted to the NRC to fulfill the milestone Technical Report/Study Plan Review Report No. 2 (IM 5702-641-522). This work was conducted under the scope of RDCO Element Subtask 4.1 of the FY95 OPS.

A revision of the draft report on the review of the Initial Summary Report for Repository/Waste Package ACD dated August 29, 1994 continued. The objective of this activity was to review the DOE Repository ACD to assist the NRC in providing input to the DOE in a timely manner. The scope of the ACD review also included review of the DOE document, FY93 Thermal Loading Systems Study Final Report, Vols. 1 and 2. The review comments report will be submitted to the NRC to fulfill the milestone Major Design Report Reviews No. 1 (IM 5702-642-501). The revision of the draft report on the review of the revised version of the ESF Title II Design Package 2C is also in progress. The objective of this review is to assist the NRC in providing input to the DOE in a timely manner during in-field verification of the TBM excavation of ESF North Ramp. The review comments will be submitted to the NRC to fulfill the milestone Major Design Report Reviews No. 2 (IM 5702-642-502). This work was conducted under the scope of RDCO Element Subtask 4.2 of the FY95 OPS.

During the next period, activities within the RDCO Element will include: (i) work on the CDM on Shafts and Ramps Design; (ii) integration of KTUs; (iii) development of the rock-joint model, evaluation of ABAQUS, assessment of Type 3 CDM Codes, and development of rock properties database; (iv) participation in field verification; (v) participation in prelicensing activities; and (vi) work on ESF Title II Design Package 2C Review and Repository Advanced Conceptual Design Review.

1.8 *Performance Assessment (PA)*

The PA Element made significant progress on the following activities: (i) completing a technical report on expert judgment, (ii) contributing to the KTU consistency/integration review, (iii) conducting various auxiliary analyses for IPA, and (iv) initiating IPA Phase 3 planning.

The document entitled Input to the Draft Staff Technical Position on Elicitation of Expert Judgment (CNWRA 95-006) was completed and submitted on schedule to the NRC. The report fulfills the milestone Proposed Basis for NRC Technical Position on Elicitation Procedure for Expert Judgment (MM 5702-712-410). This work is being conducted under the scope described in the PA Element Subtask 1.2 of the OPS.

The chapter on the PA KTU integration was completed and incorporated in the KTU integration report. This report is a deliverable under the WSE&I element. In addition, work was initiated on the preparation of CDMs 6.1—Assessment of Compliance with the Requirements for Cumulative Releases of Radioactive Materials and 6.2—Assessment of Compliance with the Requirements with the Individual Protection Requirements. An annotated outline for these CDMs was prepared and submitted to M. Lee (NRC) for review and comment. This work was conducted under the scope described in the PA Element Subtask 2.1 of the OPS.

A paper was prepared to document progress on the shallow infiltration auxiliary analysis. The paper, which is currently in the CNWRA review process, summarizes the methodology developed to predict shallow infiltration. The model is expected to be used to develop a probabilistic representation of infiltration rate for use in the TPA code. The paper will be completed in the next reporting period and will fulfill the milestone Paper on Infiltration Model (IM 5702-723-445). This work was conducted under the scope described in the PA Element Subtask 2.3 of the OPS.

Work continued on the deep percolation auxiliary analysis for YM. Current work has focused on examining spatial variation in percolation due to topographic effects and how these effects impact focusing of deep percolation. A report will be prepared to fulfill the milestone Report on Deep Percolation Analysis (IM 5702-723-520), which is due September 29, 1995. This work is integrated and coordinated with the GHGC Subregional Hydrology Project, and is being conducted under the scope described in the PA Element Subtask 2.3 of the OPS.

Limited work was performed on the auxiliary analysis of the carbon system at YM. This work is intended to produce an abstracted response surface model that can be used in the TPA code. A paper describing the method and results from this work will be prepared to fulfill the milestone Paper on Carbon System Model (IM 5702-723-545) due August 31, 1995. This work is an integrated activity performed by the PA, GHGC, and EBS staffs. This work is being conducted under the scope described in the PA Element Subtask 2.3 of the OPS.

Work continued on the development of the 3D hydrostratigraphic model for YM. Due to competing priorities, this work was slowed and will be completed in late summer in order to accelerate work on the FAULTING module. This work is being conducted under the scope described in the PA Element Subtask 2.3 of the OPS.

Significant effort was spent on completion of the technical description for a new FAULTING module for the TPA code. The new module will consider the consequences of a fault displacement in the repository block on waste-package failure. A draft of the technical description was prepared. A CNWRA letter report is being prepared to fulfill

the milestone Report on Technical Description for Faulting Module (IM 5702-723-505) due April 28, 1995. This work is being performed as an integrated activity between PA and GS staffs at the CNWRA, and S. McDuffie (NRC). This work is being conducted under the scope described in the PA Element Subtask 2.3 of the OPS.

Work continued on the sensitivity analysis of site-specific dose parameters for the YM site. This sensitivity analysis, which considers 43 parameter distributions and 20 radionuclides, is nearly complete. Simple rank correlations were calculated to aid in describing the relationship between individual input parameter distributions and the variation in total annual effective dose equivalent results. Documentation of the sensitivity analysis was initiated and is expected to be completed in the near-term. This work is being performed as an integrated activity between the PA and WSE&I staffs. Portions of this work are expected to contribute to the milestone Letter Report on Assessment of Key Radionuclides (IM 5702-723-540). This work is being conducted under the scope described in the PA Element Subtask 2.3 of the OPS.

Work continued on an updated assessment of the importance of key radionuclides for PA and compliance determination. A literature review was completed and recent TSPA reports from the DOE were reviewed in detail. A method for gauging the importance of specific radionuclides was developed based on an importance index that accounts for source inventory, release rates, travel time, and dose conversion factors. This work is being performed as an integrated effort among the GS, EBS, and PA Elements. The results of this work will be documented and submitted to the NRC to fulfill a Letter Report on Assessment of Key Radionuclides (IM 5702-723-540) that is due on May 31, 1995. This work is being conducted under the scope described in the PA Element Subtask 2.3 of the OPS.

An auxiliary analysis on near-field thermally driven flow neared completion and a draft paper has been prepared and submitted for CNWRA review. The paper summarizes a model for a single waste package which can be used to estimate the thermohydrologic conditions out to approximately 5 m from the waste packages. The paper will be submitted to the NRC on May 15, 1995, to fulfill the milestone Paper on Near-Field Coupled Liquid, Vapor, and Heat Transport (IM 5702-723-530). This work is being performed as an integrated effort with the EBS Element and is in the scope of the PA Element Subtask 2.3 of the OPS.

Work continued on a new auxiliary analysis of drift stability leading to rock-induced waste package failure for a new disruptive scenario in IPA Phase 3. This work is to evaluate the potential for rock falls in the emplacement drifts at YM. The information generated from this task will be used in the source-term calculation. This work consists of three activities. The first two are the collection of rock mass mechanical properties and development of earthquake strong-motion functions relevant to YM. The data generated from the first two activities will be used as input to a numerical drift stability analysis using the UDEC computer code. Current efforts are directed at developing seismic time functions that are representative of the YM site. This work is being performed as an integrated activity between PA, RDCO, and GS staffs. This work is being conducted under the scope described in the PA Element Subtask 2.3 of the OPS.

A significant amount of effort was expended on the IPA status report. A complete draft of this report has been prepared. The report consists of three chapters describing the regulatory framework for IPA, the integration of IPA within other HLW activities, and recent accomplishments within IPA. The report is designed to be comprehensive. Thirteen ongoing and completed technical activities are described in the report. The report will be submitted to the NRC to fulfill the milestone Report on Status of IPA (IM 5702-723-456). This work is in the scope of the PA Element Subtask 2.3 of the OPS.

In the next period, the PA Element will direct its efforts in the following areas: (i) preparing CDMs 6.1 and 6.2, (ii) continuing work on the auxiliary analyses (e.g., shallow and deep infiltration studies, carbon balance model, faulting, and volcanism modules), (iii) conducting integration meetings with PIs working on CNWRA research projects and related technical assistance activities, and (iv) assisting with the IPA Phase 3 planning.

1.9 *Research*

Research Project 1—Overall Research

Effective March 7, 1995, management of the Overall Research Project was reassigned from Dr. E. Pearcy to Mr. P. Mackin.

Revisions to the Near-Field Processes and Variations Research Project Plan were made based on recommendations received from the NRC.

Dr. W. Murphy continued preparations for chairing the 1995 Materials Research Society Symposium on the Scientific Basis for Nuclear Waste Management, with most emphasis on fund raising.

The CNWRA Semi-Annual Research Report (IM 5704-001-095-003) was completed and submitted to the NRC during this period.

Work continued on the production of the proceedings from the Workshop on Rock Mechanics Issues in Repository Design and Performance Assessment held in September 1994.

In the next period, activities related to the organization of the 1995 Symposium on the Scientific Basis for Nuclear Waste Management and preparation of the Rock Mechanics Workshop proceedings are expected to continue. Revisions will be submitted for the Sub-Regional, Near-Field, and Overall Research Projects to document cost changes.

Research Project 2—Thermohydrology

In this reporting period, the Thermohydrology Research Project has been active in one area: completion of the final report.

Review comments from the three external peer reviewers and the NRC RES were received during this period. Resolution of the comments is ongoing. The peer reviewed final report is due to the NRC on May 31, 1995.

A presentation of final results from the Thermohydrology Research Project was made to the NRC staff on March 15, 1995. Recommendations from the Thermohydrology Research Project were included as part of the presentation. Recommendations include a small field-scale heater experiment designed to test mathematical and conceptual models of thermally driven moisture flow through partially saturated, fractured porous media.

In the next period, work will continue in one area: resolving technical comments from the external peer review team.

Research Project 3—Rock Mechanics

The Rock Mechanics Research Project focused activity in the following areas: (i) analyzing the experimental results of the small-scale model of jointed rock mass for Task 4, (ii) conducting an MH laboratory study, (iii) preparing one chapter for the DECOVALEX manuscript, (iv) selecting external peers for peer review workshop on coupled TMH processes, and (v) producing the CNWRA Semi-Annual Research Report.

Analysis of the experimental results of the small-scale jointed rock mass shaking table tests continued. The objective of the analysis is to obtain a better understanding of the response of a jointed rock mass subjected to repetitive earthquake shaking and to generate a database that can be used for computer code verifications. The results of the analysis, including the triaxial compressive tests, will be documented in a report to the NRC to fulfill the milestone Report for Scale Model Experiments (IM 5704-034-095-001).

Preparation of Chapter 18 titled Dynamic Behavior of Rock Joints (IM 5704-039-095-004) for a DECOVALEX book titled Mathematical Modeling and Experimental Studies of Coupled Thermo-Mechanical-Hydrologic (TMH) Processes in Fractured Media was completed and submitted to the NRC on March 20, 1995. This chapter was also submitted to the DECOVALEX Secretariat.

The purpose of the second set of coupled MH experiments on single-joint specimens is to study the potential effects of mechanical joint deformations (both normal and shear) on joint hydrological properties under saturated and various unsaturated conditions. The strategy for gathering joint surface profile data was reviewed in order to improve the technique for extracting fracture aperture distribution data from surface profile measurements. The new technique requires that, in addition to the measurement of the thickness of the upper and the lower sample blocks, the total thickness of both the sample blocks put together also be measured, and the platform of the profilometer needs to be elevated by using 2-in. spacers on the platform legs. More realistic aperture values have been obtained by using this modified method. However, still a significant percentage of aperture data are negative values though the numbers are very close to zero. In order to account for these negative values, various tests are currently under-

way. Because of the unavailability of good specimens from the field, techniques are currently being investigated to generate fractures from the Apache Leap tuff intact rock samples. The design modification to the grout boxes is under-way to ensure that the seals used for directed fluid flow tests do not cause joint face mismatch. In the unsaturated flow measurement apparatus, the leaks have been effectively sealed and effort is currently under-way to measure fracture volume. Boyle's law porosimetry as well as an impression technique have been investigated for measuring fracture volume.

Preparation of the CNWRA Semi-Annual Research Report (IM 5704-038-095-001) has been completed and it was submitted to the NRC during this period. The activities for organizing the external peer review of coupled TMH processes continued. More than 30 responses have been received from the potential peers showing interest in participating in the peer review. Preparation of the proceedings for the Workshop on Rock Mechanics Issues in Repository Design and Performance Assessment continued.

In the next period, activities within the Rock Mechanics Research Project will include: (i) analyzing experimental results of the small-scale model of jointed rock mass, (ii) preparing the proceedings for the Workshop on Rock Mechanics Issues in Repository Design and Performance Assessment, (iii) preparing the Report for Scale-Model Experiments (IM 5704-034-095-001), (iv) preparing the Final Project Report (MM 5704-037-095-001) to summarize research findings relevant to seismic effects on jointed rock mass behavior related to a HLW repository, (v) conducting DECOVALEX MH experimental work, and (vi) conducting activities associated with the external peer review of coupled TMH processes research.

Research Project 4—Integrated Waste Package Experiments (IWPE)

Long-term localized corrosion tests of alloy 825 in solutions containing 1,000-ppm chloride at 95 °C are continuing. No localized corrosion has been observed on specimens held below the repassivation potential after exposure times ranging from 7 to 16 mo for the various specimens. The open-circuit potential of an alloy 825 specimen having crevices on both polished and mill-finished surfaces was monitored for the second month in an aerated 1,000-ppm chloride solution. The open-circuit potential of this specimen has increased in 2 mo of testing from an original value of -250 mV_{SCE} to -185 mV_{SCE}. Cyclic potentiodynamic polarization tests using specimens of alloy C-22 were conducted at 95 °C in NaCl solutions with and without the addition of 0.01 M $Na_2S_2O_3$. In a 1000-ppm chloride solution, severe pitting of alloy C-22 was observed in the presence of thiosulfate.

Stress corrosion cracking tests are continuing. Slow strain rate control tests were conducted in glycerine at 95 and 120 °C using alloy 825 specimens. In addition, control tests using notched specimens of type 316L SS and alloy 825 are presently being conducted at 95 °C. An alloy 825 specimen with a crevice-forming device placed on the gage length is also being tested in 6.2 molal NaCl at 100 °C using the slow strain rate technique under potentiostatic conditions. U-bend specimens of type 316L SS are presently being tested in both a 1,000-ppm chloride solution at 95 °C and a 1 M chloride solution also at 95 °C for a second month. The specimens are oriented such that the apex of the U-bend is just above the vapor/solution interface. After the first month of

testing, stress corrosion cracking was observed on one specimen tested under open-circuit conditions in 1000-ppm chloride.

Thermal aging of solution annealed alloy 825 specimens for 1,000 hr at 600 and 638 °C is being conducted. The degree of sensitization of these specimens will be evaluated using nitric acid and ferric sulfate/sulfuric acid tests.

The effect of microbial organisms on the corrosion potential of many alloys was reviewed critically and a summary of this review will be incorporated into the IWPE final report. All the aerobic cultures from the CEB have been recultured and are undergoing purity checks. Equipment for anaerobic plate growth of SRB has been procured and SRB from CEB have been plated to start purity checks.

The nomination of outside experts for the IWPE Project peer review panel was completed and the potential reviewers were contacted to determine availability. The appropriate documentation for evaluating the COI requirements have been received from all of them and it is currently being evaluated.

A report entitled Effects of surface chromium depletion on localized corrosion of alloy 825 as a high-level nuclear waste container material (IM 20-5704-041-140) was completed and sent to NRC.

Long-term localized corrosion tests on alloy 825 will continue. Tests with compact tension specimens will be initiated for the purpose of determining the relationship between potential and crack propagation rate in chloride solutions. The STEM of the precipitates and analysis of grain boundary composition in alloy 825 will continue as will evaluation of the degree of sensitization of long-term aged specimens (1,000 hr). Experiments on biofilm formation and open-circuit potential evolution will be initiated in the next reporting period. The preparation of the final report will continue and consultant agreements with the members of the peer review panel will be completed.

Research Project 5—Geochemical Analog of Contaminant Transport in Unsaturated Rock

Electron microprobe analyses of fracture-filling Fe-oxides/oxyhydroxides collected from the +10 level of Nopal I were conducted at Texas A&M University at the Cameca SX50 Electron Microprobe Laboratory in the Geosciences Department. The purpose of these analyses is to determine the distribution of U within Fe-oxides/oxyhydroxides (hematite and goethite) within and near the deposit.

Gamma spectrometry analyses of bulk rock samples from Nopal I were initiated, using the Canberra low-energy germanium detector, to determine the utility of this technique for U-series disequilibrium studies. Initial results are promising, however, additional testing is required to develop a reliable analysis scheme for some important isotopes that have low abundances and/or interferences (e.g., ^{234}U and ^{226}Ra). Alpha spectrometry continued on rock samples from Level +10 of the Nopal I analog site.

TEM analyses of U-bearing Fe-oxides from the 13.5-m N fracture on Level +10 of the Nopal I site were completed. Results show that U within the Fe-oxides/oxyhydroxides

is either sorbed onto mineral surfaces or coprecipitated. Discrete U-phases within the Fe-oxides/oxyhydroxides do not appear to host the U retained within this portion of the system.

Analysis of the time-domain electromagnetic survey results taken at the Peña Blanca natural analog in February and September 1994 continues. The presence of perched water is being investigated using these survey results.

Planning and coordination for field research at the Nopal I site continued with the *Universidad Autónoma de Chihuahua* during this period.

In the next period, Geochemical Natural Analog Research Project activities are anticipated to include: (i) continued mineralogic study of Nopal I samples, (ii) continued modeling of flow and transport at the Akrotiri site, (iii) interpretation of Nopal I formation conductivity measurements, (iv) continued alpha and gamma spectrometry measurements of Nopal I samples, and (v) continued preparation for field research at the Nopal I site.

Research Project 6—Sorption Modeling for High-Level Waste Performance Assessment

Batch sorption experiments designed to investigate the sorption behavior of Np on clinoptilolite and quartz were completed. Aqueous samples were taken for analysis of Np concentration using liquid scintillation counting, and pH of the solutions was measured. Experimental data are currently being evaluated.

New experiments were initiated to study Np sorption on montmorillonite [Cheto montmorillonite (SAz-1) from Apache Co., Arizona]. The experimental containers were capped immediately after adjustment of solution pH to minimize the uptake of atmospheric $CO_2(g)$.

Scoping experiments continued to evaluate and optimize a method to quantitatively separate Np and U from the same solution for subsequent radiometric counting. Once the method, most likely to be based on a $BaSO_4(s)$ precipitation technique, is fully developed, experiments that will investigate the competitive sorption of Np(V) and U(VI) onto montmorillonite and/or clinoptilolite will be started.

Preliminary analysis of EXAFS data on clinoptilolite loaded with U via two types of sorption mechanisms (ion-exchange and surface-adsorption) was conducted by E. Hudson of LLNL. His analysis suggested that there are structural differences between U loaded onto clinoptilolite by ion-exchange and U loaded by surface adsorption. Further analysis, including Fourier transforms, will be conducted during the next few weeks. New U-loaded clinoptilolite samples may be prepared for further EXAFS study sometime during the summer.

Experiments were conducted to determine plutonium sorption characteristics of plastic containers. Polycarbonate bottles sorbed around 15 percent of Pu from $NaClO_4$ solutions over a wide range of pH (2–8), but no sorption occurred at pH 9. At near-neutral pH, polypropylene was somewhat less sorbent, and Teflon-FEP was much more sorbent than

polycarbonate. Experiments were also conducted to assess the solvent extraction technique for Pu oxidation state determination at low concentrations. For 2-ppb Pu solutions, the technique gave low apparent Pu(VI) contents; after eliminating other potential sources of error, it was determined that the extraction fails to distinguish much or all of the Pu(VI) from Pu(V) at low concentrations. Work also continued on preparation of homovalent Pu solutions for mineral sorption experiments.

Revisions to the IM 20-5704-074-184, entitled Experimental and Modeling Study of Uranium (6+) Sorption on Quartz, were made to include new modeling results prior to submitting the paper to a peer-reviewed journal. The additional modeling effort focused on using a two-site (weak- and strong-site) surface-complexation model, instead of a one-site approach. The two-site model significantly improved the fit of the model to experimental data and the agreement between predicted and measured sorption values.

An abstract of an invited paper entitled Geochemical Controls on the Sorption of Uranium(6+) onto Mineral Surfaces was prepared and submitted to the NRC for programmatic review. The paper will be presented at the Spring Meeting of the AGU which will be held May 28 to June 2 in Baltimore, Maryland.

Three of the five potential peer-reviewers of the Sorption Research Project were evaluated by the CNWRA COI committee and were cleared of COI. The other two peer-reviewers still need to submit information required for the COI evaluation.

During the next period, experiments on Np sorption on montmorillonite will continue. New batch Np sorption experiments on clinoptilolite and quartz using finer-grained material will be started. Preparation and characterization of homovalent Pu solutions for use in sorption experiments will continue. Evaluation of analytical techniques for solutions with both U and Np will continue.

Research Project 7—Volcanic Systems of the Basin and Range

Work during this reporting period focused on completing revisions to the paper Three Nonhomogeneous Poisson Models for the Probability of Basaltic Volcanism: Application to the Yucca Mountain Region, Nevada, USA, which has been accepted for publication in the *Journal of Geophysical Research*. Other research activities during this reporting period continued at a lower than anticipated rate due to NRC-DWM technical assistance support for KTU integration and issues related to the Extreme Erosion Topical Report, preparations for and attendance at the Geomatrix/DOE probability meetings, and interviews for open GLGP-element staff positions.

Work continued in updating information on YMR basaltic volcanoes. Presentations at the February DOE/Geomatrix probability meeting documented the recognition of new volcanic systems in the subsurface of Frenchman Flat ($\approx$8.5 Ma) and in Oasis Valley ($\approx$7.4 Ma). Review of published literature on regional volcanic and tectonic studies shows basalts as young as 7.5 Ma occur about 25 km W of Quaternary volcanoes in Crater Flat. In addition, previously reported 11.1 ± 0.5 Ma basalts in Jackass Flats are probably 9.6 ± 0.4 Ma and thus contemporaneous with 10.0 ± 0.4 Ma basalt at Kiwi

Mesa. These new data indicate that Miocene basaltic volcanism in the YMR is not characterized adequately, which may lead to inaccurate models and interpretations.

Fault-dilation tendency models, produced under the Tectonic Processes in the Central Basin and Range Province Research Project, were combined with CNWRA nonhomogeneous Poisson probability models to produce volcanism relative-hazard maps for the YMR. These maps show N- to NNE-trending faults in the YMR have a high dilation tendency when compared to the regional least-principle stress orientation. These faults increase the hazard when they occur in zones of high eruption probability (i.e., $\geq 1 \times 10^{-4}$ in 10^4 yr) because they are potential conduits for ascending magma. High hazard faults occur at and adjacent to the proposed repository site.

During the next period, work will continue on integrating probability and fault-dilation tendency models for the YMR and on probability model development. Work also will continue on updating the Volcanism GIS with new information on the YMR and Cima Volcanic Field, California. These data will be used to develop and test probability and magmato-tectonic models for the western Basin and Range Province.

Research Project 8—Regional Hydrogeologic Processes of the Death Valley Region

The Regional Hydrogeologic Processes Research Project made progress on preparation of a report summarizing activities conducted in Task 1 (Collect and Analyze Data and Existing Models), in Task 2 (Conceptual Model Development), and in Task 3 (Computational Model Development).

Preparation of the letter report describing the GIS database continued. This database will include data describing the hydrogeologic regime of the greater Death Valley region. The report will be submitted to the NRC to fulfill the milestone Letter Report on Collected Data and GIS System (IM 5704-131-401), that has been rescheduled to mid-April. In addition, review of newly obtained data and literature continued. This work was conducted under Task 1 of the Regional Hydrogeologic Processes Project Plan.

Efforts have continued at refining the steady-state water level map. The primary effort has focused on determining if the water level measurements represent local perched conditions, potentiometric conditions in the alluvial aquifers, potentiometric conditions in the Tertiary tuff aquifers, or potentiometric conditions in the regional Paleozoic carbonate aquifer. Hydrostratigraphic columns constructed with lithologic data from the GWSI database are being used in conjunction with well construction data to determine which aquifer's hydraulic condition is represented by the measured water levels. This work was conducted under the scope of Task 2 of the Regional Hydrogeologic Processes Project Plan.

Work has also commenced on the construction of a 3D hydrostratigraphic model of the Death Valley flow system. Hydrostratigraphic columns constructed from the GWSI database have been entered into the ARC/INFO GIS. In addition, existing geologic cross-sections have been identified, and some have been acquired so that they may be digitized and entered into ARC/INFO. This work was conducted under the scope of Tasks 2 and 3 of the Regional Hydrogeologic Processes Project Plan.

Work will continue on summarizing existing data and literature from the Death Valley Region for the GIS letter report. Future activities will continue to focus on developing alternative conceptual and computational models of local and regional flow systems. During the next period, work will commence on constructing a 2D areal flow model of the carbonate aquifer system.

Research Project 9—Field Volcanism

Research activities during this reporting period continued at a much lower than anticipated rate due to NRC-DWM technical assistance support for KTU integration and issues related to the Extreme Erosion Topical Report, preparations for and attendance at the Geomatrix/DOE probability meetings, interviews for open GLGP-element staff positions, and work in the Volcanic Systems of the Basin and Range Research Project.

Analysis continued on fall deposits from the 1975 Tolbachik eruption in Kamchatka. Detailed grain-size analyses were performed on samples of the white ash that was erupted for about 18 hr at the end of Cone 1 activity. This ash consists of roughly 20-percent juvenile basalt and 80-percent pulverized wall rock, with a total eruptive volume of $>7\times10^6$ m^3. Although the white ash samples have bimodal size populations, median diameters of the white ash samples (0.05–0.25 mm) are significantly finer than wholly juvenile samples (0.5–6 mm). Initial characterization studies using a scanning electron microscope show that the white ash is composed of a mixture of clastic sedimentary wall-rocks and subordinate amounts of plagioclase-bearing mafic lavas. The upper 500 m of the crustal section around the Tolbachik volcanoes consists of older mafic lavas and scoria, many of which are plagioclase bearing. At least 1 km of predominantly sandstones and siltstones underlie the volcanic section. Larger wall-rock fragments preserved at Cone 1 show a similar range in lithology. Thus, the end stages of Cone 1 activity were marked by an episode of extreme brecciation and transport of wall rocks from depths at least 500 m below the surface. A working hypothesis is that lower mass-flow rates during the waning stages of Cone 1 activity caused a relaxation in conduit pressure. This allowed water (the water table is at about 500 m) to enter fractures and interact with the heated wall rock, causing brecciation and fragmentation.

Fall deposits from Tolbachik and Quaternary YMR volcanoes will continue to be analyzed during the next period. Detailed petrographic studies on Tolbachik and YMR scoria as well as development and testing of thermal models also will continue. Emphasis in model development will be placed on determining the field data and tests that will most successfully constrain models, in anticipation of additional field work at Tolbachik in the summer of 1995.

Research Project 10—Tectonic Processes in the Central Basin and Range

During Period 6, work on the slip- and dilation-tendency analysis has focused on checking the computer program to evaluate accuracy of calculations. This computer program provides a new technique for fault-slip hazard assessment, and has been useful in assessing consistency of earthquake focal mechanism solutions with the *in situ* stress state. In a collaborative effort between Tectonics and Volcanism research, dilation-tendency analysis has been combined with volcanic probability models to generate a

volcanic relative-hazard map for YM. Faults that are in high dilation-tendency orientations are considered to be more likely to serve as magma conduits. The volcanic relative-hazard map illustrates that the alignment of basaltic cones in Crater Flat Valley approximately parallels the traces of faults with the highest dilation tendency in the area. There are numerous faults within YM that have nearly the maximum possible dilation-tendency within the contemporary stress state. Slip- and dilation tendency analysis will be used in the critical review of compiled tectonic data that will be reported in the Critical Review NUREG/CR (IM 5704-167-004) to be completed by August 28, 1995.

Field sampling at Bare Mountain for fission track and microstructural analyses was conducted during the last period. Field observations made at Bare Mountain suggest that layer-parallel simple shear in a top-down direction contributed strongly to normal-fault block deformation. Modeling is in progress to study the implications of this deformation mechanism in general, including the prediction of fault geometry from hangingwall geometry, and to interpret the deformation history of Bare Mountain. A 3D geologic map of Bare Mountain has been generated by combining the digitized geologic map of Bare Mountain and the 30-m-pixel-resolution DEM for Bare Mountain. The 3D geologic map will be used in constructing a 3D structural model of Bare Mountain. Fission track, paleomagnetic, and microstructural analyses are under-way in order to constrain the 3D movement of Bare Mountain. Understanding movement of Bare Mountain is critical to understanding faulting at YM because of potential for seismicity on the Bare Mountain fault and the possible interaction of the Bare Mountain fault and YM faults at depth. Results of the Bare Mountain field studies will be reported in future semi-annual reports, the Tectonics Field Study NUREG/CR (MM 5704-167-008) to be completed in May, 1996, and the Tectonic Models NUREG/CR (MM 5704-167-010) to be completed in December, 1996.

The bidding process for the analog modeling deformation apparatus is nearing completion. Outfitting of the analog modeling lab has continued during the past period. Review of literature on analog modeling (especially materials and scaling properties), strike-slip faulting, and strike-slip releasing bends (e.g., Death Valley and possibly Crater Flat Valley) has continued during the reporting period. Analog modeling will be used to evaluate patterns of 3D faulting in strike-slip releasing bends in order to constrain tectonic models of the Death Valley region and the YM–Crater Flat region. These results will be reported in future semi-annual reports and the Tectonic Models NUREG/CR.

A poster presentation entitled Digital elevation models applied to Basin and Range tectonics research was presented by Tectonics Research staff at the annual meeting of the American Association of Geographers in Chicago, Illinois (March 15, 1995). The search for a structural geologist to add to the CNWRA core staff was active during this period and included on-site interviews of three candidates.

Fission track, paleomagnetic, and microstructural analyses of Bare Mountain will continue during the next period. Construction of the analog modeling deformation apparatus is expected to begin during the next period. Literature review and planning of the first round of analog models will continue. Analysis of the 3D structure within Bare Mountain is ongoing and will include construction of cross sections through Bare

Mountain. The Geology and Geophysics Element review by the NRC will be conducted during the next period and will require preparation during the next period. Regional tectonic modeling of the central Basin and Range region will be started during the next period, working in conjunction with J. Kent Snow of the California Institute of Technology. This work will focus on using computer modeling to evaluate changes in strain rates and to partition components of pure shear and simple shear strain in the region during the last 36 million years. This modeling will be used to provide a context for interpretation of neotectonic data and to identify critical problem areas that will need additional attention in the future.

Research Project 11—Subregional Hydrogeologic Flow and Transport Processes

Task 1 of the Subregional Hydrogeologic Flow and Transport Processes Research Project Plan has been completed.

Testing of the ISATIS geostatistical software has begun during this period. Precipitation data at the YMR are being used for the tests. A. Bagtzoglou attended a short course on the use of this software as part of his professional development. Considerable effort was expended by the PI towards preparing a presentation for the inaugural meeting of GEOTRAP, an OECD/NEA international project aiming at the identification, and possible resolution, of key issues in the prediction of radionuclide transport in heterogeneous media. This work is being conducted under the scope described in Task 3 of the Subregional Hydrogeologic Flow and Transport Processes Research Project Plan.

Identification of potential focused recharge zones at YM using the ARC/INFO GIS continued. The DEM shading application called GEOVIEW has been used to produce shading sequences over the course of selected days (representative of winter and summer conditions) for YM. Data on alluvium depth have been compiled and analyzed for identifying potential correlations between alluvial depth and ground surface slope. A detailed map of alluvium depth at YM will be produced and used for subsequent analyses of infiltration. This work is being conducted under the scope described in Task 4 of the Subregional Hydrogeologic Flow and Transport Processes Research Project Plan.

Mineralogy and stable isotope data for carbon, oxygen, and hydrogen and radiogenic isotope data for chlorine, carbon, and tritium from USGS and LANL published reports continue to be entered in spreadsheet format and 1D borehole models have been developed for the variation with depth of different field values. There is significant heterogeneity in the mineralogy, especially for secondary phases such as clays and zeolites. Significant clay thicknesses may reduce permeability significantly and indicate regions susceptible to perched water zone development. Modeling of carbonate chemistry was initiated using the SUPCRT92 code to examine the effects of pressure on thermodynamic equilibria. This was done to evaluate the significance of high suction pressures in the unsaturated zone on carbonate precipitation/dissolution. Preliminary results suggest that the effect is relatively minor, but effects may be more pronounced near the critical region for water. Work was continued on developing a methodology that will employ Allan Diagrams for identifying the potential of perched water zone development under conditions of uncertain hydraulic parameters. This will provide upper bound estimations on both the potential for the development of such zones and their

lateral extent. Interactions with NRC staff on the very recent events pertaining to the discovery of a perched zone at well SD-7 consumed some effort. Fruitful discussions between CNWRA and NRC staff took place and various action items are being pursued. This work is being conducted under the scope described in Task 5 of the Subregional Hydrogeologic Flow and Transport Processes Research Project Plan.

Work on the enhancement of the CTOUGH code continued. Dynamic memory management of the numerical code has been completed. All work arrays are automatically assigned the storage required based on the run-time parameters such that the program will seldom need recompilation for different size problems. A factor of two in the computing speed was attained by rewriting a few routines (routines computing the Jacobian Matrix coefficients). A set of runs is being conducted to quantify the speed-up factor and the maximum size of the problems that can be run. These results and other related computational aspects are targeted to be completed within the next period. The capability of calculating problems over 20,000 grid-blocks with 64 MB memory requirements is the goal of this effort. This work is being conducted under the scope described in Task 6 of the Subregional Hydrogeologic Flow and Transport Processes Research Project Plan.

Very little work has been conducted under Task 7 since UA staff is in the process of compiling research proposals. Consequently, no interactions were pursued during this period. This work is being conducted under the scope described in Task 7 of the Subregional Hydrogeologic Flow and Transport Processes Research Project Plan.

Work in the next period will involve the continuation of all activities.

Research Project 12—Performance Assessment (PA) Research

The PA Research project made significant progress on the following activities: (i) developing and analyzing new scenario classes for IPA, (ii) benchmarking NRC/CNWRA and DOE PA codes, and (iii) implementing PVM technology in the TPA code.

Limited work was performed on the new scenario classes due to staff commitment to KTU integration and CDM development tasks. Three new scenario classes are being studied consisting of: (i) the borehole seal performance, (ii) dose modeling, and (iii) fracture flow processes in the vicinity of canisters. Literature reviews and initial conceptualization of these scenarios were performed. This work will be documented and submitted to fulfill the milestone Paper on Scenario Classes for IPA (IM 5704-191-500) which is due July 7, 1995. This work is being conducted under the scope described in Task 1 of the PA Research Project Plan for FY94–95.

Work on the benchmark testing of the DOE two-phase flow codes continued. The purpose of this work is to determine the capabilities and limitations of the DOE codes currently being applied to evaluate the "hot repository" concept. This information will be beneficial to future reviews of: (i) DOE PAs for YM, and (ii) the DOE Topical Report on Processes Models. The DOE two-phase flow codes V-TOUGH, TOUGH2, and FEHMN are being compared against the CNWRA codes PORFLOW and CTOUGH

(an extension of V-TOUGH). The code testing will be documented and submitted to fulfill the milestone Report on Evaluation of DOE Thermohydrologic Codes (IM 5704-193-506), which is due August 31, 1995. This work is being conducted under the scope described in Task 2 of the PA Research Project Plan for FY94–95.

The evaluation of PVM computing methodology continued. The TPA was converted and modified to run under PVM applications utilizing a number of SUN workstations. Verification of the converted code was performed by comparing test results with those obtained on the original Cray version. Test runs under PVM were initiated. Significant aspects of this activity will be documented and submitted to fulfill the milestone Paper on Evaluation of Parallel Virtual Machine Computing (IM 5704-192-500). This work is being conducted under the scope described in Task 2 of the PA Research Project Plan for FY94–95.

A paper entitled Mixed Transform Finite Element Method for Solving the Equation for Variably Saturated Flow was completed ahead of schedule and submitted the NRC to fulfill the milestone Paper on Advanced Computational Method for Solving Unsaturated Flow Equation (IM 5704-192-501). In addition, the paper, which was approved by the NRC, was submitted for publication in *Water Resources Research*. This work is being conducted under the scope described in Task 2 of the PA Research Project Plan for FY94–95.

In the next reporting period, research activities will include: (i) continuing work on the new scenario classes for IPA, (ii) continuing benchmark testing of the DOE two-phase flow codes, (iii) continuing evaluation of PVM technology for use in IPA, and (v) completing the NUREG/CR version of the report on the BREATH code.

Research Project 13—High-Level Waste Near-Field Processes and Variations

Conceptual development of hypotheses for near-field processes and variations continued through interactions in multidisciplinary groups. A focus on heat and fluid flow coupled to water-rock geochemistry evoked the hypothesis that effects of chemical reactions are likely to affect matrix and fracture hydraulic properties differentially. Relatively major geochemical effects will occur at points of evaporation to dryness and at points of condensation. Evaporation will occur in the matrix, where the water finally resides. Condensation will occur where water vapor has been transported from warmer to cooler areas. Vapor phase transport is postulated to occur primarily in fractures; hence, condensation is likely to occur on fracture surfaces. Both precipitation in the matrix in areas of evaporation and water condensation (and dissolution) on fracture surfaces are likely to increase fracture permeability relative to matrix permeability. Elaboration of these hypotheses and methods for quantitative testing are being examined.

Literature review of the thermodynamic properties of uranyl minerals has continued. A recently published compilation of the chemical thermodynamics of uranium by the OECD provides a primary resource.

An assessment of availability of naturally occurring uranophane and other uranyl silicates was conducted to determine if these will be available in sufficient quantity and purity for

use in experimental studies. Inquiries were made to Dr. Carl Francis, Director of the Harvard Mineral Museum, and David Shannon, a mineral dealer in Mesa, Arizona, specializing in uranium minerals. Both indicated it would be difficult to acquire gram quantities of uranyl silicates with sufficient purity. During the next field trip to Peña Blanca, Mexico, attempts will be made to acquire uranophane samples for use in the experiments.

Laboratory synthesis of uranyl silicates for experimental studies is an alternate approach. Two recent papers described procedures for synthesizing uranophane, boltwoodite, and weeksite. One paper reported synthesis of uranyl silicate at room temperature and subsequent recrystallization of the solid at 90 °C. The second paper described a procedure of hydrothermal synthesis at 150 °C. Experimental equipment is being assembled in the geochemistry laboratory for hydrothermal synthesis. The equipment consists of three teflon-lined stainless steel reaction vessels and high-temperature furnaces. Reagent chemicals which will be used for the synthesis work have been purchased.

The Near-Field Processes and Variations Project Plan was revised according to NRC instructions.

Tests of equipment performance will be conducted and necessary modifications to the equipment will be made. Attempts to acquire uranophane from the Peña Blanca natural analog field site will be made during the next trip to the site by the principal investigators. Literature review activities will continue.

1.10 *Waste Solidification Systems (WSS)*

The CNWRA submitted an intermediate milestone Comment Resolution with WVDP (IM 5706-002-525) on February 28, 1995. This IM report documented the resolution of comments from a meeting at the WVDP to review WVDP responses to open issues raised by the CNWRA/NRC in a letter sent on January 28, 1995.

Activities associated with the development of the SER on the Vitrification Process corresponding to the SAR-003 continued. The organization of the SER was finalized, and drafts of various report sections have been completed. It will be submitted to NRC as a major milestone Draft Safety Evaluation Report on Vitrification Process (MM 5706-002-550) at the end of the next reporting period.

In support of the vitrification process review, the CNWRA plans to review SAR-002, which contains information complementing that submitted in SAR-003. A joint TRG, similar to that organized for review of SAR-003, is planned for review of SAR-002. The initial TRG meeting will be held in San Diego, California, on March 27–31, 1995, and CNWRA staff will participate at the request of the NRC.

1.11 *Integration*

This section summarizes integration activities conducted during the second quarter of FY95. Since these activities, by their nature, are multielement and multidisciplinary in nature, they have not been associated with specific WBS subtasks. Specific details of the activities have not been documented in this section of the PMPR.

An effort continued to examine the modeling and code development efforts in each element. The purpose of this examination is to ensure that: (i) CNWRA and SwRI support staff are being efficiently used; (ii) consistent use is being made of configuration management, QA procedures, and code documentation; (iii) duplication of effort is avoided; (iv) economies of scale and effort are realized where possible; and (v) modeling efforts are integrated with needs for IPA and CDM development. Two meetings were held with the EBS Element, and subsequent discussion with NRC staff may result in consolidation of the modeling effort.

KTU integration efforts continued during this period. Format and content requirements for the results were agreed to with NRC staff. All integration teams completed their work, and technical and programmatic reviews within the CNWRA are in progress. Results of these activities are to be submitted in a Letter Report on Recommended NRC Actions to Address KTUs (IM 5702-221-511) due to be submitted by March 31, 1995.

Efforts continued in support of the development and approval of a LARP roadmap. Development of this roadmap is considered to be an integration effort in that it will help define regulatory and technical interfaces among disciplines and staff elements. When complete, this roadmap will be utilized in CDM preparation.

The interdisciplinary effort to develop the 3D geological framework model continued with the addition of two lithologic units, the water table surface, additional surficial geology and alluvium data, borehole data, and porosity and hydraulic conductivity values for some units. It is expected that this model will be used by all NRC/CNWRA technical staff.

A collaborative effort among GLGP, GHGC, RDCO, and PA Elements performed Seism1.1 calculations using varying parameters to demonstrate the effect of a nearby background zone that does not enclose the site.

A multidisciplinary group met to examine needs for data archiving and access from the GIS. The GLGP Element Manager is responsible for establishing procedures to meet these needs.

RDCO and GLGP Element staffs collaborated to provide multidisciplinary field surveillance of the ESF North Ramp construction. Other staff are expected to take part in this activity as tasked by the NRC.

A team composed of staff from the RDCO, GLGP, GHGC, EBS, WSE&I, and PA Elements prepared and submitted a draft report containing comments from a review of the Initial Summary Report for Repository/Waste Package ACD. The scope of this

activity also included a review of the DOE document, FY93 Thermal Loading System Study Final Report, Volumes 1 and 2.

RDCO, GLGP, GHGC, and PA Element staffs conducted a multidisciplinary review of ESF Title II Design Package 2C. A draft of the results was transmitted to the NRC.

The PA Element coordinated with the Subregional Hydrology Project to conduct a deep percolation auxiliary analysis for YM. Current work has emphasized improved predictions of percolation in a repository near-field considering spatial variation due to focusing from topographic effects.

An integrated team from PA, GHGC, and EBS staffs is conducting an auxiliary analysis of the carbon system at YM. Results of this analysis will be reported in a paper to be delivered at the Migration '95 conference.

PA and WSE&I staff continued work on identification of site-specific dose parameters for YM. A literature search provided additional data, and information related to current agricultural water use has been requested from the appropriate State of Nevada organizations. Preparation of the associated technical report has commenced.

PA and GLGP staff continued development of a new faulting module for examining the consequences of fault displacement on waste package failure. PDFs for faulting event variables are being evaluated prior to starting development of the mathematical models/equations necessary to implement the module.

Work on an updated assessment of the importance of key radionuclides continued as an integrated effort by the GLGP, GHGC, EBS, and PA Elements. Sources of information for this assessment include IPA Phase 2, the SNL TSPA-93, and the Sorption Research Project.

PA and EBS Element staffs continued an auxiliary analysis of near-field thermally driven flow. The modeling effort incorporates a single waste package to estimate thermohydrologic conditions out to approximately 6 m. Results will be in the form of a paper to be presented at a technical conference.

PA, RDCO, and GLGP staffs are collaborating on an auxiliary analysis of drift stability relating to rock-induced waste package failure for an IPA Phase 3 disruptive scenario. The information generated in this task is expected to be used to support source term calculations.

The Tectonics and Volcanism Research Projects collaborated on the development of a preliminary volcanic hazard map for the YM area. This map was generated by combining volcanic probability analysis with dilation tendency analysis on YM faults.

Work was authorized to commence on the Near-Field Processes and Variations Research Project Plan which was submitted explicitly to address multidisciplinary technical uncertainties associated with the near field at YM. This plan requires integration among the GLGP, GHGC, PA, and EBS Elements in particular.

2. MANAGEMENT ISSUES

None.

3. MAJOR PROBLEMS

None.

4. SUMMARY OF SCHEDULE CHANGES

Table 2 provides formal documentation of schedule changes for IMs that occurred during the preceding period or are anticipated to occur during the subsequent period. Each item listed has been discussed with the cognizant NRC PEM and other parties, as appropriate.

5. SUMMARY OF FINANCIAL STATUS

Table 3 summarizes the CNWRA financial status in the context of authorized funds established by the NRC. Total commitments of the CNWRA are $358,154. Table 4 lists planned and actual costs to date, without allowance for fee, on both a per-period and a cumulative basis. Furthermore, these data do not include commitments, and variances are shown on both a dollar and percentage basis. Pertinent information is provided for the CNWRA program as a whole, the DWM JC, the RES JC, and the DIMNS JC, as well as for each Program Element and Project.

CNWRA Program

The CNWRA Composite Period 6 cost variance between estimated and actual spending is 13.4 percent. This variance has remained essentially within one percentage point since Period 3. The CNWRA still anticipates meeting or slightly exceeding the 54 FTE staffing level by the third quarter of this fiscal year, and recruitment efforts and interview scheduling have been accelerated to attain this staffing level by the end of Period 9. Spending on consultant labor year-to-date in the DWM JC and the RES JC remains below estimates. Conversely, spending on SwRI labor in the DWM JC has increased above estimates, while remaining generally consistent with estimates in the RES JC. This accelerated use of SwRI labor is particularly evident in the DWM Tasks 2, 4, and 5 as well as in the Rock Mechanics, IWPE, Tectonic Processes, Sub-regional Hydrology, and Performance Assessment RES Projects. During this period, work and associated spending in the DWM JC increased, most significantly in Task 2, and such work and spending declined slightly in the RES JC. Significant increases in Period 6 spending ensued in the Overall Research and Near-Field Processes RES Projects, while, during the same period, reductions in spending occurred in the Geochemical Analog and Sorption Modeling RES Projects. Notwithstanding over/under spending in individual elements/projects, both the DWM and RES JCs are still operating at comparable levels of aggregate underspending.

DWM JC

The DWM JC cumulative cost variance for Period 6, expressed as a percent, is the lowest since Period 1.

The greatest underrun still remains in Task 1, which accounts for about 45 percent of the total DWM cost variance. Reactive work continues at a relatively steady pace, and LARP-related activity for CDM development remains generally strong. Although underrun, Task 2 shows a dramatic increase in spending from the previous periods, yet it represents 21 percent of the total DWM cost variance. The cost variance for Task 3 has declined slightly, and it accounts for about 14 percent of the total DWM cost variance. Audits of the M&O have increased while field verification activities again have decreased. Spending for activities related to Task 4 has remained essentially the same since last period, but the consistent underspending amounts to only 6 percent of the total DWM cost variance. The cost variance for Task 5 has increased, and it represents about 14 percent of the total DWM cost variance. Overall spending decreased slightly over the previous period because of (i) reduced spending for TDOCS/RPD/OITS development, maintenance, and operation, and (ii) a minor rise in spending on the CNWRA LAN and firewall security system management and implementation.

The DWM JC cumulative cost variance is 13.7 percent.

The COPS Element cost variance is 11.0 percent. Spending in this element is expected to be less than planned for the next period, in spite of accelerated spending in Subtask 5.1 due to allocation of TDOCS-related funding in preparation for loading CNWRA documents, because of continued underspending in Subtasks 5.2 through 5.4, and as the result of aggregate overspending in Subtasks 5.6 and 5.7 that occurred primarily in the first 4 to 5 periods of this fiscal year.

The WSE&I Element cost variance is 8.7 percent. This trend in slight underspending is expected to continue for the next two periods due to current scheduling factors.

The EQA Element cost variance is 37.2 percent. This variance is partially due to postponements of several early DOE audits and no NRC-directed work in the Field Verification Subtask. The underspent condition will be reduced with the initiation of upcoming Field Verification work and the subsequent report writing efforts in the latter part of the FY.

The GLCP Element is 12.5 percent underspent at the end of Period 6. The underspending is largely the result of untasked reactive work. Proactive work in the LARP Development and Investigate issues subtasks are currently overspent.

At the end of Period 6, there is a cost variance of 29.3 percent in GHGC. It is anticipated that this underrun will be reduced as a result of the increased effort going into development of CDMs. Plans are also being made to expand efforts on GWTT. The addition of an anticipated hydrogeologist to the staff will also reduce this variance and accelerate associated work.

The EBS Element cost variance is 9.1 percent, which is greater than that of previous periods. The scope of activities and the expenditures are expected to track close to planned spending when the vacant staff position is filled. While the LARP development activities were somewhat affected by the current decrease in staff, the EBSPAC development activities continued at the same pace, and activities in the prelicensing interactions area proceeded at a moderate level.

The RDCO Element cost variance is 14.2 percent. This variance largely reflects underspending in Subtasks 1.1 and 1.2 due to a lack of tasking in DBE Rulemaking and NWPA-Mandated Actions and slower progress in CDM development (Subtask 2.1) and Investigation of Issues

Related to RDCO (Subtask 2.3) due to resource constraint. Action has already been taken to accelerate the progress of the activities of several RDCO subtasks through the recruitment of a new RDCO core staff who will join the CNWRA in a few weeks and more use of consultants. Furthermore, since the DBE Rulemaking package has been published in the Federal Register for public comments, it is expected that the tasking on DBE Rulemaking will be received from NRC within the next few periods. Thus, it is expected that the RDCO Element cost variance will be rectified during the remaining seven periods of FY95.

The PA Element cost variance is 14.5 percent. This variance is significantly smaller than the previous period variance. The trend of increasing technical activity and spending observed in this period is expected to continue. The current cost variance is due to lack of NRC tasking in Model Validation Strategy (Subtask 1.3) and limited code development work under TPA Code Development (Subtask 2.4).

RES DRA JC

The RES DRA JC cumulative cost variance, expressed as a percent, has increased over the previous period, and it has risen since Period 1.

Several factors have contributed to the cost variance for the RES JC. These include: (i) delayed start of the High-Level Waste Near-Field Processes and Variations research project, (ii) unachieved staffing level of 54 FTE, (iii) inclusion of budget but lack of SOW for a follow-on materials research project, and (iv) net underspending among certain research projects, especially Overall Research, Rock Mechanics, IWPE, Field Volcanism, Regional Hydrology, Near Field Processes, and Tectonic Processes.

Actual expenditures are expected to remain generally consistent with estimates for at least the next two periods.

The RES DRA JC Period 6 cumulative cost variance is 14.4 percent.

The cost variance for the Overall Research Project was reduced from 25.5 percent to 13.1 percent underspent during this period, primarily due to costs associated with the production of the Semi-Annual Research Report. Costs associated with the Evans Workshop are anticipated to continue to reduce this variance in coming periods. Future costs may continue somewhat below estimated values, however, until activity occurs on the anticipated Hydrogeology Research Project plan development and the planned Geology Workshop.

Costs to date for the Thermohydrology Research Project are currently 5.1 percent below estimated costs. This rate is close to the projected spending rate and reflects the increased level of activity associated with preparation of the final report. Final costs, including consulting and peer review team fees, may exceed the projected budget. Sufficiency of funding will be evaluated next period to ensure a timely and successful conclusion to the Thermohydrology Project.

The Rock Mechanics Research Project cost variance has been reduced during this period from 22.9 percent to 18.3 percent. This variance is due to the low level of effort to date on organizing the external peer review of coupled TMH processes research (Task 6), and preparation of the Final Technical Report (Task 7) because of a high level of effort on prelicensing activities. These

activities are expected to increase during the next few periods which will bring the spending close to planned spending.

The IWPE Research Project cost variance is 23.5 percent which is slightly lower than last period. The addition of the microbiologist is undoubtedly correcting the pronounced underspending in Task 4 noted in previous periods. The slight overspending in Task 3 is being corrected and an increased effort on Task 5 related to issues of alternative materials and designs is reflected in increasing expenditures. It is expected that the costs in this project will be close to that planned for the next reporting periods.

The Geochemical Natural Analog Research Project cost variance is 4.5 percent. Future costs may be somewhat below planned values due to additional duties undertaken by the Principal Investigator.

The Sorption Research Project cost variance is −11.3, compared to the previous period's variance of −17.3 percent. The level of spending is expected to approach the planned level in coming periods as work is conducted in the Near-Field Processes Project and in other CNWRA tasks.

Volcanic Systems of the Basin and Range Research Project cost variance is about 29.5 percent, down from last period. The variance is due to carryover expenses from the Volcanism peer-review meeting and preparation of three reports during Period 4. The spending rate is expected to decrease steadily over the next few periods.

The Regional Hydrogeologic Processes Project cost variance is 33.7 percent. This large cost variance is primarily due to: (i) the PI being temporarily assigned to completion of other research, KTU integration and GWTT activities; and (ii) the need for additional hydrogeologist support. Arrangements were made to add a consultant and a student scientist to assist with the interpretation of data and development of hydrostratigraphic representations. However, the spending rate for the project is not expected to increase markedly until the additional hydrogeologist is hired.

Underspending in the Field Volcanism Project cost variance is about 41.9 percent. Underspending was due to staff being occupied in activities related to NRC-DWM technical support and the Volcanic Systems of the Basin and Range Research Project. Underspending will continue until fieldwork is started in the spring.

Cost variance for the Near-Field Processes and Variations Research Project is 86.3 percent. Expanding work to set up experimental equipment, to generate hypotheses, and to conduct the literature review is anticipated to reduce this under spending in the future.

Tectonics Research is under the projected budget for the first six periods of FY95 by 23.6 percent. This reflects continued deliberate underspending in anticipation of an increased level of activity early in 1995 with the initiation of analog modeling, and increased, field work, paleomagnetic and fission track data collection, and computer modeling activities.

The cost variance for the Subregional Research Project is −2.2 percent. Expenditures for the next period are expected to be consistent with estimates.

The PA Research Project cost variance is 4.7 percent. This small cost variance reflects the continued efforts to maintain effective cost control.

DIMNS JC

At the end of the this period, WSS has an overspending of 21.1 percent, as a result of activities in Task 2 currently under-way. The expenditures will tend to level off at the end of next reporting period but an additional allocation is being considered by NRC to support the review of SAR-003.

Table 1. CNWRA Core Staff—Current Profile and Hiring Plan* (03/17/95)

EXPERTISE/EXPERIENCE	CURRENT NO.	PROFESSIONAL STAFF	POSITIONS OPEN FY95
ADMINISTRATION	5	H.GARCIA, P.MACKIN, W.PATRICK, J.RUSSELL, B.SAGAR	
CODE ANALYSIS	2(1)‡	B.HENDERSON‡, R.JANETZKE, R.MARTIN	
DATABASE MANAGEMENT AND DATA PROCESS	1	A.JOHNSON	1
ELECTROCHEMISTRY	1	G.CRAGNOLINO	
ENGINEERING GEOLOGY/GEOLOGICAL ENGNG	1	G.OFOEGBU	1
ENVIRONMENTAL SCIENCES	1	P.LaPLANTE	
GEOCHEMISTRY	5 (1)†	P.BERTETTI†, W.MURPHY, R.PABALAN, E.PEARCY, J.PRIKRYL, D.TURNER	
GEOHYDROLOGY/HYDROGEOLOGY	5	A.BAGTZOGLOU, R.GREEN, A.B.GUREGHIAN, S.STOTHOFF, G.WITTMEYER	(1)‡
GEOLOGY	2	L.McKAGUE, M.MIKLAS	
INFORMATION MANAGEMENT SYSTEMS	2	R.JOHNSON, R.MARSHALL	
MATERIAL SCIENCES	3(1)†(1)**	P.ANGELL†, D.DUNN, H.MANAKTALA, N.SRIDHAR, J.SONG**	1
MECHANICAL, INCLUDING DESIGN & FABRICATION	1	C.TSCHOEPE	
MINING ENGINEERING	1	S-M.HSIUNG	
NUCLEAR ENGINEERING	1	H.KARIMI	
NUMERICAL MODELING/SIMULATION	1	M.JARZEMBA	
PERFORMANCE ASSESSMENT	3	R.BACA, R.MANTEUFEL, S.MOHANTY	1(1)†
QUALITY ASSURANCE	2	R.BRIENT, B.MABRITO	
RADIOISOTOPE GEOCHEMISTRY	1	D.PICKETT	
REGULATORY ANALYSIS	1	S.SPECTOR (law)	
ROCK MECHANICS	3	M.AHOLA, A.CHOWDHURY, A.GHOSH	
SEISMOLOGY	1	R.HOFMANN	
SOURCE-TERM/SPENT FUEL DEGRAD	1	P.LICHTNER	
STRUCTURAL GEOLOGY/SEISMO-TECTONICS	2	D.FERRILL, G.STIREWALT	1
SYSTEMS ENGINEERING	1	A.DeWISPELARE	
VOLCANOLOGY/IGNEOUS PROCESSES	2	C.CONNOR, B.HILL	
TOTAL	**49 (4)**		**5 (2)**

* SEE STAFFING PLAN FOR DETAILS
† LIMITED TERM
‡ ADDITIONAL POSITION TO IMPLEMENT AGGRESSIVE HIRING PLAN
** VISITING SCIENTIST, LIMITED TERM

Table 2. Summary of Schedule Changes

Milestone Number	Type	Description	Original Date	Revised Date	Rationale for Change
5702-221-520	IM	Procedures for Uncertainty Identification and Resolution	03/31/95	07/31/95	NRC directed to minimize any impact on other deliverables.
5702-421-502	IM	CDM for RRT 3.2.1.5 Structural Deformation	04/3/95	09/29/95	CDM will be tracked with AI 5702-421-502
5702-423-501	IM	CDM 3.2.2.5 Flooding	12/19/94	04/27/95	Awaiting NRC response
5702-423-502	IM	CDM 3.2.4.1 Evapotranspiration	01/16/95	05/16/95	Awaiting NRC response
5704-027-025-002	IM	Final Peer Reviewed Report	03/31/95	05/31/95	Delay in receipt of external peer reviews

Table 3. Financial Status

	Funds Authorized	Funds Costed to Date	Funds Uncosted	Commitments
GLGP	2,849,970	2,820,622	29,348	5,823
GHGC	354,938	208,367	146,571	1,966
EBS	1,964,425	1,921,684	42,742	28,228
RDCO	2,500,328	2,389,482	110,846	27,284
WSEI	3,330,073	3,233,076	96,997	12,041
EQA	347,520	306,192	41,328	2,200
PA	3,540,271	3,388,434	151,837	163,332
COPS	5,199,564	5,069,833	129,731	5,228
DWM COSTS	**20,087,089**	**19,337,690**	**749,400**	
DWM AWARD FEE	**1,032,768**	**356,391**	**676,377**	
DWM BASE FEE	**691,428**	**725,209**	**(33,782)**	
TOTAL DWM	**21,811,285**	**20,419,290**	**1,391,995**	**246,101**
OVERALL	508,127	469,671	38,456	18,494
GEOCHEM	396,353	396,353	0	0
THERMO	970,347	937,840	32,507	2,047
SEISMIC	1,211,618	1,143,067	68,551	10,759
IWPE	1,414,051	1,306,320	107,732	8,650
STOCH	474,407	474,407	0	0
ANALOGS	1,034,278	1,001,467	32,811	1,294
SORPTION	1,063,491	1,063,028	463	1,324
RES PA	1,177,585	1,139,235	38,350	19,120
VOLCAN (R)	705,427	732,526	(27,099)	28,895
VOLCAN (FLD)	669,221	581,986	87,236	7,905
REG HYDRO	434,001	370,677	63,324	300
NEAR FIELD	29,011	11,900	17,111	3,177
TECTONIC	1,002,461	908,325	94,136	7,453
SUB-REG HYDRO	142,417	145,576	(3,159)	835
RES COSTS	**11,232,796**	**10,682,376**	**550,420**	
RES AWARD FEE	**581,964**	**207,371**	**374,593**	
RES BASE FEE	**381,664**	**381,883**	**(219)**	
TOTAL RES	**12,196,424**	**11,271,630**	**924,794**	**110,254**
WSS COSTS	**311,093**	**325,272**	**(14,179)**	**1,800**
WSS AWARD FEE	**12,808**	**7,330**	**5,478**	
WSS BASE FEE	**11,490**	**12,966**	**(1,476)**	
TOTAL WSS	**335,392**	**345,569**	**(10,177)**	
TOTAL	**34,343,101**	**32,036,489**	**2,306,612**	**358,154**

Note: Additional Authorized Funds of $3,111,633 for DWM, and $2,067,551 for RES have not been allocated. Amount authorized includes carryover.

Table 4. Planned and Actual Costs, and Cost Variances

CENTER COMPOSITE
5700-000

ITEM	01	02	03	04	05	06	07	08	09	10	11	12	13	Total
Est Pd Cost	1,092,281	1,094,802	1,086,330	1,129,254	1,160,008	1,187,493	1,130,635	1,174,809	1,120,657	1,170,993	1,108,428	1,179,845	1,103,148	6,760,169
Actual Pd Cost	981,172	939,506	913,138	926,917	999,873	1,082,694	0	0	0	0	0	0	0	5,842,300
Variance, $	111,109	155,296	173,192	203,338	160,135	104,798	0	0	0	0	0	0	0	907,869
Variance, %	10.2%	14.2%	15.9%	18.0%	13.8%	8.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	13.4%
Est FY Cumul	1,092,281	2,187,083	3,273,413	4,402,667	5,562,676	6,750,169	7,880,804	9,055,612	10,176,270	11,347,263	12,455,691	13,635,536	14,738,684	
Actual FY Cumul	981,172	1,920,678	2,833,816	3,759,732	4,759,606	5,842,300	0	0	0	0	0	0	0	
Percent Complete	6.7%	13.0%	19.2%	25.5%	32.3%	39.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
Cumul Variance, $	111,109	266,405	439,597	642,935	803,071	907,869	0	0	0	0	0	0	0	
Cumul Variance, %	10.2%	12.2%	13.4%	14.6%	14.4%	13.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	

DIVISION OF WASTE MANAGEMENT
5702-000

ITEM	01	02	03	04	05	06	07	08	09	10	11	12	13	Total
Est Pd Cost	665,318	666,554	662,409	670,160	717,441	730,331	712,858	733,302	706,228	727,868	696,891	733,663	692,740	4,112,214
Actual Pd Cost	593,363	548,852	564,074	538,034	617,914	688,178	0	0	0	0	0	0	0	3,550,405
Variance, $	71,966	117,702	98,335	132,126	99,527	42,153	0	0	0	0	0	0	0	561,809
Variance, %	10.8%	17.7%	14.8%	19.7%	13.9%	5.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	13.7%
Est FY Cumul	665,318	1,331,872	1,994,281	2,664,441	3,381,883	4,112,214	4,825,072	5,558,376	6,264,602	6,992,470	7,689,361	8,423,024	9,115,764	
Actual FY Cumul	593,363	1,142,204	1,706,278	2,244,312	2,862,227	3,550,405	0	0	0	0	0	0	0	
Percent Complete	6.5%	12.5%	18.7%	24.6%	31.4%	38.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
Cumul Variance, $	71,966	189,668	288,003	420,129	519,656	561,809	0	0	0	0	0	0	0	
Cumul Variance, %	10.8%	14.2%	14.4%	15.8%	15.4%	13.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	

CNWRA OPERATIONS
5702-100

ITEM	01	02	03	04	05	06	07	08	09	10	11	12	13	Total
Est Pd Cost	165,866	166,160	165,572	166,565	188,607	189,872	188,219	190,161	183,232	181,783	178,710	183,080	177,424	1,042,642
Actual Pd Cost	169,759	151,910	183,445	121,645	146,261	154,496	0	0	0	0	0	0	0	927,516
Variance, $	(3,892)	14,249	(17,873)	44,920	42,246	35,376	0	0	0	0	0	0	0	115,026
Variance, %	-2.3%	8.6%	-10.8%	27.0%	22.4%	18.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	11.0%
Est FY Cumul	165,866	332,026	497,598	664,163	852,670	1,042,542	1,230,760	1,420,921	1,607,154	1,788,936	1,967,646	2,150,726	2,328,150	
Actual FY Cumul	169,759	321,669	505,114	626,759	773,020	927,516	0	0	0	0	0	0	0	
Percent Complete	7.3%	13.8%	21.7%	26.9%	33.2%	39.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
Cumul Variance, $	(3,892)	10,357	(7,516)	37,404	79,650	116,026	0	0	0	0	0	0	0	
Cumul Variance,%	-2.3%	3.1%	-1.5%	5.6%	9.3%	11.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	

WASTE SYSTEMS ENGINEERING AND INTEGRATION
5702-200

ITEM	01	02	03	04	05	06	07	08	09	10	11	12	13	Total
Est Pd Cost	96,747	96,775	96,151	97,527	95,831	97,614	94,763	98,031	94,073	98,188	93,759	98,640	93,594	580,645
Actual Pd Cost	100,394	82,672	86,606	84,352	87,447	88,524	0	0	0	0	0	0	0	529,995
Variance, $	(3,647)	14,103	9,546	13,174	8,384	9,090	0	0	0	0	0	0	0	50,650
Variance, %	-3.8%	14.6%	9.9%	13.5%	8.7%	9.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	8.7%
Est FY Cumul	96,747	193,522	289,673	387,200	483,031	580,645	675,408	773,439	867,511	965,700	1,059,458	1,158,098	1,251,692	
Actual FY Cumul	100,394	183,066	269,671	354,024	441,471	529,995	0	0	0	0	0	0	0	
Percent Complete	8.0%	14.6%	21.5%	28.3%	35.3%	42.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
Cumul Variance, $	(3,647)	10,456	20,002	33,176	41,560	50,650	0	0	0	0	0	0	0	
Cumul Variance,%	-3.8%	5.4%	6.9%	8.6%	8.6%	8.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	

QUALITY ASSURANCE
5702-300

ITEM	01	02	03	04	05	06	07	08	09	10	11	12	13	Total
Est Pd Cost	16,530	16,532	16,460	16,663	16,514	16,731	16,253	16,732	16,251	16,862	16,171	16,863	16,013	99,420
Actual Pd Cost	13,456	6,488	10,158	8,449	10,291	13,560	0	0	0	0	0	0	0	62,402
Variance, $	3,074	10,044	6,292	8,214	6,223	3,171	0	0	0	0	0	0	0	37,018
Variance, %	18.6%	60.8%	38.3%	49.3%	37.7%	19.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	37.2%
Est FY Cumul	16,530	33,062	49,512	66,176	82,689	99,420	115,673	132,404	148,655	165,517	181,688	198,551	214,564	
Actual FY Cumul	13,456	19,944	30,102	38,551	48,842	62,402	0	0	0	0	0	0	0	
Percent Complete	6.3%	9.3%	14.0%	18.0%	22.8%	29.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
Cumul Variance, $	3,074	13,118	19,410	27,624	33,847	37,018	0	0	0	0	0	0	0	
Cumul Variance,%	18.6%	39.7%	39.2%	41.7%	40.9%	37.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	

GEOLOGY AND GEOPHYSICS
5702-400A

ITEM	01	02	03	04	05	06	07	08	09	10	11	12	13	Total
Est Pd Cost	62,300	62,579	62,030	63,089	73,646	75,189	70,110	71,818	68,350	72,165	68,244	72,802	67,926	398,843
Actual Pd Cost	32,066	53,708	45,177	54,670	73,838	89,331	0	0	0	0	0	0	0	348,790
Variance, $	30,234	8,871	16,853	8,429	(191)	(14,142)	0	0	0	0	0	0	0	50,053
Variance, %	48.5%	14.2%	27.2%	13.4%	-0.3%	-18.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	12.5%
Est FY Cumul	62,300	124,879	186,909	250,008	323,654	398,843	468,953	540,772	609,121	681,286	749,530	822,332	890,258	
Actual FY Cumul	32,066	85,774	130,951	185,622	259,459	348,790	0	0	0	0	0	0	0	
Percent Complete	3.6%	9.6%	14.7%	20.9%	29.1%	39.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
Cumul Variance, $	30,234	39,105	55,958	64,387	64,195	50,053	0	0	0	0	0	0	0	
Cumul Variance,%	48.5%	31.3%	29.9%	25.8%	19.8%	12.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	

GEOHYDROLOGY AND GEOCHEMISTRY
5702-400B

ITEM	01	02	03	04	05	06	07	08	09	10	11	12	13	Total
Est Pd Cost	44,660	44,821	44,185	45,111	57,165	58,600	60,397	63,411	61,130	63,794	59,479	64,237	58,826	294,541
Actual Pd Cost	50,055	30,558	25,090	25,619	35,321	41,724	0	0	0	0	0	0	0	208,367
Variance, $	(5,395)	14,263	19,095	19,492	21,844	16,876	0	0	0	0	0	0	0	86,174
Variance, %	-12.1%	31.8%	43.2%	43.2%	38.2%	28.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	29.3%
Est FY Cumul	44,660	89,481	133,665	178,776	236,941	294,541	364,938	418,349	478,379	542,173	601,652	665,889	724,815	
Actual FY Cumul	50,055	80,613	105,703	131,322	166,643	208,367	0	0	0	0	0	0	0	
Percent Complete	6.9%	11.1%	14.6%	18.1%	23.0%	28.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
Cumul Variance, $	(5,395)	8,868	27,963	47,454	69,298	86,174	0	0	0	0	0	0	0	
Cumul Variance,%	-12.1%	9.9%	20.9%	26.5%	29.4%	29.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	

ENGINEERED BARRIER SYSTEM
5702-500

ITEM	01	02	03	04	05	06	07	08	09	10	11	12	13	Total
Est Pd Cost	60,340	60,421	60,079	60,786	69,775	71,392	69,179	71,869	68,658	72,184	68,313	72,481	67,921	382,793
Actual Pd Cost	58,486	52,588	59,988	57,553	63,718	55,723	0	0	0	0	0	0	0	348,055
Variance, $	1,856	7,832	91	3,233	6,057	15,669	0	0	0	0	0	0	0	34,738
Variance, %	3.1%	13.0%	0.2%	5.3%	8.7%	21.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	9.1%
Est FY Cumul	60,340	120,761	180,839	241,626	311,401	382,793	451,971	523,840	592,498	664,683	732,996	805,478	873,399	
Actual FY Cumul	58,486	111,073	171,060	228,614	292,332	348,055	0	0	0	0	0	0	0	
Percent Complete	6.7%	12.7%	19.6%	26.2%	33.5%	39.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
Cumul Variance, $	1,856	9,688	9,779	13,012	19,069	34,738	0	0	0	0	0	0	0	
Cumul Variance,%	3.1%	8.0%	5.4%	5.4%	6.1%	9.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	

REPOSITORY DESIGN, CONSTRUCTION, AND OPERATIONS
5702-600

ITEM	01	02	03	04	05	06	07	08	09	10	11	12	13	Total
Est Pd Cost	97,544	97,876	96,849	98,265	96,719	98,668	94,861	98,753	93,798	99,581	93,619	100,252	92,710	584,922
Actual Pd Cost	84,365	78,602	73,996	98,297	80,362	86,488	0	0	0	0	0	0	0	502,109
Variance, $	13,179	19,275	22,853	(32)	16,357	12,180	0	0	0	0	0	0	0	82,813
Variance, %	13.5%	19.7%	23.6%	0.0%	16.0%	12.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	14.2%
Est FY Cumul	97,544	195,420	292,269	390,535	486,254	584,922	679,783	778,536	872,334	971,916	1,065,434	1,165,686	1,258,396	
Actual FY Cumul	84,365	162,967	236,963	335,260	415,622	502,109	0	0	0	0	0	0	0	
Percent Complete	6.7%	13.0%	18.8%	26.6%	33.0%	39.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
Cumul Variance, $	13,179	32,453	55,307	55,275	70,632	82,813	0	0	0	0	0	0	0	
Cumul Variance,%	13.5%	16.6%	18.9%	14.2%	14.5%	14.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	

PERFORMANCE ASSESSMENT
5702-700

ITEM	01	02	03	04	05	06	07	08	09	10	11	12	13	Total
Est Pd Cost	121,331	121,390	121,094	122,145	120,283	122,266	119,077	122,528	118,836	123,310	118,697	125,307	118,227	728,509
Actual Pd Cost	84,773	92,326	79,615	87,448	120,676	158,333	0	0	0	0	0	0	0	623,171
Variance, $	36,558	29,064	41,478	34,697	(393)	(36,067)	0	0	0	0	0	0	0	105,337
Variance, %	30.1%	23.9%	34.3%	28.4%	-0.3%	-29.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	14.5%
Est FY Cumul	121,331	242,721	363,815	485,960	606,243	728,509	847,585	970,114	1,088,950	1,212,260	1,330,957	1,456,264	1,574,491	
Actual FY Cumul	84,773	177,099	256,715	344,163	464,838	623,171	0	0	0	0	0	0	0	
Percent Complete	5.4%	11.2%	16.3%	21.9%	29.5%	39.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
Cumul Variance, $	36,558	65,622	107,101	141,797	141,404	105,337	0	0	0	0	0	0	0	
Cumul Variance,%	30.1%	27.0%	29.4%	29.2%	23.3%	14.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	

RESEARCH
5704-000

ITEM	01	02	03	04	05	06	07	08	09	10	11	12	13	Total
Est Pd Cost	410,802	412,086	408,045	442,569	427,783	441,365	403,354	425,653	400,241	427,143	397,673	430,119	396,623	2,542,650
Actual Pd Cost	371,839	370,797	334,063	376,939	363,321	359,483	0	0	0	0	0	0	0	2,176,442
Variance, $	38,963	41,288	73,982	65,630	64,462	81,882	0	0	0	0	0	0	0	366,208
Variance, %	9.5%	10.0%	18.1%	14.8%	15.1%	18.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	14.4%
Est FY Cumul	410,802	822,887	1,230,932	1,673,501	2,101,286	2,542,650	2,946,004	3,371,657	3,771,898	4,199,041	4,596,714	5,026,832	5,423,456	
Actual FY Cumul	371,839	742,636	1,076,699	1,453,638	1,816,959	2,176,442	0	0	0	0	0	0	0	
Percent Complete	6.9%	13.7%	19.9%	26.8%	33.5%	40.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
Cumul Variance, $	38,963	80,251	154,234	219,864	284,326	366,208	0	0	0	0	0	0	0	
Cumul Variance,%	9.5%	9.8%	12.5%	13.1%	13.5%	14.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	

OVERALL RESEARCH
5704-000

ITEM	01	02	03	04	05	06	07	08	09	10	11	12	13	Total
Est Pd Cost	16,642	16,670	16,873	16,649	16,197	17,378	16,195	17,481	14,686	17,481	14,658	17,831	14,667	98,209
Actual Pd Cost	16,715	10,482	18,467	5,949	9,624	25,150	0	0	0	0	0	0	0	86,386
Variance, $	827	6,088	(2,593)	10,700	6,573	(7,772)	0	0	0	0	0	0	0	12,823
Variance, %	5.0%	36.7%	-16.3%	64.3%	36.7%	-44.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	13.1%
Est FY Cumul	16,642	33,112	48,986	66,634	80,831	98,209	113,405	130,886	145,571	163,052	177,709	195,540	210,196	
Actual FY Cumul	16,715	26,197	44,663	50,612	60,237	85,386	0	0	0	0	0	0	0	
Percent Complete	7.6%	12.5%	21.2%	24.1%	28.7%	40.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
Cumul Variance, $	827	6,915	4,322	15,022	20,595	12,823	0	0	0	0	0	0	0	
Cumul Variance,%	5.0%	20.9%	8.8%	22.9%	25.5%	13.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	

THERMOHYDROLOGY
5704-020

ITEM	01	02	03	04	05	06	07	08	09	10	11	12	13	Total
Est Pd Cost	37,221	37,193	37,469	37,105	37,469	37,105	0	0	0	0	0	0	0	223,563
Actual Pd Cost	24,001	24,932	20,806	51,910	45,606	44,887	0	0	0	0	0	0	0	212,141
Variance, $	13,221	12,262	16,663	(14,805)	(8,137)	(7,782)	0	0	0	0	0	0	0	11,422
Variance, %	35.5%	33.0%	44.5%	-39.9%	-21.7%	-21.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	5.1%
Est FY Cumul	37,221	74,415	111,884	148,989	186,458	223,563	223,563	223,563	223,563	223,563	223,563	223,563	223,563	
Actual FY Cumul	24,001	48,932	69,739	121,648	167,254	212,141	0	0	0	0	0	0	0	
Percent Complete	10.7%	21.9%	31.2%	54.4%	74.8%	94.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
Cumul Variance, $	13,221	25,482	42,145	27,341	19,204	11,422	0	0	0	0	0	0	0	
Cumul Variance,%	35.5%	34.2%	37.7%	18.4%	10.3%	5.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	

ROCK MECHANICS
5704-030

ITEM	01	02	03	04	05	06	07	08	09	10	11	12	13	Total
Est Pd Cost	36,700	37,174	36,257	37,210	36,074	37,549	35,496	37,665	34,688	37,690	34,563	38,224	34,391	220,963
Actual Pd Cost	33,373	26,665	25,408	25,877	30,286	38,932	0	0	0	0	0	0	0	180,432
Variance, $	3,327	10,619	10,850	11,332	5,787	(1,384)	0	0	0	0	0	0	0	40,532
Variance, %	9.1%	28.6%	29.9%	30.5%	16.0%	-3.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	18.3%
Est FY Cumul	36,700	73,874	110,132	147,341	183,415	220,963	256,460	294,124	328,813	366,503	401,066	439,280	473,672	
Actual FY Cumul	33,373	59,928	85,336	111,213	141,500	180,432	0	0	0	0	0	0	0	
Percent Comp'ete	7.0%	12.7%	18.0%	23.5%	29.9%	38.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
Cumul Variance, $	3,327	13,946	24,796	36,128	41,915	40,532	0	0	0	0	0	0	0	
Cumul Variance,%	9.1%	18.9%	22.5%	24.5%	22.9%	18.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	

INTEGRATED WASTE PACKAGE EXPERIMENTS
5704-040

ITEM	01	02	03	04	05	06	07	08	09	10	11	12	13	Total
Est Pd Cost	52,705	52,762	52,575	53,350	51,795	53,353	50,857	53,898	50,689	53,958	50,607	54,396	50,578	316,541
Actual Pd Cost	45,642	29,027	38,800	34,931	44,423	49,473	0	0	0	0	0	0	0	242,295
Variance, $	7,063	23,735	13,775	18,419	7,372	3,880	0	0	0	0	0	0	0	74,245
Variance, %	13.4%	45.0%	26.2%	34.5%	14.2%	7.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	23.5%
Est FY Cumul	52,705	105,467	158,042	211,392	263,187	316,541	367,398	421,296	471,985	525,943	576,551	630,946	681,525	
Actual FY Cumul	45,642	74,669	113,469	148,400	192,822	242,295	0	0	0	0	0	0	0	
Percent Complete	6.7%	11.0%	16.6%	21.8%	28.3%	35.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
Cumul Variance, $	7,063	30,798	44,573	62,993	70,365	74,245	0	0	0	0	0	0	0	
Cumul Variance,%	13.4%	29.2%	28.2%	29.8%	26.7%	23.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	

GEOCHEMICAL ANALOG
5704-060

ITEM	01	02	03	04	05	06	07	08	09	10	11	12	13	Total
Est Pd Cost	34,871	35,053	34,758	35,157	34,276	35,158	33,729	35,187	33,726	35,244	33,493	35,324	33,464	209,273
Actual Pd Cost	32,054	39,004	36,029	30,206	43,978	18,579	0	0	0	0	0	0	0	199,850
Variance, $	2,817	(3,951)	(1,271)	4,951	(9,703)	16,579	0	0	0	0	0	0	0	9,423
Variance, %	8.1%	-11.3%	-3.7%	14.1%	-28.3%	47.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	4.5%
Est FY Cumul	34,871	69,924	104,683	139,839	174,115	209,273	243,002	278,189	311,916	347,160	380,653	415,977	449,442	
Actual FY Cumul	32,054	71,058	107,087	137,293	181,271	199,850	0	0	0	0	0	0	0	
Percent Complete	7.1%	15.8%	23.8%	30.5%	40.3%	44.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
Cumul Variance, $	2,817	(1,134)	(2,405)	2,547	(7,156)	9,423	0	0	0	0	0	0	0	
Cumul Variance,%	8.1%	-1.6%	-2.3%	1.8%	-4.1%	4.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	

SORPTION MODELING
5704-070

ITEM	01	02	03	04	05	06	07	08	09	10	11	12	13	Total
Est Pd Cost	34,922	34,923	34,897	34,952	34,507	35,379	33,902	35,380	33,708	35,380	33,600	35,381	33,599	209,580
Actual Pd Cost	46,671	37,967	39,640	39,793	40,215	28,994	0	0	0	0	0	0	0	233,281
Variance, $	(11,749)	(3,044)	(4,744)	(4,840)	(5,709)	6,385	0	0	0	0	0	0	0	(23,701)
Variance, %	-33.6%	-8.7%	-13.6%	-13.8%	-16.5%	18.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-11.3%
Est FY Cumul	34,922	69,845	104,742	139,694	174,201	209,580	243,482	278,862	312,570	347,951	381,550	416,932	450,530	
Actual FY Cumul	46,671	84,638	124,278	164,071	204,286	233,281	0	0	0	0	0	0	0	
Percent Complete	10.4%	18.8%	27.6%	36.4%	45.3%	51.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
Cumul Variance, $	(11,749)	(14,793)	(19,536)	(24,377)	(30,086)	(23,701)	0	0	0	0	0	0	0	
Cumul Variance, %	-33.6%	-21.2%	-18.7%	-17.5%	-17.3%	-11.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	

VOLCAN SYSTEMS
5704-120

ITEM	01	02	03	04	05	06	07	08	09	10	11	12	13	Total
Est Pd Cost	24,981	25,183	24,846	25,263	24,008	25,642	22,934	25,685	22,907	25,798	22,802	26,070	22,715	149,823
Actual Pd Cost	37,758	48,413	32,846	42,218	16,034	16,787	0	0	0	0	0	0	0	194,055
Variance, $	(12,777)	(23,230)	(8,001)	(16,955)	7,975	8,855	0	0	0	0	0	0	0	(44,232)
Variance, %	-51.1%	-92.2%	-32.2%	-67.1%	33.2%	34.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-29.5%
Est FY Cumul	24,981	50,164	75,009	100,272	124,280	149,823	172,757	198,441	221,349	247,146	269,949	296,018	318,733	
Actual FY Cumul	37,758	86,170	119,017	161,234	177,268	194,055	0	0	0	0	0	0	0	
Percent Complete	11.8%	27.0%	37.3%	50.6%	55.6%	60.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
Cumul Variance, $	(12,777)	(36,006)	(44,008)	(60,962)	(52,988)	(44,232)	0	0	0	0	0	0	0	
Cumul Variance, %	-51.1%	-71.8%	-58.7%	-60.8%	-42.6%	-29.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	

REGIONAL HYDROGEOLOGIC PROCESS
5704-130

ITEM	01	02	03	04	05	06	07	08	09	10	11	12	13	Total
Est Pd Cost	27,820	27,822	27,042	27,903	26,984	27,992	26,578	27,993	2 ,058	28,382	26,002	28,642	25,894	166,563
Actual Pd Cost	16,817	20,203	17,856	20,126	18,607	17,233	0	0	0	0	0	0	0	109,843
Variance, $	12,003	7,619	9,186	7,777	8,377	10,759	0	0	0	0	0	0	0	56,720
Variance, %	43.1%	27.4%	34.0%	27.9%	31.0%	38.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	33.7%
Est FY Cumul	27,820	55,642	82,684	110,587	137,570	165,563	192,141	220,134	246,192	274,574	300,576	329,218	355,112	
Actual FY Cumul	16,817	36,021	53,877	74,003	92,610	109,843	0	0	0	0	0	0	0	
Percent Complete	4.5%	10.1%	15.2%	20.8%	26.1%	30.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
Cumul Variance, $	12,003	19,621	28,807	36,584	44,961	55,720	0	0	0	0	0	0	0	
Cumul Variance, %	43.1%	35.3%	34.8%	33.1%	32.7%	33.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	

FIELD VOLCANISM
5704-140

ITEM	01	02	03	04	05	06	07	08	09	10	11	12	13	Total
Est Pd Cost	29,074	29,155	28,944	29,393	28,526	29,504	28,133	29,588	28,130	29,617	27,921	29,617	27,842	174,595
Actual Pd Cost	13,396	35,694	11,724	11,816	16,834	11,972	0	0	0	0	0	0	0	101,437
Variance, $	15,678	(6,539)	17,220	17,577	11,690	17,532	0	0	0	0	0	0	0	73,158
Variance, %	53.9%	-22.4%	59.5%	59.8%	41.0%	59.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	41.9%
Est FY Cumul	29,074	58,229	87,173	116,566	145,091	174,595	202,728	232,316	260,446	290,062	317,983	347,600	375,442	
Actual FY Cumul	13,396	49,090	60,814	72,630	89,465	101,437	0	0	0	0	0	0	0	
Percent Complete	3.6%	13.1%	16.2%	19.3%	23.8%	27.0%	0.0%	0.0%	(0%	0.0%	0.0%	0.0%	0.0%	
Cumul Variance, $	15,678	9,139	26,359	43,936	55,626	73,158	0	0	0	0	0	0	0	
Cumul Variance, %	53.9%	15.7%	30.2%	37.7%	38.3%	41.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	

NEAR FIELD
5704-160

ITEM	01	02	03	04	05	06	07	08	09	10	11	12	13	Total
Est Pd Cost	0	0	0	29,011	29,011	29,112	29,033	29,558	29,030	29,688	28,900	29,689	28,511	87,135
Actual Pd Cost	0	0	0	0	2,355	9,545	0	0	0	0	0	0	0	11,900
Variance, $	0	0	0	29,011	26,656	19,567	0	0	0	0	0	0	0	75,235
Variance, %	0.0%	0.0%	0.0%	100.0%	91.9%	67.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	86.3%
Est FY Cumul	0	0	0	29,011	58,023	87,135	116,168	145,726	174,757	204,445	233,345	263,034	291,545	
Actual FY Cumul	0	0	0	0	2,355	11,900	0	0	0	0	0	0	0	
Percent Complete	0.0%	0.0%	0.0%	0.0%	0.8%	4.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
Cumul Variance, $	0	0	0	29,011	55,668	75,235	0	0	0	0	0	0	0	
Cumul Variance,%	0.0%	0.0%	0.0%	100.0%	95.9%	86.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	

TECTONIC PROCESS
5704-160

ITEM	01	02	03	04	05	06	07	08	09	10	11	12	13	Total
Est Pd Cost	52,326	52,554	52,268	52,556	51,346	52,730	50,697	52,815	49,849	52,951	49,161	53,037	49,100	313,782
Actual Pd Cost	52,603	41,680	32,578	35,399	32,686	44,831	0	0	0	0	0	0	0	239,776
Variance, $	(277)	10,875	19,691	17,157	18,660	7,900	0	0	0	0	0	0	0	74,005
Variance, %	-0.5%	20.7%	37.7%	32.6%	36.3%	15.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	23.6%
Est FY Cumul	52,326	104,880	157,148	209,705	261,051	313,782	364,479	417,294	467,143	520,095	569,256	622,293	671,393	
Actual FY Cumul	52,603	94,282	126,860	162,259	194,945	239,776	0	0	0	0	0	0	0	
Percent Complete	7.8%	14.0%	18.9%	24.2%	29.0%	35.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
Cumul Variance, $	(277)	10,598	30,288	47,446	66,106	74,005	0	0	0	0	0	0	0	
Cumul Variance,%	-0.5%	10.1%	19.3%	22.6%	25.3%	23.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	

SUB-REGIONAL HYDROGEOLOGIC FLOW AND TRANSPORT PROCESSES
5704-170

ITEM	01	02	03	04	05	06	07	08	09	10	11	12	13	Total
Est Pd Cost	24,839	24,839	24,737	24,944	21,071	21,485	20,662	21,665	20,662	21,835	20,323	22,009	20,221	141,915
Actual Pd Cost	10,309	19,193	28,282	35,769	26,335	25,161	0	0	0	0	0	0	0	145,047
Variance, $	14,530	5,646	(3,545)	(10,824)	(5,264)	(3,676)	0	0	0	0	0	0	0	(3,132)
Variance, %	58.5%	22.7%	-14.3%	-43.4%	-25.0%	-17.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-2.2%
Est FY Cumul	24,839	49,678	74,415	99,359	120,430	141,915	162,577	184,142	204,804	226,640	246,963	268,971	289,193	
Actual FY Cumul	10,309	29,501	57,783	93,552	119,886	145,047	0	0	0	0	0	0	0	
Percent Complete	3.6%	10.2%	20.0%	32.3%	41.5%	50.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
Cumul Variance, $	14,530	20,177	16,632	5,808	544	(3,132)	0	0	0	0	0	0	0	
Cumul Variance,%	58.5%	40.6%	22.4%	5.8%	0.5%	-2.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	

PERFORMANCE ASSESSMENT RESEARCH
5704-190

ITEM	01	02	03	04	05	06	07	08	09	10	11	12	13	Total
Est Pd Cost	38,800	38,867	38,379	39,076	37,520	39,077	36,570	39,270	36,568	39,486	36,147	40,209	36,146	231,709
Actual Pd Cost	44,288	37,646	31,629	42,946	36,337	27,941	0	0	0	0	0	0	0	220,787
Variance, $	(5,488)	1,211	6,750	(3,871)	1,184	11,136	0	0	0	0	0	0	0	10,922
Variance, %	-14.1%	3.1%	17.6%	-9.9%	3.2%	28.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	4.7%
Est FY Cumul	38,800	77,667	116,036	155,112	192,632	231,709	268,279	307,549	344,117	383,603	419,750	459,959	496,104	
Actual FY Cumul	44,288	81,934	113,563	156,510	192,846	220,787	0	0	0	0	0	0	0	
Percent Complete	8.9%	16.5%	22.9%	31.5%	38.9%	44.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
Cumul Variance, $	(5,488)	(4,277)	2,473	(1,398)	(214)	10,922	0	0	0	0	0	0	0	
Cumul Variance,%	-14.1%	-5.5%	2.1%	-0.9%	-0.1%	4.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	

WASTE SOLIDIFICATION SYSTEMS
5706-000

ITEM	01	02	03	04	05	06	07	08	09	10	11	12	13	Total
Est Pd Cost	16,162	16,163	15,876	16,525	14,784	15,797	14,422	15,853	14,189	15,983	13,864	16,064	13,785	95,305
Actual Pd Cost	15,981	19,857	15,001	10,944	18,638	35,033	0	0	0	0	0	0	0	115,453
Variance, $	181	(3,695)	875	5,581	(3,854)	(19,236)	0	0	0	0	0	0	0	(20,148)
Variance, %	1.1%	-22.9%	5.5%	33.8%	-26.1%	-121.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-21.1%
Est FY Cumul	16,162	32,324	48,200	64,725	79,508	95,305	109,728	125,581	139,770	155,752	169,616	185,680	199,464	
Actual FY Cumul	15,981	35,838	50,838	61,783	80,420	115,453	0	0	0	0	0	0	0	
Percent Complete	8.0%	18.0%	25.5%	31.0%	40.3%	57.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
Cumul Variance, $	181	(3,514)	(2,639)	2,942	(912)	(20,148)	0	0	0	0	0	0	0	
Cumul Variance, %	1.1%	-10.9%	-5.5%	4.5%	-1.1%	-21.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	