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7. Abstract

The statements of work for each activity and task of the Hanford Low-Level Tank Waste Performance Assessment project are given for the fiscal years 1996 through 2001. The end product of this program is approval of a final performance assessment by the Department of Energy in the year 2000.

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**STATEMENTS OF WORK
FOR FY 1996 TO 2001
FOR THE HANFORD LOW-LEVEL TANK WASTE
PERFORMANCE ASSESSMENT PROJECT**

June, 1995

Hanford Tank Low-Level Waste
Performance Assessment Group

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MASTER

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INTRODUCTION

I: BACKGROUND

This report contains the statements of work for fiscal year 1996 through the year 2001 of the Performance Assessment (PA) Project for the Hanford Low-Level Tank Waste. It updates last year's report which covered the years from 1995 to 2000. There are three functions in this project:

- A) Provide management of the performance assessment project.
- B) Prepare an interim performance assessment before construction begins on any Hanford low-level tank waste facilities.
- C) Prepare a final performance assessment (which is approved by U.S. Department of Energy (DOE) headquarters) prior to the beginning of operation of the Hanford low-level tank waste disposal facility.

Appendix A provides a multi-year outline of activities and tasks in this project.

By DOE Order 5820.2A (and its proposed successor 5820.2B), before any low-level waste can be disposed, a performance assessment covering the disposal facility must be approved by DOE headquarters. The performance assessment is to provide "reasonable assurance" that the disposal activities will protect long-term human health and safety. Thus along with constraints imposed by the Safety Analysis Report, various state permits, financial matters, and management objectives, the constraints imposed by the performance assessment are a major driver in the low-level waste project.

II. MANAGEMENT

As the program matures, the knowledge and advice of the performance assessment group is moving from white papers to actual performance assessment documents. Therefore, what was known as the final guidance activity will now be placed in the activities actually creating the Interim, Preliminary, and Final Performance Assessments. Progress made in the Interim Guidance activity is, however, in this activity.

The Management activity (1.3) more clearly defines the scope of management (for example, the breakdown between PNL and WHC) than last year's document. Also all external review is now covered in section III below.

III. INTERIM PERFORMANCE ASSESSMENT

The Peer Review Panel (the body established by DOE headquarters to judge the technical adequacy of the performance) has determined the performance assessment must contain site-specific and waste form-specific data. It will not be possible to obtain such specific data before the start of construction of the Hanford low-level tank waste facilities, presently scheduled for 1997. Instead a performance assessment based on as much specific data as possible will be created using the methods and techniques to be used in the final performance assessment. This performance assessment is designed to demonstrate prior to any construction that there will be a high likelihood that the final performance assessment will be approved.

The activities will be

- 1) determine data packages for the Interim Performance Assessment (activity 2.1), which is due at the end of FY 1995.
- 2) perform calculations and analyses and write the document (activity 2.2), and
- 3) define contingencies (activity 2.3).

The data packages for the Interim Performance Assessment will be completed in FY 1995. The calculations and analyses will be based on the data packages created in FY 1995. Based on the format and content guidelines of the Peer Review Panel (PRP) and the Performance Assessment Task Team (PATT), the Interim Performance Assessment will then be written and internally reviewed. Because the interim performance assessment is not formerly part of the DOE process, it is probable that a body other than the Peer Review Panel (but comparable in expertise) will review the entire document and process.

IV. PRELIMINARY AND FINAL PERFORMANCE ASSESSMENT

By DOE Order 5820.2A (and its draft successor 5820.2B) before waste can be disposed in a facility, the performance assessment that provides reasonable assurance that the disposal action will not harm long-term human health and safety must be approved by DOE headquarters. The new draft order also requires that the local DOE field office approves the preliminary performance assessment before construction can begin on the disposal facility and that updated performance assessments be issued periodically with the last performance assessment being the final closure document.

Thus performance assessments are the among the key documents in the life of a disposal facility.

The main activities in the preliminary and final performance assessment are:

- 1) Update performance objectives from interim performance assessment (activity 3.1.1),
- 2) Update scenarios from interim performance assessment (activity 3.1.2),
- 3) Tool selection (activity 3.1.3),

- 4) Obtain data for preliminary performance assessment (activities 3.1.4 through 3.1.6),
- 5) Calculate response and document for preliminary performance assessment (activity 3.2),
- 6) Peer Review Panel review of preliminary performance assessment (activity 3.3),
- 7) Obtain data for final performance assessment (activity 3.4), and
- 8) Calculate responses and document for final performance assessment (activity 3.5).

In accordance with the Defense Nuclear Facility Safety Board recommendation 94-2, the effect of previous Hanford actions on compliance points of this proposed disposal action will be explicitly calculated. Thus the strategy will not be to assume a dose allocation for this disposal action, but to provide reasonable assurance that this disposal action along with the impact of previous actions will meet performance objectives.

The pattern of activities follow that of the interim performance assessment, but the emphasis is strongly on justification. Because of the long-lead times for gathering data, activities in the "obtaining data for preliminary performance assessment" started in fiscal year 1995.

V. CONTENTS OF THIS REPORT

The remainder of this report contains statements of work for each of the activities and tasks in the performance assessment area in fiscal years 1996 through 2001. Appendix A outlines the schedules for the activities and the tasks. The format and contents for each activity and task are the same and are described in Appendix B. Appendix C lists the deliverables for all tasks in chronological order. Finally, Appendix D provides expense and capital budgets along with a non-WHC budget.

1.2 Interim Guidance

I. SUMMARY

Using tools that will be use in performance assessments, provide guidance after July 1993 and in FY 1995 to other parts of the low-level waste project on how their choices will affect the long-term behavior of the system.

II. GENERAL

This task is scheduled to be completed in FY 1995. A major accomplishment was issuing "The Effects of System Design Options on Low-Level Glass Waste Disposal System Performance" WHC-EP-0810 by John Rawlins et al published September 2, 1994. A revision addressing comments on the original and incorporating new information is planned to be released at the end of FY 1995. Tasks were completed on-time and within budget.

III. TASK DESCRIPTIONSA. Summary list of tasks

- 1) Advise site selection using Performance Assessment methods.
- 2) Advise system functions and requirements using Performance Assessment methods.
- 3) Advise glass development using Performance Assessment methods.
- 4) Advise matrix development using Performance Assessment methods.
- 5) Advise characterization and process engineering using Performance Assessment methods.
- 6) Advise on sensitivity of answers to uncertainties.
- 7) Manage performance assessment activities.

B. Advise site selection using PA methods

The impacts on long-term environmental and safety for the six proposed low-level waste disposal sites were determined and communicated to the Tank Waste Remediation Systems (TWRS) decision panel.

C. Advise system functions and requirements using PA methods

Interactions continued with the TWRS Program Office and with TWRS Engineering.

D. Advise glass development using PA methods

Input for the disposal options paper as well as a DOE-sponsored meeting on glass release requirements held in Park City, Utah in November 1994 was provided.

E. Advise matrix development using PA methods

Interactions continued with the Pacific Northwest Laboratory (PNL) on the definition and planning of their experiments which are funded separately by the Tank Waste Remediation System (TWRS) Program Office.

F. Advise characterization and process engineering using PA methods

A major question addressed in the disposal options paper was the need for additional pretreatment.

G. Advise on sensitivity of answers to uncertainties

The methods recommended by the Nuclear Regulatory Commission were reviewed for their applicability to this work.

H. Manage performance assessment activities

On-going activity.

1.3 Management

I. SUMMARY

This activity provides the project management tasks and general supporting tasks for the Interim, Preliminary, and Final Performance Assessments.

II. GENERALA. Background

Project management is separated from technical management since so many disciplines and organizations are being teamed together.

B. Organization

The responsible organization will be the Environmental Modeling Section of the Westinghouse Hanford Company, Nick Anderson, Manager. The cognizant scientist will be Fred Mann. The lead contact at PNL will be Joe Westsik, Jr.

C. Vision

To ensure that all members of the Hanford low-level tank waste performance assessment team know all the information for them to succeed in their tasks. To provide supporting services as necessary.

D. Objectives

This activity will provide project management and general support tasks.

E. Deliverables

- 1) Statement of Work for FY 1997 to 2002 due to program office
June 15, 1996.
- 2) Statement of Work for FY 1998 to 2003 due to program office
June 15, 1997.
- 3) Statement of Work for FY 1999 to 2004 due to program office
June 15, 1998.
- 4) Statement of Work for FY 2000 to 2005 due to program office
June 15, 1999.
- 5) Statement of Work for FY 2001 to 2006 due to program office
June 15, 2000.

III. TASK DESCRIPTIONS

A. Summary list of tasks

- 1) Provide WHC Management.
- 2) Provide PNL Project Management.
- 3) Support of PATT Chairman.
- 4) Program Overhead Costs.

B. Provide WHC Management

This task provides management for the overall glass performance assessment effort. This task also includes training of Performance Assessment Team members, WHC computer use, and general secretarial support.

Each year, this task will provide statements of work (that is, updates to this document) for the following six years. Each document will include a description of progress made during the year since the last statement of work.

Eight (8) man-months of professional time costing \$130,000 per FTE and 6 man-months of secretarial time costing \$70,000 per FTE will be needed each year to manage the task. This results in a total labor cost of \$122,000. This cost estimate is based on prior year's management of this team.

C. Provide PNL Project Management

The purpose of the PNL Vitrification Technology Development (PVTD) Project Low-Level Waste Management Task is to formalize and centralize the management of the PVTD low-level waste activities including PNL activities in support of WHC's glass performance assessment effort. Specific objectives of this task are to provide a focal point for the following:

- Planning, integrating, coordinating, controlling, and reporting project activities in accordance with PNL and TWRS Program requirements.
- Identifying project issues/concerns and their timely resolutions.
- Interfacing with RL, the Integrating Contractor, and other project participants.
- Interfacing with other U.S. and foreign organizations involved in vitrifying radioactive wastes.
- Performing Information Resource Management activities on a level-of-effort basis.
- Supporting quality assurance activities.

The cost of this activity each year is estimated to be \$270,000 in FY 96. These costs are based on previous experience managing projects including those with TWRS. These costs include 0.4 FTE of a Project Manager, 0.4 FTE of a Project Manager Specialist, 0.25 FTE of an Administrative Assistant/Records Management Specialist, and 0.25 FTE of a Quality Engineer. The costs also include \$15,000 to provide coordination in PNL Geosciences. PNL Project Management costs are estimated to be \$270,000 each year in FY 1997, 1998, and 1999.

D. Support of PATT Chairman/Hanford PRP Representative

This task provides funding in support of oversight and analysis of developing and existing DOE, NRC, EPA, and Washington State radiological regulations and waste classification issues that might impact tank waste disposal. Activities include reviews, comment letters, advice on impacts, recommendations on compliance and classification approaches, and contacts with appropriate regulators. The task also includes liaison with national performance assessment projects, so this activity is to be conducted by the chairman (Don Wood) of the Performance Assessment Task Team (PATT). The PATT is a DOE-Headquarters chartered group which advises preparers of DOE Performance Assessments and the Peer Review Panel on contents and format to be used in performance assessments.

This task also provides for reviews of documents produced by the Hanford Low-level Tank Waste Performance Assessment team by the Hanford Peer Review Panel member.

0.2 FTE of WHC professional time costing \$130,000 per FTE per year for a cost of \$26,000 per year is required. 0.0833 FTE of PNL team costing \$200,000 per FTE for a cost of \$16,700. The total cost is \$42,700.

E. Program Overhead Costs

Some items support many tasks. Such items include travel, training, computer costs, and special presentation costs. The costs listed below are to cover WHC expenses for these items. The cost for others will be included in their own budgets and overheads.

Although travel will be minimized, some travel is expected to occur to attend meetings where this performance assessment is discussed or where topics of interest to this performance assessment will be discussed. All travel will be reviewed with the Program Office.

Because of the complex nature of the modeling for this performance assessment, many computer analyses will be performed. This item will cover the cost of using Hanford's Science and Engineering Computer Center (SECC) for anyone performing computer analyses in support of the performance assessment. This item will also include the costs of upgrading equipment of staff and of the SECC.

Training is a normal part of professional development. During FY 1996, the members of the steering group will attend a special course on leadership development, teaming, and presentation. The tuition costs of this course will be covered by this item.

It is extremely important to be able to communicate the results and the justifications of the performance assessments to management and to the general public. Therefore special presentation material (including videos) will be prepared by IRM. Three broadcast quality videos (one each for the interim, preliminary, and final performance assessment documents) will be produced with an average of 50% taken from the previous segment. The video serving as an introduction and discussing performance objectives and scenarios will be completed in FY 1995.

Each year \$15,000 is estimated for WHC travel costs and \$90,000 for computer costs on the SECC. Approximately \$25,000 of expense funds and \$25,000 of CENTRC (capital) funds are needed each year for computer upgrades. In FY 1996 and FY 1999, an additional \$75,000 will be needed in CENTRC funds for upgrading compute servers in the SECC. Ten thousand dollars (\$10,000) is allocated for training each year except for FY 1996 when a special leadership/teaming course at Columbia Basin College will be used which will increase the total budget for training to \$20,000. Special presentation preparation costs are estimated at \$21,000 per year.

1.4 External Review with Public Input

I. SUMMARY

An external group will review the activities of the performance assessment team and advise the program office. It is expected that interested parties from the public will also have access to the documents produced by the team and will provide comments.

II. GENERALA. Background

The Peer Review Group (PRP) established by DOE usually reviews performance assessments generated in the DOE complex. However, the interim performance assessment is not part of their established procedure. Therefore, another external review group will be set up and used for the review of the Interim Performance Assessment.

Because of the strong interest of the public in Hanford activities, public interaction is expected and desired.

B. Organization

The responsible organization will be the Environmental Modeling Section of the Westinghouse Hanford Company, Nick Anderson, Manager. The cognizant scientist will be Fred Mann.

C. Vision

External review is deemed necessary for any document analyzing the impact of such a major Hanford action.

D. Objectives

This activity will provide external review of the interim performance assessment and other Performance Team activities.

E. Deliverables

- 1) Communications from the external review groups on the quality of the interim performance assessment (June 30, 1997).

III. TASK DESCRIPTIONSA. Summary list of tasks

- 1) External review of the interim performance assessment.
- 2) Advise Program Office concerning performance assessment activities.

B. External review of the interim performance assessment

1. Detailed Description

Groups external to Hanford will review the interim performance assessment and provide comments. Public review is also expected.

The main interface to the review groups will be Fred Mann.

2. Interfaces

The input for this task is the interim performance assessment (activity 2.2) (possibly modified based on comments received from internal review, activity 2.4).

The output of this task will be a thoroughly reviewed document outlining the expected impact of the disposal action given the limited site-, design-, and waste form-specific data available.

3. Standards

There are no relevant standards in this area.

4. Quality Assurance

The review groups will determine their own quality assurance requirements.

5. Schedule

The task will start after internal review of the interim performance assessment (activity 2.4) is completed and will be completed six (6) months later (June 30, 1997).

6. Cost

FY 1996/7: 0.2 FTE of WHC professional time costing \$130,000 per FTE for a total cost of \$26,000 will be required to interact with the outside reviewers. External costs are estimated to be \$30,000.

FY 1998/9: costs are estimated at half of FY 1996/7.

Cost estimations are based on the costs of setting up workshops for the performance assessment program.

2.1.1 Determine Performance Objectives for Interim Performance Assessment

I. SUMMARY

Through reviewing regulations and other performance assessments, interacting with low-level waste project management, and involving the public, develop the performance objectives for the interim performance assessment.

II. GENERAL

This activity was completed in FY 1995. The document "Performance Objectives of the Tank Waste Remediation System Low-Level Waste Disposal Program" (WHC-EP-0826, Rev.0) was written as was its summary "Overview of the Performance Objectives and Scenarios of the TWRS Low-Level Waste Disposal Program" (WHC-EP-0827, Rev. 0). Based on public comment, these documents were slightly modified and reissued as Revision 1.

The performance objectives will be used in the Interim Performance assessment.

III. TASK DESCRIPTIONSSummary list of tasks

- 1) Determine performance objectives.
- 2) Respond to comments on determination of performance objectives.

The tasks were completed on schedule and within budget.

2.1.2 Determine Pathways and Scenarios for Interim Performance Assessment

I. SUMMARY

Through reviewing regulations and other performance assessments, interacting with other disposal actions at Hanford, and involving the public, develop the pathways and scenarios for the interim performance assessment.

II. GENERAL

This activity was completed in FY 1995. The document "Scenarios of the TWRS Low-Level Waste Disposal Program" (WHC-EP-0828, Rev.0) was written as was its summary "Overview of the Performance Objectives and Scenarios of the TWRS Low-Level Waste Disposal Program" (WHC-EP-0827, Rev. 0). Based on public comment, these documents were slightly modified and reissued as Revision 1.

The scenarios will be used in the Interim Performance assessment.

III. TASK DESCRIPTIONSSummary list of tasks

- 1) Determine scenarios.
- 2) Respond to comments on determination of scenarios.

The tasks were done on schedule and within budget.

2.1.3 Select and Verify Tools for the Interim Performance Assessment

I. SUMMARY

Through establishing criteria for the tools (probably computer software) needed in the performance assessment, then selecting appropriate tools based on those criteria, and finally verifying those tools meet the criteria, obtain a set of tools usable for the interim performance assessment.

II. GENERAL

This activity will be completed in FY 1995. Code selection criteria and code selection have been documented (see task descriptions below). The verification of the contaminant transport code has also been completed. The verification of the contaminant release code is expected in June 1995.

These tasks have been completed on time and within budget.

III. TASK DESCRIPTIONSA. Summary list of tasks

- 1) Select and justify tools in each analysis area.
- 2) Document verification studies of tools in each analysis area.

B. Select and justify tools in each analysis area.

Code selection criteria were approved by the steering group and have been published in WHC-SD-WM-CSWD-073, "Computer Code Selection Criteria and Considerations for the Hanford Low-Level Tank Waste Interim Performance Assessment".

The PORFLOW computer code was selected to be the flow and transport code for the interim performance assessment by the steering group. The document "Selection of Flow and Transport Code for the Hanford Low-Level Tank Waste Interim Performance Assessment" (WHC-SD-WM-CSWD-074, Rev. 0) describes the reasons and the choice.

The ARREST-CT computer code was selected to be the code to calculate contaminant release from glass. The PNL document "Selection of a Computer Code for Hanford Low-Level Waste Engineered-System Performance Assessment" (PVTD-C95-04.01E, Rev. 1) describes the reasons and the choice.

C. Document verification studies of tools in each analysis area

The PORFLOW code has been verified as documented in "The Grout/Glass Performance Assessment Code System (GPACS) with Verification and Benchmarking" (WHC-SD-WM-UM-019, Rev. 0):

The ARREST-CT code will be verified by June 1995. The verification will be documented at that time.

2.1.4 Inventory

I. SUMMARY

Review tank-waste inventories and preliminary treatment flow sheets in order to determine inventory to be used in the Hanford Low-Level Tank Waste Interim Performance Assessment.

II. GENERAL

The work in FY 1995 was performed in two phases. A complete up-to-date calculation of all radionuclides produced during the entire history of all the Hanford production reactors was completed during the first phase. The purpose was to establish a well-documented basis for inventory assessments and to identify where further work was necessary.

During the second phase, an in-depth study of three radionuclides identified in phase I, ^{99}Tc , ^{235}U , and ^{237}Np , was undertaken.

As these statements of work are being prepared, two documents on the current understanding of inventory, "Consequence Ranking of Radionuclides in Hanford Tanks Waste" (WHC-SD-WM-RPT-163, Rev. 0) and "Inventories for Low-Level Waste Interim Performance Assessment" (WHC-SD-WM-RPT-164, Rev.0) are being written and reviewed. This activity should be on time and on budget.

2.1.5 Obtain Disposal Facility Data for Interim Performance Assessment

I. SUMMARY

Translate design activities into information useful for the interim performance assessment activities.

II. GENERAL

The purpose of this FY 1995 activity was to provide information on the low-level tank waste disposal facility for the interim performance assessment (Activity 2.2). This activity was completed in two parts. The first part, consisting of tasks one and two, was producing a data package on the proposed low-level waste form and the disposal facility. Different inputs from those stated in the 1995 Statements of Work (revision 0 of this document) changed the direction of the first two tasks (see task descriptions below). However, the tasks were completed.

The second part, consisting of tasks three and four, was to determine if the design contained barriers were to be made from materials that would need to be researched. No new materials for barriers are currently being proposed. Thus, no further action was taken on this part of the activity.

III. TASK DESCRIPTIONSA. Summary List of Tasks

- 1) Determine geometry and volume of waste form.
- 2) Determine important barriers used in design.
- 3) Determine parameters for transport through barriers.
- 4) Review of barrier transport parameters.

B. Determine Geometry and Waste Form

Concepts for the waste form geometry and volume were available March 1, 1995. Guidance from the interfacing group, Process Design in TWRS Disposal Engineering, determined which waste form to document since the TWRS decision board had not approved a baseline waste form at that time. The waste form selected for the interim performance assessment was a glass cullet/sulfur polymer cement block contained in a 2 X 2 X 8 meter carbon steel canister. The details of the waste package (waste form and canister) to be used for the interim performance assessment are in the report "Disposal Facility Data for the Interim Performance Assessment" (WHC-SD-WM-RPT-159).

The report was issued May 15, 1995. The report was slightly issued late due to later than anticipated issuance of the report containing the waste form concepts. The delay had no impact on the cost. The delay also did not impact the schedule for the calculations for the interim performance assessment.

C. Determine Important Barriers Used In Design

Guidance from the interfacing group, Process Design in TWRS Disposal Engineering, determined which disposal facility to document for this activity. A disposal facility concept and one variation of it are documented in the report "Disposal Facility Data for the Interim Performance Assessment" (WHC-SD-WM-RPT-159). The variation was based on input from performance assessment contributors.

The report was issued May 15, 1995. The report was issued slightly late due to later than anticipated issuance of the report containing the facility concepts. The delay had no impact on the cost. The delay also had no impact on the schedule for the interim performance assessment calculations.

D. Determine Parameters for Transport Through Barriers

No work was performed under this task because common barriers are shown in the current disposal facility concepts. (Important barriers used in the disposal facility concepts are a surface barrier (Hanford type barrier), a moisture diverter, and a water conditioning layer.) The intent of this task was to determine parameters for barrier material that has not been studied.

E. Review of Barrier Transport Parameters

No work was performed under this task since it was dependent on the results of Task D above.

2.1.6 LLW Glass Source-Term for Interim Performance Assessment

I. SUMMARY

The purpose of this task is to provide estimates of radionuclide release from a low-level waste glass product that will be used for input to an interim systems performance assessment of the Hanford low-level tank waste site. Because many specific characteristics of the glass waste product and disposal system components will be unknown at the time the interim assessment is drafted, the data used to estimate radionuclide releases will be largely based upon values obtained from a literature review, expert judgment, or extrapolated from laboratory data obtained on reference low-level waste glasses.

II. GENERAL

A. Background

This task will provide estimates of radionuclide releases from low-level waste glass for use as input to an interim performance assessment of a low-level tank waste disposal system at Hanford. The data for these calculated estimates were obtained and documented in FY 1996.

The specific characteristics of the low-level waste glass and other disposal system components that can affect release from the glass will be largely unknown at the time this report is drafted. Consequently, the extensive literature on aqueous corrosion of silicate glasses will be a key source of data needed to estimate releases from the low-level waste glass. A review of the literature was completed in January 1995 and a report was issued entitled "Predicting the Performance of LLW Glass: A Literature Review," PVT-D-C94-23.01H. The literature data will be supplemented to the extent possible with data from short-term laboratory tests. A data package that summarizes the results from laboratory testing of several reference low-level waste glasses was completed in May 1995. These two reports will be principal sources of data used to complete radionuclide release estimates from low-level waste glass for the Interim Performance Assessment report.

B. Organization

The responsible organization will be the Nuclear Systems and Services Department of the Pacific Northwest Laboratory (PNL), Walt Laity, Manager. The cognizant scientist will be Peter McGrail also of PNL.

C. Vision

In FY 1997, an interim performance assessment for a low-level tank waste disposal system on the Hanford low-level tank waste site will be submitted for peer and public review. Estimates of radionuclide release from the low-level waste glass product are a critical part of an overall performance assessment for the disposal system and site. The results from the interim performance assessment will also provide feedback to glass developers on data needs and performance criteria for the waste form.

D. Objectives

The objectives for this task are

- 1) Estimate the release rate of important contaminants from low-level waste glass disposed of near-surface and provide these results as the source-term for the Interim Performance Assessment.
- 2) Identify, modify or adapt appropriate models as needed to perform the release calculations.
- 3) Conduct literature reviews and analyze the available laboratory testing data on reference low-level waste glasses to obtain the parameters needed for selected model.

E. Deliverable

- 1) Radionuclide Release Rate Calculations and Supporting Data for Interim Performance Assessment ready as a letter report for internal review (April 29, 1996).

III. TASK DESCRIPTIONSA. Summary list of tasks

- 1) Update and Document Data.
- 2) Conduct and Document Release Estimates.

B. Update and Document Glass Release Parameters

1. Detailed Description

The objective of this task is to determine the parameters required to calculate radionuclide release rates from low-level waste glass. This will be accomplished by compiling and analyzing data from the literature and from ongoing laboratory tests with reference low-level waste glasses. This work will update values documented in the spring of 1995. The release estimates will be done using an existing model for the aqueous corrosion of silicate glasses that was identified as the most suitable model for this purpose ("Parameters Affecting Long-Term Performance of LLW Glass", PVTD-C94-23.01F).

2. Interfaces

This task requires a direct interaction of staff from PNL and WHC staff responsible for low-level waste glass formulation, and Argonne National Laboratory staff (John Bates and Bill Ebert) responsible for long-term glass durability studies.

3. Standards

There are no relevant standards in this area.

4. Quality Assurance

Work at PNL will be conducted in accordance with PNL-MA-70, "PNL Quality Assurance Program Manual". PNL's quality assurance program responds to 10 CFR 830.120 and conforms to the requirements of ASME NQA-1, "1989 Quality Assurance Requirements for Nuclear Facilities", as interpreted by Parts 1 and 3 of PNL-MA-70. PNL uses a graded methodology for implementing the management controls used on projects and discrete work activities. The quality assurance plan (ETC-001) for PNL support to TWRS vitrification activities provides detailed information regarding the grading selection (impact level) and project specific requirements applicable to PNL Vitrification Technology Development Project work activities.

5. Schedule

This activity will start October 1, 1995 and will end with the completion of the letter report on April 29, 1996.

6. Cost

0.20 professional FTE at \$180,000 per FTE = \$36,000.

The labor is for assembling, reviewing, and analyzing glass testing data and writing a report with the results of the analysis.

C. Conduct and Document Release Calculations

1. Detailed Description

The purpose of this task is to develop preliminary radionuclide release rate estimates for low-level waste glass. The release rate estimates will be done using data obtained from the literature search and data package reports completed last fiscal year, and from laboratory testing results that will be compiled under Task B just prior to the time the letter report is prepared. Existing models that describe the aqueous reaction of silicate glasses with water will be used to calculate the glass corrosion rate. The potentially significant effects of other disposal system components will not be taken into account in the release estimates. The release estimates will consist of mass fluxes of radionuclides based on the calculated rate of glass alteration and inventory estimates for radionuclides in the glass. This will provide conservative estimates for radionuclide release. Significant reductions (perhaps orders of magnitude) in the release rates would be expected when a more detailed chemical model is used that accounts for important chemical processes such as dissolution/precipitation reactions. This model is under development for use in the preliminary and final performance assessment reports (see Activity 3.1.6).

2. Interfaces

The main interfaces will be with Performance Assessment Core Group team, PNL and WHC staff responsible for low-level waste glass formulation, and Argonne National Laboratory staff (John Bates and Bill Ebert) responsible for long-term glass durability studies.

3. Standards

There are no relevant standards in this area.

4. Quality Assurance

Work at PNL will be conducted in accordance with PNL-MA-70, "PNL Quality Assurance Program Manual". PNL's quality assurance program responds to 10 CFR 830.120 and conforms to the requirements of ASME NQA-1, "1989 Quality Assurance Requirements for Nuclear Facilities", as interpreted by Parts 1 and 3 of PNL-MA-70. PNL uses a graded methodology for implementing the management controls used on projects and discrete work activities. The quality assurance plan (ETC-001) for PNL support to TWRS vitrification activities provides detailed information regarding the grading selection (impact level) and project specific requirements applicable to PNL Vitrification Technology Development Project work activities.

5. Schedule

This activity will start October 1, 1995 and will end with the completion of the letter report on April 29, 1996.

6. Cost

Funding for this task is being provided under Activity 2.2, Calculate Responses and Document. Funding provided in that activity is for 0.25 PNL professional at \$200,000 per FTE costing \$50,000.

2.1.7 Compile and interpret flow and transport properties for flow and transport studies

I. SUMMARY

Gather and justify (to the degree possible given the uncertainties in features and location of the disposal facility) the data to be used in flow and transport calculations in the interim performance assessment.

II. GENERAL

As these statements of work are being prepared, the writing and review of the document describing these data, "A Compilation of Geohydrologic Properties for Low-Level Glass Waste Disposal Facility Performance Assessment", WHC-SD-WM-RPT-163, Rev. 0, is being performed.

2.2 Calculate Responses and Document

I. SUMMARY

This activity consists of the actual calculations and analyses that appear in the interim performance assessment and write the document itself.

II. GENERALA. Background

Earlier activities (2.1.X) produced the data and methods to be used in the interim performance assessment.

B. Organization

The responsible organization will be the Environmental Modeling Section of the Westinghouse Hanford Company, Nick Anderson, Manager. The cognizant scientist will be Fred Mann.

C. Vision

The interim performance assessment will provide the program office assurance that the final performance assessment will be accepted and hence that waste can be disposed into the proposed disposal facility.

D. Objectives

This activity will produce the interim performance assessment.

E. Deliverables

- 1) Interim Performance Assessment as a letter report ready for internal review (September 30, 1996).

III. TASK DESCRIPTIONSA. Summary list of tasks

- 1) Write interim performance assessment.

B. Write Interim Performance Assessment

1. Detailed Description

All calculations and analyses performed by the performance assessment team will appear in the interim performance assessment. The interim performance assessment (including required background information, integration, and interpretation) will be written.

The main contributors to this task will be the entire performance assessment team.

2. Interfaces

The inputs for this task were generated in 2.1.X tasks.

The output of this task will be the interim performance assessment ready for review by the program office, RL, and other internal (Hanford) reviews.

3. Standards

Guidance from the DOE Peer Review Panel, the DOE Performance Assessment Task Team, and the NRC staff will be used.

4. Quality Assurance

The letter report will be reviewed by the performance assessment team before issuance.

Work at PNL will be conducted in accordance with PNL-MA-70, "PNL Quality Assurance Program Manual". PNL's quality assurance program responds to 10 CFR 830.120 and conforms to the requirements of ASME NQA-1, "1989 Quality Assurance Requirements for Nuclear Facilities", as interpreted by Parts 1 and 3 of PNL-MA-70. PNL uses a graded methodology for implementing the management controls used on projects and discrete work activities. The quality assurance plan (ETC-001) for PNL support to TWRS vitrification activities provides detailed information regarding the grading selection (impact level) and project specific requirements applicable to PNL Vitrification Technology Development Project work activities.

5. Schedule

The task will start October 1, 1995 with the letter report written and reviewed by the Performance Assessment Steering Group by September 30, 1996).

6. Cost

FY 1996:

1.25 WHC professional FTE @ \$130,000 per FTE costing \$162,500. 0.25 PNL professional @ \$200,000 per FTE costing \$50,000, \$50,000 for outside contract. The total cost is \$262,500.

The WHC labor is for analyst's time (0.25 FTE) for the calculation of contaminant transport and of dose, for the writer's time (0.5 FTE), and for the use of an editor (0.5 FTE). The PNL labor is for analyst's time for the calculation of contaminant release from the glass.

2.3 Define Contingencies

I. SUMMARY

Based on the results of the interim performance assessment, it may be necessary to rethink major components of the disposal system to meet objectives.

II. GENERAL

A. Background

The purpose of the interim performance assessment is to provide assurance that the final performance assessment will meet the desired performance objectives. However, the analysis may show that with the current designs, approaches, or data that such approval is unlikely.

The timing of this activity is such that recommendations can be reviewed by the program office before the scheduled start of construction of the Hanford low-level tank waste facilities.

B. Organization

The responsible organization will be the Environmental Modeling Section of the Westinghouse Hanford Company, Nick Anderson, Manager. The cognizant scientist will be Fred Mann.

C. Vision

Although this activity may not be necessary, it is included so that if the interim performance assessment reveals major problems, there is time to rethink components in the design to increase the chance of success.

D. Objectives

This activity will determine the changes in approach to increase the probability of approval of the final performance assessment if the interim performance assessment shows the existence of serious problems.

E. Deliverables

- 1) Letter report providing suggested changes in approach and design to overcome possible problems revealed in the interim performance assessment (March 30, 1997).

III. TASK DESCRIPTIONS

A. Summary list of tasks

- 1) Determine possible contingencies to solve problems revealed from interim performance assessment.

B. Determine possible contingencies to solve problems revealed from interim performance assessment

1. Detailed Description

Define different approaches, methods, or designs that will eliminate or greatly lessen problems revealed by the interim performance assessment.

The main contributors to this task will depend upon the problems revealed in the interim performance assessment. The effort will be lead by Fred Mann.

2. Interfaces

The input for this task is the interim performance assessment.

The output of this task will be a series of options presented to the program office.

3. Standards

There are no relevant standards in this area. However, guidance from the DOE Peer Review Panel and from the NRC staff will be used.

4. Quality Assurance

The letter report will be reviewed internally before issuance.

5. Schedule

The task will start at the completion of the writing of the interim performance assessment with the letter report written six months later. The report will be issued within ninety days. Thus, the letter report will be written by December 31, 1996, and issued by March 30, 1997.

6. Cost

FY 1997: 0.33 FTE at \$130,000 per FTE for cost of \$43,400.

2.4 Have Internal Review Assessment

I. SUMMARY

The Program Office, the Internal Review Team, RL, and other internal Hanford review teams will review the interim performance assessment.

II. GENERALA. Background

The interim performance assessment will be a large significant document. Because of its purpose to provide assurance that the final performance assessment will be approved, significant levels of review are needed.

It is expected that most of the reviewers will be familiar with the data, methods, and results through on-going prior briefings.

B. Organization

The responsible organization will be the Environmental Modeling Section of the Westinghouse Hanford Company, Nick Anderson, Manager. The cognizant scientist will be Fred Mann.

C. Vision

The interim performance assessment should withstand any attacks on its methods, data, or interpretations.

D. Objectives

This activity will perform the internal Hanford review for the interim performance assessment.

E. Deliverables

- 1) Communications from review bodies on the adequacy of the interim performance assessment (December 31, 1996).

III. TASK DESCRIPTIONSA. Summary list of tasks

- 1) Internal review of the interim performance assessment.

B. Internal review of the interim performance assessment

1. Detailed Description

Hanford groups will review the interim performance assessment. Such groups will be determined by the Program Office but are expected to include the program office itself, the Internal Review Team of the performance assessment activity, and RL.

The main interface to the reviewers will be Fred Mann.

2. Interfaces

The input for this task is the interim performance assessment generated in activity 2.2.

The output of this task will be comments that may lead to changes in the interim performance assessment or may indicate that the document serves its intended purpose.

3. Standards

There are no relevant standards in this area.

4. Quality Assurance

The review groups will establish their own quality assurance.

5. Schedule

The task will start once the final version of the interim performance assessment is written (September 30, 1996) with comments received on the interim performance assessment within ninety days (December 31, 1996).

6. Costs

Costs covered by other activities.

3.1.1 Update Performance Objectives for Performance Assessment

I. SUMMARY

Through reviewing regulations and other performance assessments; interacting with low-level waste project management, and involving the public, update the performance objectives for the preliminary performance assessment.

II. GENERAL**A. Background**

Performance objectives are the criteria against which the predicted long-term impact of the disposal action to the environment is judged. Although regulations do set some explicit criteria, most of the criteria are general, for example "protect human health and safety". Thus performance objectives are based upon project vision, prior experience from other performance assessments (particularly the Hanford performance assessments), and from public input.

B. Organization

The responsible organization will be the Environmental Modeling Section of the Westinghouse Hanford Company, Nick Anderson, Manager. The cognizant scientist will be Fred Mann.

C. Vision

The performance objectives are the criteria against which success or failure of the analyses of the performance assessment are judged. They thus provide not only direction but also the ultimate technical goal for the entire Hanford low-level tank waste disposal activity.

D. Objectives

This activity will determine the performance objectives for the preliminary performance assessment.

E. Deliverables

- 1) Letter report providing performance objectives for the preliminary performance assessment (March 30, 1997).
- 2) Letter report documenting comments from review boards on the performance objectives as well as responses to comments (June 30, 1997).

III. TASK DESCRIPTIONS**A. Summary list of tasks**

- 1) Determine performance objectives.
- 2) Respond to comments on determination of performance objectives.

B. Determine performance objectives

1. Detailed Description

Based upon regulations, past practices, program office input, and public input, performance objectives from the interim performance assessment will be updated and documented.

Comments from the program office and from the public will be documented and each will receive an individual response.

The main contributor to this task will be Fred Mann.

2. Interfaces.

The inputs for this task will be evolving regulations, evolving program office viewpoints, and evolving public values.

The output of this task will be a major factor in deciding the measures against which the results of the preliminary performance assessment will be judged. The letter report will be formally reviewed by the standing performance assessment review groups.

3. Standards

There are no relevant standards in this area. However, guidance from the DOE Peer Review Panel and from the NRC staff will be used.

4. Quality Assurance

The letter report will be reviewed internally before issuance.

5. Schedule

The task will formally start October 1, 1996 with the letter report written by March 30, 1997. Informally monitoring of regulations, program office requirements, and public values will continue after the performance objectives for the preliminary performance assessment is completed.

6. Cost (FY 1997)

0.15 FTE of WHC professional time costing \$130,000 per FTE for a total of \$19,500 will be required.

This cost estimation is based on the work performed for the interim performance assessment. The cost includes funding a technical editor.

C. Respond to comments on determination of performance objectives

1. Detailed Description

Comments from the review groups on the letter report documenting the determination of performance objectives for the preliminary performance assessment will be documented. Each comment will be responded to. A revised letter report will be issued if necessary.

The main contributor to this task will be Fred Mann.

2. Interfaces

The main interfaces will be the internal and external review groups.

The output of this task will be the performance objectives to be used in the preliminary performance assessment.

3. Standards

There are no relevant standards in this area.

4. Quality Assurance

The letter report will be reviewed before issuance.

5. Schedule

The task will start after the initial letter report is written with a revised report due 90 days after the start. The revised report will be issued by June 30, 1997.

6. Cost (FY 1997)

0.04 FTE of WHC professional time costing \$130,000 per FTE for a total of \$5,200 will be required.

3.1.2 Update Scenarios for Performance Assessment

I. SUMMARY

Through reviewing regulations and other performance assessments and involving the public, update the scenarios for the preliminary performance assessment.

II. GENERALA. Background

Radionuclides and other hazardous substances can reach the environment by a large variety of pathways. In addition, based on demographics and land use, the number of exposure scenarios is also quite large. Although regulations do set some explicit criteria, most of the criteria are general, for example "protect groundwater". In addition, there are important parameters and values (such as land use) which only a public involvement process can decide. Thus the pathways and scenarios which should be analyzed are based upon prior experience from other performance assessments (particularly the Hanford performance assessments) and from public input.

B. Organization

The responsible organization will be the Environmental Modeling Section of the Westinghouse Hanford Company, Nick Anderson, Manager. The cognizant scientist will be Fred Mann.

C. Vision

The pathways and scenarios are the ways that radionuclides and hazardous chemicals move from the disposed waste to the environment and expose mankind. They are the objects which must be analyzed in the performance assessment. They thus provide the "what's" of the performance assessment.

D. Objectives

This activity will determine the pathways and scenarios which will be analyzed in the preliminary performance assessment.

E. Deliverables

- 1) Letter report providing scenarios for the preliminary performance assessment (March 30, 1997).
- 2) Letter report documenting comments from review boards on the scenarios as well as responses to comments (June 30, 1997).

III. TASK DESCRIPTIONSA. Summary list of tasks

- 1) Determine scenarios for the preliminary performance assessment.
- 2) Respond to comments on determination of the scenarios.

B. Determine performance objectives

1. Detailed Description

Based upon regulations, past practices, and public input, scenarios from the interim performance assessment will be updated and documented.

Comments from the public will be documented and each will receive an individual response.

The main contributor to this task will be Fred Mann.

2. Interfaces

The inputs for this task will be evolving regulations and evolving public values.

The output of this task will be the determination of what exposure scenarios and what pathways will be used in the preliminary performance assessment. The letter report will be formally reviewed by the standing Performance Assessment review groups.

3. Standards

There are no relevant standards in this area. However, guidance from the DOE Peer Review Panel and from the NRC staff will be used.

4. Quality Assurance

The letter report will be reviewed internally before issuance.

5. Schedule

The task will formally start October 1, 1996 with the letter report written by March 30, 1997. Informally monitoring of regulations, program office requirements, and public values will continue after the performance objectives for the preliminary performance assessment is completed.

6. Cost (FY 1997)

0.15 FTE of WHC professional time costing \$130,000 per FTE for a total of \$19,500 will be required.

This cost estimation is based on the work performed for the interim performance assessment. The cost includes funding a technical editor.

C. Respond to comments on determination of scenarios

1. Detailed Description

Comments from the review groups on the letter report documenting the determination of scenarios for the preliminary performance assessment will be documented. Each will be responded to. A revised letter report will be issued if necessary.

The main contributor to this task will be Fred Mann.

2. Interfaces

The main interfaces will be the internal and external review groups.

The output of this task will be the scenarios to be used in the preliminary performance assessment.

3. Standards

There are no relevant standards in this area.

4. Quality Assurance

The letter report will be reviewed before issuance.

5. Schedule

The task will start after the initial letter report is written with a revised report due 90 days after the start. The revised report will be issued by June 30, 1997.

6. Cost (FY 1997)

0.04 FTE of WHC professional time costing \$130,000 per FTE for a total of \$5,200 will be required.

3.1.3 Tool Selection, Verification, and Certification

I. SUMMARY

Through establishing criteria for the tools (probably computer software) needed in the performance assessment, then selecting appropriate tools based on those criteria, and finally verifying those tools meet the criteria, obtain a set of tools usable for the preliminary performance assessment.

II. GENERAL

A. Background

Complex computer modeling is usually used in the analysis upon which a performance assessment is based. The DOE Peer Review Panel has determined that a careful and thoughtful process be used in selecting such tools. The process consists of:

- 1) Setting criteria.
- 2) Selecting the tools.
- 3) Verifying the tools.
- 4) Certifying the tools.

B. Organization

The responsible organization will be the Environmental Modeling Section of the Westinghouse Hanford Company, Nick Anderson, Manager. The cognizant scientist will be Fred Mann. Others in the team will represent the major analysis functions in the performance assessment (groundwater transport - Allen Lu, vadose zone transport - Niall Kline, and waste form - Pete McGrail)

C. Vision

The tools of a performance assessment form a core component of a performance assessment. However, unlike other components (criteria and data), it is far more difficult to demonstrate that the tools provide reasonable results (a process here call certification) because they are used to extrapolate beyond our knowledge base.

D. Objectives

This activity will determine the tools (probably computer codes) to be used in the analyses for the preliminary performance assessment.

E. Deliverables

- 1) Letter report reviewing and modifying (if necessary) code selection used for interim performance assessment for applicability to the preliminary performance assessment (December 31, 1996).
- 2) Letter reports justifying selection of tools in each analysis area (March 30, 1997).

- 3) Letter reports documenting verification efforts on the selected codes (September 30, 1997).
- 4) Letter reports documenting strategy for certifying codes (September 30, 1997).

III. TASK DESCRIPTIONS

A. Summary List of Tasks

- 1) Review code selection criteria.
- 2) Review choice of codes.
- 3) Verify codes.
- 4) Define strategy for certification of codes.
- 5) Perform experiments needed for code certification.
- 6) Certify codes.

B. Review Code Selection Criteria

1. Detailed Description

The code selection criteria from the interim performance assessment will be reviewed based on experience in the interim performance assessment and on the experience of other performance assessments in the DOE complex.

The main contributors to this task will be those with lead responsibility in each analysis area:

- a) groundwater transport - Allen Lu.
- b) vadose zone transport - Niall Kline.
- c) waste form - Pete McGrail.

2. Interfaces

The interfaces will be with other team members and with analysts actually performing the work.

The output of this task will be the code selection criteria for the tools to be used in the preliminary performance assessment area for each analysis area.

3. Standards

There are no relevant standards in this area. However, guidance from the DOE Peer Review Panel and from the NRC staff will be used.

4. Quality Assurance

The letter report will be reviewed before issuance.

5. Schedule

The activity will start after the interim performance is written (that is, October 1, 1996). The task will take three months, resulting in the report being issued December 31, 1996.

6. Cost

Cost is included under the WHC management task and under participation tasks.

The costs will be incurred in FY 1997.

C. Review Choice of Codes

1. Detailed Description

The choice of codes selected for the interim performance assessment will be reviewed. Selection of new codes may be necessary.

It is expected that some code development will be necessary to tune the codes for use in the preliminary performance assessment. The documentation shall cover the version of the code to be used in the preliminary performance assessment.

The main contributors to this task will be those with lead responsibility in each analysis area:

- a) groundwater transport - Allen Lu.
- b) vadose zone transport - Niall Kline.
- c) waste form - Pete McGrail.

2. Interfaces

The interfaces will be with other team members and with analysts actually performing the work.

The output of this task will be the documenting of the selection of the code for each analysis area in the preliminary performance assessment area.

3. Standards

There are no relevant standards in this area. However, guidance from the DOE Peer Review Panel and from the NRC staff will be used.

4. Quality Assurance

The letter report will be reviewed before issuance.

5. Schedule

The task will start after the updating of the code selection criteria (see prior task) and will take 3 months. Thus the report for each code area is due March 30, 1997.

6. Cost

Cost is included under the WHC management task and under participation tasks.

The costs will be incurred in FY 1997.

D. Verify codes

1. Detailed Description

Those codes modified since their verification during the interim performance assessment must be reverified.

The main contributors to this task will be those with lead responsibility in each analysis area:

- a) groundwater transport - Allen Lu.
- b) vadose zone transport - Niall Kline.
- c) waste form - Pete McGrail.

2. Interfaces

The interfaces will be with other team members and with analysts actually performing the work.

The output of this task will be the documentation showing that modified codes have been verified.

3. Standards

There are no relevant standards in this area. However, guidance from the DOE Peer Review Panel and from the NRC staff will be used.

4. Quality Assurance

The letter report will be reviewed before issuance.

5. Schedule

The activity will start after each code is selected for use in the preliminary performance assessment (see previous task). Letter reports documenting verification for modified codes will be issued by September 30, 1997.

6. Cost

Costs are covered in each task using code.

E. Define strategy for certification of codes

1. Detailed Description

Normally after a code is verified, it must be validated (shown to agree with experiments which contain the important aspects of the problem). However, due to the long-time periods involved in a performance assessment, codes can only meet a lesser standard, a standard denoted here by the word "certification".

For each analysis area, a strategy for the certification of the code selected for the preliminary performance assessment must be determined and documented. For some areas, certification may approach quite closely the traditional ideal of verification, while in others there may be a larger difference.

The main contributors to this task will be those with lead responsibility in each analysis area:

- a) groundwater transport - Allen Lu.
- b) vadose zone transport - Niall Kline.
- c) waste form - Pete McGrail.

2. Interfaces

The interfaces will be with other team members and with analysts actually performing the work.

The output of this task will be the strategy for certifying each code used in the preliminary performance assessment.

3. Standards

There are no relevant standards in this area. However, guidance from the DOE Peer Review Panel and from the NRC staff will be used.

4. Quality Assurance

The letter report will be reviewed before issuance.

5. Schedule

The activity will start after each code is selected for use in the preliminary performance assessment (see previous task). Letter reports documenting verification for modified codes will be issued by September 30, 1997.

6. Cost

Costs are covered in each task using code.

F. Perform experiments needed for code certification

1. Detailed Description

Some experiments may be needed to certify the codes. It is expected that such experiments will be performed under other tasks in the preliminary and final performance assessment activities. This task is described here for completeness.

2. Interfaces

The interfaces will be with other team members and with the people responsible for performing the experiments.

The output of this task will be the documentation describing the experiments, their results, and their uncertainties.

3. Standards

There are no relevant standards in this area.

4. Quality Assurance

The letter report will be reviewed before issuance.

5. Schedule

The activity will start July 1, 1995. The final reports are needed to be used in the certification of the relevant codes (see next task).

6. Cost

Costs are covered in each task using code.

G. Certify codes

1. Detailed Description

Each code used in the preliminary performance assessment will be certified following the strategy outlined above. This task is included here for completeness.

The main contributors to this task will be those with lead responsibility in each analysis area:

- a) groundwater transport - Allen Lu.
- b) vadose zone transport - Niall Kline.
- c) waste form - Pete McGrail.

2. Interfaces

The interfaces will be with other team members, with analysts actually performing the work, and with the experimenters.

The output of this task will be the documenting of the certification of the code for each analysis area in the preliminary performance assessment area.

3. Standards

There are no relevant standards in this area. However, guidance from the DOE Peer Review Panel and from the NRC staff will be used.

4. Quality Assurance

The letter report will be reviewed before issuance.

5. Schedule

The task will start as soon as code verification occurs and necessary experimental results are available. Letter reports are due by the time the preliminary performance assessment is written.

6. Cost

Costs are covered in each task producing or using the code.

3.1.4 Inventory

I. SUMMARY

Review tank-waste inventories in order to determine gross inventories supporting the Low-Level Waste Preliminary Performance Assessment. Initiate work on determination of individual tank inventories. Inventories of radionuclides in the glass waste are among the most important parameters in the performance assessment.

II. GENERAL

A. Background

The inventories of hazardous chemicals and radionuclides presently in the Hanford single- and double-shell tanks are the starting point for assessing the inventories that will be in the final waste form that is placed in the disposal facility. These final inventories will also depend on the subsequent pretreatment "splits" along with other losses before the formation of the glass waste form.

Work in FY 1995 was performed in two phases. A complete up-to-date calculation of all radionuclides produced during the entire history of all the Hanford production reactors was completed during the first phase. The purpose was to establish a well-documented basis for inventory assessments and to identify where further work was necessary.

During the second phase, an in-depth study of three radionuclides identified in phase I, ^{99}Tc , ^{233}U , and ^{237}Np , was undertaken.

B. Organization

The responsible organization is the Environmental Modeling Section, Nick Anderson, Manager. The cognizant scientist is F. Schmittroth with support from the Environmental Modeling Staff.

C. Vision

An awareness of the tank inventories, treatment options, and secondary melter waste streams is an on-going effort that must be sustained as better knowledge in these activities becomes available. The performance of the disposal depends directly on the inventory of key materials.

D. Objectives

This activity will supply the inventories in the final waste form in a manner that is supported by the on-going programs in tank characterization, in process treatments, and in melter secondary waste streams as well as theoretical analyses.

E. Deliverables

- 1) Letter report documenting gross tank inventories suitable for the Preliminary Performance Assessment (September 30, 1997).
- 2) Letter report documenting status of work on detailed tank inventories (December 30, 1997).

III. TASK DESCRIPTIONSA. Summary list of activities

- 1) Determine total inventories.
- 2) Review individual tank inventories.
- 3) Advise.

B. Determine total inventories.

1. Description

Total inventories will be established for the Preliminary Performance Assessment. Individual radionuclides that are difficult to estimate but potentially important will be emphasized. Examples include ^{236}U , ^{14}C , and ^3H . Supporting data including tank characterization measurements and historical records will be used.

2. Interfaces

Coordination with process engineering will continue as pretreatment processes evolve and the radionuclide splits to low-level waste become better established. Coordination with the tank characterization program will become increasingly essential. The intent of this task is to rely on results from other programs to the maximum extent possible. Independent work will be pursued only to the extent necessary to justify a sound basis for the chosen values.

4. Schedule

The task starts after the inventory data is obtained for the interim performance assessment. Work will be completed in FY 1997.

5. Cost

Estimated cost is \$110,000 (0.85 FTE at \$130,000 per FTE) in FY 1996 and \$60,000 (0.46 FTE at \$130,000 per FTE) in FY 1997.

The cost estimate is based on effort spent on this area for the interim performance assessment.

C. Review individual tank inventories.

1. Description

As progress evolves towards specific retrieval and pretreatment operations, variations in individual tank inventories will become important. For example, it is known that 13 kg of neptunium was put in a single tank, an issue that could affect Performance Assessment calculations.

2. Interfaces

See interfaces for previous Task B.

3. Schedule

Work will be completed by June 1997.

4. Cost

Estimated FY 1996 cost is \$120,000 (0.92 FTE at \$130,000) and the same in FY 1997.

The cost is based on the level of effort expended on the interim performance assessment.

D. Advise

1. Description

Participate in steering group meetings and provide assistance/advise to other tasks on inventory questions.

2. Interfaces

Coordinate with related programs, especially characterization, retrieval, and pretreatment.

3. Schedule

Task is a continuing activity.

4. Cost

Estimated FY 1996 cost is \$10,000 (0.08 FTE at \$130,000 per FTE) with the same in FY 1997.

3.1.5 Obtain Disposal Facility Data for Preliminary Performance Assessment

I. SUMMARY

Translate waste package and disposal facility designs into information useful for the preliminary performance assessment calculations.

II. GENERALA. Background

The models of the disposal facility and waste package used for the performance assessments must reflect the actual designs. The disposal facility and waste package are evolving from concepts to designs. The performance assessment models must reflect the evolving designs.

As designs for the disposal facility and waste package are developed, designers need to know which aspects of the design may hinder or help the performance assessment of the design. Open communications between the performance assessment members and the designers are crucial to having a robust disposal system.

This activity has two purposes. One is to continue keeping communications open between the performance assessment team and the designing team. The other purpose is to produce a data package on the disposal facility and waste package for the preliminary performance assessment calculations (Activity 3.2).

B. Organization

The responsible organization will be the Environmental Modeling Section of the Westinghouse Hanford Company, Nick Anderson, Manager. The cognizant scientist will be Fred Mann. The cognizant engineer performing the tasks will be Cheryl Eiholzer of TWRS Disposal Engineering, Process Design Section, John Garfield, Manager.

C. Vision

To keep the models used in the performance assessment current with the facility and waste package concepts and designs being considered by the TWRS Program Office and designing organization.

D. Objectives

The objectives for this activity are:

- 1) To keep the modelers and the performance assessment team informed of the current disposal facility and waste packaging concepts and designs.
- 2) To keep the designers of the disposal facility and the waste package advised of current performance assessment philosophy and modeling results.

- 3) To translate disposal facility and waste package design information into usable information for the preliminary performance assessment calculations.

E. Deliverables

- 1) Quarterly internal memos to the performance assessment members on current status and decisions on the waste package design and the disposal facility. (Due at the end of each quarter during the fiscal year except for the last quarter when the data package will be issued.)
- 2) Letter report defining waste package and disposal facility designs to be used for the preliminary performance assessment. (September 30, 1997)

III. TASK DESCRIPTIONS

A. Summary List of Tasks

- 1) Identify waste package design.
- 2) Identify disposal facility design.
- 3) Produce the disposal facility data package for the preliminary performance assessment.
- 4) Advise and steering group participation.

B. Identify Waste Package Design

I. Detailed Description

The source-term model requires information on the waste package design: the geometry, size, and materials. This information needs to be based on the current design information provided by the designing or producing organization. To produce a robust design, the designing organization will need input from the performance assessment members in order to consider the performance assessment aspects of the design.

This task focuses on keeping communications open between the performance assessment personnel and the personnel making the designs and the decisions. An interface with TWRS Engineering, TWRS Program Office, and the Architect Engineer (AE), when chosen, will be maintained. Decisions and designs from the interfacing groups will be used to determine the waste package to be used for preliminary performance assessment.

2. Interfaces

The input to this task consists of information from TWRS Engineering, TWRS Program Office, and the Architect Engineer when one is chosen. The required information consists of technical and decision documents on the waste package. These data will be used

for the quarterly internal status memos. Design information for input to the disposal facility data package for the preliminary performance assessment calculations (Task D, below) will be due June 30, 1997.

The output from this task will provide the following:

- 1) Improve communications between the performance assessment members and designers of the waste package.
- 2) Provide data for the data package (Task D) containing waste package information that will be used by the modelers for the source term for the preliminary performance assessment calculations (Activity 3.2).
- 3) Identify materials which need to be investigated for long-term behavior in order to correctly model the materials (Waste Package Materials Interaction, activities 3.1.7, 3.4.7 and Integrated Testing, activities 3.1.E, 3.4.E).

3. Standards

There are no relevant standards in this area.

4. Quality Assurance

All reports and memos will be reviewed before issuance.

5. Schedule

This task will start October 1, 1995. The interface portion is continuous and will end on September 30, 1997. During the scheduled time, quarterly internal memos updating the performance assessment team on the waste package design progress will be issued.

6. Costs

The following cost breakdown, in FY 1995 dollars, includes engineering time and secretarial support.

FY 1996: 2.6 man-months at \$130,000/man-year - \$28,167.

FY 1997: 2.5 man-months at \$130,000/man-year - \$27,083.

All costs are based on previous experience on time needed for interfacing with the waste package design organization.

C. Identify Disposal Facility Design

1. Detailed Description

The near-field model requires information on the disposal facility design: size, construction materials, barriers, filler material. This information needs to be based on the current design information provided by the designing organization. To produce a robust design, the designing organization will need input from the performance assessment members in order to consider the performance assessment aspects of the design.

This task focuses on keeping communications open between the performance assessment personnel and the personnel making the facility designs and the decisions. An interface with TWRS Engineering, TWRS Program Offices, and the Architect Engineer (AE), when chosen, will be maintained. Decisions and designs on the disposal facility from the interfacing groups will be used for the preliminary performance assessment.

2. Interfaces

The input to this task consists of information from TWRS Engineering, TWRS Program Office, and the Architect Engineer when one is chosen. The required information consists of technical and decision documents on the disposal facility. These data will be used for quarterly internal status memos. Design information for input to the disposal facility data package for the preliminary performance assessment calculations (Task D, below) will be due June 30, 1997.

The output from this task will provide three things:

- a. Improve communications between the performance assessment members and designers of the disposal facility.
- b. Provide data for the data package (Task D) containing disposal facility information that will be used by the modelers for the preliminary performance assessment calculations (Activity 3.2).
- c. Identify materials which need to be investigated for long-term behavior in order to correctly model the materials (Waste Package Materials Interaction, activities 3.1.7, 3.4.7; Integrated Testing, activities 3.1.E, 3.4.E; Chemical Transport Data, activities 3.1.10, 3.4.10; and Hydraulic Data, activities 3.1.8, 3.4.8).

3. Standards

There are no relevant standards in this area.

4. Quality Assurance

All memos will be reviewed before issuance.

5. Schedule

This activity will start October 1, 1995. The interface portion of the task is continuous and will end at the end of this task on September 30, 1997. During the scheduled time, quarterly internal memos will be issued to the performance assessment team.

6. Costs

The following cost breakdown, in FY 1995 dollars, includes engineering time and secretarial support.

FY 1996: 1.8 man-months at \$130,000/man-year - \$19,500.

FY 1997: 1.7 man-months at \$130,000/man-year - \$18,417.

All costs are based on previous experience needed for interfacing with the waste package design organization.

D. Disposal Facility Data Package

1. Detailed Description

The models to be used for the preliminary performance assessment need to reflect the most recent designs for the disposal facility and the waste package. The disposal facility data package written for the interim performance assessment (Activity 2.1.5) will probably need to be updated or re-written for the preliminary performance assessment. The revision is due to revising and approving the designs.

This task focuses on writing the disposal facility data package for the preliminary performance assessment.

2. Interfaces

The input to this task consists of the most recent disposal facility and waste package design. The organizations with these designs need to provide the input by June 30, 1997.

The output from this task will be the disposal facility data package for the preliminary performance assessment. The data package is due September 30, 1997.

3. Standards

There are no relevant standards in this area.

4. Quality Assurance

All reports will be reviewed before issuance.

5. Schedule

This task will start on July 1, 1997. The end date will be September 30, 1997, when the data package is issued.

6. Costs

The following cost breakdown, in FY 1995 dollars, includes engineering time and secretarial support.

FY 1996: none

FY 1997: 2.25 man-months at \$130,000/man-year - \$24,400

All costs are based on previous experience needed for interfacing with the waste package design organization.

E. Advise

1. Description

Participate in steering group meetings and provide assistance/advise to other tasks.

2. Interfaces

Coordinate with related programs.

3. Schedule

Task is a continuing activity.

4. Cost

Cost is contained in above tasks.

IV. OTHER CONSIDERATIONS

This activity is highly dependent on the contributions of other organizations and these organizations meeting their design and decision making milestones.

3.1.6 Integrated Source-Term for Preliminary Performance Assessment

I. SUMMARY

A performance assessment of the Hanford low-level waste site will require a determination of the source-term for radionuclide release from the glass waste form. The purpose of this task is to develop the necessary data and models for generating source-term calculations that will be used in the preliminary performance assessment.

II. GENERAL

A. Background

A performance assessment for the Hanford low-level tank waste site on the Hanford reservation will be performed to demonstrate that the site meets all applicable regulatory and stakeholder requirements for safe disposal of low-level waste glass that is to be produced during remediation of Hanford Tank Farm wastes. The performance assessment will require predictions of radionuclide releases from the glass waste form as a source-term for far-field transport and radiation dose calculations. Because radionuclide release from the glass is also affected by other engineered materials, the source-term calculations will be done using an integrated-system modeling approach.

B. Organization

The responsible organization will be the Nuclear Systems and Services Department of the Pacific Northwest Laboratory (PNL), Walt Laity, Manager. The cognizant scientist will be Peter McGrail also of PNL.

C. in

Additional radionuclide release calculations are needed for the Preliminary Performance Assessment of the Hanford low-level tank waste site. Performing these calculations requires a defensible model that describes the alteration rate of the glass and interactions with other components of the disposal system. This task is closely related with and directly dependent on tasks conducting glass and long-term glass durability testing that are funded under the Technology Development Program Office. The cognizant scientist has responsibility for ensuring that appropriate laboratory data are generated under these separate tasks so that the required data for the source-term model is available.

this task include:

release of important contaminants from low-level waste from the engineered disposal system and provide these results to the preliminary performance assessment.

- 2) Conduct literature reviews and interact with staff performing low-level waste glass and engineered barrier materials development to obtain data and models needed for release rate calculations.
- 3) Identify, modify or adapt models as needed to perform release calculations.
- 4) Plan and conduct verification and certification studies for the selected model.

E. Deliverables

- 1) Report on Unsaturated, Pressurized Column test results ready for internal review (June 28, 1996)
- 2) Journal article on AREST-CT Model Description ready for review (July 29, 1996)
- 3) Journal article on AREST-CT Model Application ready for review (July 29, 1996)

III. TASK DESCRIPTIONS

A. Summary list of tasks

- 1) Release Model for Low-Level Waste Glass.
- 2) Integrated Source-Term Modeling.
- 3) Source-Term Model Verification and Certification.
- 4) Advise and Steering Group Participation.

B. Release Model for LLW Glass

1. Detailed Description

Except for the possibility of physical intrusion into the site, radionuclide release from the low-level waste glass is the essential first step that is required for any subsequent transport to the accessible environment. The release rate from the glass may dominate the overall performance of the site in the long-term so it is essential that a credible method be used to calculate releases from the glass waste form. Because release rates must be projected far into the future and over a range of environmental conditions that cannot be completely investigated in the laboratory, a model must be developed that is a reasonable and defensible representation of the system. Experience has shown that models based on fundamental principles of physics, chemistry, and thermodynamics (mechanistic models) are best suited for this application. Consequently, this task will develop and test a suitable model describing radionuclide release from low-level waste glass. It is expected that this model will be implemented in an integrated source-term model for the low-level waste disposal system under Task C.

Development of the release model is directly dependent on long-term glass durability studies that are being funded as part of another effort by the TWRS Program Office. The most important of the tests for model development purposes are the low temperature experiments that must run for extended periods of time (1-3 years). This work depends on the successful completion of those tests.

The main contributor to this task will be Pete McGrail.

2. Interfaces

The input to this task will consist of data derived from laboratory testing done as part of glass formulation studies conducted under the Vitrification Projects of the Tank Waste Remediation System. Because the laboratory testing and model development work will be done under different projects, close coordination and planning of the experiments by the modelers and experimentalists are essential. The output from this task will consist of a mathematical model and supporting database that will be implemented by the Integrated Source-term Modeling Task.

3. Standards

There are no relevant standards in this area. However, guidance from the DOE Peer Review Panel and from the NRC staff will be used.

4. Quality Assurance

Work at PNL will be conducted in accordance with PNL-MA-70, "PNL Quality Assurance Program Manual". PNL's quality assurance program responds to 10 CFR 830.120 and conforms to the requirements of ASME NQA-1, "1989 Quality Assurance Requirements for Nuclear Facilities", as interpreted by Parts 1 and 3 of PNL-MA-70. PNL uses a graded methodology for implementing the management controls used on projects and discrete work activities. The quality assurance plan (ETC-001) for PNL support to TWRS vitrification activities provides detailed information regarding the grading selection (impact level) and project specific requirements applicable to PNL Vitrification Technology Development Project work activities.

5. Schedule

The task will start October 1, 1995 and be completed March 30, 1998.

6. Cost

FY 1996 - 0.27 professional FTE at \$180,000/FTE = \$50,000
FY 1997 - 0.32 professional FTE at \$180,000/FTE = \$58,000
FY 1998 - 0.20 professional FTE at \$180,000/FTE = \$36,000

Costs for this task were determined based upon previous experience of the principal investigator in preparing models for performance assessment reports. It was also assumed that current investigation plan for long-term glass corrosion evaluation is followed and that the data expected from the laboratory tests has been made available to the principal investigator on schedule.

C. Integrated Source-Term Modeling

1. Detailed Description

Radionuclide release from glass waste forms is highly dependent upon the composition of the glass, the chemistry of the water contacting the glass and aqueous chemistry of the particular radionuclide, temperature, and the local hydrologic conditions. Materials surrounding the glass (whether engineered matrix materials or soil) will affect the aforementioned parameters and impact release rates from the glass and overall release from the engineered system.

The objective of this task is to develop and/or adapt a model that is a reasonable and defensible representation of the engineered system. The integrated model will incorporate the mechanistic model developed for the corrosion of low-level waste glass, and models that describe the important physical, chemical, and hydrological properties of the other engineered materials planned for the disposal system. Output from the integrated model will be time-dependent fluxes for radionuclides exiting the engineered disposal system which will be used as inputs for far-field transport and dose assessment modeling (Activity 3.2).

Selection of a suitable computer code (AREST-CT) was accomplished in FY 1995 with the issuance of the report, "Selection of a Computer Code for Hanford Low-Level Waste Engineered-System Performance Assessment," PVTD-C95-04.01E, Rev. 1. Work in FY 1996 will focus on making the necessary code modifications to support the modeling needs identified in the code selection document, and in applying the code to simulate model confirmation experiments (see Task D). An important modification to be made in FY 1996 is the capability to compute water mass balance in the engineered system. Water consumption/production from chemical reactions with the glass and other engineered materials was identified as a key issue by staff in TWRS Disposal Engineering last fiscal year.

2. Interfaces

Inputs to this task will come from virtually every task on the Hanford Low-Level Tank Waste project that is responsible for characterizing the physical and chemical properties of the site and the engineered materials being developed for the disposal system. The main outputs will be to the tasks responsible for far-field transport and dose assessments. Professor George Yeh of Pennsylvania State University is also planning to spend a six month sabbatical at PNL starting sometime in the first quarter of CY 1996. Prof. Yeh will be bringing his latest version of KEMOD

to PNL which will be used to help verify the chemical kinetics module in AREST-CT. We also plan to co-author a paper with Prof. Yeh on reactive transport modeling.

3. Standards

There are no relevant standards in this area.

4. Quality Assurance

Work at PNL will be conducted in accordance with PNL-MA-70, "PNL Quality Assurance Program Manual". PNL's quality assurance program responds to 10 CFR 830.120 and conforms to the requirements of ASME NQA-1, "1989 Quality Assurance Requirements for Nuclear Facilities", as interpreted by Parts 1 and 3 of PNL-MA-70. PNL uses a graded methodology for implementing the management controls used on projects and discrete work activities. The quality assurance plan (ETC-001) for PNL support to TWRS vitrification activities provides detailed information regarding the grading selection (impact level) and project specific requirements applicable to PNL Vitrification Technology Development Project work activities.

5. Schedule

The task will start October 1, 1995 and be completed March 30, 1998.

6. Cost

FY 1996 - 1.34 professional FTE at \$180,000/FTE = \$242,000
FY 1997 - 1.56 professional FTE at \$180,000/FTE = \$280,000
FY 1998 - 0.50 professional FTE at \$180,000/FTE = \$90,000

Costs for this task were determined from the principal investigator's previous 10 years of experience in developing and modifying the AREST code for various DOE and international programs and in using the code to supply calculations for performance assessment reports. Costs incurred for this task exclusively support the Low-Level Tank waste Performance Assessment Project although portions of the code development, quality assurance, and maintenance costs, from which this project benefits, are being funded by other DOE programs.

D. Source-Term Model Verification and Certification

1. Detailed Description

The integrated source-term model developed under the Integrated Source-Term Modeling Task will be subjected to verification and certification testing to build confidence in the reliability of the model for calculating release rates from the engineered disposal system. Verification testing will consist of checking code outputs against standard analytical solutions and against benchmark cases run with other computer codes. Verification

testing will be performed routinely during model development in accordance with software control procedures.

Certification tests will consist of controlled laboratory experiments designed to test release and migration predictions of radionuclide contaminants through idealizations of the engineered disposal system. The laboratory tests will primarily involve long duration, unsaturated, flow-through tests in columns packed with low-level waste glass, engineered barrier materials and/or Hanford soils.

In FY 1995, a design for a High-Temperature Pressurized Unsaturated Column (HTPUC) was conceived, designed, built, and tested. Additional testing of the performance and reliability of this system will be done in FY 1996. After the test procedures are well established, a series of tests will be performed that vary a selected set of pertinent variables designed to challenge the predictive capability of the integrated source-term model. Some important variables include the composition of the water entering the column (e.g., deionized H₂O vs buffered silicate solutions) and the partial pressure of important gases such as O₂ and CO₂ that may influence glass corrosion or dissolution/precipitation of secondary minerals.

The main contributors to this task will be Clark Lindenmeier, Richard Holdren, Jeff Serne, and Pete McGrail of PNL.

2. Interfaces

Inputs to this task will come from virtually every task on the Hanford Low-Level Tank Waste project associated with development and application of engineered materials for processing and final disposal of low-level glass waste. Additionally, this task will be closely coordinated with the Integrated Source-Term Modeling Task to help define the test configurations and test parameters that will best evaluate the underlying assumptions and theories incorporated in the integrated source-term model.

3. Standards

There are no relevant standards in this area.

4. Quality Assurance

Work at PNL will be conducted in accordance with PNL-MA-70, "PNL Quality Assurance Program Manual". PNL's quality assurance program responds to 10 CFR 830.120 and conforms to the requirements of ASME NQA-1, "1989 Quality Assurance Requirements for Nuclear Facilities", as interpreted by Parts 1 and 3 of PNL-MA-70. PNL uses a graded methodology for implementing the management controls used on projects and discrete work activities. The quality assurance plan (ETC-001) for PNL support to TWRS vitrification activities provides detailed information regarding the grading selection (impact level) and project specific requirements applicable to PNL Vitrification Technology

Development Project work activities:

5. Schedule

The task will start October 1, 1995 and be completed September 30, 1998.

6. Cost

FY 1996 - 1.10 professional FTE at \$180,000/FTE = \$201,000
 0.20 tech. serv. FTE at \$160,000/FTE = \$32,000
 Capital Equipment (Micro Injection Pumps) = \$35,000
FY 1997 - 1.35 professional FTE at \$180,000/FTE = \$240,000
 0.25 tech. serv. FTE at \$160,000/FTE = \$40,000
FY 1998 - 1.50 professional FTE at \$180,000/FTE = \$270,000
 0.35 tech. serv. FTE at \$160,000/FTE = \$56,000

Costs for professional time for this task were determined from the previous year's experience in the time required to setup, execute, and analyze results from a HTPUC test. Costs for technical services were determined based upon expectations for number of samples requiring chemical and/or microscopic analysis (such as ICP-MS and SEM) and the present costs for doing these analyses.

E. Advise

1. Description

Participate in steering group meetings and provide assistance/advise to other tasks.

2. Interfaces

Coordinate with related programs.

3. Schedule

Task is a continuing activity.

4. Cost

Cost is contained in above tasks.

3.1.7 Waste Package Materials Interaction

I. SUMMARY

This activity focuses on the testing and results of the interactions of materials in the waste package. The waste package consists of the waste form and the canister holding the waste form. To model the source term, the mechanisms of the material interactions and long-term material performance of the waste package need to be known.

II. GENERALA. Background

The waste package will be a composite consisting of vitrified low-level tank waste, a canister containing the vitrified waste, and currently, a matrix material integrated with the vitrified waste. Each material in the composite will degrade over the life of the disposal system. Each material and reacted components will interact with each other, changing local environments (e.g., pH) and material properties. A basic understanding of the chemistry, physics, and thermodynamics of the material's interactions and the changing local environment is needed for producing a defensible mechanistic source-term model. Experiments will support the source-term modeling by providing insight to the degradation processes and the interactions between the materials.

Currently, the PNL Vitrification Technology Development (PVTD) Project is funding testing on the matrix material and matrix material/glass interaction (Low-Level Waste Process Product Development Task, Product Package Evaluation, Investigation Plan, PVTD C95-02.02B, Revision 1, January 1995). An on going dialogue is being maintained between the Performance Assessment team and the Product Packaging group. Recently, other studies on the matrix material have been identified. These studies are being done by the Savannah River and Sandia National Laboratories. However, additional studies will be needed for the performance assessment effort.

B. Organization

The responsible organization will be the Environmental Modeling Section of the Westinghouse Hanford Company, Nick Anderson, Manager. The cognizant scientist will be Fred Mann. The cognizant engineer performing the tasks will be Cheryl Eiholzer of TWRS Disposal Engineering, Process Design Section, John Garfield, Manager.

Direction of required testing for the performance assessment objectives will be closely integrated with Pete McGrail (PNL) and the Low-Level Waste Performance Assessment team. TWRS low-level waste disposal personnel will also provide information on experiments they are considering. Work supporting this activity will be performed through other Department of Energy contractors and outside contractors to take advantage of expertise within the Department of Energy Complex and in the commercial sector.

C. Vision

To understand the chemical, physical, and thermodynamics of the materials and material interactions of the waste package to support the source-term modeling effort for the performance assessment.

D. Objectives

The main objective is to understand the behavior of the materials in the waste package and how these materials interact with each other. This main objective can be achieved by the following:

- 1) To identify ongoing or planned waste package material testing being done or sponsored by TWRS Engineering, TWRS Program Office, and other outside sources. The objective would be to prevent unnecessary duplication of experiments, focus experiments to meet both disposal facility and Performance Assessment needs, and to pass data freely between organizations.
- 2) To obtain more information on the targeted matrix material for the preliminary performance assessment.
- 3) To identify and obtain other waste package material interaction information required for verifying or developing the mechanistic source term model for the preliminary performance assessment.
- 4) To identify and obtain other waste package material interaction information to provide answers to concerns about long-life performance of the material.

E. Deliverables

- 1) An internal memo identifying and summarizing ongoing and planned waste package material studies. (November 30, 1995)
- 2) Internal memo identifying performance assessment waste materials testing needs and strategies for FY 1997 and FY 1998. (March 31, 1996 and March 31, 1997, respectively)
- 3) Status reports on waste material testing sponsored by Performance Assessment team. Delivery dates need to be determined based on contracts.
- 4) Letter report evaluating the current leading candidate matrix material (sulfur polymer cement) as an engineering barrier. (September 30, 1996)
- 5) A letter report describing the present understanding of the interactions of the waste package materials. This data package will be used for the preliminary performance assessment. (September 30, 1997)

III. TASK DESCRIPTIONS

A. Summary List of Activities

- 1) Identify ongoing and planned waste package materials testing.
- 2) Matrix material testing.
- 3) Other waste packaging material testing.
- 4) Current understanding of waste package materials summary.
- 5) Matrix materials workshop.
- 6) Advise and steering group participation.

B. Identify Ongoing and Planned Waste Package Materials Testing

1. Detailed Description

Organizations related to the design, decision making, technology development, and the performance assessment need data on the waste package materials to support their efforts. Many of these organizations have started or will be planning testing on components of the waste package. Instead of unintentionally duplicating work, the Performance Assessment team could possibly obtain needed data from other experiments and visa versa. This approach could save the general program time and money.

The scope of this task consists of identifying ongoing and planned testing on the low-level waste package materials and interfacing with the sponsoring group. Testing other than the PNL Product Packaging group testing, will be examined for expanding to give useful data for the source-term modeling effort. The PNL Product Packaging group is already focusing on getting data for the performance assessment. Thus communications between the Performance Assessment team and the Product Packaging group will be maintained under this task. Communications between other groups interested in the low-level waste package materials will be started or enhanced.

The major contributor performing this interfacing task will be Cheryl Eiholzer.

2. Interfaces

The input to this task consists of information from TWRS Program Office, PNL Technology Development, TWRS Engineering, and the Performance Assessment team. These groups would help identify people doing, planning, or needing material testing data for the waste package. Pete McGrail will provide the specific data requirements for the source term modeling activity (Activity 3.1.6). The facility reports (Activities 2.1.5, 3.1.5) or most recent waste facility designs from TWRS Engineering or the Architect Engineer will be used as input. Outside concerns (Activity 1.4) will also provide input.

The output from this task will be information on testing that is being done on the Hanford low-level waste package materials. If identified experiments can provide data for the performance

assessment, these data would be used by the modelers for the near-field and source-term calculations for performing the preliminary performance assessment (Activity 3.2).

3. Standards

If identified tests can be used for obtaining Performance Assessment data, the tests will be required to follow appropriate standards. Standards will be decided on a case-by-case basis.

4. Quality Assurance

If identified tests can be used for obtaining Performance Assessment data, the tests will be required to have the appropriate quality assurance for data used for decision making. Scoping tests could have a lesser quality assurance level. The quality assurance level will be decided on a case-by-case basis.

5. Schedule

This coordination task is continuous. The task begins October 1, 1995 and will continue through September 30, 1997. An internal memo to the performance assessment team about the ongoing and planned materials testing will be released by November 30, 1995. Contact with other cognizant engineers initiating packaging material testing will continue. Any testing identified as being able to produce data for the performance assessment will be closely followed. Materials testing needs and strategy for the following fiscal year will be produced by March 31, 1996 and March 31, 1997.

6. Costs

The following cost breakdown, in FY 1995 dollars, includes engineering time and secretary support.

FY 1996: 3.5 man-months at \$130,000/man-year - \$38,200

FY 1997: 3.4 man-months at \$130,000/man-year - \$36,700

All costs are based on previous experience for interfacing with organizations, advising the performance assessment team, and writing quarterly memos.

7. Other Considerations

This task is highly dependent on the cooperation of many groups. The success of this task will increase with the increased willingness of groups to communicate with each other.

C. Matrix Material Data

1. Detailed Description of Task

The current TWRS Engineering design of the waste form includes a matrix material for enhancing the performance of the vitrified low-level waste. The current design focuses on sulfur polymer cement as a chemical barrier. Thus the current focus of matrix material development is on sulfur polymer cement (SPC). However, other matrix materials have been considered and work could be performed on these materials later.

Results from a FY 1995 literature search conducted by the PNL Product Package team show that no work has been published on a sulfur polymer cement/glass composite. Questions about sulfur polymer cement developed such as how does the glass and sulfur polymer cement react together, how does sulfur polymer cement work as a chemical barrier for Tc released from the glass corrosion process, and how does biodegradation affects sulfur polymer cement. To fully answer these questions and to be able to model these mechanisms for the source term model, a chemical, physical, and thermodynamic understanding of the mechanisms is needed. Although PNL has started or plans work for obtaining data and answers for most of these questions, more work is needed in selected areas. Already three areas of concern have been identified: SPC/Tc interaction, biodegradation of sulfur polymer cement, and unsaturated flow testing of sulfur polymer cement.

The scope of this task is to obtain the needed data on the matrix material for the source-term model and for providing a defensible case for the performance assessment. The task initiates work in three critical areas: sulfur polymer cement as a chemical barrier for Tc, sulfur polymer cement biodegradation, and testing sulfur polymer cement in unsaturated conditions. If additional information is needed on the matrix material and cannot be obtained from new initiated experiments, PNL Technology Development, or experiments from Task B, then additional experiments will be initiated under this task.

Contributors to the testing tasks will be contractors inside and outside Hanford in order to take advantage of expertise within the Department of Energy Complex and in the commercial sector. One commercial laboratory has been identified as a potential contributor, SouthWest Research Institute (SWRI). SWRI has been identified as an investigator for the SPC/Tc relationship and for the biodegradation of sulfur polymer cement. SWRI is very familiar with sulfur polymer cement since the company has formulated its own sulfur polymer cement. SWRI has facilities for testing with Tc. This testing will complement the SPC/Tc testing being done at PNL. Since the current waste form depends on the SPC/Tc interaction, duplication of this process is necessary to verify the process.

SWRI can also contribute to the biodegradation question. SWRI buried sulfur polymer cement throughout the Western Hemisphere over 20 years ago for retrieving and analyzing. These samples can give us insight to biodegradation of sulfur polymer cement. Robert Young of SWRI has been identified as the technical contact on both SWRI experiments.

PNL has been identified for performing sulfur polymer cement experiments in unsaturated flow conditions. Most testing on sulfur polymer cement has been under saturated conditions. However, the material in the proposed disposal facility will be unsaturated. PNL has developed techniques for performing unsaturated experiments for sulfur polymer cement. Pete McGrail will be the prime contact on this experiment.

Cheryl Eiholzer will be doing the coordination and following of the experiments. Other contributors to this task are Pete McGrail who will be doing the source term-modeling (Activities 3.1.6, 3.4.6) and the testing organizations.

2. Interfaces

Input for this task is information from the performance assessment personnel on additional information needed on the matrix material for defensible source-term and near-field models. Also information from the public and reviews on the concerns and doubts of the matrix material (Activity 1.4) will be considered.

Output from this task will be data and an understanding of the mechanisms for the matrix material and matrix material/glass interaction. Fiscal year 1996 results up to July 31, 1996 will be needed for Task E, evaluation of the matrix material. Each testing organization will write a summary report of the testing done during the fiscal year. These data from the matrix material testing will be used for the source-term modeling (Activities 3.1.6, 3.4.6).

3. Standards

The tests will be required to follow appropriate standards. Standards will be decided on a case-by-case basis.

4. Quality Assurance

The tests will be required to have the appropriate quality assurance for data used for decision making. Scoping tests could have a lesser quality assurance level. The quality assurance level will be decided on a case-by-case basis.

Work at PNL will be conducted in accordance with PNL-MA-70, "PNL Quality Assurance Program Manual". PNL's quality assurance program responds to 10 CFR 830.120 and conforms to the requirements of ASME NQA-1, "1989 Quality Assurance Requirements for Nuclear Facilities", as interpreted by Parts 1 and 3 of PNL-MA-70. PNL uses a graded methodology for implementing the

management controls used on projects and discrete work activities. The quality assurance plan (ETC-001) for PNL support to TWRS vitrification activities provides detailed information regarding the grading selection (impact level) and project specific requirements applicable to PNL Vitrification Technology Development Project work activities.

5. Schedule

This task begins October 1, 1995 and will continue through September 30, 1997. Reports on testing initiated by the performance assessment team will be written by the testing organization. Fiscal year 1996 results up to July 31, 1996 for sulfur polymer cement will be needed for Task E, Evaluation of the Matrix Material. Each contributor shall write a report on each fiscal year developments. Other final reports on testing will be determined during the contractual phase. Summary reports for information to be used for the preliminary performance assessment will be required by July 1, 1997.

6. Costs

The following cost breakdown, in FY 1995 dollars,

FY 1996

WHC staff - 3 man-months at \$130,000/man-year = \$32,500
PNL testing - \$80,000
SWRI biological testing - \$150,000
SWRI TC testing - \$100,000

FY 1997

WHC staff - 3 man-months at \$130,000/man-year = \$21,666
PNL testing - \$20,000
SWRI biological testing - \$170,000
SWRI TC testing - \$120,000

The costs include engineering time for oversight of the tests. The oversight costs includes all contractual work to start testing. The tests proposed in this task are supplemental to PNL Technology Development testing on matrix materials (see detailed description for this task).

If the decision is made to not use sulfur polymer cement as a matrix material, then the money will be redirected to matrix property testing of the selected matrix materials. Costs do not include any contingency money for additional needed testing identified during any of the fiscal years.

D. Other Waste Packaging Material Data

1. Detailed Description

The current TWRS Engineering waste package design shows a metal container for containing the waste form. The container has internal steel components for structural reinforcement. Currently, carbon steel has been selected as the container material. Thus, testing on the influence of carbon steel on the glass, matrix material, or glass/matrix material must be done to understand the interaction between the materials. One concern has been identified as the interaction between the iron, water, and glass corrosion rates. In other studies, iron has been identified as temporarily enhancing the glass corrosion rate.

The scope of this task is to obtain the needed data for the source term model and for providing a defensible case for the performance assessment. The task initiates work in one critical area, the iron, water, glass corrosion rate interaction. If additional information is needed on the carbon steel and cannot be obtained from new initiated experiments, PNL Technology Development, or experiments from Task B, then additional waste package materials interaction experiments will be initiated under this task.

PNL is a candidate for performing the iron/water/glass corrosion experiments. PNL is already studying water/SPC and water/SPC/glass interactions.

The main contributor to the task is Cheryl Eiholzer who will be coordinating the task. Data needs for the source term model will come from Pete McGrail (PNL). Contributors to the testing tasks will be contractors inside and outside Hanford to take advantage of expertise within the Department of Energy Complex and in the commercial sector.

2. Interfaces

The input to this task will be from the performance assessment personnel. They will identify information that is required for a defensible performance assessment and models. Also information from the public and reviews on the concerns and doubts of the canister material (Activity 1.4). Other input will be from the laboratories chosen to conduct the investigation(s).

The output to this task will be data useable in the source term and near-field models. (Activities 3.1.6, 3.4.6).

3. Standards

Any tests will be required to follow appropriate standards. Standards will be decided on a case-by-case basis.

4. Quality Assurance

Any tests will be required to have the appropriate quality assurance for data used for decision making. Scoping tests could have a lesser quality assurance level. The quality assurance level will be decided on a case-by-case basis.

5. Schedule

This task begins October 1, 1995 and will continue through September 30, 1997. Reports on testing initiated under this task will be written by the testing organization. Each contributor shall write a summary report on each fiscal year's development. Final reports will be determined during the contractual phase. However, summary reports for information to be used for the preliminary performance assessment will be required by June 30, 1997.

6. Costs

The following cost breakdown, in FY 1995 dollars, is:

FY 1996

WHC staff - 0.4 man-months at \$130,000/man-year - \$4,333
Testing - \$100,000

FY 1997

WHC staff - 0.4 man-months at \$130,000/man-year - \$4,333
Testing - \$100,000

The costs includes times for engineering oversight and for some testing on the metal/waste form interactions. A literature search is envisioned before experimentation starts since work has been done on metal/glass interaction.

E. Summary of Waste Package Material Testing

1. Detailed Description

The scope of this task is two-fold. First the data collected on sulfur polymer cement for two years will be evaluated with respect to the performance assessment. A report will be written summarizing the findings on sulfur polymer cement and recommending the progress on future work. This evaluation is needed for ascertaining if sulfur polymer cement will perform adequately as a chemical barrier. If it appears that sulfur polymer cement will perform well, then testing can continue and possibly modified toward missing information. If it appears that sulfur polymer cement will not perform well, money can be redirected to other matrix material testing. This report will be written jointly by WHC, PNL, and SWRI.

The second part of the scope for this task is to write a data report on the most recent understanding of the interaction between the materials of the waste package. The data report will be for the preliminary performance assessment data package. The reason for the report is to summarize the testing results in one document for the modelers.

2. Interfaces

The input data needed are the status and final reports from the testing organizations (Tasks B, C, and D of this activity).

The output data will be two reports. The first will be used to help confirm or redirect the testing of the most focused matrix material (sulfur polymer cement). The organization designing the waste package and the TWRS Program Office will be able to use the information in the report. The second report will be used by the performance assessment personnel for the modeling efforts for the preliminary performance assessment (Activity 3.2).

3. Standards

There are no relevant standards in this area.

4. Quality Assurance

All reports will be reviewed before issuance.

5. Schedule

This task will start July 1, 1996 with the start of the matrix material summary and evaluation report. This report will be issued by September 30, 1996. The task will continue to July 1, 1997 when writing on the material interaction data package will start. The data package will be issued by September 30, 1997.

6. Costs

The following cost breakdown, in FY 1995 dollars, includes engineering time and secretary support.

FY 1996: 2 man-months at \$130,000/man-year - \$21,667

FY 1997: 2 man-months at \$130,000/man-year - \$21,667

The cost is for producing a supporting document for each fiscal year. Time is based on writing, secretarial support, graphic support, and document control. The time estimate is based on previous experience in producing supporting documents.

F. Matrix Material Workshop

1. Detailed Description

The scope of this task is to organize a workshop on the matrix material. A workshop would provide peer assessment and input to the testing and data being obtained on the matrix material. Topics would be determined during the initial development stage of organizing the workshop.

The main contributor to the task will be Cheryl Eiholzer.

2. Interfaces

The input to this task would be from the performance assessment team especially Pete McGrail and the organizations performing tests on the matrix material.

The output of this task will be data, suggestions, direction, and opinions on the matrix material. The information will be used to formulate the direction for the matrix material testing.

3. Standards

None.

4. Quality Assurance

None.

5. Schedule

This activity will start the beginning of FY 1997. This will be after the evaluation stated in Task E. During the start of FY 1997, the details of the workshop will be determined.

6. Cost

The cost, in FY 1995 dollars, of the initial planning of the workshop is as follows:

FY 1996: none

FY 1997: 1 man-month at \$130,000/man-year - \$10,833.

The cost is based on the cost for planning the Recharge Workshop held in May, 1995.

G. Advise

1. Description

Participate in steering group meetings and provide assistance/advise to other tasks.

2. Interfaces

Coordinate with related programs, especially characterization, retrieval, and pretreatment.

3. Schedule

Task is a continuing activity.

4. Cost

Cost is contained in above tasks.

IV. OTHER CONSIDERATIONS

This task is based on the current preliminary conceptual design for the waste package. However, if the current waste package design is dramatically changed (i.e., uses significantly different materials or material combinations), testing for the new waste package materials must start. (Performance assessment personnel will be briefed on any waste packaging design changes via of Activity 3.1.5.) Also, if the performance assessment personnel determines that a material will not function as anticipated, the low-level waste program office and the waste packaging organization will be advised to direct the testing efforts toward a new replacement material. In either case, all design changes will be analyzed for needed data for the source-term modeling. New data needs and strategies would be written. All tests would be re-evaluated for their usefulness. Some testing may be stopped in order to start testing new materials. Monies from the stopped tests would be directed to the new testing. Thus, the same steps outline in this active would be followed for the new materials and design.

This activity depends on the PNL Product Packaging Team to be funded for continuing current investigations as given in the investigation plan (Product Package Evaluation, Cost Account 02.02.02.02, PVTD C95-02.02B, Revision 1, January, 1995). This activity only supplements this work currently being done at PNL. The work being done by PNL and given in this task is considered as the complete materials program needed for the non-glass material components of the waste package.

3.1.8 Hydrologic Data and Conceptual Model Testings

I. SUMMARY

This activity is designed to determine site-specific hydrologic data needed for materials within and near the low-level tank waste disposal facility (near-field media) and for materials within the vadose zone (far-field media). Note that glass release rate, recharge rate, and retardation factors are covered in other activities. Experiments will be designed to identify the appropriate conceptual model(s) for simulation of flow and transport in the vadose zone and to provide the parameters necessary for simulations.

II. GENERALA. Background

The Peer Review Panel (the group selected by the Department of Energy to judge whether a performance assessment is technically adequate) has mandated that site-specific data used in the analyses of water flow and contaminant transport be selected and justified. Such selection and justification can be based on expert judgement, available literature, or project-specific experiments.

The hydraulic properties of backfill materials (matrix) emplaced as part of the engineered disposal system require a close study. The materials selected might present very different flow fields to the contaminant transport. To examine the effect on the contaminant transport, conceptual models have to be developed and evaluated by numerical models. Methods for dealing with characteristics of fractures will be explored, if the material that is selected may experience fracturing.

Vadose zone flow and transport models are recognized as necessary tools for baseline risk assessments. The purpose of these models is, in part, to evaluate the potential migration of contaminants within vadose zone soils to the water table. Confidence in the predictions of these models improves progressively as they are repeatedly shown to represent reality.

The proposed experiments are designed to help resolve outstanding technical issues related to current vadose zone flow and transport modeling at Hanford such as:

- 1) how to resolve differences between field and laboratory measurements of water retention characteristics and unsaturated hydraulic conductivities,
- 2) how representative are laboratory measurements of unsaturated hydraulic conductivity determined using centrifugation techniques relative to estimates obtained using other methods, and
- 3) how to address the issue of scale and to build confidence in the predictions of the vadose zone flow and transport models.

B. Organization

The cognizant organization is the Environmental Modeling Section of Westinghouse Hanford Company; Nick Anderson, Manager. The cognizant scientist is Allen Lu. Supporting this effort will be the Environmental Technology Division of the Pacific Northwest Laboratory (in particular, M.L. Rockhold, M.J. Fayer, R.R. Kirkham, C.T. Kincaid, A.L. Ward, and M.P. Bergeron will provide technical coordination and interface for this task for the PNL Vitrification Technology Department (PVTD) Program).

C. Vision

This task will contribute to the understanding of the low-level tank waste disposal facility and its behavior in Hanford sediments. The task will improve the ability to simulate the flow of fluids and transport of contaminants within the facility and in the surrounding vadose zone through the measurement of physical and hydraulic properties and the study of alternate constitutive models.

D. Objectives

The objectives of this task are to identify the appropriate conceptual model(s) for simulation of flow and transport in the vadose zone and to provide the parameters necessary for simulations.

E. Deliverables

- 1) A data package containing the data and parameter estimates, including descriptive statistics and estimates of spatial correlation lengths for each of the hydraulic parameters, will be provided for use in the performance assessment calculations by July 15, 1996.
- 2) A draft manuscript describing the field measurement experiments using the modified instantaneous profile method and field results will be prepared by September 30, 1996.
- 3) The above journal manuscript describing results of both field and laboratory analyses will be submitted to a peer reviewed journal by April 30, 1997.
- 4) A draft of the final report on the Sisson and Lu injection experiment will be prepared by July 28, 1995. (Expected to be completed on time in FY 1995.)
- 5) An interim report summarizing site selection, model simulations for experimental design purposes, and instrumentation selection and calibration for the controlled field test to be conducted adjacent to the tank low-level waste disposal facility will be prepared by September 30, 1997.
- 6) A "wet" site validation data set will be published on CD-ROM by September 30, 1996. The CD-ROM will include 3-dimensional site drawings, radionuclide, soil characteristics and weather data sets.

- 7) A "dry" site validation data set will be published on CD-ROM by September 30, 1997. The CD-ROM will include radionuclide, soil characteristics and weather data sets.
- 8) Submit to clearance by January 12, 1996 a topical report on the conceptual and constitutive models, and model parameters for unsaturated hydraulic properties of near field materials.
- 9) Submit to clearance by March 29, 1996 a test plan for measurements of hydraulic properties of near field materials.
- 10) Submit to WHC by December 30, 1996 a progress report on measured unsaturated hydraulic and physical properties of near-field materials.
- 11) Submit to clearance by September 30, 1997 a topical report on the conceptual and constitutive models, and model parameters for unsaturated hydraulic and physical properties supporting the preliminary performance assessment.
- 12) Submit a letter report by September 30, 1996 describing the results of field testing of the PORFLOW code.

III. TASK DESCRIPTIONS

A. Summary List of Activities

- 1) Field measurement of unsaturated hydraulic conductivities using a modified Instantaneous Profile Method (IPM).
- 2) Controlled field testing of flow and transport models.
- 3) Disposal site testing of flow and transport model.
- 4) Development of conceptual models for flow in the near field.
- 5) Determination of hydraulic properties of matrix materials.
- 6) Model Testing

B. Field Measurement of Unsaturated Hydraulic Conductivities Using Modified IPM

1. Detailed Description

The primary objective of this task is to conduct field experiments to obtain justifiable and defensible parameter estimates, based on site-specific data, to support unsaturated water flow and solute transport modeling for the performance assessment. A second objective is to generate a sufficient quantity of high quality data so that spatial correlation lengths can be estimated for flow and transport parameters. Quantifying spatial correlation structure is important because this structure influences the anisotropy of hydraulic conductivity and the potential dispersion of contaminants. Quantification of spatial structure is also

required to effectively upscale unsaturated hydraulic properties determined from small point measurements to the larger grid block sizes typically used in numerical simulation models.

Testing began in FY 1995 on a segmented, remote diode-shortening time-domain reflectometry (TDR) probe. This type of TDR probe will be used to measure water contents for in-situ determination of unsaturated soil hydraulic properties. A preliminary laboratory system for automated measurement of soil hydraulic properties was designed. This system will be used to measure the hydraulic properties of soil core samples, for comparison with the field measurements. A test plan for the work to be conducted in FY 1995 was reviewed and completed, satisfying PVTD milestone C95-04.02A. Some effort was also expended on developing alternative segmented TDR probe designs that will allow solute transport parameters to be estimated. A preliminary version of the datalogger and multiplexer system for automating measurements of water content and pressure heads using TDR and tensiometers, respectively, was configured and tested.

A series of field experiments will be conducted at or near the location selected for siting of the low-level tank waste disposal facility. The experiments will be based on a modification of the instantaneous profile method for estimating unsaturated hydraulic properties, as described by Rockhold (1995).

Field plots will be instrumented with segmented, remote diode-shortening TDR probes and multi-depth tensiometers for measuring soil-water contents and tensions, respectively. The tensiometers will be equipped with transducers and the TDR/tensiometer system will be automated and multiplexed for continuous, near real-time data acquisition. Water will be ponded on the surface of the field plots until the plots are wetted to the deepest depth of interest. Water contents and tensions will be monitored during the infiltration and drainage phases of the experiments. *In situ* water retention characteristics and unsaturated hydraulic conductivities will be estimated from the water content and hydraulic head profiles. Details on the method and data reduction procedures are given by Rockhold (1995).

Each field plot will be instrumented with multiple TDR probes and tensiometers. These instruments will be arranged to maximize the number of lag pairs available for quantifying the autocorrelation structure of the unsaturated hydraulic properties and estimating correlation lengths. In addition, *in situ* measurements of saturated and unsaturated hydraulic conductivity will be made using ponded and tension infiltrometers. Because of the portability and low water-use requirements of infiltrometers, they are ideally suited for spatial variability studies. The infiltrometer measurements will be made in collaboration with the Recharge activity (3.1.9).

After the IPM experiments have been conducted, core samples will be collected from the field plots to determine bulk densities, porosities, particle-size distributions, water retention

characteristics, and saturated hydraulic conductivities using standard laboratory methods. All laboratory analyses will be conducted by the WHC Geotechnical Engineering Laboratory (WHC-GEL). In addition, unsaturated hydraulic conductivities will be directly measured on subsamples of some of the cores using a centrifuge technique (Conca and Wright 1990). The data from the field experiments and laboratory analyses will be analyzed and compared. The data generated will simultaneously provide site-specific hydraulic properties that are needed for flow and transport modeling in the performance assessment, estimates of spatial variability and parameter uncertainty that are needed to evaluate the uncertainty associated with performance assessment predictions, and field-scale experimental data for model testing and confirmation exercises.

2. Interfaces

Allen Lu (WHC) will oversee the task. The principal investigators from PNL are Mark Rockhold and Andy Ward, with some support provided by Mike Fayer and Randy Kirkham for data acquisition and analysis activities. John Relyea and Paula Heller (WHC-GEL) will provide support for laboratory measurements of physical and hydraulic properties. Jim Conca (WSU - Tri-Cities) will provide support for centrifuge measurements.

Results will be presented to the technical community and reviews and comments will be solicited. The findings will be provided to the vadose zone modeling team so they may use the data in the preliminary and final performance assessment.

3. Standards

There are no standards in this area. However, past experience with risk and performance assessments will be used to guide activities. Standard laboratory techniques will be used to process any collected samples. If new techniques are developed, replicable procedures will be prepared and documented.

4. Quality Assurance

Periodic reviews will be conducted of work in progress. Topical reports will be subjected to PNL and WHC peer review before being issued.

Work at PNL will be conducted in accordance with PNL-MA-70, "PNL Quality Assurance Program Manual". PNL's quality assurance program responds to 10 CFR 830.120 and conforms to the requirements of ASME NQA-1, "1989 Quality Assurance Requirements for Nuclear Facilities", as interpreted by Parts 1 and 3 of PNL-MA-70. PNL uses a graded methodology for implementing the management controls used on projects and discrete work activities. The quality assurance plan (ETC-001) for PNL support to TWRS vitrification activities provides detailed information regarding the grading selection (impact level) and project specific requirements applicable to PNL Vitrification Technology

Development Project work activities.

5. Schedule

FY 1995: The focus of the IPM task was on developing a fully automated TDR/tensiometer data acquisition system and testing it at one field site. (Expected to be completed on schedule and within cost.)

FY 1996: Up to 4 additional IPM experiments will be conducted. Chloride will also be used as a conservative tracer during one or more of the field experiments in FY 1996 to estimate dispersivities.

FY 1997: The instrumentation, data acquisition systems, and data processing/analysis tools will be adapted for use in the Controlled Field Testing of Flow and Transport Model task.

6. Cost

These costs are based on the man-hours and costs of similar field work conducted under the former Hanford Site Performance Assessment and Hanford Site Protective Barrier Program. Estimates of labor hour and equipment costs are also based on previous research using the proposed methods conducted by Mark Rockhold and Andy Ward.

FY 1996: PNL costs are \$204,000 in FY 1996; \$164,000 for 12 man-months (PNL S/E Grade 2 staff) and \$40,000 for equipment. The labor cost will support field experimental work and associated analyses. The equipment cost will be used for procurement of materials for additional TDR probes and associated equipment for the solute transport experiments.

Approximately \$40,000 is anticipated for the WHC-GEL for laboratory analyses. Also about 1.5 man-months of WHC professional time (at \$130,000 per man-year) is anticipated, costing about \$16,000.

FY 1997: 4 man-months of professional time is anticipated for PNL, costing approximately \$55,000.

7. Deliverables

- a) A data package will be prepared containing the data and parameter estimates resulting from these experiments. This data package will also contain descriptive statistics (mean, variance, distribution type) and estimates of spatial correlation lengths for each of the hydraulic parameters. This data package will be provided for use in the performance assessment calculations by July 15, 1996. A draft manuscript(s) describing the experiments and results will be prepared by September 30, 1996. This manuscript will be submitted for publication in a peer-reviewed journal

in FY 1997.

- b) The journal manuscript(s) describing the results of the field experiments and laboratory analyses will be submitted to a peer-reviewed journal by April 30, 1997. Peer review comments will be addressed as needed.

8. References

Conca, J.L.; and J. Wright. 1990. "Diffusion Coefficients in Gravel Under Unsaturated Conditions." Water Resources Research 26:1055-1066.

Rockhold, M. L. 1995. Experimental Determination of Unsaturated Hydraulic Properties for Near-Surface Sediments - (FY 1995) Test Plan, PVTD-C95-04.02C Rev.1, Pacific Northwest Laboratory, Richland, Washington.

C. Controlled Field Testing of Flow and Transport Models

1. Detailed Description

The objective of this task is to use field data from controlled field experiments to build confidence in the predictions of the vadose zone flow and transport models. This task is using field data collected in a subsurface injection experiment that was conducted in 1980 to test flow and transport models (Sisson and Lu 1984; Fayer et al. 1993). In FY 1995, wells at the injection site were relogged with more accurate logging tools and with the original neutron probes. An analysis and comparison of these data are ongoing. The knowledge gained from this analysis will be used to determine the nature and extent of additional controlled field testing.

A new injection experiment will be designed with objectives oriented to the needs of the low-level tank waste performance assessment project. The injection will involve introducing to the subsurface water and one or more solutes with characteristics related to the contaminants expected to occur in the vitrified waste. Such experiments provide useful information in a short time, but the sediments are usually wetter than expected around the disposal facility. The experiments are generally unable to provide data under drier conditions in a reasonable amount of time. To overcome this limitation, heat may be added following injection. The heat will be used to cause redistribution in both liquid and vapor flow and will provide flow and transport data for drier conditions. Data collected from the controlled field test will be used to test several aspects of the conceptual model as well as demonstrate overall model performance.

Monitoring equipment today is vastly improved. Instruments such as TDR probes enable more or less instantaneous measurements of water content distributions, something that is not possible with the neutron probe method. TDR measurements can also be taken at a much higher spatial and temporal frequency than the neutron probe.

Logging tools such as the RLS spectral gamma-ray tool can be used to measure and discriminate minute quantities of radionuclides.

Post-experiment sampling of the sediments may occur to obtain water and contaminant distributions.

2. Interfaces

Allen Lu (WHC) will oversee the task. Principal investigators from PNL include Mike Fayer, Mark Rockhold, Dan Kaplan, and Rick Lewis.

This work will be conducted in collaboration with three other tasks: instantaneous profile measurements (IPM), disposal site testing, and chemical retardation factors. The IPM task is developing TDR and tensiometer techniques for high-speed measurements of water contents, matrix potentials, and electrical conductivity. These techniques will be used for the new field test. The disposal site test will provide a large-scale data set for model testing. Coordination with the disposal task will ensure that the controlled field and the disposal tests will be complementary and that issues that cannot be addressed at the large scale will be addressed by the controlled field tests. The chemical retardation task will be involved in the planning and analysis of the controlled field test to ensure that chemical aspects of the test are appropriate (e.g., Glass-specific primary contaminants, competition for sorption sites, etc.).

Results will be presented to the technical community and reviews and comments will be solicited. The findings will be provided to the vadose zone modeling team so they may be used directly in the preliminary and final performance assessment.

3. Standards

There are no standards in this area. However, past experience with risk and performance assessments will be used to guide activities. Standard laboratory techniques will be used to process any collected samples. If new techniques are developed, replicable procedures will be prepared and documented.

4. Quality Assurance

Periodic reviews will be conducted of work in progress. Topical reports will be subjected to PNL and WHC peer review before being issued.

Work at PNL will be conducted in accordance with PNL-MA-70, "PNL Quality Assurance Program Manual". PNL's quality assurance program responds to 10 CFR 830.120 and conforms to the requirements of ASME NQA-1, "1989 Quality Assurance Requirements for Nuclear Facilities", as interpreted by Parts 1 and 3 of PNL-MA-70. PNL uses a graded methodology for implementing the management controls used on projects and discrete work activities. The quality assurance plan (ETC-001) for PNL support to TWRS

vitrification activities provides detailed information regarding the grading selection (impact level) and project specific requirements applicable to PNL Vitrification Technology Development Project work activities.

5. Schedule

This schedule is for the baseline budget. The schedule will be adjusted for the accelerated and reduced budget at a later date.

FY 1996: A new field experiment will be designed with objectives oriented to the needs of the low-level tank waste performance assessment project and at a site appropriate to the proposed disposal site. The proposed test will be coordinated with the tasks on hydraulic property characterization, chemical retardation factors, and disposal site testing. A test plan will be prepared and submitted for review. Also in FY 1996, the final report and papers from the FY 1995 work on the Sisson-Lu experiment will be published.

FY 1997: The site of the controlled field test will be selected. The experiment will be simulated to understand what to expect and to determine the necessary probe locations and frequency of monitoring. Instruments and sensors will be purchased and calibrated. An interim report summarizing the site selection, simulations, and instrumentation calibration will be prepared by September 30, 1997.

6. Cost

These costs are based on past experience on this project.

FY 1996: PNL costs are \$32,000 for 2.0 man-months. Sixteen thousand dollars (\$16,000) is also required for WHC professional time (1.47 man-months at \$130,000 per man-year).

FY 1997: PNL costs are \$150,000: \$96,000 for 6 man-months and \$54,000 for equipment. \$16,000 is required for WHC professional time (1.47 man-months at \$130,000 per man-year) to oversee the activity.

7. Deliverables

- a) A draft of the final report on the Sisson and Lu injection experiment will be prepared by July 28, 1995.
- b) An interim report summarizing the site selection, model simulations for experimental design purposes, and instrumentation selection and calibration for the controlled field test to be conducted adjacent to the low-level tank waste disposal facility will be prepared by September 30, 1997.

8. References

Fayer, M.J., J.B. Sisson, W.A. Jordan, A.H. Lu, and P.R. Heller; 1993. Subsurface Injection of Radioactive Tracers. NUREG/CR-5996, PNL-8499, Pacific Northwest Laboratory, Richland, Washington.

Sisson, and A.H. Lu, 1984. Field Calibration of Computer Models for Application to Buried Liquid Discharges: A Status Report. RHO-ST-46 P, Rockwell Hanford Operations, Richland, Washington.

D. Disposal Site Testing of Flow and Transport Model

1. Detailed Description

The objective of this task is to use field data from past releases of contaminants from existing disposal sites to build confidence in the predictions of vadose zone flow and transport models. The accidental releases and planned low-level burial practices of the early 60's provide natural field experiments with 30 years of equilibration time. Development of these data sets will supplement the companion tasks by providing data sets with greater temporal and spatial scales.

As with past disposal practices, the vitrification program will most likely be subjected to continued review. Model validation will remain a critical area continually open to examination by regulatory agencies and the public. This task develops a defensible data set that can be used to validate transport models. Model validation is defined here to mean the ability to predict infiltration of water and/or contaminants using realistic values of parameters that control redistribution of water and radionuclides in the geologic media surrounding the waste material.

Onsite data sets of actual contaminant plumes are limited and generally describe only sites (e.g., "wet" sites) where contaminants have been released in association with large amounts of water.

This task will further develop the existing data set describing a "wet" site and develop a new data set for a "dry" site which has been exposed to near natural rates of infiltration. This will allow model validation to be bracketed by a worst case and a scenario more representative of the vitrification disposal site. Data sets to be generated include down well high resolution gamma-ray scans (Koizumi et. al. 1994), water balance data for the study sites, and soil samples for radionuclide content.

2. Interfaces

Allen Lu (WHC) will oversee the task. A summary document/paper will be presented to the technical community. All data sets generated will be made available via Internet servers or electromagnetic media to the vadose zone modeling team for performance assessment modeling. PNL principal investigators are

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Saie Kincaid, Mike Fayer, Mark Rockhold, Dan
wis. The WHC-GEL will be involved with sample

standards in this area. However, past experience
performance assessments will be used to guide
Standard laboratory techniques will be used to
collected samples. If new techniques are developed,
procedures will be prepared and documented.

Assurance

ic reviews will be conducted of work in progress. Topical
ts will be subjected to PNL and WHC peer review before being
ed.

rk at PNL will be conducted in accordance with PNL-MA-70, "PNL
Quality Assurance Program Manual". PNL's quality assurance
program responds to 10 CFR 830.120 and conforms to the
requirements of ASME NQA-1, "1989 Quality Assurance Requirements
for Nuclear Facilities", as interpreted by Parts 1 and 3 of PNL-
MA-70. PNL uses a graded methodology for implementing the
management controls used on projects and discrete work activities.
The quality assurance plan (ETC-001) for PNL support to TWRS
vitrification activities provides detailed information regarding
the grading selection (impact level) and project specific
requirements applicable to PNL Vitrification Technology
Development Project work activities.

5. Schedule

FY 1995

The objective has been to identify past disposal sites
useful in developing a validation data set. We are
looking for sites that already have data sets or would
have "value" if appropriate sampling/monitoring
activities were conducted. A document describing the
selected sites and an appropriate experimental
approach will be published. An analysis of the
measurement techniques and expected accuracies will be
included.

FY 1996

The existing "wet" site will be monitored with high
resolution Gamma-Ray Spectroscopy logging, historic
and newly acquired high resolution data sets compared
against model simulations. Surface geophysical
surveys will be conducted at candidate "dry" sites to
help with safety issues related to sampling in dry
land burial sites. A final selection of the
appropriate "dry" site will be made and environmental
monitoring of near surface water balance will be
initiated.

FY 1997

Well installation, sample collection and High Resolution Gamma-Ray Spectroscopy logging will be conducted at the "dry" site. Environmental monitoring of near surface water balance at both the "dry" and "wet" sites will continue. Collected data will be compared against model simulations.

6. Cost

These cost estimates are based on cost and effort required to perform work conducted during FY 1995 on this and the preceding task where well log data were collected and analyzed.

FY 1996

Four man-months of PNL labor (\$64,000), to include reference specialists to help locate published and unpublished records and drawings for sites selected in FY 1995 work (10%); scientist support for review of these data sets and assigning estimates of accuracy and precision to the data sets (50%); clerical support to convert hardcopy to digital format (20%). Other costs include well logging contract for "wet" site (estimates of raw data collection/well is \$1,500 by WHC, 8 wells = \$12,000), photographic, computer supplies and maintenance \$4,000. Total=\$80,000.

Sixteen thousand dollars (\$16,000) is required for WHC professional time (1.47 man-months at \$130,000 per man-year) to oversee the activity.

FY 1997

New data sets will be generated by drilling contractor and sample analysis contractor (general estimate for drilling and sampling at Hanford is \$3300/meter, every effort will be made to minimize this cost, possibly using the 4" one penetrometer equipment. Drilling for four wells with limited physical sampling and RLS downwell monitoring is estimated to cost \$400,000.

Six man-months of PNL labor (\$100,000), scientist support for review of these data sets (10%); generate multiyear hydrologic input data sets from HMS meteorologic data, historic waste site loading data, Hanford Site water balance data sets, and new site specific measurements of vadose zone recharge at the waste site (40%), prepare sample model simulations (30%), prepare and distribute data sets electronically (20%).

Sixteen thousand dollars (\$16,000) is required for WHC professional time (1.47 man-months at \$130,000 per man-year) to oversee the activity.

7. Deliverables

- a) A "wet" site validation data set will be published on CD-ROM by September 30, 1996. The CD-ROM will include 3-dimensional site drawings, radionuclide, soil characteristics and weather data sets.
- b) A "dry" site validation data set will be published on CD-ROM by September 30, 1997. The CD-ROM will include radionuclide, soil characteristics and weather data sets.

8. References

Koizumi, C.J., Brodeur, J.R., Price, R.K., Meisner, J.E., and Stromswold, D.C. 1994. "High-resolution Gamma-ray Spectrometry Logging for Contamination Assessment. Nuclear Geophysics, Vol. 8 No. 2, 149-164.

E. Development of Conceptual Models for Flow in the Near Field

(Note, Item 5 (Determination of Hydraulic Properties) has been incorporated into item 4; the conceptual model development is highly linked to hydraulic property measurement)

1. Detailed Description

a. Concern

This study of near-field conceptual and constitutive models needs to continue until the final performance assessment is completed in fiscal year 1999. Past programs have shown that changes in both the waste form and key near-field materials can occur quite late in the performance assessment schedule, and therefore, an assessment of hydraulic properties of new materials and new disposal engineering systems may be required late in the performance assessment cycle. Initial conceptual, constitutive models and hydraulic properties of materials will be provided by the close of FY 1995 for use in the interim performance assessment. These models and data will be updated by the close of FY 1997 for use in the preliminary performance assessment, and finally updated by the close of FY 1998 for use in the final performance assessment. This study will continue over the duration of performance assessment preparation activities because final decisions on materials have not been made for the waste form, the near-field matrix, or the engineered structures. Accordingly, degradation of engineered materials and systems will require some form of accelerated aging experiments followed by material hydraulic property tests. These property measurements, and associated conceptual and constitutive models will be critical to long-term estimates of the performance of the glass/matrix and engineered disposal system.

b. General Description of the Near-Field Task

This task deals with the development of scientifically defensible conceptual and constitutive models for the flow of fluids in the near-field environment of the low-level tank waste disposal facility. Several program elements will decide the materials of interest and the configuration of candidate glass, matrix, structures, and barriers. As materials are identified for potential use in the near-field environment, the purpose of the task is to:

- Improve our basic understanding of and ability to simulate the flow of fluids in the near field through the measurement of physical and hydraulic properties and the study of alternate constitutive models.
- Assist in the simulation of the near-field release of contaminants from the waste package, and the overall engineered system (bounded below by the natural environment and laterally by backfill soil) by providing conceptual and constitutive models of water flow in the near-field environment (i.e., waste, matrix, and engineered system components).
- Assist in the simulation of the far-field migration and fate of contaminants by providing conceptual and constitutive models of the near-field hydraulics and associated physical and hydraulic properties.
- Resolve issues (if they arise) involving the physical and computational scales and associated model parameters necessary to perform mass conserving and accurate simulations in both the near- and far-field for flow and contaminant release from the glass waste form.

Initially, a literature review will be conducted and a topical report prepared on constitutive hydraulic models, model parameter values, and an interim conceptual model of the near-field hydraulic environment. Then experiments and measurement protocols will be designed to resolve outstanding technical issues related to the conceptual model and physical or hydraulic properties. These measurements will be made on matrix materials proposed to surround or be mixed with the low-level radioactive waste glass, materials proposed for use in engineered structure and barriers, and the backfill soil. The experiments and measurements will be designed to address or discriminate between the following:

- Alternate constitutive models (e.g., equivalent-porous media models, dual-porosity models, or discrete fractured media models).

- Alternate constitutive models for the unsaturated hydraulic properties of matrix media, (i.e., backfill soil, backfill soil with favorable geochemical additives, air, and sulfur polymer cement or other matrix materials), and structural materials, (i.e., concrete, gravel, clay).
- Alternate constitutive models for degraded matrix and structural materials.
- Influences of laboratory- and field-scale instruments on measured property values.
- Issues of spatial and temporal scale-up (laboratory-specimen to disposal-system scales) related to the accuracy of both near- and far-field hydraulic models.

Use will be made of laboratory instruments, measurement protocols, and sample preparation capabilities established under other tasks. This activity will be coordinated with those tasks performing laboratory-scale measurements for characterization of near-field geochemical reactions and unsaturated hydraulic properties.

As final decisions are made on (a) the matrix, structural, and barrier materials, (b) the material, size, and shape of the "retrievable" waste package, and (c) the design of the engineered storage/disposal system, characterization of the unsaturated hydraulic properties of prototype materials will proceed and final constitutive and conceptual models will be presented for use in the preliminary and final performance assessments.

For the purposes of this task, the near-field is defined as including all engineered elements of the disposal facility and barriers. This includes the

- Glass/matrix storage/disposal zone.
- The structural components of the engineered disposal facility (e.g., catchment basins, floor, walls, drains, interim covers).
- Engineered barriers surrounding the facility (e.g., capillary barriers).
- Backfill soils/sediments immediately surrounding the facility.

The study of conceptual and constitutive hydraulic models for the near-field environment will consider the behavior of intact and degraded materials. Toward that end, the probable mechanisms leading to degradation will be identified, the resulting form of physical or chemical degradation will be discussed, and the influence of

degradation on the hydraulic conceptual and constitutive models will be described and, if possible, quantified.

Measurements of hydraulic properties (e.g., saturated hydraulic conductivity, water retention, and relative permeability) need to be performed at the scale appropriate to accurately simulate releases from the near-field. Whenever possible, the material specimens used for measuring physical and hydraulic properties are to be of the actual materials proposed for the waste disposal system (i.e., representative specimens collected from engineering or vendor stockpiles).

In the near term (the latter part of FY 1995 and in FY 1996), greatest attention will be given to identifying and supporting conceptual and constitutive models for flow through currently proposed disposal systems, (e.g., alternate materials for the waste form matrix, and for engineered structures and barriers). This will include both intact and degraded materials. Protocols for conducting needed measurements of unsaturated hydraulic properties will be prepared, reviewed, and approved. Plans for experiments and measurements will also be prepared, reviewed and approved. When appropriate, these plans will involve materials that will be fractured or otherwise degraded to represent possible future physical states and then their hydraulic properties will be determined. In other cases, where the aging process should be accelerated but still be relatively slow, efforts will be made to design experiments to age materials and then determine their hydraulic properties. These latter experiments may be multiyear experiments designed to determine intermediate steps in aging and associated hydraulic properties.

The performance of a gravel capillary barrier over the waste disposal zone has been identified as a key hydraulic barrier for both interim and long-term disposal. Glendon Gee has been involved in review and assistance to WHC during the spring of 1995. Under the near-field task, Gee will continue to advise and support the effort to design functional hydraulic barriers for the disposal system. The application of a capillary barrier (permanent moisture barrier) for the low-level tank waste disposal facility requires an analysis of capillary barrier performance under conditions that have not been tested previously. Issues that need resolution are identified below.

- Will the designed capillary barrier to be constructed withstand 1000-year storm events at the Hanford Site?
- What failure modes can be expected for a large-area (several hundred square meters or more) layered barrier that has a relatively low slope (less than 5%)? What hydraulic instabilities might exist at the interface of the capillary barriers?

- Are standard construction practices consistent with the required interface continuity (e.g., smoothness of slope) associated with a capillary break?

To resolve these issues and others that arise, Glendon Gee will use the existing literature and analyses to assist and advise the program.

In later years, in preparation for final issue of the performance assessment, samples from contractor material stockpiles for the matrix, engineered structures and barriers will be tested to provide assurance that conceptual and constitutive hydraulic models used in the performance assessment are supported by the hydraulic properties of stockpiled materials and waste form packaging to be present in the final engineered facility.

c. Detailed Description of the Near-Field Task

Under this task the principle investigators, Charles Kincaid (Near-Field Conceptual Model and Hydraulics) and Glendon Gee (Capillary Barriers), both of PNL, will develop conceptual and constitutive models of the near-field by determining hydraulic properties of materials of interest, evaluating alternate constitutive models, and posing consistent conceptual models for near- and far-field simulations.

During FY 1995 the listed program documents have been reviewed in order to better understand the scope of near-field hydraulic conceptual models and hydraulic property issues for low-level glass waste.

- Rawlins, J.R., et al., 1994, "Impacts of Disposal System Design Options on Low-Level Glass Waste Disposal System Performance", WHC-EP-0810.
- Mann, Oct 1994, "Concerns, Uncertainties, and Unknowns" [version 2a]
- Lu, Rockhold and Fayer, (Oct 7) 1994, "Key Parameters in Vadose Zone Flow and Transport Analysis for LLW Glass Performance Assessment"
- Hanford Low-Level Tank Waste Performance Assessment Group, (Nov 8) 1994, "Computer Code Selection Criteria and Considerations for the Hanford Low-Level Tank Waste Interim Performance Assessment"

Under the near-field task, Gee has provided the program expert assistance and advice on the potential for a capillary barrier composed of gravel overlain by fine soils to wick deep drainage away from the waste form.

The remainder of FY 1995 activities for the near-field task will perform three activities:

- i. Define the long-term scope of work to determine the potential effectiveness of the gravel capillary break.
- ii. Review the published literature to identify applicable constitutive models; measured hydraulic properties, and those devices and methods used to perform hydraulic property measurements on alternate near-field materials. Materials currently of interest in near-field designs are as follows:
 - backfill soil (with and without glass simulant)
 - backfill soil with amendments (e.g., zeolites) added (with and without glass simulant)
 - glass cullet or other shapes with air filled voids
 - sulfur polymer cement (with and without glass form)
 - concrete (used in the disposal facility structure; e.g., the walls, floor, and ceiling of the facility and the RCRA catch basin underlying the glass/matrix storage/disposal volume)
 - well-sorted (clean) gravel
 - poorly-sorted gravel with sand and silt
- iii. Prepare a fiscal-year progress report on the conceptual and constitutive models, and model parameters for unsaturated hydraulic properties of near-field materials.

During FY 1996 this multiyear activity will

- i. Prepare a topical report on the conceptual and constitutive models, and model parameters for unsaturated hydraulic properties of near-field materials.
- ii. Continue to evaluate the hydraulic performance of the near-field environment.
- iii. Develop the test plan to obtain measurements of the hydraulic properties of those materials being considered for use in the disposal of low-level waste in glass at the Hanford Site.

- iv. Establish the capability to perform the necessary hydraulic property measurements.
- v. Conduct measurements to support the site-specific near-field modeling to be reported in the interim and preliminary performance assessments.
- vi. Prepare a topical report on the measurements of unsaturated hydraulic properties and related physical properties for near-field materials.

During FY 1997 this multiyear activity will

- vii. Continue to perform hydraulic property measurements.
- viii. Prepare a topical report on the conceptual and constitutive models as well as model parameters for unsaturated hydraulic properties of all near-field materials incorporated in the design of the disposal facility to be used in the preliminary performance assessment.

2. Interfaces

Productive effort on this task is largely driven by decisions on candidate materials and designs for both the waste form and the engineered disposal facility. Candidate materials designs have been identified and do not currently pose a limitation to the conduct of work. However, as decisions change on the waste form and engineered disposal system, so to does the scope of work; i.e., additional waste form and system design concepts would need to be explored. This task will work closely with the facility activity (Activity 3.1.5).

The output of this task will be state-of-the-art conceptual and constitutive models, and measured values of physical and unsaturated hydraulic properties to be used in release rate calculations for the interim, preliminary, and final performance assessments. This information will also feed directly to design of engineered systems. The dates for which the information is needed correspond to dates which specific performance assessment calculation and design tasks are conducted.

Allen Lu (WHC) will oversee the task. Allen Lu is the cognizant scientist for the activity and he resides within the Environmental Modeling Section of WHC. Charles Kincaid, PNL, is the principle investigator. Other PNL participants include Glendon Gee, and other technical staff as determined necessary to support hydraulic and physical property measurements and confirmatory constitutive modeling.

Primary interfaces consist of the WHC participants, (i.e., Allen Lu, Frank Schmittroth, and Fred Mann), and B. Pete McGrail (PNL) who is performing release-rate calculations (Activities 3.1.6 and 3.2). The PNL interface for sulfur polymer cement and other matrix materials is Paul Sliva.

3. Standards

No single specific standard is relevant to the topic of developing the conceptual model of hydraulic characteristics for a disposal facility. However, guidance documents from the DOE (including the DOE/HQ Peer Review Panel) on performance assessment of low-level waste disposal and from the Nuclear Regulatory Commission for site selection and licensing of low-level waste sites will be used. ASTM standards on vadose zone investigations and modeling of the subsurface will also be reviewed and used when applicable to conceptual model development. The measurement of hydraulic and physical properties of candidate near-field materials will follow established standards when appropriate, and will follow accepted methods for the measurement of especially difficult materials, e.g., hydraulic conductivity of highly impermeable materials such as sulfur polymer cement.

4. Quality Assurance

Topical reports will be subjected to PNL and WHC peer review before being issued. Periodic reviews will be conducted on work in progress.

Work at PNL will be conducted in accordance with PNL-MA-70, "PNL Quality Assurance Program Manual". PNL's quality assurance program responds to 10 CFR 830.120 and conforms to the requirements of ASME NQA-1, "1989 Quality Assurance Requirements for Nuclear Facilities", as interpreted by Parts 1 and 3 of PNL-MA-70. PNL uses a graded methodology for implementing the management controls used on projects and discrete work activities. The quality assurance plan (ETC-001) for PNL support to TWRS vitrification activities provides detailed information regarding the grading selection (impact level) and project specific requirements applicable to PNL Vitrification Technology Development Project work activities.

5. Schedule

- a) Prepare a topical report on the conceptual and constitutive models, and model parameters for unsaturated hydraulic properties of near-field materials. (start October 1, 1995; end January 12, 1996).
- b) Continue evaluating the hydraulic performance of the near-field environment for release-rate calculations. (start October 1, 1995; end September 30, 1996).
- c) Develop the test plan to obtain measurements of the hydraulic properties of those materials being considered for use in the disposal of low-level waste in glass at the Hanford Site. (start December 1, 1995; end March 29, 1996).
- d) Establish the capability to perform the necessary hydraulic property measurements. (start February 1, 1996; end May 31, 1996).

- e) Conduct measurements to support the site-specific near-field modeling to be reported in the preliminary performance assessment. (start April 1, 1996; end September 30, 1996).
- f) Prepare a fiscal-year progress report on the measurements of unsaturated hydraulic properties and related physical properties for near-field materials. (start July 1, 1996; end September 30, 1996).
- g) Continue hydraulic property measurements and evaluate the hydraulic performance of the near-field environment for release-rate calculations. (start October 1, 1996; end September 30, 1997).
- h) Prepare a topical report on the conceptual and constitutive models, and model parameters for unsaturated hydraulic properties of all near-field materials incorporated in the final design for use in release-rate calculations for the preliminary performance assessment. (start April 1, 1997; end September 30, 1997).

6. Cost

The cost estimates for this task are based on the effort and cost associated with hydraulic property determinations for the Hanford Site Performance Assessment project, the Hanford Protective Barriers Programs and for private industry. Costs of hydraulic property measurements for near-field materials may need to be reevaluated depending on where these analyses are performed (e.g., within PNL, WHC, or at an off-site laboratory specializing in certain materials or methods of interest). This may require a subcontract to an outside laboratory. Until the needed measurements are better known and a decision is made, funding for measurements may be best held in an "other" or a "contingency" category. Once materials are defined (i.e., either simply of interest or selected for use) and it is determined that published hydraulic and physical properties are not available or representative, the measurements need to be made. Therefore, the funding doesn't really represent a contingency fund.

FY-1996: Total itemized below: Expense \$246,000

Near-field conceptual model & hydraulics; \$130,000 (0.5 FTE Charles Kincaid, ~\$104,000; few hours over the year from supporting scientific staff including Mark Rockhold, Michael Fayer, and Mark White, ~\$26,000).

Hydraulic property measurements; estimated \$50,000 (funding requirement for measurements will depend heavily on the materials and methods; e.g., measurements of hydraulic properties for intact and degraded sulfur polymer cement may be expensive).

Gravel Capillary Barrier; Expense \$50,000, 0.2 FTE Glendon Gee, \$50,000.

Sixteen thousand dollars (\$16,000) is required for WHC professional time (1.47 man-months at \$130,000 per man-year) to oversee the activity.

FY-1997: Total itemized below: Expense \$301,000

Near-field conceptual model & hydraulics; \$180,000 0.7 FTE Charles Kincaid, ~\$150,000; about 0.05 FTE each from supporting scientific staff including Mark Rockhold, Michael Fayer, and Mark White, ~\$30,000.

Gravel Capillary Barrier; Expense \$50,000, 0.2 FTE Glendon Gee, \$50,000.

Hydraulic property measurements; estimated \$55,000 (funding requirement for measurements will depend heavily on the materials and methods; e.g., measurements of hydraulic properties for intact and degraded sulfur polymer cement may be expensive).

Sixteen thousand dollars (\$16,000) is required for WHC professional time (1.47 man-months at \$130,000 per man-year) to oversee the activity.

7. Deliverables

- a) Topical report on the conceptual and constitutive models, and model parameters for unsaturated hydraulic properties of near field materials submitted to clearance January 12, 1996.
- b) Test plan for measurements of hydraulic properties of near field materials submitted to clearance by March 29, 1996.
- c) Progress report on measured unsaturated hydraulic and physical properties of near-field materials submitted to WHC by September 30, 1996.
- d) Topical report on the conceptual and constitutive models, and model parameters for unsaturated hydraulic and physical properties supporting the preliminary performance assessment submitted to clearance by September 30, 1997.

F. Determination of Hydraulic Properties

See Task E, just above.

G. Model Testing

1. Detailed Description

Field testing of models used in performance assessment is required in support of a technically defensible analysis of long-term assessment of waste disposal options. Available field data in the 200 Areas from two sites will be used in testing the PORFLOW code.

The Blush report (March 1995) made references to inadequate testing of codes used in performance assessments prepared thus far at the Hanford Site. The DOE-HQ Peer Review Panel responsible for determining the technical adequacy of performance assessments across the DOE Complex asked the performance assessment preparers to "calibrate/validate" models used in their performance assessments.

The purpose of the proposed study is to provide veracity (i.e., "calibration/validation") of the vadose zone flow and transport models (codes) in predicting subsurface flow and contaminant migration in Hanford soils. This will be a continuation of Smoot et al. (1989) work using the 241-T-106 tank leak data. The 241-T-106 single-shell tank is located in the 200 West Area. The tank 241-T-106 leak was first documented in 1973 (ARHCO 1973). A report by the U.S. Atomic Energy Commission (AEC 1973) provides a detailed chronology of the leakage that began on or about April 20, 1973. Leakage stopped on June 10, 1973, when the pumpable liquid contents of the tank were removed (Routson et al. 1979). The total duration of the leak was approximately 52 days, during which 115,000 gal of supernate were lost from the tank.

Most of the radionuclide inventory of the supernate solution within the tank consists of ^{144}Ce and ^{144}Pr , ^{137}Cs , ^{87}Sr and ^{90}Sr , and ^{106}Ru and ^{106}Rh , with lesser amounts of the other radionuclides (Routson et al. 1979). With the exception of ^{106}Ru and ^{106}Rh , the inventory is characterized by long half-lives and high sorption coefficients. The inventory corresponds to 2.67×10^5 total Curies of ^{106}Ru and 3.85×10^5 total Curies of ^{137}Cs that leaked from the tank. The ^{106}Ru has a half-life of 1 yr and sorption coefficients are generally considered to be approximately zero; the ^{137}Cs has a half-life of 30.17 yr (Walker et al. 1984) and is considered to be highly sorbed by Hanford Site soils. The movement of ^{106}Ru is of interest because its transport should be essentially concurrent with the fluid front.

Smoot et al. used moisture characteristic data for vadose zone soils that were not site-specific. PORFLOW (a variably saturated flow and transport code) simulations will be conducted using the recent data that have been collected for vadose zone soils in the vicinity of T-106 tank. Numerical simulation results will be compared against the experimental data on contaminant concentrations from the T-106 tank leak in order to "calibrate and validate" the PORFLOW code. Moisture-dependent anisotropy relationships for T-106 soils will be investigated and considered

for possible incorporation in numerical simulations of flow and transport.

Work will also be conducted to provide for "validation" of PORFLOW code using the available Injection/Test Site data. Again, moisture-dependent anisotropy relationships for Injection Site soils will be investigated and considered for possible incorporation in numerical simulations of flow and transport. Results of field testing from these two sites will be documented in a form so that the results can be directly incorporated as an appendix during preparation of performance assessments for the low-level tank waste facility.

The lead contributor to this task will be Raz Khaleel of the Environmental Modeling Section. Supporting in this effort is Niall Kline.

2. Interfaces

These analyses will be based on past and continuing work on field testing of models at Hanford.

3. Standards

There are no standards in this area.

4. Quality Assurance

The reports documenting this work will be reviewed.

5. Schedule

The work will begin October 1, 1995 with a letter report describing the results issued September 30, 1996.

6. Cost

FY 1996: \$97,000 total (based on \$130,000 per man-year and having Raz Khaleel work 3 man-months and Niall Kline work 6 man-months). The time estimate is based on earlier model testing of VAM and PORFLOW.

7. Deliverable

A letter report describing the results of field testing of PORFLOW code by September 30, 1996.

8. References

Blush, S, March 1995. "Train Wreck Along the River of Money."

AEC, 1973. "Report on the Investigation of the 106 T Tank Leak at The Hanford Reservation, Richland, Washington", Atomic Energy Commission, Richland, Washington.

Atlantic Richfield Hanford Company (ARHCO), 1973. "241-T-106 Tank

Leak Investigation", ARH-2874, ARHCO, Richland, Washington.

Routson, R.C., W.H. Price, D.J. Brown, and K.R. Fecht, 1979.
"High-Level Waste Leakage from the 241-T-106 Tank at Hanford",
RHO-ST-14, Rockwell Hanford Operations, Richland, Washington.

Smoot, J.L., J.E. Szecsody, B. Sagar, G.W. Gee and C.T. Kincaid,
1989. "Simulations of Infiltration of Meteoric Water and
Contaminant Plume Movement in the Vadose Zone at Single-Shell Tank
241-T-106 at the Hanford Site", Westinghouse Hanford Company,
Richland, Washington.

Walker, F.W., D.G. Miller, and F. Feiner, 1984. "Chart of the
Nuclides", General Electric Company, San Jose, California.

3.1.9 Recharge

I. SUMMARY

Generating defensible estimates of recharge rates at the Hanford Site for use in the preliminary performance assessment.

II. GENERALA. Background

Recharge is a major driver for contaminant transport through the vadose zone to the water table. A clear understanding of recharge under potential future climate, soil, and vegetation is therefore of great importance to the performance assessment activities.

B. Organization

- The cognizant organization is the Environmental Modeling Section of Westinghouse Hanford Company; Nick Anderson, Manager. The cognizant scientist will be Raz Khaleel. Supporting this effort will be the Geosciences Group of the Pacific Northwest Laboratory (in particular, Mike Fayer, Mark Rockhold, Glendon Gee, Anderson Ward, and Ellyn Murphy).

C. Vision

A lack of accurate and technically defensible recharge estimates will result in the use of conservative data in performance assessment modeling.

D. Objectives

The objective of this task is to provide defensible estimates of recharge rates for current and long-term conditions applied to the shallow-land disposal of low-level tank waste at the Hanford Site.

E. Deliverables

- 1) Letter report on the status of tracer experiments due September 30, 1996.
- 2) Letter report on the status of tracer experiments due September 30, 1997.
- 3) Letter report on the status of tracer experiments due September 30, 1998.
- 4) Letter report on completion of tracer experiments for final performance assessment due March 30, 1999.
- 5) Test plan on low-level tank waste site field monitoring instrumentation due March 30, 1996.

- 6) Interim status report on integrated recharge estimation due September 30, 1996.
- 7) Interim status report on integrated recharge estimation due September 30, 1997.
- 8) Manuscript on plant behavior due June 30, 1998.
- 9) Manuscript on climate record due July 31, 1998.
- 10) Manuscript on plant/soil variability due August 31, 1998.
- 11) Interim status report on integrated recharge estimation due September 30, 1998.
- 12) Final documentation of UNSAT-H code due July 30, 1999.
- 13) Final report with recharge estimates for all scenarios due September 30, 1999.

III. TASK DESCRIPTIONS

A. Summary List of Tasks

- 1) Tracer studies
- 2) Integrated recharge assessment
- 3) Advise and steering group participation

B. Tracer Studies

1. Detailed Description

The scope of work in FY 1996 on the tracer recharge activity includes six subtasks which are described in more detail below:

- Field Sampling and Physical Characterization of Sediments
- Chloride Mass Balance Laboratory Analyses
- Modeling Cl^- Profiles; vapor flow, climate variations
- Anthropogenic Tracers
- $\text{D}/^{18}\text{O}$
- Task Administrative Coordination/Manuscripts/Reports

a. *Field Sampling and Physical Characterization of Sediments*

Approach: Continuous cores will be sampled at preselected sites to a depth of ~50 feet (~15 meters). At the recent Recharge Workshop, reviewers recommended that the chlorine sampling continue to the water table which will cause a substantial number of samples to be analyzed. However, below 50 feet, the sampling will not be continuous. Subsamples will be taken and analyzed for:

i) Particle size distribution

The samples will be analyzed for gravel, sand, silt, and clay content. The gravel and sand fractions will be determined using sieve sizes 3 in, 0.75 in, 0.5 in, #4, #10, 1 mm, 0.5 mm, 0.25 mm, 0.1 mm, and 0.053 mm (#270).

ii) Water retention

On the <2 mm fraction of sample, retention will be determined using pressure plates and the CX-1 humidity sensor.

iii) Hydraulic conductivity

Saturated conductivity will be determined. A subset of samples will be submitted for unsaturated conductivity measurements.

b. *Chloride Mass Balance Laboratory Analyses*

Approach: Laboratory analyses for chloride mass balance include determination of:

- Gravimetric water content
- Bulk density
- Chloride and bromide analyses by ion chromatography
- Measurement of $^{36}\text{Cl}/\text{Cl}$ ratios at 3 depths to determine the long-term accumulation rate of chloride.

c. *Modeling Cl^- Profiles*

Approach: A generalized chlorine mass balance model has been developed which will be applied to the chlorine profiles taken at the Hanford low-level tank waste disposal site. This model allows a more critical evaluation of the processes that may have influenced the shape of the chlorine profile such as transient fluxes arising from variations in paleoclimatic conditions. The model also accounts for surface mixing layers. The model can be applied to borehole data in the inverse sense to determine recharge rates over the Holocene. The model can also be used in the predictive mode to simulate current chlorine profiles. In addition to applying this model to the disposal site, the model will be extended to account for transient variations in vegetation over the Holocene and for non-atmospheric sources of chloride.

d. *Anthropogenic Tracers*

Approach: In the early years of operations at Hanford, several radioactive isotopes were released to the atmosphere by the uranium separations processes in the 200 Area. These radioactive isotopes were deposited as dry fallout across the Site, with the highest concentrations deposited in the direction of prevailing winds (i.e., to the southeast). The long-lived isotopes can be used as environmental tracers as long as the magnitude and timing of the release can be determined. The advantage of using local anthropogenic tracers over the bomb-pulse tracers is that the time period over which the recharge rate is calculated is approximately 20% longer (e.g., ~1945 for local ^{129}I vs 1958 for bomb-pulse ^{36}Cl). ^{129}I , released during past plutonium extraction processes at Hanford, will be analyzed in the boreholes used for chloride mass balance above. This anthropogenic tracer will be used to verify piston flow at the field site (an assumption used in the chloride mass balance method above) and to estimate short-term (~50 y) recharge rates. Anthropogenic tracer peaks are also used in the unsaturated transport modeling to determine the effective thickness of the mixing layer in the profile.

Approximately 25-100 g of dried sediment is combusted and purified by a micro-extraction technique. A negative-ion, thermal-emission mass spectrometer is used to measure low-level ^{129}I concentrations ($\sim 10^7$ atoms or 10^{-6} picoCuries). Recharge rates are based on the depth of the center of mass of the ^{129}I pulse.

e. $D/^{18}\text{O}$

Approach: The application of deuterium- ^{18}O isotope profiles in the unsaturated zone can be much more complicated than other environmental tracers. However, the additional information that can be gained on the evapotranspirative processes affecting water movement in the unsaturated zone may be worth the added difficulty. For example, in previous studies deuterium- ^{18}O isotope profiles have been used in combination with other tracer techniques to determine the vapor phase component of recharge (Knowlton 1989).

In order to apply this tracer technique, several activities will be performed in FY 1996:

- i. Obtain and test the numerical models that have been used by groups in Australia and New Mexico for analyzing deuterium- ^{18}O isotope profiles.
- ii. Determine best approach for measuring soil temperatures in the profile.

- iii. Test ultracentrifugation technique for extracting pore water against azeotropic distillation and immiscible displacement.
- iv. Perform limited analyses on one borehole drilled in FY 1996.

Evaluation of the numerical models will define the information needs that will guide the design of the field sampling. If successful, ultracentrifugation of pore water will be faster, cheaper, and less likely to introduce errors in the stable isotope measurements.

f. Task Administrative Coordination/Manuscripts/Reports

The actions in this task primarily involve project coordination, monthly reporting, project meetings, and preparation of manuscripts and reports.

FY 1996 Budget by Subtask:

Sample Collection (covered in 3.1.D)	\$ 0,000
Field Sampling and Physical Characterization of Sediments	\$ 50,000
Chloride Mass Balance Laboratory Analyses	\$ 30,000
Modeling Cl Profiles	\$ 60,000
Anthropogenic Tracers	\$ 62,000
D/ ¹⁸ O	\$ 50,000
Administrative Coordination/Manuscripts/Reports	\$ 20,000
Total	\$272,000

Milestones for FY 1996:

Completion of field sampling and physical characterization
 Completion of chloride mass balance
 Completion of anthropogenic tracer analysis
 Completion of D/¹⁸O analysis

Deliverable for FY 1996

Status letter report - September 30, 1996

FY 1997 Statement of Work

The work in FY 1997 will be a continuation of tasks started in FY 1996, with the following additions specified at the recent Recharge Workshop (May 1995):

- g. Conduct sensitivity analyses with the chloride mass balance model to determine which parameters drives the processes and hence the dominant factors controlling recharge at the site. This sensitivity analysis will also involve examination of the sensitivity of the mass balance technique to basic assumptions. Many of these assumptions are tied into the representation of small time-scale infiltration processes as

large time-scale averaged processes. This approximation if valid can provide a link between recharge estimation techniques which focus on vastly different time scales (for example, chloride mass balance on a 10,000 year scale; direct measurements on a 10 year scale). Thus this subtask will include a significant effort on examining the time-averaging basis for the chlorine mass balance model.

- h. Results of paleorecharge rates determined by generalized chloride mass balance modeling will be compared with paleoflood dating, pollen records, and climate change history in Ken Petersen's subtask.

FY 1997 Budget by Subtask:

Sampling/tracer analyses of additional characterization borehole	\$100,000
Modeling of Cl Profiles (con't from FY 1996)	\$ 70,000
Modeling of evapotranspiration processes using D/ ¹⁸ O	\$ 40,000
Administrative Coordination/Manuscripts/Reports	\$ 50,000
Total	\$260,000

Milestones for FY 1997

Sampling/tracer-analyses of additional characterization borehole

Completion of chloride mass balance modeling at disposal site

Completion of D/¹⁸O modeling

Publication of results and reporting at professional meetings

Deliverables for FY 1997

Status letter report - September 30, 1997

FY 1998 Statement of Work

The work in FY 1998 will focus on additional important items identified in the 1995 Recharge Workshop.

- i. Drill deep boreholes above the flood limit and use the inverse chloride mass balance modeling approach to determine recharge during glacial periods.
- j. Compare tracer results at the disposal site with a site that has similar sediments (for example, thin layer of dune sand overlying a relatively homogeneous medium to coarse sand) which historically lacks vegetation. This type of environment is commonly found in the stabilized dunes northwest of the Wye Barricade. This comparison would show

the range in recharge that might be expected between mature shrub vegetation and primarily grass vegetation.

FY 1998 Budget by Subtask

Sampling/tracer-analyses of additional boreholes	\$130,000
Modeling of C1 profiles (3-5 profiles)	\$ 40,000
Modeling of evapotranspiration processes using D/ ¹⁸ O	\$ 40,000
Administrative Coordination/manuscripts/reports	\$ 30,000
Total	\$240,000

Deliverables for FY 1998

Status letter report - September 30, 1998

FY 1999 Statement of Work

The work in FY 1999 will focus on completion of FY 1998 tasks and prepare the final report on the tracer task.

FY 1999 Budget

Completion of task/manuscripts/final tracer report \$140,000

FY 1999 Deliverables

Final Report - March 30, 1999.

The lead contributor to this task will be Ellen Murphy.

2. Interfaces

These analyses will be based on past and continuing tracer work at Hanford.

3. Standards

There are no standards in this area.

4. Quality Assurance

Work at PNL will be conducted in accordance with PNL-MA-70, "PNL Quality Assurance Program Manual". PNL's quality assurance program responds to 10 CFR 830.120 and conforms to the requirements of ASME NQA-1, "1989 Quality Assurance Requirements for Nuclear Facilities", as interpreted by Parts 1 and 3 of PNL-MA-70. PNL uses a graded methodology for implementing the management controls used on projects and discrete work activities. The quality assurance plan (ETC-001) for PNL support to TWRS vitrification activities provides detailed information regarding the grading selection (impact level) and project specific requirements applicable to PNL Vitrification Technology Development Project work activities.

5. Schedule

The work will begin October 1, 1995. A letter report describing the present status of the understanding of long-term recharge using tracer techniques at Hanford will be issued by July 31, 1997.

6. Cost (see detailed description above for breakdown into subtasks)

FY 1996: \$272,000 total
FY 1997: \$260,000 total
FY 1998: \$240,000 total
FY 1999: \$140,000 total

7. References

Knowlton et al, 1989. "A Stable Isotope Investigation of Vapor Transport During Groundwater Recharge in New Mexico", New Mexico Water Resources Research Institute of Technology Completion Report number 237, New Mexico State University

C. Integrated Recharge Assessment

1. Detailed Description

The objective of this task is to evaluate and integrate the recharge estimates made using various techniques (i.e., lysimetry, tracers, numerical simulation, etc.). This task will also investigate issues regarding the effects of spatial variability and measurement uncertainty on the recharge estimates. Rockhold et al. (1995) summarized the available recharge information relative to the needs of the Hanford low-level tank waste disposal facility and identified where more information was needed. This task is designed to collect the information needed to provide defensible estimates of recharge and satisfy the above objective.

The spatial scope of this task includes the cover over the proposed disposal facility, the surrounding ecosystem, and the Hanford Site (to the extent that site-wide recharge affects groundwater beneath the facility). The temporal scope of this task covers the time interval from facility closure until the predicted occurrence of peak doses.

This work will be conducted in collaboration with the Tracer Studies task to identify and select appropriate sites for field sampling. Surface sampling and excavations at the disposal site will be used for characterization of important parameters including surface microtopography, the distribution of plant types and areal cover, rooting depths and distributions, chloride concentrations, bulk densities, particle-size distributions, and hydraulic properties. The characterization data will be used to understand the existing ecosystem, estimate parameters for numerical simulations of soil-water dynamics at the site, and evaluate spatial correlation lengths.

Recharge rates will be estimated using several techniques, the estimates compared, and differences explained. The ability to resolve and explain differences between techniques will provide independent confirmation and confidence in the recharge rate predictions. The variability in the recharge rates generated using the various techniques will provide estimates of uncertainties associated with both spatial variability and measurement errors.

When the disposal facility construction begins, samples will be collected at different elevations during construction. These samples will be used to map important variables in three dimensions. These maps will provide valuable information on the spatial correlation structure of the variables and allow for testing of assumptions that are important to the recharge estimation techniques.

Specific Activities in FY 1996 include:

a. *Monitoring*

The objective of this subtask is to collect field data to estimate recharge rates and test predictive models. An area within the domain of the proposed disposal site will be instrumented with time domain reflectrometry (TDR) probes that will extend to the 6.5-m depth. These probes will be used to monitor water contents within and below the root zone for three years, thus providing a baseline water balance for the site. Ten lysimeters within the Field Lysimeter Test Facility (FLTF) will be renovated to contain replicate treatments that address project specific needs. Major treatments include dune sand, dune sand over a barrier, and irrigation. Finally, two sites will continue to be monitored at a low level of effort. Both sites have been monitored for at least 10 years. Records of this duration will be needed to establish credibility in the predictions of long-term recharge rates. At the Buried Waste Test Facility (BWTF), drainage will be collected from the south caisson, which is unvegetated and filled with sand. At the Grass Site, water contents will be measured with a neutron probe several times in the spring and several times in the late fall. Changes in storage will be used to estimate recharge rates.

b. *Variability*

The objective of this subtask is to determine means, variances, and spatial correlations of the system variables (e.g., soil properties, vegetation, climate) to support estimation of recharge rate means, variances, and correlation structure. In FY 1996, ponded and tension infiltrometers will be used to quantify the variation of surface soil conductivity. An exploratory excavation will be used to demonstrate the feasibility of mapping three-dimensional root distributions along with particle size distribution and chloride concentrations. A researcher at

the University of Oregon will analyze the pollen record contained in a sediment core drilled in Carp Lake in Goldendale, Washington. The pollen record will then be used to estimate past climate states, possibly as far back as the last interglacial period.

c. *Modeling*

The objective of this subtask is to obtain and develop modeling tools to estimate recharge rates for specific scenarios. The primary model being used is UNSAT-H. Other models will be used for verification and special tests that can not be completed with the 1-d model UNSAT-H. In FY 1996, a freezing soil/snow melt capability will be added to UNSAT-H. Other capabilities, such as hysteresis, that were added informally for other projects will be tested and included in the controlled version of the code.

d. *Estimation*

The objective of this subtask is to provide estimates of recharge rates for all scenarios, taking care to explain any discrepancy in the recharge estimates made using various techniques. In FY 1996, a manuscript describing the estimation of recharge rates at the Grass Site will be prepared and submitted for publication. An interim report will be prepared that details the results of the FY 1996 work conducted under each subtask.

The major contributors to this task will be Mike Fayer, Glendon Gee, Mark Rockhold, and Anderson Ward of PNL.

2. Interfaces

This task will utilize data from other tasks as much as possible. Under the Hydraulic Properties Activity (3.1.8), soil hydraulic parameters will be determined with the instantaneous profile method. These parameters will be used to understand the hydrology of the site and estimate recharge rates. Under the Site Characterization Activity (3.1.6), information will be generated from borehole samples. This information will include, but not be limited to, water content, pressure potential, temperature distributions, and major and minor stratigraphic units. Individual samples may be analyzed for chloride, pressure potential, water content, and soil hydraulic properties. This information will be used to understand the hydrology of the disposal site and estimate both current and future recharge rates. All of this information is needed by September 30, 1998.

3. Standards

There are no standards in this area. However, past experience with risk and performance assessments will be used to guide activities. Standard laboratory techniques will be used to process and collect samples. If new techniques are developed,

replicable procedures will be prepared and documented.

4. Quality Assurance

Periodic reviews will be conducted of work in progress. Topical reports will be subjected to PNL and WHC peer review before being issued.

Work at PNL will be conducted in accordance with PNL-MA-70, "PNL Quality Assurance Program Manual". PNL's quality assurance program responds to 10 CFR 830.120 and conforms to the requirements of ASME NQA-1, "1989 Quality Assurance Requirements for Nuclear Facilities", as interpreted by Parts 1 and 3 of PNL-MA-70. PNL uses a graded methodology for implementing the management controls used on projects and discrete work activities. The quality assurance plan (ETC-001) for PNL support to TWRS vitrification activities provides detailed information regarding the grading selection (impact level) and project specific requirements applicable to PNL Vitrification Technology Development Project work activities.

5. Schedule

FY 1996

- a) Instrument the proposed disposal field site to collect baseline hydrologic data.
- b) Retrofit seven FLTF lysimeters to study soil-vegetation-climate scenarios for which little or no data currently exist.
- c) Measure spatial distributions of selected variables, including hydraulic conductivity and climate.
- d) Formalize the existing modeling capability.
- e) Provide status report with updates of the best estimates or recharge for the various scenarios that are important to the performance assessment.

FY 1997

- a) Monitor the proposed disposal site and the seven FLTF lysimeters.
- b) Continue measurements of spatial distributions of selected variables.
- c) Conduct modeling testing.
- d) Provide status report with updates of the best estimates or recharge for the various scenarios that are important to the performance assessment.

FY 1998

- a) Continue monitoring the proposed disposal site and the seven FLTF lysimeters.
- b) Complete measurements of spatial distributions of selected variables.
- c) Continue modeling testing.
- d) Provide status report with updates of the best estimates or recharge for the various scenarios that are important to the performance assessment.

FY 1999

- a) Complete monitor the proposed disposal site and the seven FLTF lysimeters. (Facilities will be left in standby mode if continued monitoring is desired.)
- b) Complete modeling testing and document results.
- c) Provide final report with best estimate or recharge for the various scenarios that are important to the performance assessment.

6. Cost

These cost estimates are based on previous experience on this project, the Hanford Barriers project, and the inactive Hanford Site Performance Assessment project.

FY 1996: \$308,000 total (15.8 man-months costing \$236,000, \$22,000 subcontract to the University of Oregon, and \$50,000 for equipment)

FY 1997: \$370,000 total (21.8 man-months) costing \$347,000 and \$23,000 subcontract to the University of Oregon)

FY 1998: \$288,000 total (16.4 man-months costing \$263,000 and \$25,000 subcontract to the University of Oregon)

FY 1999: \$256,000 total (16.0 man-months)

Subtask Costs:

Subtask	Costs (\$1000)			
	1996	1997	1998	1999
Monitoring	192	162	112	112
Variability	52	120	96	16
Modeling	32	56	48	64
Estimation	32	32	32	64
Total	308	370	288	256

Deliverables:

FY 1995

- a) Test plan for lysimeter retrofitting (PVTD-C95-04.02S, expected August 1995).
- b) Letter report on integrated recharge assessment (PVTD-C95-04.02T, expected September 1995).
- c) Letter report on evaporation modeling (PVTD-C95-04.02U, expected September 30, 1995).

FY 1996

- a) Test plan on low-level tank waste site field monitoring instrumentation due March 30, 1996.
- b) Letter report on interim status due September 30, 1996.

FY 1997

- a) Letter report on interim status due September 30, 1997.

FY 1998

- a) Manuscript on plant behavior due June 30, 1998.
- b) Manuscript on climate record due July 31, 1998.
- c) Manuscript on plant/soil variability due August 31, 1998.
- d) Letter report on interim status due September 30, 1998.

FY 1999

- a) Final documentation of UNSAT-H code due July 30, 1999.
- b) Final report with recharge estimates for all scenarios due March 30, 1999.

D. Advise

1. Description

Participate in steering group meetings and provide assistance/advise to other tasks.

2. Interfaces

Coordinate with related programs.

3. Schedule

Task is a continuing activity.

4. Cost

A cost of \$20,000 is anticipated for WHC scientific staff time for each fiscal year. This cost is based on prior experience.

IV. OTHER CONSIDERATIONS

If budget constraints cause the schedule to be stretched or partially delayed, the monitoring activity should take first priority. The need to collect as many years of data as possible cannot be overstated. The other activities will be less affected by a delay.

3.1.A Determination of Geochemical Data for the Preliminary Performance Assessment

I. SUMMARY

The purpose of this task is to determine and quantify, through the use of existing data and laboratory experiments, the geochemical parameters important to the preliminary performance assessment. This work includes determining the effects of sorption and solubility on contaminant transport through the waste matrix, the vadose zone, and the aquifer. This activity also includes identifying geochemical codes for use in the performance assessment, geochemical characterization of core samples from site characterization, and determining the long-term fate of water contained within concrete.

II. GENERAL

A. Background

The Hanford tank low-level waste performance assessment requires knowledge of the site-specific geochemical parameters that will influence the transport of contaminants after release from the glass waste form. Chemical retardation of the contaminants through native sediments and engineered barriers emplaced in the near-field will be quantified in this activity. The data will be obtained through literature review, bench-scale laboratory testing, and mechanistic and empirical modeling. Long-term confirmation analyses will be attempted using critical analyses of available thermodynamic and natural analogue information gleaned from the literature. The major activity will be empirical laboratory testing using traditional batch and column techniques and the newly developed UFA (unsaturated flow apparatus) to generate site-specific and waste-form-specific chemical retardation data compatible with the needs of near- and far-field transport computer codes. The emphasis for the preliminary performance assessment will be on obtaining accurate measurements of distribution coefficients (K_d) for Tc, I, Np, and U in Hanford soils and engineered waste-form materials/barriers. The empirical data will be generated in an iterative fashion such that some chemical retardation data of key contaminants will be available for each set of performance assessment calculations. Chemical and mineralogical characterization of test samples from the site will be carried out to aid in understanding of sorption results with these samples.

Solubility values will be determined under a range of conditions for several key radionuclides to determine to what degree the precipitation of solid phases may limit the source term for contaminant release. These solubility determinations will also indicate to what degree geochemical conditioners, placed beneath the waste facility, may be effective in slowing the transport of contaminants.

The geochemical conditions that may exist along a contaminant flow path will be complex and it is impossible to duplicate all of them in laboratory experiments. Thus, it is important to identify geochemical codes that can, in conjunction with laboratory data, quantify important transport parameters such as solubility and speciation. This activity will examine available geochemical codes and determine which is most

useful for application to contaminant transport in the low-level tank waste performance assessment.

In cases of very low recharge (vadose water flow rates), diffusion in the matrix materials and vadose sediments may become the most significant component of contaminant transport. The relation between diffusion rates and sorption will be defined and an evaluation of the potential importance of diffusion in the performance of the low-level tank waste disposal facility will be carried out.

Transport of contaminants as colloidal particles or sorbed on colloidal particles has the potential of significantly affecting transport of contaminants away from the low-level waste glass disposal facility. This mode of contaminant transport could be of particular importance if silica colloids are formed as a result of waste glass dissolution. The potential for colloidal transport in the Hanford vadose zone will be evaluated and laboratory studies to evaluate this process will be carried out.

The geochemical environment may influence the fate of water bound in concrete structures, which in turn will influence the quantity of water available to interact with the glass and to transport contaminants after dissolution. In the short term, concrete may be a sink for water in the system because of incomplete initial hydration. However, much of the water of hydration in cements is contained within hydrous calcium silicate gels. Gels, like glass, are thermodynamically unstable, and in the long-term will crystallize. An important question is whether the crystalline phases formed are hydrous or anhydrous. If the crystalline phases are anhydrous, the water contained within the gels may be released into the repository environment where it will affect both glass behavior and contaminant transport.

B. Organization

The responsible organization will be the Groundwater Management Section of the Westinghouse Hanford Company, J. S. Schmid, Manager. The cognizant scientist will be F. N. Hodges. The lead contact at PNL will be D. I. Kaplan of the Environmental Technology Center and for WSU-TC will be J. Conca.

C. Vision

Estimations of the potential range of contaminant releases from the disposal facility to the accessible environment are key to the low-level waste performance assessment. The purpose of this task is to provide the geochemical data that will allow estimation of contaminant transport rates through the waste package, the vadose zone, and the aquifer in the far field. This transport data, coupled with the source terms, will allow the necessary modeling of contaminant release.

D. Objectives

The objectives of this activity are:

- 1) Provide high quality K_d and solubility values for use in the preliminary performance assessment for both vadose zone and aquifer contaminant transport.
- 2) Provide an evaluation of the importance of contaminant diffusion to the preliminary performance assessment.
- 3) Provide an evaluation of the potential importance of colloidal contaminant transport to the preliminary performance assessment.
- 4) To evaluate concrete as a potential source of water within the waste facility.
- 5) Identify geochemical codes for use in the preliminary performance assessment.

E. Deliverables

- 1) WHC report on geochemical issues and their resolutions: Conclusions from the Geochemical Workshop (January 1996).
- 2) A topical paper on "Influences of Moisture Content on Measured K_d Values" (August 1996).
- 3) A topical paper on "Importance of Colloid-Facilitated Transport of Contaminants for Hanford LLW Performance Assessment" (July, 1996).
- 4) A topical paper on "The Long-Term Fate of Water in Concrete" (August 1996).
- 5) Progress letter report on geochemical data measurements (September, 1996).
- 6) A topical paper on "Proper Treatment of Reactive Contaminant Diffusion in Partially Saturated Matrix Material and Sediments" (March 1996).
- 7) A letter report on results of initial geochemical code evaluation (November 1996).
- 8) A topical paper on "Technical Rationale for Chemical Retardation Values Used in the Preliminary Performance Assessment" containing an updated pedigreed data set of saturated and unsaturated K_d values will be issued for the preliminary performance assessment (June 1997).

III. TASK DESCRIPTIONS**A. Summary List of Task**

- 1) Advise
- 2) Geochemical workshop
- 3) Sample characterization
- 4) Geochemical code identification
- 5) Determine fate of water in concretes
- 6) Determine K_d 's and solubilities for key radionuclides
- 7) Determine effect of moisture content on K_d 's
- 8) Determine effective diffusion coefficients for reactive contaminants
- 9) Evaluate importance of colloidal transport
- 10) Technical Defensibility

B. Advise**1. Detailed Description**

This task provides coordination between the geochemistry data effort and other parts of the glass performance assessment effort and provides project management with needed information concerning project needs and progress. It also provides for review of documentation and oversight of work performed at PNL and WSU. The principal contributor will be F. N. Hodges.

2. Interfaces

This task interfaces with project management, other steering panel members, and organizations carrying out work in this area, including PNL and WSU.

3. Standards

There are no applicable standards in this area.

4. Quality Assurance

not applicable.

5. Schedule

Work will be done to meet the schedules of the steering panel.

6. Costs

This task is funded at \$32,500 and includes 0.25 FTE of WHC professional time at \$130,000 per FTE. This is a best professional estimate of the time required to attend meetings, review documentation, stay current about developments in other tasks, and to oversee work at PNL and WSU-TC.

C. Geochemical Workshop

1. Detailed Description

A workshop will be held in September 1995 (FY 1995) to help resolve several key geochemical issues and to buttress the technical defensibility of the approach used for data gathering and application. Several geochemical issues that need discussion include:

- a) appropriate lab methods to obtain accurate K_d/R_f results for low absorbing contaminants; i.e., the "small- K_d issue",
- b) dependency of K_d on moisture content,
- c) appropriate treatment of sorption on coarse material; i.e., the "gravel-corrected- K_d issue",
- d) long-term extrapolation of short-term laboratory data using thermodynamic and natural analogues,
- e) adequacy of the K_d approach versus more mechanistic adsorption conceptual models, and
- f) influence of colloids on facilitating contaminant transport.

Contributors will be F. N. Hodges and J. Shade of WHC and R. J. Serne and D. I. Kaplan of PNL.

2. Interfaces

Interaction between WHC and PNL staff and staff from universities, consulting companies and other laboratories will take place at this workshop.

3. Standards

Not applicable.

4. Quality Assurance

Not applicable.

5. Schedule

The workshop is currently planned for September 1995. The workshop report will be produced by January 1996.

6. Cost

This task is funded at \$40,000 for FY 1996, including 0.5 man month of PNL professional time and 2.0 man month of WHC professional time. This is a best estimate of the time required to prepare, review, and publish the workshop results.

D. Sample Characterization

1. Detailed Description

As samples become available from site characterization, K_d measurements (see G. below) will be carried out with site specific material. In order to understand this sorption process and variability between samples, it is necessary to understand the chemistry and mineralogy of the samples used in the sorption studies. This understanding strongly supports the technical defensibility of the performance assessment effort.

The characterization work will be carried out under pre-existing WHC contracts and by WHC technical staff. The chemistry will be determined by XRF analysis under existing contract with WSU (Pullman). The mineralogy will be determined by XRD under existing contract with the R. J. Lee Company. Optical microscopy will be carried out by WHC technical staff and any required electron microscopy will be carried out by R. J. Lee. The principal WHC contributor will be F. N. Hodges.

2. Interfaces

This task will interface with the Integrated Borehole Task (Activity 3.1.D) which will provide the samples and with the PNL staff (D. I. Kaplan and R. J. Serne) carrying out sorption determinations with the samples. It will also interface with off-site contractors who will carry out the XRD (R. J. Lee) and XRF (WSU) analyses.

3. Standards

Laboratory standards included in existing contracts with WSU and R. J. Lee Corp. will be applicable for all analytical work.

4. Quality Assurance

Work at WSU and R. J. Lee will be done under the QA requirements of the existing contracts. Work done at WHC will be done under the appropriate EII's.

5. Schedule

If two wells are drilled in FY 1996 and one well in FY 1997 a characterization report will be prepared in September 1997. In any case the characterization data will be included in the borehole completion package for each well.

6. Cost

Eight thousand dollars (\$8,000) is allocated for analyses of samples during FY 1996 and during FY 1997 with and \$12,000 is budgeted for FY 1998. This cost distribution is based on the assumption of one borehole per year with a final report after the completion of the third hole. This budget is based upon professional judgement of the requirements for analysis of samples, interpretation of results, and preparation of a characterization report.

E. Geochemical code identification

1. Detailed Description

The transport properties of many key radionuclides, including both their K_d and solubility, depend strongly on their oxidation state and speciation. In order to understand the behavior of these radionuclides, it is necessary to identify geochemical codes, for application in both the near- and far-fields, that can predict oxidation state, speciation, and solubilities under various geochemical conditions that may exist within the vadose zone and aquifer beneath the low-level waste disposal site.

The choice of the geochemical code will depend on several factors, such as what data bases can it access, what data bases are available, kinetics or equilibrium assumptions, hydraulic capability, etc. This task will survey the available geochemical codes that are available (there is no intent to do development here) and the corresponding data bases, document the pros and cons of each code, weigh the needs of the low-level tank waste performance assessment and choose a code that best fits the needs of the performance assessment. With the variable K_d being developed by PNL, a geochemical code that will predict and keep track of the variables (pH, competing ions, etc.) that the variable K_d needs, will be useful. As the factors that affect K_d values change over time and space, the K_d will change accordingly.

During FY 1996 two geochemical codes will be obtained and evaluation initiated. The principal contributors will be F. N. Hodges and E. C. Thornton. of WHC.

2. Interfaces

WHC staff will coordinate with PNL and other geochemists at outside laboratories who have experience in using geochemical codes and their linking with flow/transport codes. Within the geochemistry task computer code identification task will interface with the staff involved in the sorption and solubility work. Within the performance assessment project the computer code identification task will interface with the vadose and groundwater transport tasks.

3. Standards

Not applicable.

4. Quality Assurance

Only codes with complete, publicly available user's guides that address code verification exercises will be considered.

5. Schedule

A letter report indicating results of initial code evaluation will be produced in November 1996.

6. Cost

This task is funded at \$47,500 for FY 1996, including 4 man-months of WHC professional time (\$32,500) and \$15,000 for code acquisition. This is a best professional estimate of the time required to obtain the codes, set them up on WHC workstations, become familiar with code operations, and to make preliminary runs with the codes.

F. Determine fate of water in concrete

1. Detailed Description

Concrete or cement contains a high percentage of water after setting. Given the large quantity of concrete that may exist within the disposal facility, the fate of this water is important to the overall performance of the waste disposal system. In the short term concrete normally acts as a sink for water because of unreacted clinkers of anhydrous calcium-aluminum silicates within the concrete. However, the reaction between clinkers and water produces a hydrous calcium-aluminum silicate gel that is inherently unstable from a thermodynamic point of view. The important question over the long-term is whether the phases that eventually crystallize from the gels are hydrous or anhydrous. If the phases are anhydrous, or less hydrous than the gels, the excluded water may be released into the waste vault environment.

The work planned for FY 1996 consists of a detailed study of all available data available that is pertinent to this issue. This data will include data on modern and ancient concretes, thermodynamic data on the stability of various potential phases that may form in the concretes, and natural analogues that indicate the relative stabilities of hydrous and anhydrous mineral phases. A topical report will be prepared that sets forth what is known about the long-term fate of water in concrete. This paper will either resolve the issue or recommend future work necessary to resolve the issue.

Principal contributors will be R. J. Serne of PNL and F. N. Hodges of WHC.

2. Interfaces

This task will interface with the design engineering function and the source term task.

3. Standards

Not applicable.

4. Quality Assurance

Work at PNL will be conducted in accordance with PNL-MA-70, "PNL Quality Assurance Program Manual". PNL's quality assurance program responds to 10 CFR 830.120 and conforms to the requirements of ASME NQA-1, "1989 Quality Assurance Requirements for Nuclear Facilities", as interpreted by Parts 1 and 3 of PNL-MA-70. PNL uses a graded methodology for implementing the management controls used on projects and discrete work activities. The quality assurance plan (ETC-001) for PNL support to TWRS vitrification activities provides detailed information regarding the grading selection (impact level) and project specific requirements applicable to PNL Vitrification Technology Development Project work activities.

5. Schedule

A topical report setting forth the findings of the study, including proposals for future work if needed, will be prepared in August 1996.

6. Cost

This task is funded for \$55,000 for FY 1996, including \$16,000 for 1.5 man-months of WHC professional time to research and write up available data on natural analogues and \$37,000 for 2 man months of PNL professional time to document available data on ancient and modern concretes and propose direction of future work. Two thousand dollars (\$2,000) is budgeted for library search and miscellaneous expenses. The budget is based on the best professional judgement of time required.

G. Determination of sorption K_d and solubilities of key radionuclides

1. Detailed Description

Batch adsorption tests, which are performed at high water to solid ratios, are an important source of K_d data; however, they may not accurately measure small K_d values in the zero to one range, which is a very important (sensitive) range for performance assessment results. The use of column studies to measure breakthrough curves of key species is a way to indirectly obtain K_d values. The column breakthrough curve provides a retardation factor, which is the ratio of groundwater velocity to species velocity. The K_d value can be calculated from the retardation factor. The advantage of K_d values generated from column studies is that they

tend to have less variability than batch-generated K_d values. The disadvantage of column studies is that they are about 50 times more expensive than batch studies.

Radionuclide retardation is strongly dependent on the chemistry of the mobile (groundwater) and immobile (sediment) phases, the degree of saturation, and the unique solubility/precipitation and adsorption properties of each contaminant. No single K_d can adequately describe the partitioning of a contaminant in the range of environmental conditions likely present in both the near and far fields of the Hanford low-level tank waste site. To address this issue, "variable K_d s" will be developed that vary with the aqueous and solid phase conditions along the flow path. Variable K_d s will be developed through a systematic series of bench-scale laboratory studies by determining the empirical relationships between K_d values and various important geochemical parameters, such as ionic strength, complexants, competing ions, Eh, pH, number of sorption sites, etc. (thus variable $K_d = f[\text{ionic strength, complexants, competing ions, Eh, pH, number of sorption sites, etc.}]$).

The batch test will continue with previously used Hanford sediment samples and will be supplemented with column tests. These tests will be phased over to site specific test materials as samples from the characterization well become available.

The solubility of some contaminants of interest may be sufficiently low that release from the barrier material will be limited by a precipitated solid phase. If so, the maximum solution concentration is time invariant (assuming chemical conditions remain constant in the area where precipitation has occurred) and determined by the equilibrium reaction between the solid phase and whatever water is available. The equilibrium solution concentration can, in this case, be used as the source-term for release from the waste package. The affect of geochemical variables such as Eh and pH on solubilities will be key in determining the viability of geochemical barriers beneath the disposal facility. At a different level, solubility data are necessary for the proper interpretation of sorption tests. In order to perform sorption experiments unambiguously, it is necessary to ensure that initial radionuclide or contaminant concentrations do not exceed solubility. If concentrations exceed solubility, sorption effects cannot be distinguished from precipitation effects when the element is removed from the aqueous phase.

A critical literature review of solubility data will be carried out to identify solubility data usable in the performance assessment. This literature review will be used as a basis for determining what solubility tests should be carried out in support of the performance assessment. Following the literature review a limited number of solubility determinations will be carried out to fill gaps in the existing data base. The determinations will be carried out in expected fluid compositions both with and without matrix solids present. The solubility values will, to the extent

possible, be approached from both the solid and solution side (reversed) to help insure that equilibrium solubility values are obtained. They will also be carried out at several pH and Eh values to allow an estimate of the range of conditions under which these solubility values represent a reasonable source term.

The main contributors to this task will be R. J. Serne and D. I. Kaplan, of PNL and J. A. Conca of the WSU-TC.

2. Interfaces

Interfaces will be maintained with other team members dealing with parameters not covered in this task to understand the possible range of interactions. Interfaces will also be maintained with the geologists who are responsible for getting sediment cores for testing, with the engineers in charge of choosing barrier materials, and with the glass release source-term effort to ensure that the retardation studies use waters that cover the range of actual glass leachate compositions. This task will contribute K_d (or retardation) and solubility data to the vadose and groundwater transport tasks and will provide sorption and solubility values to the engineers designing the barrier systems. This task may also contribute to and perhaps perform laboratory tests on integrated systems should activity integrated testing become a key activity.

3. Standards

There are no laboratory standards per se in this area to follow. Past experience with chemical retardation aspects of risk and performance assessments will be used to guide activities.

4. Quality Assurance

Work at PNL will be conducted in accordance with PNL-MA-70, "PNL Quality Assurance Program Manual". PNL's quality assurance program responds to 10 CFR 830.120 and conforms to the requirements of ASME NQA-1, "1989 Quality Assurance Requirements for Nuclear Facilities", as interpreted by Parts 1 and 3 of PNL-MA-70. PNL uses a graded methodology for implementing the management controls used on projects and discrete work activities. The quality assurance plan (ETC-001) for PNL support to TWRS vitrification activities provides detailed information regarding the grading selection (impact level) and project specific requirements applicable to PNL Vitrification Technology Development Project work activities.

5. Schedule

This task was started in FY 1995 and will be completed during FY 1997 once the chemical composition of the glass and its leachates are better known, once the vadose zone sediments from the chosen site, and once engineered barrier materials are selected. Pedigree values for the preliminary performance assessment will be issued by June 1997 in a PNL topical report. A PNL letter report

describing work on this task will be submitted in September 1996.

"Variable K_d values" for already identified contaminants was started in FY 1995 and will be completed during FY 1996 via a factorial series of batch experiments in which the effect of a number of aqueous and solid phase parameters will be investigated. If necessary, variable K_d values for newly identified contaminants will be determined during FY 1997 and FY 1998. Confirmatory tests with actual glass waste form leachate will be completed by early FY 1999. A report of the site specific retardation of studied contaminants and of the results of expert opinion on lesser contaminants will be issued by July 1997.

The FY 1996 sorption experiments provide an essential step in acquiring the defensible sorption data necessary in the final performance assessment. First, since acquiring site-specific sediment samples is extremely expensive and only small volumes will be available for sorption experiments (< 10 kg), it is essential to determine sorption variability in mineralogically similar sediments that are easily acquired from nearby exposed trenches (e.g., Trench 94 submarine core disposal pit). With variability estimates from these similar sediments, site specific strategies for distributing the borehole core (for adsorption tests as well as other needs) can be optimized to provide the greatest amount of defensibility for the allotted budget. Secondly, the sorption work for FY 1996 will include a number of experiments requiring large amounts of sediments (~20 kg) to evaluate the effects of solute parameters (e.g., pH, carbonate concentration) and sediment parameters (e.g., Fe-oxides, 2:1 clays) on radionuclide sorption. The work from FY 1996 will provide the necessary information to direct our attention, time, and resources to quantifying the effects of only the important geochemical factors on radionuclide sorption on the site-specific borehole sediments when they become available.

6. Cost

This task is funded at \$400,000 for work at PNL for FY 1996 and 1997 (3 man-years of technical time and 0.2 man-years of professional time).

This cost estimate is based upon the previous years work on this task. A minimal amount of professional oversight will be required for this task because the laboratory staff has become familiar with the technical procedures doing similar work in FY 1995, the necessary materials and radionuclides have already been purchased, the QA/QC is in place, and the necessary paperwork and training have occurred.

This work is heavily dependent on technical time because much of it must be done in radiologic control zones in controlled atmosphere glove boxes.

Capital Equipment for FY 1996:

- 1) \$40,000 is needed for a BET surface area analyzer. Since sorption is a surface phenomenon, K_d is a function of available surface area. This surface area dependence is the reason for the so called "gravel effect", where only the finer (higher surface area) soil components seem to affect sorption. Thus, accurate measurements of surface areas are vital to understanding the sorption on site specific samples.
- 2) \$15,000 is needed for a laboratory upgrade in Sigma 5. The Sigma 5 facility offers the low cost alternative for non-radioactive work; however, the space available is below standards required for this work. The purchase of laboratory furniture to upgrade this facility will allow some work to be moved from the more expensive radiochemistry laboratories.

H. Determination of effect of moisture content on K_d

1. Detailed Description

Most K_d determinations have been done with a considerable excess of water, conditions most applicable to transport in the saturated zone. In the case of the Hanford low-level tank waste disposal facility the vadose zone represents a major barrier to contaminant transport and retardation under unsaturated conditions. The major purpose of this task is to determine whether, and to what extent, saturated K_d values are applicable to transport through the vadose zone.

Sorption under unsaturated conditions is determined from column breakthrough experiments. A retardation factor (R_f), the ratio of water velocity to contaminant velocity, is determined from the column results. The K_d is then calculated from the retardation factor. Because the determination of K_d s under unsaturated conditions is a relatively new field, and because of conflicting interpretations of preliminary data gathered in FY 1995, two different test techniques will be pursued in FY 1996. The first will use the unsaturated flow apparatus (UFA) developed by J. Conca at WSU-TC. The second series of tests will be carried out using Wierenga flow-through columns. Comparison between these two types of tests should greatly advance our understanding of the use of K_d s under unsaturated conditions.

The principal contributors will be F. N. Hodges of WHC, D. I. Kaplan of PNL, and J. Conca of WSU-TC.

2. Interfaces

There will be close coordination between the efforts at PNL and WSU-TC. The principal outside interface is with the vadose zone transport modeling task (Activity 3.2).

3. Standards

There are no applicable standards.

4. Quality Assurance

Work at PNL will be conducted in accordance with PNL-MA-70, "PNL Quality Assurance Program Manual". PNL's quality assurance program responds to 10 CFR 830.120 and conforms to the requirements of ASME NQA-1, "1989 Quality Assurance Requirements for Nuclear Facilities", as interpreted by Parts 1 and 3 of PNL-MA-70. PNL uses a graded methodology for implementing the management controls used on projects and discrete work activities. The quality assurance plan (ETC-001) for PNL support to TWRS vitrification activities provides detailed information regarding the grading selection (impact level) and project specific requirements applicable to PNL Vitrification Technology Development Project work activities.

5. Schedule

A topical paper dealing with the effect of moisture content on K_d values will be co-authored by PNL and WSU-TC staff. This report will be produced in August 1996.

6. Cost

The cost for this task for FY 1996 is \$150,000 which includes \$100,000 for PNL (0.6 man-year of technical time and 0.1 man-year of professional time) and \$50,000 for WSU-TC. The funds for PNL include \$5,000 for chemical analysis of water samples generated at WSU-TC. The funding level is based on professional judgement of the time and level of effort required to complete and interpret necessary laboratory tests. It is based upon experience in this area during FY 1995. The same amount is needed for FY 1997.

I. Determine effective diffusion coefficients for reactive constituents

1. Detailed Description

Contaminant diffusion is a relatively slow process and normally becomes a significant component of contaminant transport only in the case of very low advective flow. In the absence of sorption or other reactions, diffusion rates in most materials are simply a function of water content. Sorption, however, will retard the diffusion of contaminants in much the same way that it retards contaminant transport during advection. Sorption results in an effective diffusion coefficient, smaller than would be the case in the absence of sorption.

There are major thrusts of this work. The first thrust will determine the proper way to treat effective diffusion coefficients and to estimate values for key radionuclides. The second will be to estimate the potential importance of diffusion effects on the long-term performance of the disposal facility. If the results

indicate that diffusion may be an important factor in long-term performance, tests will be planned to further quantify the effective diffusion coefficients.

The principal contributor will be J. Conca of WSU-TC.

2. Interfaces

This task will interface with the sorption/solubility task and the vadose zone transport task,

3. Standards

Not applicable.

4. Quality Assurance

Not applicable.

5. Schedule

A topical paper addressing the proper treatment of effective diffusion coefficients and the importance of diffusion in the performance of the low-level tank waste disposal facility will be prepared in March 1996. Funding for future determinations of diffusion coefficients will be based upon the conclusions in this paper.

6. Cost

The cost for this task is \$25,000 for WSU-TC for FY 1996. The funding is based upon best professional judgement of time required to review and evaluate existing data on diffusion, model the effects of diffusion on transport away from the waste facility, and to document and report the results.

J. Determine significance of colloidal transport of contaminants

1. Detailed Description

Contaminant transport models generally treat the subsurface environment as a two-phase system in which contaminants are distributed between a mobile aqueous phase and an immobile solid phase (sediment). Contaminants with a high affinity for sorbing to rock or vadose zone sediments are assumed to be retarded relative to the rate of groundwater flow. However, an increasing body of evidence indicates that under some subsurface conditions, components of the solid phase may exist as colloids suspended in and transported with the flowing water. Association of contaminants with this additional mobile phase may enhance the rate of contaminant transport and bypass normal K_d and solubility considerations. Conversely, deposition of the colloidal particles may reduce the permeability of a formation and thereby decrease transport. Accurate assessment of current contamination problems, engineering and safety assessment of containment and disposal

options, and development of cost effective remediation strategies all require fundamental understanding of the potential role of colloidal particles in enhancing or diminishing contaminant transport in the subsurface.

The distinction between colloidal and dissolved phases is arbitrary, that is there is a continuum of particle sizes down to the single free ion and an operational definition must be imposed to define the colloidal fraction. Because mobile colloids can flow only where water flows and water in unsaturated conditions is limited to film flow, only very small (perhaps less than 100 nm) mobile colloids could possibly exist in the Hanford unsaturated system to be modeled. This immediately limits the types of colloids that are likely to exist as vectors for contaminant transport. Unlikely mobile colloids are those composed of detrital inorganic minerals which are typically greater than 100 nm in diameter and are the most commonly reported types of mobile colloid under saturated conditions. Colloids formed as precipitates of contaminant low solubility constituents and silica colloids (with sorbed contaminants) formed as a result of waste glass dissolution are the most likely colloids of concern. Colloids composed of contaminants sorbed to naturally occurring organic substances might be candidates for mobile colloids in the system to be modeled; however, naturally occurring organic substances are generally quite low in the vadose zone of the Hanford site. Thus, colloids formed as a product of waste dissolution appear to be the most reasonable potential source for mobile colloids in this system.

The extent of colloid formation likely to occur in these systems will be a function of contaminant solubility, nucleation properties of solid phases, and the rate of release of silica from the waste glass. A topical paper on the potential importance of colloids for contaminant at the Hanford low-level tank waste disposal site will be prepared. This report will evaluate the potential for colloidal transport and set forth what testing, if any, is needed to resolve this issue.

The main contributors to this task will be R. J. Serne and D. I. Kaplan of PNL.

2. Interfaces

We will consult with colleagues performing similar work at Hanford and at other national laboratories.

3. Standards

There are no laboratory standards in this area to follow. Past experience with laboratory, large-scaled lysimeters, and large-scale field experiments at other national laboratory sites will be used to guide activities.

4. Quality Assurance

Work at PNL will be conducted in accordance with PNL-MA-70, "PNL Quality Assurance Program Manual". PNL's quality assurance program responds to 10 CFR 830.120 and conforms to the requirements of ASME NQA-1, "1989 Quality Assurance Requirements for Nuclear Facilities", as interpreted by Parts 1 and 3 of PNL-MA-70. PNL uses a graded methodology for implementing the management controls used on projects and discrete work activities. The quality assurance plan (ETC-001) for PNL support to TWRS vitrification activities provides detailed information regarding the grading selection (impact level) and project specific requirements applicable to PNL Vitrification Technology Development Project work activities.

5. Schedule

A topical report on the potential for colloidal transport will be prepared in September 1996. Future work in this task will be based upon the recommendations of this report.

6. Cost

This task is funded for \$50,000 at PNL for FY 1996 and 1997. This is based on best professional judgement of time and level of effort needed to review and evaluate data on colloidal transport and to plan future work in this area.

K. Technical Defensibility

1. Detailed Description

This task will provide technical defensibility for the use of short-term laboratory through thermodynamic analysis and data from natural analogue systems. These geochemical issues that emanate from the reviewers of the performance assessments will be addressed using letter reports or topical reports that draw from literature and project specific laboratory studies.

2. Interfaces

This task will interface with other task and with reviewers of the interim performance assessment

3. Standards

To be determined.

4. Quality Assurance

To be determined.

5. Schedule

To be determined.

6. Cost

No cost is budgeted for FY 1996. \$170,000 are budgeted for FY 1997. This cost is based on professional experience.

3.1.B Groundwater Data for Preliminary Performance Assessment

I. SUMMARY

Develop a conceptual model of groundwater flow and contaminant transport in the vicinity of the low-level tank waste disposal site (LLTWDS) and obtain the groundwater site-specific data needed to perform flow and transport calculations for the preliminary performance assessment. This activity also will generate the tools and data to calculate the effect of previous Hanford actions on the compliance points of this disposal action in accordance with Defense Nuclear Facility Safety Board recommendation 94-2.

II. GENERALA. Background

A generalized Hanford site-wide groundwater flow model is needed to

- 1) develop a conceptual model of groundwater flow and contaminant transport in the vicinity of the LLTWDS,
- 2) provide boundary or reference conditions for disposal site specific models, and
- 3) evaluate potential plume mixing.

Furthermore, because of the variability within similar sediment types displayed across the Hanford site, it is necessary to gather site specific data if site-specific decisions and models are to be made.

VAM3D has been used for site-wide groundwater studies. These studies were funded by the Environmental Restoration program (WHC) and the liquid effluent/groundwater impact program (WHC) over the past several years. An initial calibration (subject to change) of the flow model for a two-layer geologic system was completed at the end of FY 1994. The two-layer system consists of a high-conductivity layer representing the pre-Missoula/Hanford, where it exists, over a low-conductivity layer representing the "E" sequence of the Ringold formation. Responsibility for continued calibration of the model has been transferred to Bechtel Hanford. However, in recognition of the need for applying the model to evaluating consequences of disposing effluents of waste management facilities and obtaining field scale parameters, WHC will continue the effort to refine site-wide flow and transport models.

B. Organization

The cognizant organization is the Environmental Modeling Section, Nick Anderson, Manager, WHC. The cognizant scientist will be Allen Lu. Key investigators will be Allen Lu, Frank Schmittroth, Gene Freeman, and Dave Langford.

C. Vision

Defence of groundwater flow and contaminant transport modeling depends on the appropriate conceptual model and the acquisition and

implementation of adequate and appropriate data.

D. Objectives

Develop a conceptual model of groundwater flow and contaminant transport in the vicinity of the LLTWDS and obtain the groundwater site-specific data needed to perform flow and transport calculations for the preliminary performance assessment.

E. Deliverables

- 1) A letter report describing the groundwater flow modeling development, results of testing and calibration, and the data collection and analysis. The letter report will be written by August 1, 1996 and issuance by September 30, 1996 (after peer review).
- 2) A letter report describing the groundwater flow modeling development, results of testing and calibration, and the data collection and analysis. The letter report will be written by August 1, 1997 and issuance by September 30, 1997 (after peer review).

III. TASK DESCRIPTIONS

A. Summary List of Activities

- 1) Groundwater flow model development.
- 2) Model testing and calibration.
- 3) Obtain groundwater data for preliminary performance assessment
- 4) Visualization.
- 5) Identify groundwater flow field testing location and approach.
- 6) Advise and steering group participation.

B. Groundwater Flow Model Development

1. Detailed Description

Although the calibration of the site-wide model is in progress, additional capabilities are needed in several respects. For multi-source site-wide models, a numerical code can become unwieldy. Moreover, there has not been a practical demonstration of large scale transport where problems of numerical dispersion are well known. Regions with strong discontinuities in aquifer hydraulic conductivities pose yet another potential difficulty that has not been previously addressed.

Work on a semi-analytical code to address these problems was initiated to mitigate these problems. A multi-layer analytical model for transport through the vadose zone was demonstrated, and a robust particle-tracking algorithm was developed. The intent of the particle-tracking method is to provide a foundation for adding contaminant dispersion to the traditional pure particle-tracking model.

2. Schedule

FY 1996

Complete development of the particle-tracking algorithm and apply to the VAM3D site-wide model.

Complete development and testing of multi-layer analytical vadose zone transport code, LAYER.

Continue development of an integrated dispersive particle-tracking model. This may require investigation of more sophisticated techniques such as Laplace transform techniques that have shown some promise.

FY 1997

Continue development coordinated with data analysis.

3. Costs

FY 1996: 0.83 FTE is anticipated for WHC scientists at \$130,000 per FTE, costing approximately \$108,000.

FY 1997: 1.06 FTE is anticipated for WHC scientists at \$130,000 per FTE, costing approximately \$138,000.

C. Groundwater Flow Model Testing and Calibration

1. Detailed Description

A large amount of data has been collected at Hanford that can be used to check flow and transport models. Work is continuing in this area. There is a need to better coordinate these efforts and to consolidate past efforts into a more coherent framework. The site-wide model would be a useful tool for integrating these efforts. Model testing and calibration process will enhance the understanding and interpretation of these data.

2. Schedule

FY 1996

Several subtasks are identified to facilitate a full use of site-wide flow and transport models: (1) identify the geology and hydrology used in the flow model, (2) verify the values representing the physical characteristics and hydraulic properties of various geohydrologic settings, (3) identify liquid source term (artificial recharge) and the estimates of projected discharge so that a post-Hanford flow field can be predicted, and (4) cooperate with Bechtel Hanford to complete the calibration of the flow and transport models using tritium plumes. In the process of calibration, field scale parameters such as hydraulic conductivities and dispersivities can be estimated.

FY 1997

Continue testing and calibration of the site-wide transport model with other contaminant plumes such as Technetium-99 and Iodine-131. Establish clear and consistent interpretation of the existing plumes.

3. Costs

FY 1996 0.35 FTE is anticipated for WHC scientists at \$130,000 per FTE, costing approximately \$46,000.

FY 1997 0.35 FTE is anticipated for WHC scientists at \$130,000 per FTE, costing approximately \$46,000.

D. Obtain Groundwater Data for Preliminary Performance Assessment

1. Detailed Description

Describe tasks which will help define physical parameters at work beneath the Hanford low-level waste tank disposal site. These physical parameters are primarily associated with hydraulic flow and contaminant transport properties. Parameters of interest include, (1) hydraulic conductivity distribution, (2) storativity, (3) boundary values, (4) distribution coefficients (k_d), and (5) dispersivity.

Dispersivity is the spread of a contaminant plume about its center of mass due to redistribution of contaminant mass along peripheral flow channels in the porous media. One potential method for defining the dispersivity is by using spatial moments analysis. Spatial moments were used in previous studies by Freyburg (1986), Garabedian et al. (1991), Knox (1993), and Farrell et al. (1994) to define plume characteristics. Using the spatial moments method, the mass of the plume is calculated by the zeroth moment. The center of mass is calculated from the first spatial moment. And the variance (dispersivity) about the center of mass is calculated from the second spatial moment.

There is a tritium plume in the groundwater near the proposed Hanford tank low-level waste disposal site. By applying the spatial moments technique to contaminant distributions measured at monitoring wells, it is hoped that the dispersivity can be derived from the second spatial moment. Additionally, the flow path can be derived from the first spatial moment (center of mass) at different time steps. Use of this method for a reactive constituent in conjunction with a nonreactive constituent will provide a means of calculating the distribution coefficient of the reactive contaminant plume.

2. Schedule

FY 1996

Collection of the data and development of the mathematical model are expected to take eight to twelve weeks. The model will be designed to define a 2-D plume. Definition of a 3-D plume is not feasible because of a deficit of wells which adequately define the vertical distribution. Evaluation of results and collation of the report should take another four to six weeks.

FY 1997

Application of the model to a reactive constituent. Collection of data is expected to take eight to twelve weeks. A 2-D model will be used from the same reasons cited above. Evaluation of results and collation of the report should take another four to six weeks.

3. Costs

FY 1996

0.34 FTE is anticipated for WHC scientists at \$130,000 per FTE, costing approximately \$44,000; \$26,000 data access support is anticipated (other scientist).

FY 1997

0.34 FTE is anticipated for WHC scientists at \$130,000 per FTE, costing approximately \$44,000; \$26,000 is anticipated for data access support (other scientist).

4. Reference:

Farrell, D.A. and A.D. Wood, 1994, "The 1978 Borden Tracer Experiment: Analysis of the Spatial Moments," Water Resources Research, Vol. 30, No. 11, pp 3213-3223.

Freyburg D.L., 1986, "A Natural Gradient Experiment on Solute Transport in a Sand Aquifer, 2. Spatial Moments and the Advection and Dispersion of Nonreactive Tracers", Water Resources Research, Vol. 22, No.13, pp. 2031-2046.

Garabedian, S.P., D.R. LeBlanc, L.W. Gelhar, and M.A. Celia, 1991, "Large Scale Gradient Tracer Test in Sand and Gravel, Cape Cod, Massachusetts, 2. Analysis of Spatial Moments for a Nonreactive Tracer", Water Resources Research, Vol. 27, No. 5, pp. 911-924.

Knox, R.C., 1993, "Spatial Moments Analysis of Mass Balance Calculations and Tracking Movement of a Subsurface Hydrocarbon Mound." Ground Water Monitoring and Remediation, Summer, pp. 139-147.

E. Visualization

1. Detailed Description

It may prove helpful to input the measured data into a package which will provide visualization in three dimensions. This process will allow evaluation and identification of areas at the site which require (a) additional conceptualization (data gaps), (b) parameter distributions, and (c) show spatial distribution of sampling points. The advantage of visualization is that the data is viewed as an ensemble package with all components of the physical system present. Westinghouse Hanford Company has a current license for such software. This software is designed to represent geologic structures, hydrologic features, and contaminant distributions. Well locations and screen intervals can be shown. While the program is active, physical and chemical properties of the wells can be defined by clicking on each selected well. Plume dimensions are calculated from the scatter data using a minimum tension gridding routine. Plume dimensions can then be plotted and contaminant volumes for user define concentration isopleths can be calculated.

2. Schedule

FY 1996

Familiarization with program capabilities will take about six to eight weeks. Collection of data, data entry, and grid generation and refinement will also take about six to eight weeks. The final product will be a set of two and three-dimensional figures that show groundwater flow and contaminant plume properties. The operator has the ability to manipulate display of data parameter limits.

FY 1997

Incorporation of additional data, refinement of data fields, incorporation of more advanced software refinement capabilities. This is meant to serve to fine tune and improve the images generated during FY 1996. Requires six to eight weeks.

3. Costs

FY 1996

0.10 FTE is anticipated for WHC scientists at \$130,000 per FTE, costing approximately \$13,000; \$13,000 is anticipated for data support services (\$2,5000 for license key at 3200 George Washington Way workstation).

FY 1997

Five thousand dollars (\$5,000) for WHC scientist; \$13,000 for data support services.

F. Identify Groundwater Flow Field Testing Location and Approach

1. Detailed Description

The conceptual model will identify those areas requiring field work for collecting necessary information. Plans to perform the field work must be written, approved, and implemented. Certain areas may require drilling, if no wells currently exist in the area of concern, or the existing wells are unsuitable. Expert consultation will be used to assist in the test plan and enhance the credibility of the test results.

2. Schedule

FY 1996 Evaluation of potential sites, scheduling of personnel and equipment, and work time-tables.

FY 1997 Drill wells (nested) if necessary. Implementation of tracer test and monitoring. Data collection and integration for use in analysis. Use a nonreactive constituent during the test.

3. Costs

FY 1996 \$20,000 is anticipated for WHC scientist; \$13,000 is anticipated for other support.

FY 1997 \$28,000 is anticipated for WHC scientist; \$26,000 is anticipated for other support.

G. Advise

1. Description

Participate in steering group meetings and provide assistance/advise to other tasks.

2. Interfaces

Coordinate with related programs, especially characterization, retrieval, and pretreatment.

3. Schedule

Task is a continuing activity.

4. Cost

A cost of \$20,000 is anticipated for WHC scientific staff time for each fiscal year. This cost is based on prior experience.

3.1.C Dose Modeling Data for the Preliminary Performance Assessment

I. SUMMARY

Continue upgrades to the food chain data base used for performance assessment calculations. Areas of specific interest are special receptors, such as Native Americans.

II. GENERALA. Background

Based on demographics and land use, the number of exposure scenarios is quite large. Included among the individuals exposed are people with special dietary customs. The special customs include both the foods eaten as well as the manner in which those foods are prepared. It is possible that these special customs may lead to doses which are greater than the traditional gardener and farmer usually analyzed.

B. Organization

The responsible organization will be the Environmental Modeling Section of the Westinghouse Hanford Company, Nick Anderson, Manager. The cognizant scientist will be Paul Rittmann.

C. Vision

The goal of the performance assessment is to provide "reasonable assurance" that the disposal activities will protect long-term human health and safety, including identifiable special groups such as Native Americans.

D. Objectives

This activity will determine the parameters which characterize special receptor populations for the preliminary performance assessment.

E. Deliverable

- 1) Letter report providing parameters for interim performance assessment (September 30, 1995). On schedule to be issued as "Data and Assumptions for the Estimation of Radiation Doses for the Glass Low-Level Waste Interim Performance Assessment", WHC-SD-WM-T-707.
- 2) Letter report providing parameters for the preliminary performance assessment (September 30, 1997).

III. TASK DESCRIPTIONSA. Summary List of Tasks

Identify key parameters for special groups.

B. Key Parameters for Special Populations

1. Detailed Description

Based upon relevant literature searches and suitable interviews, potential special populations and customs will be identified and documented. Doses will be compared with standard models.

The main contributor to this task will be Paul D. Rittmann.

2. Interfaces

The inputs for this task will be technical literature and the opinions of individuals with first-hand knowledge of the problem.

The output of this task will determine the need for including special groups in the dose modeling for the preliminary performance assessment. The letter report will be formally reviewed by the standing low-level waste performance assessment review groups.

3. Standards

There are no relevant standards in this area. However, guidance from the DOE Peer Review Panel and from the NRC staff will be used.

4. Quality Assurance

The letter report will be reviewed internally before issuance.

5. Schedule

The task will formally start October 1, 1995 with the letter report written by September 30, 1997.

6. Cost

0.5 FTE of WHC professional time costing \$130,000 per FTE for a total of \$65,000 will be required each of the fiscal years 1996 and 1997.

C. Advise

1. Description

Participate in steering group meetings and provide assistance/advise to other tasks.

2. Interfaces

Coordinate with related programs and with the performance assessment steering group.

3. Schedule

Task is a continuing activity.

4. Cost

Cost is contained in above tasks.

3.1.D Integrated Borehole

I. SUMMARY

The activities described by this statement of work are directed at integrating the collection of the site characterization data from borehole studies needed to develop and validate constituent release and migration models for the low-level glass waste form, the low-level waste form matrix, any engineered barrier system incorporated into the low-level tank waste storage/disposal system design, and to meet all regulatory criteria.

II. GENERALA. Background

Characterization plans are required to fully implement the *Hanford Site Groundwater Protection Management Program* plan (DOE/RL 1989) required by U.S. Department of Energy (DOE) Order 5400.1, and the *General Environmental Protection Program* (DOE 1988). In addition, the DOE guidance on the management of low-level waste (DOE/LLW-13Tg) indicates that a complete environmental monitoring program for a disposal site should consist of four phases corresponding to the four phases in the life-cycle of the disposal site: site characterization, preoperational monitoring, operational, and postoperational.

The site characterization phase is the first step and is designed to assure that the site can be designed, operated, closed, and controlled after closure so "that a reasonable assurance exists that exposure to humans are within limits established by performance objectives" (DOE/LLW-13Tg). This goal is accomplished through the Performance Assessment with in situ characterization data.

The Integrated Borehole Task is designed to drill and sample boreholes for site characterization and Performance Assessment needs. This activity is closely integrated with the general site characterization activity (3.1.G) and will provide data to support preoperational monitoring which will be done on the low-level tank waste disposal site at a later time.

B. Organization

The responsible organization will be the Environmental Projects, Hanford Technical Services, Westinghouse Hanford Company. The cognizant scientists are Steve Reidel and Ann Tallman.

C. Vision

The performance objectives for the performance assessment and the low-level waste disposal regulatory requirements provide the basis for data collection. The data quality objectives (DQO) process was used to translate these needs into the data required to support the performance assessment. The data quality objectives process is designed to insure that borehole data are acquired under an integrated plan and that there is no unnecessary duplication of activities.

D. Objectives

The objective of collecting borehole data for the vadose and saturated zones characterization is to develop a conceptual geohydrologic model of the low-level waste disposal site for use in the performance assessment. This model includes geologic, hydrologic, geochemical, and hydrochemical parameters as defined by the data quality objectives process. These data are exclusively obtained from borehole samples. The object of this task is to (1) provide an integrated borehole construction and data collection plan for all geohydrologic studies and (2) provide a groundwater monitoring structure.

E. Deliverables

- 1) Borehole completion package (4 months after completion of borehole, BH-1, 6/96; BH-2, 6/97; BH-3, 6/98);
- 2) Sampling and analysis data package (BH-1, 6/96; BH-2, 6/97; BH-3, 6/98 part of borehole completion package);
- 3) Geophysical logging data report (3 months after completion of borehole; BH-1, 5/96; BH-2, 5/97; BH-3 5/98);
- 4) Shallow borehole completion report. (To be determined, 3 months after completion of borehole).

III: TASK DESCRIPTIONS

This document provides summaries of those tasks, along with sampling and analysis plans and quality assurance plans, which are described in the "TWRS Complex Site Characterization Plan", WHC-SD-WM-SE-021.

A. Summary List of Tasks

- 1) Drill new characterization/groundwater monitoring wells.
- 2) Sampling and analysis of sediments.
- 3) Geophysical Logging of boreholes.
- 4) Drill shallow boreholes.
- 5) Aquifer characterization.
- 6) Borehole contaminated sediment sampling.
- 7) Advise and steering group participation.

B. Drill new characterization/groundwater monitoring wells**1. Detailed Description**

Three boreholes will be drilled through the vadose zone into the saturated zone. State of practice will be used in attempting to obtain as continuous a record of the sediment as possible for characterization studies. Samples will be described and logged, and analyzed for physical property and chemical compositions. Selected samples will be analyzed for potential chemical and radiological contamination.

2) Interfaces

Samples from these boreholes will be used for characterization tests and analyses by PNL and WHC.

3) Standards

Applicable standards are described in the "TWRs Complex Site Characterization Plan".

4) Quality Assurance

Applicable quality assurance are described in the Site Characterization Plan.

5) Schedule

Borehole	Begin	End
BH-1	11/95	2/96
BH-2	11/96	2/97
BH-3	11/97	2/98

6) Costs

Costs are based on Hanford experience and current regulatory requirements. Some of the drilling costs will be capital expenditures, but the amount will be determined only after the hole is drilled:

FY 1996:

Drilling:	\$194,000
Staff	\$ 43,300 for 4 man months of WHC professional time at \$130,000 per man-year

FY 1997:

Drilling:	\$183,000
Staff	\$ 43,300 for 4 man-months of WHC professional time at \$130,000 per man-year

FY 1998:

Drilling:	\$183,000
Staff	\$ 43,300 for 4 man-months of WHC professional time at \$130,000 per man-year

C. Sampling and analysis

1. Detailed Description

Laboratory analyses will be preformed on the samples from the characterization boreholes. Analyses will include selected chemical characteristics, grain size distribution, physical and hydraulic properties, and mineralogy.

2. Interfaces

Samples from these boreholes will be used for characterization tests and analyses by PNL and WHC. The results of these models will be incorporated into the geohydrologic model for the Hanford tank low-level waste disposal site.

3. Standards

Applicable standards are described in the "TWRS Complex Site Characterization Plan" or in sampling and analysis plans by the sample users.

4. Quality Assurance

Applicable quality assurance procedures are described in the TWRS Complex Site Characterization Plan" or in individual sampling and analysis plans by sample users.

5. Schedule

The schedule is tied to the drilling of the boreholes. At least 10 samples will be obtained from each borehole for geotechnical tests plus 10 contingency analyses as described in the "TWRS Complex Site Characterization Plan". Samples will be taken every 5 feet (~1.5 meter) for sieve and CaCO₃ analyses for screening and characterization.

6. Costs

Costs are based on depth of boreholes, assumed stratigraphy, and current analytic costs.

FY 1996:	\$47,600
FY 1997:	\$38,400
FY 1998:	\$38,400
FY 1999:	\$10,000

D. Geophysical Logging

1. Detailed Description

All deep boreholes and shallow boreholes will be geophysically logged. The purpose of geophysical logging is to supplement data from core for stratigraphic interpretation, density (porosity) estimation, and relative moisture content of the sediments drilled. Geophysical tools will be used to help define hydrostratigraphic units, and to correlate these units among adjacent boreholes. They will also be used to identify any possible zones that are contaminated by gamma-ray emitting radionuclides.

2. Interfaces.

Westinghouse Hanford geophysical monitoring group will do the logging. Logging data will be integrated with borehole sample data and interpreted.

3. Standards

Applicable standards are described in the "TWRS Complex Site Characterization Plan".

4. Quality Assurance

Applicable quality assurance procedures are described in the "TWRS Complex Site Characterization Plan".

5. Schedule

Logging schedule is tied to the drilling of the boreholes. The decision to log shallow boreholes will be made at a later time.

6. Costs (Deep Boreholes Only)

Costs are based on borehole depth and a cost of \$30 per foot for the suite of tests.

FY 1996:	\$12,000
FY 1997:	\$12,000
FY 1998:	\$12,000
FY 1999:	\$ 6,000

E. Shallow Boreholes

1. Detailed Description

The shallow boreholes may be constructed after completion of the first deep borehole. The decision to construct shallow boreholes and the number and depths required will depend upon the outcome of the study by Ellyn Murphy (to be completed in 1995) as described in the "TWRS Complex Site Characterization Plan". If it is determined that shallow boreholes are necessary, they will be constructed to specifically address the infiltration rates at the site in support of Ellyn Murphy. The samples from these boreholes will be used to measure the presence of specific isotopes which are related to climatic trends of the Pleistocene and fall-out from the 1940's. In addition, the boreholes will be logged and samples collected to support model development of the vadose zone following the same procedures as the deep boreholes.

2. Interfaces.

Samples from these boreholes will be used for PNL studies (Ellyn Murphy) and geohydrologic model development.

3. Standards

Applicable standards are described in the "TWRS Complex Site Characterization Plan" and in PNL sampling and analysis plans.

4. Quality Assurance

Applicable quality assurance procedures are described in the "TWRS Complex Site Characterization Plan" and in the quality assurance plan.

5. Schedule

- a) Define needs for shallow boreholes (October 1995).
- b) Develop plan for boreholes (November 15, 1995).

6. Costs

These costs are based on similar boreholes constructed in 1995.

FY 1996: \$20,000
FY 1997: \$10,000

F. Aquifer Characterization

1. Detailed Description

This task describes geohydrologic characterization of the unconfined aquifer at the site. Geohydrologic characterization describes the conditions and properties that control groundwater flow and contaminant transport paths in the unconfined aquifer. The characterization boreholes will be located and constructed as monitoring wells. Data collection and interpretation are focused on geology, geochemistry, hydrogeology, hydrochemistry, groundwater contaminant monitoring, and groundwater flow modeling.

Groundwater chemical measurements and hydrologic tests will be used to evaluate the flow system characteristics. Sampling and analysis for appropriate regulatory constituents will provide "natural" background data for regulatory and environmental restoration purposes. One borehole will penetrate the base of the unconfined aquifer; the other two will penetrate the upper three meters of the aquifer.

2) Interfaces.

Samples from these boreholes will be used for characterization tests and analyses by WHC and PNL. The test data will be incorporated into the aquifer model and the Performance Assessment.

3) Standards

Applicable standards are described in the TWRS Complex Site Characterization Plan".

4) Quality Assurance

Applicable quality assurance procedures are described in the "TWRS Complex Site Characterization Plan".

5) Schedule

The schedule is tied to drilling boreholes.

6) Costs (part of costs are in sampling and analysis)

These costs are based on current costs for quaterly groundwater sampling and analyses.

FY 1996: \$12,000

FY 1997 and beyond \$24,000

The sampling can terminate when the State of Washington determines that the groundwater monitoring is unnecessary.

G. Borehole contaminated sediment sampling

1. Detailed Description

This task will provide field screening of selective samples from the boreholes for possible contaminant constituents in subsurface sediments of the TWRS Complex site. Samples will be collected and analyzed for both chemical and radiological contamination. This task deals with the boreholes only. A similar task deals with surface samples.

2. Interfaces.

This will be integrated with other borehole sampling and geophysical logging.

3. Standards

Applicable standards are described in the "TWRS Complex Site Characterization Plan", sampling and analysis plan.

4. Quality Assurance

Applicable quality assurance are described in the "TWRS Complex Site Characterization Plan", quality assurance plan.

5. Schedule

Begin sample collection (FY 1996). This is tied to the borehole drilling schedule.

6. Costs

Costs are based on about 6 samples per borehole and current analysis costs.

FY 1996: \$3,000
FY 1997: \$2,000
FY 1998: \$2,000

H. Advise

1. Description

Participate in steering group meetings and provide assistance/advise to other tasks. This task also provides guidance and oversight to integrated borehole activities.

2. Interfaces

Coordinate with related programs, especially characterization, retrieval, and pretreatment.

3. Schedule

Task is a continuing activity.

4. Cost

Cost is based on experience of managing and integrating field operations and data integration.

FY 1996: \$65,000 based on 0.5 FTE of WHC professional time at \$130,000 per FTE.

FY 1997: \$32,500 based on 0.25 FTE of WHC professional time at \$130,000 per FTE

FY 1998: \$25,000 based on 0.2 FTE of WHC professional time at \$130,000 per FTE

FY 1999: \$25,000 based on 0.2 FTE of WHC professional time at \$130,000 per FTE

FY 2000: \$25,000 based on 0.2 FTE of WHC professional time at \$130,000 per FTE

FY 2001: \$25,000 based on 0.2 FTE of WHC professional time at \$130,000 per FTE

3.1.E Integrated Testing of the Low-Level Waste Package and Disposal System

I. SUMMARY

This activity focuses on the integrated testing of the waste package and disposal system performance. Establishing the release rates of radioactive waste constituents and hazardous constituents from the engineered Hanford low-level tank waste disposal system and establishing how these materials move in the environment are critical to assessing the long-term performance of the disposal system.

II. GENERALA. Background

An assessment of the long-term performance of the low-level tanks waste disposal system is being developed as required by DOE Order 5820.2A (DOE 1988). This order establishes the requirements for preparing and maintaining a site-specific performance assessment. The performance assessment needs to show that the engineered disposal system and the natural environment work together to protect the health and safety of the public by preventing excessive release of contaminants determined by State, Local, and Federal regulations and ALARA (as low as reasonably achievable) principles. To show this protection, measurements, experiments, and analyses on the waste disposal system are necessary. Among the key inputs required to support the performance assessment are experimental data, physical models, and computational models.

A long-term effort is needed to develop computational and physical models that describe the release of the constituents from the disposal system. The computational models for the performance assessment describe the release of the constituents from the low-level waste package and the influence of various design features incorporated into the engineered disposal system. To validate these computational models, physical models closely approximating the conditions expected in the low-level waste disposal system are needed. Testing protocols are also needed to reflect the conditions in the disposal system. This activity is directed at meeting these programmatic needs by developing and implementing a plan for integrated testing of the engineered disposal system.

This activity was Activity 3.1.C "Integrated Testing" in the Statement of Work for fiscal years 1995 - 2000. For this statement of work (FY 1996-2001), last year's activity has been split into "Integrated Borehole" (Activity 3.1.D) and this activity. No work was done in fiscal year 1995 on the integrated testing of the disposal system. A reference disposal system was not available. Current plans show that a reference disposal system will be selected around October 1995.

B. Organization

The responsible organization will be the Environmental Modeling Section of the Westinghouse Hanford Company, Nick Anderson, Manager. The cognizant scientist will be Fred Mann. The cognizant engineer performing the tasks will be Cheryl Eiholzer of TWRS Disposal

Engineering, Process Design Section, John Garfield, Manager.

C. Vision

To develop and execute tests simulating the disposal system for understanding the behavior of the system and for obtaining data for performance assessment computer models.

D. Objectives

The objective of this activity is to initiate and coordinate testing activities directed at the development and validation of the constituent release models for the disposal system. The focus of the integrated testing will be on the interaction between the waste package and the components of the engineered disposal system, and between engineered components, and the release rate from the disposal system.

E. Deliverables

- 1) A plan for testing the integrated performance of the disposal system will be developed following the selection of a reference disposal system design. Currently, the disposal facility design selection is scheduled for September 30, 1995. The plan will be issued three months after selection.
- 2) Semiannual internal memos summarizing the testing progress will be issued to the performance assessment team. (Due March 30, 1996, September 30, 1996, and March 30, 1997.)
- 3) Annual testing summaries will be issued by the testing organization at the end of the fiscal year and at the end of this activity if the activity does not stop at the end of a fiscal year. The later is due on July 1, 1997.
- 4) A letter report containing the most recent understanding of the disposal systems performance. This data report will be used for the preliminary performance assessment. (September 30, 1997)

F. Reference

DOE 1988 *Radioactive Waste Management Order, DOE Order 5820.2A, U.S. Department of Energy, Washington, D.C.*

III. TASK DESCRIPTIONS

A. Summary List of Tasks

- 1) Development of a test plan and methodologies for testing the performance of the integrated disposal system and related components. Plan is updated for the following fiscal year.
- 2) Implementation and coordination of the testing outlined in the test plan in the above task.

- 3) Summary of the current understanding of waste disposal system release rate.
- 4) Advise and steering group participation.

B. Development of a Test Plan and Methodologies for Testing the Performance of the Integrated Disposal System and Related Components

1. Detailed Description

A test plan will be developed for characterizing the release of constituents from the integrated low-level tank waste disposal system. The test plan will be approved by the performance assessment steering committee before testing is implemented in Task C of this activity. The plan will be based on the data needs for the performance assessment. There will be an effort to identify other integrated testing funded by other organizations. The plan will be updated for the following fiscal year. This task is contingent on the development of a reference disposal system design for testing.

2. Interfaces

The main input will be from the PNL and WHC staff responsible for the waste package development, the engineered barrier development, and the performance assessments activities.

The main output from this task is data to use or verify computational models being used for the performance assessment (Activities 3.1.6, 3.2, 3.4.6, and 3.5).

3. Standards

There are no applicable standards in this area.

4. Quality Assurance

The internal memo produced through this task will be reviewed before issuance.

5. Schedule

This task will start when the reference disposal facility design and possible back-up design are selected. The approximate selection date is October 1995. An internal memo describing the plan will be issued three months after the baseline design has been approved.

The testing needs of the performance assessment personnel will be reevaluated for the next fiscal years will be produced by March 31, 1996 and March 31, 1997.

6. Cost

The estimated cost, in FY 1995 dollars, is:

FY 1996: 1.8 man-months at \$130,000/man-year - \$19,500

FY 1997: 1.25 man-months at \$130,000/man-year - \$13,600

Costs are based on previous experience for planning, advising, and writing memos.

C. Implementation and Coordination of the Testing Outlined in Task B

1. Detailed Description

The test plan developed in Task B will be implemented. This activity is contingent on the development of the test plan. Implementation will consist of finding an organization(s) that can do the testing and of directing and following the testing.

2. Interfaces

Input will be from PNL and WHC staff responsible for the waste package development, the engineered barrier development, and the performance assessment activities (Task B). There will also be interfaces between the cognizant engineer and the contracts personnel and the organization performing the work.

The main output from this task is data to use or verify computational models being used for the performance assessments. (Activities 3.1.6, 3.2, 3.4.6, and 3.5).

3. Standards

The tests will be required to follow appropriate standards. Standards will be decided on a case-by-case basis.

4. Quality Assurance

Tests producing data for decision making will be required to have the appropriate quality assurance plans. Scoping tests could have a lesser quality assurance level. The quality assurance level will be decided on a case-by-case basis.

5. Schedule

This task will start after the integrated testing plan in Task B is approved by the performance assessment steering panel. This task will continue through the end of the task period (September 30, 1997). Internal memos summarizing the progress of the testing for the performance assessment will be issued. These memos will be due March 31, 1996, September 30, 1996, and March 31, 1997. The report for task D will replace the end of year memo for FY 1997. Organizations performing the testing will be required to submit end of the fiscal year summaries. Updates of these summary reports for information to be used for the preliminary

performance assessment will be required by June 30, 1997.

6. Cost

The estimated cost, in FY 1995 dollars, is:

FY 1996: 4 man-months at \$130,000/man-year - \$43,333
testing: \$150,000 (estimated)
FY 1997: 1.9 man-months at \$130,000/man-year - \$20,583
testing \$200,000 (estimate)

Costs are based on previous experience with procuring work, writing memos, and interfacing with testing organizations. The estimated testing costs are based on starting other testing programs. Testing costs in FY 1996 are lower than in FY 1997 due to delay in starting testing due to planning and procurement. There is a possibility that the costs for testing in FY 1997 may need to be modified as testing needs are identified.

D. Summary of the Current Understanding of Waste Disposal System Release Rate

1. Detailed Description

The scope for this task is to write a data report on the most recent understanding of the disposal system performance based on the ongoing test(s). The data report will be for the preliminary performance assessment data package. The reason for the report is to summarize the testing results in one document in order to document assumptions that will be made for the preliminary performance assessment.

2. Interfaces

The input data needed are the status and final reports from the testing organizations.

The output data will be used by the performance assessment team for the modeling efforts for the preliminary performance assessment (Activity 3.2).

3. Standards

There are no relevant standards in this area.

4. Quality Assurance

All reports will be reviewed before issuance.

5. Schedule

The task will start on July 1, 1997 when writing on the disposal system data package will start. The data package will be issued by September 30, 1997.

6. Costs

The following is the cost breakdown, in FY 1995 dollars, for this task.

FY 1996: none

FY 1997: 2 man-months at \$130,000/man-year - \$21,667

The cost includes time for writing the document, secretarial support, graphic support, and document control. The time estimate is based on producing other supporting documents.

E. Advise

1. Description

Participate in steering group meetings and provide assistance/advise to other tasks.

2. Interfaces

Coordinate with related programs as listed in the above tasks.

3. Schedule

Task is a continuing activity.

4. Cost

Cost is contained in above tasks.

3.1.F Sensitivity

I. SUMMARY

Develop uncertainty/sensitivity strategies and implement conceptual and summary models suitable for analysis and presentation of uncertainties.

II. GENERAL

A. Background

Uncertainties arise from scenario selections, conceptual models, data uncertainties, extrapolation to future times, and implementation in numerical computer models. This task supports the Performance Assessment by providing independent and supporting justification for the selected methods and models.

Preliminary work has included a review of regulatory papers and work by others that will assist in developing an acceptable strategy for treating uncertainties. It is recognized that while formal uncertainty analyses may be required, there may well be aspects of the Performance Assessment that are not amenable to these approaches. In these situations, it is deemed imperative that the sources of uncertainty or ambiguity be clearly stated such that independent reviewers and stakeholders are fully informed with the best attainable data.

B. Organization

The responsible organization is the Environmental Modeling Section, WHC, Nick Anderson, Manager. The cognizant scientist is F. Schmittroth with support from the Environmental Modeling Staff.

C. Deliverables

Letter report documenting uncertainty analysis for representative tasks.

III. TASK DESCRIPTIONSA. Summary list of tasks

- 1) Conceptual models,
- 2) Simplified mathematical representations of conceptual model,
- 3) Advise.

B. Conceptual Models

1. Description

This task shall provide independent assessments of the validity and appropriateness of the supporting methodologies and models selected for the performance assessment tasks. Alternative models shall be considered as needed.

Critical independent assessments of conceptual models supporting the Performance Assessment are needed to obtain a defensible analysis. Many aspects of the Performance Assessment models depend on expert judgments where contrasting approaches and viewpoints are beneficial and necessary.

2. Interfaces

Close coordination with the respective Performance Assessment team tasks is required.

3. Schedule

Application to selected tasks will be addressed in FY 1996. The scope will be expanded to additional tasks in FY 1997.

4. Cost

Thirty thousand dollars (\$30,000) in FY 1996 and \$30,000 in FY 1997 (that is, 0.23 FTE at \$130,000 per FTE). The costs are based on past experience.

C. Simplified mathematical representation of conceptual model.

1. Description

Develop simple alternative models representative of both global and individual processes that support more complex calculations but that transparently represent the fundamental processes.

This task represents one specific alternative to complex numerically-based models. The initial work will focus on the feasibility of the approach using simple models to represent source terms, release rates, and transport through the vadose zone and unconfined aquifer. Continuing work will further develop the consequences of these simple models.

2. Interfaces

Application of alternative models requires close coordination with the respective Performance Assessment team tasks.

3. Schedule

Complete a feasibility demonstration in FY 1996 with the expanded scope in FY 1997.

4. Cost

Sixty thousand dollars (\$60,000) are needed in FY 1996 and in FY 1997 (that is, 0.46 FTE at \$130,000 per FTE). These costs are

based on past experience.

D. Advise

1. Description

Advise and coordinate independent uncertainty assessments in this task with those performed directly within the respective subtasks.

2. Interfaces

Application of alternative models requires close coordination with the respective Performance Assessment team tasks.

3. Schedule

This task is a continuing activity

4. Cost

\$20,000 in FY 1996 and in FY 1997 (that is, 0.15 FTE at \$130,000 per FTE). The cost is based on past experience.

3.1.G TWRS Complex Characterization

I. SUMMARY

The site characterization plan (SCP) presents a program for the Tank Waste Remediation System (TWRS) Complex Site meeting relevant regulatory requirements using the data quality objectives (DQO) process. The Integrated Borehole Activity is part of the site characterization activity and uses data from the boreholes as part of site characterization. This activity includes all tasks other than that described in the Integrated Borehole Task. Characterization of the site includes:

- 1) The vadose zone at the low-level tank waste disposal site,
- 2) The upper saturated zone at the Hanford low-level tank waste disposal site,
- 3) The surface and near-surface soil of the entire TWRS Complex Site,
- 4) Vadose-zone and groundwater monitoring plans, and
- 5) Planning for the pre-operational environmental baseline.

II. GENERAL**A. Background**

Characterization plans are required to fully implement the *Hanford Site Groundwater Protection Management Program* plan (DOE/RL 1989) required by U.S. Department of Energy (DOE) Order 5400.1, and *General Environmental Protection Program* (DOE 1988).

DOE guidance on the management of low-level waste (DOE/LLW-13Tg) indicates that a complete environmental monitoring program for a disposal site should consist of four phases. These phases correspond to the four phases in the life-cycle of the disposal site: site characterization, preoperational monitoring, operational, and postoperational. The site characterization phase is the first step and is designed to assure that the site can be designed, operated, closed and controlled after closure so "that a reasonable assurance exists that exposure to humans are within limits established by performance objectives" (DOE/LLW-13Tg).

This task addresses the work that will be done to characterize the site and provide preliminary information for use in the preoperational monitoring. It is closely integrated with the Integrated Borehole Task.

B. Organization

The responsible organization will be the Environmental Projects, Hanford Technical Services, Westinghouse Hanford Company. The cognizant scientists are Steve Reidel and Ann Tallman.

C. Vision

The performance objectives for the Performance Assessment and the regulatory requirements provide the technical criteria for data collection. The data quality objectives process was used to translate these requirements into the data required to support the Performance Assessment and site characterization. The characterization plan provides the roadmap to obtain the characterization data to meet the performance objectives and the regulatory requirements.

D. Objectives

The objective of the surface, vadose, and saturated zone characterization is to develop a conceptual geohydrologic model of the Hanford low-level tank waste site for use in the performance assessment. This model includes geologic, hydrologic, and hydrochemical parameters as defined by the data quality objectives process. The conceptual model will be used in the final performance assessment to model the movement of moisture and contaminants through the vadose zone. The characteristics of the saturated zones, as well as results of in situ testing, will be used in groundwater flow modeling.

E. Deliverables

- 1) Interim geologic map (July 1996).
- 2) Preliminary evaluation of surface structures and contamination (September 1996).
- 3) Preliminary Ground Penetrating Radar/EMI survey report (September 1996).
- 4) Literature-existing data compilation (June 1996).
- 5) Planning
 - a) Aquifer Test Plan (April 1996).
 - b) Preoperational Monitoring Plan (June 1996).
 - c) Analog Studies (May 1996).
 - d) Vadose monitoring system planning-update based on design (June 1996).

III. TASK DESCRIPTIONS

These tasks are more fully described in "TWRS Complex Site Characterization Plan", WHC-SD-WM-SE-021.

A. Summary List of Tasks

- 1) Geologic Mapping.
- 2) Surface contaminated soil sampling survey.
- 3) Ground penetrating radar-EMI Survey.
- 4) Literature survey/data compilation/report writing.
- 5) Analog study.
- 6) Advise and steering group participation.

B. Geologic Mapping.

1. Detailed Description

Geologic mapping is a judgement process dependent upon the observation skills of the geologists. The map is accomplished by physically walking over an area and observing the geologic features present at the site. In areas that have been disrupted by human activity, identifying sedimentary features is extremely difficult; in these areas geophysical techniques will be used. Mapping emphasis will be on vertical disruptions to the normal horizontally layered sediments that could have greatest impact on the performance of the disposal site. (See ground penetrating radar task, task D.)

2. Interfaces.

This study will be closely correlated with the ground penetrating radar (GPR) and electromagnetic inductance (EMI). Ground penetrating radar will be used in the geologic mapping task to locate features such as clastic dikes; GPR will be used to field verify surface and near surface features as well.

3. Standards

Applicable standards are described in the TWRS Complex Site Characterization Plan".

4. Quality Assurance

Applicable quality assurance procedures are described in the "TWRS Complex Site Characterization Plan".

5. Schedule

Begin April 1996; end September 1998

The date of completion is tied to the EMI/GPR task (D) below.

6. Costs

The cost is based on 2 man-months at \$130,000 per man-year

FY 1996:	\$21,700
FY 1997:	\$21,700
FY 1998:	\$21,700

C. Surface Contaminated Soil Sampling Survey.

1. Detailed Description

This task will provide field screening of selective samples for possible contaminant constituents in surface soils of the TWRS Complex site. Soil samples will be collected and analyzed for both chemical and radiological contamination. This task deals with the surface only. A similar task deals with boreholes.

2. Interfaces.

This will be integrated with the Ground Penetrating Radar and existing data evaluation. Under existing data evaluation, EG&G overflow the site collecting gamma emissions and published the results. These data will be examined and used to help design sample collection.

3. Standards

Applicable standards are described in the "TWRS Complex Site Characterization Plan", sampling and analysis plan.

4. Quality Assurance

Applicable quality assurance are described in the "TWRS Complex Site Characterization Plan", quality assurance plan.

5. Schedule

Begin sample collection (FY 1997)

6. Costs

The number of samples is based on current knowledge of the Hanford Site's past practices. FY 1997 represents about 40 samples and two man-months of sample collection and data management.

FY 1996:	0
FY 1997:	\$31,000
FY 1998:	\$10,000
FY 1999:	\$10,000

D. Ground Penetrating Radar-Electromagnetic Inductance Survey

1. Detailed Description

Two kinds of surface geophysics will be used to identify near-surface geologic features and manmade disturbances including buried objects. Ground Penetrating Radar (GPR) is an electromagnetic sounding method which uses radio frequencies to probe the ground for natural and man-made features. Electromagnetic Inductance (EMI) measures electrical resistivity contrasts within the subsurface. Such changes in resistivity are usually due to changes in moisture content which are, in turn,

related to soil grain-size.

2. Interfaces

Information from these studies will be incorporated into the Geologic Mapping Task and Surface Contaminant Soil Survey.

3. Standards

Applicable standards are described in the "TWRS Complex Site Characterization Plan".

4. Quality Assurance

Applicable quality assurance procedures are described in the TWRS Complex Site Characterization Plan".

5. Schedule

Begin October, 1995; end August 1996.

6. Costs (FY 1996)

The costs are based on 2.3 man-years of effort in FY 1996, 2.5 man-years in FY 1997, and 1 man-year in FY 1998 to complete 540 line-kilometers.

FY 1996:	\$300,000
FY 1997:	\$325,000
FY 1998:	\$130,000

Capital funds in FY 1996: \$ 39,000

E. Literature Survey/Data Compilation/Report Writing

1. Detailed Description

This task covers reviewing literature related to site characterization activities, examining and compiling data, and writing reports.

2. Interfaces.

All tasks involve literature survey and data compilation and report writing. An evaluation of the EG&G report on an aero gamma survey will be integrated with the surface contaminated soil sampling survey task (Task C).

3. Standards

Applicable standards are described in the Site "TWRS Complex Characterization Plan".

4. Quality Assurance

Applicable quality assurance procedures are described in the "TWRS Complex Site Characterization Plan".

5. Schedule

Begin October 1995; end September, 1996.

6. Costs

Costs are based on experience in data compilation and writing large reports. Cost of FTE is assumed to be \$130,000.

FY 1996	3 man months	\$ 32,500
FY 1997	6 man months	\$ 65,000
FY 1998	12 man months	\$130,000

F. Planning

The following plans will be written during FY 1996.

- 1) Aquifer Test Plan
- 2) Preoperational Monitoring Plan
- 3) Analog Studies
- 4) Vadose Monitoring System Planning-update (based on design).

1. Aquifer Test Plan

When all three groundwater monitoring wells are installed, a multiple-well aquifer test will be used to obtain in situ hydraulic conductivities and to refine estimates of groundwater travel time. In situ flow direction and velocity measurements will also be made in each of the three boreholes to confirm inferred flow and direction velocity based on water table elevations (gradient) and Darcy's law. Hydrologic testing will consist of instantaneous slug tests and constant rate discharge tests at one well. The other two wells and/or the nearest existing monitoring wells will be used as observation wells during the constant rate discharge tests. A separate test plan will be written for this aquifer testing after installation of the proposed boreholes has begun.

2. Preoperational Monitoring Plan

The scope of the preoperational environmental monitoring plan is to provide an atmospheric, hydrologic/geologic, and radioecological sampling strategy based on potential pollutant releases, TWRS Site Complex site geometry, and potential pollutant release points. A plan will be written to define preoperational monitoring following the data quality objectives (DQO) process. Compilation of existing data and the collection of additional data will be required to provide an environmental baseline for meteorology, geology, cultural resources, and ecological resources of the TWRS Site Complex. Characterization data from

Geohydrologic Model study (Site Characterization Plan) will support parts of this study. Sampling will include both hazardous and radiological constituents. Media sampled will include the following:

- a) ambient air,
- b) surface soil,
- c) vadose zone,
- d) radiation dose (TLDs),
- e) groundwater,
- f) surface water,
- g) vegetation, and
- h) wildlife.

The analyses for soil, vegetation, and ambient air will be determined based on current and previous site activities as well as the proposed treatment methods and waste composition. Further the sample location and density cannot be finalized until the type and location of various facilities are better known.

3. Analog Study

Because of the conditions of the site or the nature of a test, the low-level tank waste disposal site does not provide an adequate environment to determine some important physical properties in situ. One such data need is the physical properties of clastic dikes. The presence or absence of clastic dikes will be determined ("TWRS Complex Site Characterization Plan") but because they are subsurface features their physical properties cannot be directly determined at the low-level tank waste disposal site. Plans will be developed to determine characteristics of clastic dikes from exposures elsewhere in the Pasco Basin.

4. Vadose Monitoring Plan - Update

There are two main reasons to establish a vadose zone monitoring system for a hazardous waste treatment, storage and disposal facility. First vadose zone monitoring is intended to provide early detection of the contaminant migration prior to groundwater degradation. That means avoiding contamination. By installing and using early warning leak detection systems in the vadose zone, migrating contamination can be detected before groundwater quality is compromised. The second consideration involves the expensive, time-consuming burden that the Resource Conservation and Recovery Act (RCRA) groundwater monitoring regulations leave on the facility operator.

The vadose monitoring system can not be designed until a final design has been determined for the site facilities. This task will update the vadose monitoring plan as more information becomes available about the site and about the design of the disposal facility, and as vadose zone monitoring technology develops.

2. Interfaces.

This task interfaces with all aspects of the Site Characterization Plan.

3. Standards

Applicable standards are described in the Site Characterization Plan.

4. Quality Assurance

Applicable quality assurance procedures are described in the Site Characterization Plan.

5. Schedule

Begin October 1995; end September 1996.

6. Costs

The costs are based on experience. Implementation costs reflect preconceptual planning and design, and hence are such to change. One FTE is assumed to be \$130,000.

FY 1996

8 man months - \$86,700

FY 1997

implement analog study 4.6 man-months	\$ 50,000
plan vadose zone monitoring	\$ 50,000
implement preoperational monitoring	\$100,000

G. Advise

1. Detailed Description

This task covers managing and overseeing all drilling activities, related studies and projects, and characterization activities.

2. Interfaces.

This task interfaces with all characterization activities.

3. Standards

Applicable standards are described in the Site Characterization Plan.

4. Quality Assurance

Applicable quality assurance procedures are described in the Site Characterization Plan.

5. Schedule

Begin October 1995; end September 1996.

6. Costs

Costs are based on experience of managing and integrating multiple field projects. 1 FTE is assumed to cost \$130,000.

FY 1996:	0.4 man-years	\$50,000
FY 1997:	0.25 man years	32,000
FY 1998:	0.2 man-year	25,000
FY 1999:	0.2 man-year	25,000
FY 2000:	0.2 man-year	25,000
FY 2001:	0.2 man-year	25,000

3.2 Calculate Results and Write Preliminary Performance Assessment

I. SUMMARY

This activity consists of performing the actual calculations and analyses that appear in the preliminary performance assessment and writing the preliminary performance assessment.

II. GENERALA. Background

Earlier activities (3.1.X) produced the data and methods to be used in the preliminary performance assessment.

B. Organization

The responsible organization will be the Environmental Modeling Section of the Westinghouse Hanford Company, Nick Anderson, Manager. The cognizant scientist will be Fred Mann.

C. Vision

The preliminary performance assessment is needed before construction of the disposal facility (per draft DOE Order 5820.2B) and is used by the Peer Review Panel to guide the preparation of the final performance assessment.

D. Objectives

This activity will produce the preliminary performance assessment.

E. Deliverables

- 1) Preliminary Performance Assessment as a letter report ready for review (March 30, 1998).

III. TASK DESCRIPTIONSA. Summary list of tasks

- 1) Write preliminary performance assessment

B. Write Preliminary Performance Assessment

1. Detailed Description

All calculations and analyses that will appear in the preliminary performance assessment will be performed.

The preliminary performance assessment (including required background information, integration, and interpretation) will be written.

The main contributors to this task will be the entire performance

assessment team.

2. Interfaces

The inputs for this task were generated in 3.1.X activities.

The output of this task will be the preliminary performance assessment ready for external review.

3. Standards

There are no relevant standards in this area.

4. Quality Assurance

The letter report will be reviewed by the performance assessment team before issuance.

5. Schedule

The task will start six months before the time when the data packages are approved. The task will last twelve months with the document being sent to the Program Office on March 30, 1998.

6. Cost

3.5 FTE costing \$130,000 per FTE for a total cost of \$455,000 will be required for analysis, writing, and editing. This estimate is based on the experience of preparing the Hanford Grout Performance Assessment and assuming efficiencies learned from that experience. The estimate is also based on the experience of preparing the design options documents for this project. The breakdown of the staff will be 1 FTE to write the document, 1 to perform editing, and 1.5 for calculations and analysis.

The yearly breakdown is

FY 1997 - \$200,000

FY 1998 - \$255,000

3.3 RL/PRP Review

I. SUMMARY

The Program Office, the Internal Review Team, RL, and other internal Hanford review teams will review the preliminary performance assessment.

II. GENERALA. Background

The preliminary performance assessment will be a large significant document. Under the draft DOE Order 5820.2B, a preliminary performance assessment must be approved by the local operations before the construction of the disposal facility can begin. Under current practice, the Peer Review Panel also reviews the preliminary performance assessment.

B. Organization

The responsible organization will be the Environmental Modeling Section of the Westinghouse Hanford Company, Nick Anderson, Manager. The cognizant scientist will be Fred Mann.

C. Vision

The preliminary performance assessment should withstand any attacks on its methods, data, or interpretations.

D. Objectives

This activity will consist of the review of the preliminary performance assessment.

E. Deliverables

- 1) Communications from review bodies on the adequacy of the preliminary performance assessment (September 30, 1998).

III. TASK DESCRIPTIONSA. Summary list of tasks

- 1) Review of the preliminary performance assessment

B. Review of the preliminary performance assessment

1. Detailed Description

RL, the Peer Review Panel, and other groups will review and provide comments on the preliminary performance assessment.

The main interface to the reviewers will be Fred Mann.

2. Interfaces

The input for this task is the preliminary performance assessment generated in activity 3.2.

The output of this task will be comments that may lead to changes in the final performance assessment or may indicate that the preliminary performance assessment is adequate.

3. Standards

There are no relevant standards in this area.

4. Quality Assurance

The review groups will establish their own quality assurance.

5. Schedule

The task will start after the Preliminary Performance Assessment is written. It is expected to take 6 months. Thus communications from the Peer Review Panel is expected by September 30, 1998.

6. Cost

Costs will be included in the management task (Activity 1.3).

3.4.1 Update Performance Objectives

I. SUMMARY

The same performance objectives used in the preliminary performance assessment are expected to be used in the final performance assessment. This activity consists of reviewing the selection and determining whether modifications should be made.

II. GENERALA. Background

Performance objectives are the criteria against which expected performance is judged. Although unlikely, it is possible that the reasons for choosing the performance objectives for the preliminary performance assessment may be different for the final performance assessment.

B. Organization

The responsible organization will be the Environmental Modeling Section of the Westinghouse Hanford Company, Nick Anderson, Manager. The cognizant scientist will be Fred Mann.

C. Vision

The performance objectives are the criteria against which success or failure of the analyses of the performance assessment are judged. They thus not only provide direction but also are the ultimate technical goal for the entire low-level waste disposal activity.

D. Objectives

This activity will determine the performance objectives for the final performance assessment.

E. Deliverables

- 1) Letter report justifying selection of performance objectives for the final performance assessment (December 31, 1998).

III. TASK DESCRIPTIONSA. Summary list of tasks

- 1) Review choice of performance objectives

B. Review Choice of Performance Objectives

1. Detailed Description

The choice of performance objectives selected for the preliminary performance assessment will be reviewed.

2. Interfaces

The input for this task will be the performance objectives from the preliminary performance assessment plus any new information affecting performance objectives since that selection was made.

The output of this task will be the documenting of the selection of the performance objectives for the final performance assessment.

3. Standards

There are no relevant standards in this area. However, guidance from the DOE Peer Review Panel and from the NRC staff will be used.

4. Quality Assurance

The letter report will be reviewed before issuance.

5. Schedule

The task will start when comments are received from the Peer Review Panel on the Preliminary Performance Assessment. The activity will take three months with the document available December 31, 1998.

6. Cost (FY 1999)

0.04 FTE costing \$130,000 per FTE for a total cost of \$5,200 is required.

3.4.2 Update Scenarios

I. SUMMARY

The same scenarios used in the preliminary performance assessment are expected to be used in the final performance assessment. This activity reviews that selection and determines whether modifications should be made.

II. GENERAL**A. Background**

Scenarios are the various projections into the future on how events will occur. Although unlikely, it is possible that the reasons for choosing the scenarios for the preliminary performance assessment may be different for the final performance assessment.

B. Organization

The responsible organization will be the Environmental Modeling Section of the Westinghouse Hanford Company, Nick Anderson, Manager. The cognizant scientist will be Fred Mann.

C. Vision

The scenarios are the events and pathways used in the analyses.

D. Objectives

This activity will determine the scenarios for the final performance assessment.

E. Deliverables

- 1) Letter report justifying selection of scenarios for the final performance assessment (December 31, 1998).

III. TASK DESCRIPTIONS**A. Summary list of tasks**

- 1) Review choice of scenarios

B. Review Choice of Scenarios**1. Detailed Description**

The choice of scenarios selected for the preliminary performance assessment will be reviewed.

2. Interfaces

The input for this task will be the scenarios from the preliminary performance assessment plus any new information affecting performance objectives since that selection was made.

The output of this task will be the documenting of the selection of the scenarios for the final performance assessment.

3. Standards

There are no relevant standards in this area. However, guidance from the DOE Peer Review Panel and from the NRC staff will be used.

4. Quality Assurance

The letter report will be reviewed before issuance.

5. Schedule

The task will start when comments are received from the Peer Review Panel on the Preliminary Performance Assessment. The activity will take three months with the document available December 31, 1998.

6. Cost (FY 1999)

0.04 FTE costing \$130,000 per FTE for a total cost of \$5,200 is required.

3.4.3 Update Tools

I. SUMMARY

The same analysis tools used in the preliminary performance assessment are expected to be used in the final performance assessment. This activity enforces the discipline of consciously making the decision of which tools to use. All tools used in the final performance assessment must be verified and certified.

II. GENERALA. Background

Complex computer modeling is usually used in the analysis upon which a performance assessment is based. The DOE Peer Review Panel has determined that a careful and thoughtful process be used in selecting such tools. The process consists of

- 1) setting criteria.
- 2) selecting the tools.
- 3) verifying the tools.
- 4) certifying the tools.

All areas of analysis will have had tools that have been verified and certified. During the activities in the preliminary performance assessment, it is possible that some of the tools were found inadequate. This activity allows the modification of such tools but requires that such modified tools still meet the requirements of verification and certification.

B. Organization

The responsible organization will be the Environmental Modeling Section of the Westinghouse Hanford Company, Nick Anderson, Manager. The cognizant scientist will be Fred Mann. Others in the team will represent the major analysis functions in the performance assessment (groundwater transport - Allen Lu, vadose zone transport - Niall Kline, and waste form - Pete McGrail).

C. Vision

The tools of a performance assessment form a core component of a performance assessment. However, unlike other components (criteria and data), it is far more difficult to demonstrate that the tools provide reasonable results (a process here called certification) because they are used to extrapolate beyond our knowledge base.

D. Objectives

This activity will determine the tools (probably computer codes) to be used in the analyses for the final performance assessment.

E. Deliverables

- 1) Letter reports justifying selection of tools in each analysis area for the final performance assessment. The report will include any needed verification and certification information for codes changed from those used in the preliminary performance assessment.

III. TASK DESCRIPTIONSA. Summary list of tasks

- 1) Review choice of codes
- 2) Certification of codes.

B. Review Choice of Codes

1. Detailed Description

The choice of codes selected for the preliminary performance assessment will be reviewed. If different codes from those used in the preliminary performance assessment are used, then they must be verified and certified.

The main contributors to this task will be those with lead responsibility in each analysis area:

- a) Groundwater transport - Allen Lu.
- b) Vadose zone transport - Niall Kline.
- c) Waste form - Pete McGrail.

2. Interfaces

The interfaces will be with other team members and with analysts actually performing the work.

The output of this task will be the documenting of the selection of the code for each analysis area in the final performance assessment area. Also included in the documentation for those codes which differ from the codes used in the preliminary performance assessment will be verification and certification information.

3. Standards

There are no relevant standards in this area. However, guidance from the DOE Peer Review Panel and from the NRC staff will be used.

4. Quality Assurance

The letter report will be reviewed before issuance.

5. Schedule

The task will begin after the corresponding task for the Preliminary Performance Assessment ends. The activity continues until the start of the calculations for the final performance assessment begin, October 1, 1997 to March 31, 1999.

6. Cost

The cost will be covered in the activities supporting or using the code.

3.4.4 Inventory

I. SUMMARY

Complete work identified from previous studies and support final documentation.

II. GENERAL

A. Background

The inventories of hazardous chemicals and radionuclides presently in the Hanford single- and double-shell tanks are the starting point for assessing the inventories that will be in the final waste form that is placed in the disposal facility. These final inventories will also depend on the subsequent pretreatment "splits" along with other losses before the formation of the glass waste form.

As tank characterization studies progress, issues identified from earlier work will be resolved, including impacts of heterogenous tank inventories on the Performance Assessment. Examples of tank specific issues include known significant concentrations of ^{233}U and ^{237}Np in individual tanks.

B. Organization

The responsible organization is the Environmental Modeling Section, WHC, Nick Anderson, Manager. The cognizant scientist is F. Schmittroth with support from the Environmental Modeling staff.

C. Vision

An awareness of the tank inventories, treatment options, and secondary melter waste streams is an on-going effort that must be sustained as better knowledge in these activities becomes available. The performance of the disposal depends directly on the inventory of key materials.

D. Objectives

This activity will supply the inventories in the final waste form in a manner that is supported by the on-going programs in tank characterization, in process treatments, and in melter secondary waste streams as well as theoretical analyses.

E. Deliverables

1. Letter report updating the inventories to be use in the final performance assessment (March 31, 1999).

III. TASK DESCRIPTIONS**A. Summary List of Activities**

1. Determine total inventories
2. Determine tank specific inventories
3. Advise and steering group participation

B. Determine total inventories**1. Detailed Descriptions**

The total inventory will be determined by reviewing available tank characterization data and process flow sheet data. Such process flow data will include the split between high-level and low-level waste and the split among melter losses, off-gas losses, and waste-form incorporation.

2. Interfaces

The intent of this task is to rely on results from other programs to the maximum extent possible. Independent work will be pursued only to the extent necessary to justify a sound basis for the chosen values.

3. Schedule

The task starts after the inventory data is obtained for the preliminary performance assessment. A letter report will be issued by March 30, 1999.

4. Cost

Estimated cost is \$50,000 (0.39 FTE at \$130,000 per FTE) in FY 1998 and in FY 1999. These costs are based on past experience.

C. Determine tank specific inventories**1. Detailed Descriptions**

This task will focus on the issues and benefits that depend on detailed tank inventories. Glass inventories will be determined by reviewing available tank characterization data and process flow sheet data. Such process flow data will include the split between high-level and low-level waste and the split among melter losses, off-gas losses, and waste-form incorporation.

2. Interfaces

The intent of this task is to rely on results from other programs to the maximum extent possible. Independent work will be pursued only to the extent necessary to justify a sound basis for the chosen values.

3. Schedule

The task starts after the inventory data is obtained for the preliminary performance assessment. A letter report will be issued in March 30, 1999.

4. Cost

Estimated cost is \$100,000 (0.79 FTE at \$130,000 per FTE) in FY 1998 and 50,000 (0.39 FTE) in FY 1999. These costs are based on past experience.

D. Advise

1. Description

Participate in steering group meetings and provide assistance/advise to other tasks.

2. Interfaces

Coordinate with related programs, especially characterization, retrieval, and pretreatment.

3. Schedule

Task is a continuing activity.

4. Cost

Cost is estimated to be \$10,000 (0.08 FTE at \$130,000 per FTE) in FY 1998 and in FY 1999 increasing to \$30,000 (0.23 FTE) in FY 2000 when the final performance assessment is written. These costs are based on past experience.

3.4.5 Obtain Disposal Facility Data for Final Performance Assessment

I. SUMMARY

Translate design activities into information useful for the final performance assessment calculations.

II. GENERALA. Background

The models of the disposal facility and the waste package used for the final performance assessment must reflect the actual design or product. The disposal facility and waste package designs may change from to-build designs to as-built designs. The models must reflect these changes.

This activity has two purposes. One is to continue keeping communications open between the performance assessment team and the designing team. The other purpose is to produce a data package on the disposal facility and waste package for the final performance assessment calculations (Activity 3.5).

B. Organization

The responsible organization will be the Environmental Modeling Section of the Westinghouse Hanford Company, Nick Anderson, Manager. The cognizant scientist will be Fred Mann. The cognizant engineer performing the tasks will be Cheryl Eiholzer of TWRS Disposal Engineering, Process Design Section, John Garfield, Manager.

C. Vision

To keep the models used in the performance assessment current with the concepts and designs being used by the program office and the architect-engineer.

D. Objectives

The objectives for this activity are:

- * To keep the modelers informed of the current disposal facility and waste package designs.

- * To keep the Architect Engineer of the disposal facility, the waste production organization, and the TWRS Program Office advised of current modeling results.

- * To translate design information into usable information for the final performance assessment calculations.

E. Deliverables

- 1) Quarterly internal memos to the performance assessment personnel on the current status of the disposal facility. At least one internal memo per fiscal year will be written to notify modelers of any design changes.
- 2) Letter report defining the disposal facility and waste package designs to be used for the final performance assessment (March 31, 1999).

III. TASK DESCRIPTIONSA. Summary List of Tasks

- 1) Update waste package design.
- 2) Update disposal facility design.
- 3) Produce the disposal facility data package for the final performance assessment.
- 4) Advise and steering group participation.

B. Update Waste Package Design

1. Detailed Description

The near-field model requires information on the waste package design: the geometry, size, and materials. This information needs to be based on the current design information provided by the designing or producing organization. The design will be progressing toward an as-built design. The performance assessment team needs to be inform of substantial changes.

This task is focused on keeping communications open between the waste package organization(s), TWRS Program Office, and the performance assessment team. The most recent waste package design from the interfacing group will be used as the waste package for the final performance assessment.

2. Interfaces

The input to this task consists of information from TWRS Program Office and the company(ies) chosen to produce the waste package. The required information consists of any substantial changes to the waste package materials and the most recent waste package drawings which will be needed by December 31, 1998.

The output from this task will be continuing communications with the companies producing the waste package and data for the data package (Task D) for the final performance assessment (Activity 3.5).

3. Standards

There are no relevant standards in this area.

4. Quality Assurance

Any memos written will be reviewed before issuance.

5. Schedule

This activity will start October 1, 1997. The interface portion of the task is continuous and will end at the end of this task (March 31, 1999). Internal memos updating the performance assessment team of current designs will be issued as needed.

6. Costs

The following cost breakdown, in FY 1995 dollars, includes engineering time, secretary support and drawing support.

FY 1998: 1.75 man-months at \$130,000/man-year - \$19,000
FY 1999: 0.75 man-months at \$130,000/man-year - \$ 8,100

These estimates are based on previous experience interfacing with the waste package design organization. The time estimate for this task is less than for the one described in Task 3.1.5.B as it is assumed that the waste form will be well defined and minimum communications will be needed. Written quarterly memos would not be needed.

C. Update Disposal Facility Design

1. Detailed Description

The near-field model requires information on the disposal facility design: size, construction materials, barriers, filler material. This information needs to be based on the current design information provided by the designing organization. Continuous communications between the Performance Assessment team and the disposal facility organization is required to obtain up-to-date information and to produce a robust design.

This task is focused on keeping communications open between the Architect Engineer of the disposal facility, TWRS Program Office, and the performance assessment team. The most recent design for the disposal facility from the interfacing group will be used for final performance assessment calculations (Activity 3.5).

2. Interfaces

The input to this task consists of information from TWRS Program Office, and the Architect Engineer. The information will be periodic updates on the design. This information will be used for the quarterly internal status memos. Design information, preferably a detail design, for input to the disposal facility

data package for the final performance assessment calculations (Task D, below) will be due December 31, 1998.

The output from this task will be used by the modelers for the near-field and the source term for performing calculations for the final performance assessment (Activity 3.5).

3. Standards

There are no relevant standards in this area.

4. Quality Assurance

All memos will be reviewed before issuance.

5. Schedule

This activity will start October 1, 1997. The interface portion of the task is continuous and will end with this activity on March 31, 1999. During the scheduled time, quarterly internal memos will be issued to the performance assessment personnel except when the disposal facility data package will be issued.

6. Costs

The following cost breakdown, in FY 1995 dollars, includes engineering time and secretarial support.

FY 1998: 1.8 man-months at \$130,000/man-year - \$19,500

FY 1999: 0.78 man-months at \$130,000/man-year - \$ 8,450

Time estimate is based on previous experience of interfacing with the waste package design organization and writing memos.

D. Disposal Facility Data Package

1. Detailed Description

The models to be used for the final performance assessment need to model the most recent designs for the disposal facility and the waste package. The disposal facility data package written for the preliminary performance assessment (Activity 3.1.5) will need to be updated or re-written due to revising and approving the designs.

This task focuses on writing the disposal facility data package for the final performance assessment.

2. Interfaces

The input to this task consists of the most recent disposal facility and waste package designs. The organizations with these designs need to provide the input by December 31, 1998.

The output from this task will be the disposal facility data package for the final performance assessment. The data package is due March 31, 1999.

3. Standards

There are no relevant standards in this area.

4. Quality Assurance

The report will be reviewed before issuance.

5. Schedule

This task will start on January 1, 1999. The end date will be March 31, 1999 when the data package is issued.

6. Costs

The following cost breakdown, in FY 1995 dollars, includes engineering time and secretarial support.

FY 1998: none

FY 1999: 2.5 man-months at \$130,000/man-year - \$24,400

Time is based on writing, reviews, graphic support, and document control.

E. Advise

1. Description

Participate in steering group meetings and provide assistance/advise to other tasks.

2. Interfaces

Coordinate with related programs.

3. Schedule

Task is a continuing activity.

4. Cost

Cost is contained in above tasks.

3.4.6 Integrated Source-Term for Final Performance Assessment

I. SUMMARY

A performance assessment of the Hanford low-level tank waste site will require a determination of the source-term for radionuclide release from the glass waste form. The purpose of this task is to develop the necessary data and models for generating source-term calculations that will be used in the final performance assessment.

II. GENERAL

A. Background

A performance assessment for the Hanford low-level tank waste site on the Hanford reservation will be performed to demonstrate that the site meets all applicable regulatory and stakeholder requirements for safe disposal of Hanford low-level tank waste that is to be produced during remediation of Hanford Tank Farm wastes. The performance assessment will require predictions of radionuclide releases from the glass waste form as a source-term for far-field transport and radiation dose calculations. Because radionuclide release from the glass is also affected by other engineered materials, the source-term calculations will be done using an integrated-system modeling approach.

B. Organization

The responsible organization will be the Nuclear Systems and Services Department of the Pacific Northwest Laboratory (PNL), Walt Laity, Manager. The cognizant scientist will be Peter McGrail also of PNL.

C. Vision

Defensible radionuclide release calculations are needed for the Final Performance Assessment of the Hanford low-level tank waste disposal site. Performing these calculations requires a defensible model that describes the alteration rate of the glass and interactions with the other components of the disposal system. This task is coordinated with and directly dependent on tasks conducting glass formulation and long-term glass durability testing that are funded separately under the TWRS Program Office. The cognizant scientist of this task has responsibility for ensuring that appropriate laboratory testing is done under these separate tasks so that the required data for the integrated source-term model is available.

D. Objectives

The objectives for this task include:

- 1) Calculate the release of important contaminants from low-level waste glass and the engineered disposal system and provide these data as input for the final performance assessment
- 2) Conduct literature reviews and interact with staff performing low-level waste glass and engineered barrier materials development

to obtain data and models needed for release rate calculations.

- 3) Identify, modify or adapt models as needed to perform release calculations.
- 4) Plan and conduct verification and certification studies for the selected model.

E. Deliverables

- 1) Topical Report: Laboratory Confirmation Tests in Support of Integrated Source-Term Modeling (December 31, 1997).
- 2) Topical Report: An Integrated Source-Term Model for the Hanford Low-Level Waste Engineered Disposal System (March 30, 1998).
- 3) Topical Report: Source-Term Calculations for Radionuclide Release from the Hanford Low-Level Waste Engineered Disposal System (March 30, 1998)
- 4) Final Report: Laboratory Confirmation Tests in Support of Integrated Source-Term Modeling ready for internal review March 30, 1999.
- 5) Final Report: Source-Term Calculations for Radionuclide Release from the Hanford Low-Level Waste Engineered Disposal System ready for internal review March 30, 1999.

III. TASK DESCRIPTIONS

A. Summary List of Tasks

- 1) Release Model for Low-Level Waste Glass
- 2) Integrated Source-Term Modeling
- 3) Source-Term Model Verification and Certification
- 4) Advise and steering group participation

B. Release Model for LLW Glass

1. Detailed Description

Except for the possibility of physical intrusion into the site, radionuclide release from the low-level waste glass is the essential first step that is required for any subsequent transport to the accessible environment. The release rate from the glass may dominate the overall performance of the site in the long-term so it is essential that a credible method be used to calculate releases from the glass waste form. Because release rates must be projected far into the future and over a range of environmental conditions that cannot be completely investigated in the laboratory, a model must be developed that is a reasonable and defensible representation of the system. Experience has shown that models based on fundamental principles of physics, chemistry, and thermodynamics (mechanistic models) are best suited for this application. Consequently, this task will develop and test a

suitable model describing radionuclide release from low-level waste glass. It is expected that this model will be implemented in an integrated source-term model for the Hanford low-level tank waste disposal system under Task C.

Development of the release model is directly dependent on long-term glass durability studies that are being funded by the TWRS Technology Development Program Office. The most important of the tests for model development purposes are the low temperature experiments that must run for extended periods of time (1-3 years). Long-term testing is planned (Activity 4.2) after completion of the final performance assessment to confirm expectations.

The main contributor to this task will be Pete McGrail.

2. Interfaces

The input to this task will consist of data derived from laboratory testing done as part of glass formulation studies conducted under the Vitrification Projects of the Tank Waste Remediation System (TWRS). Because the laboratory testing and model development work will be done under different projects, close coordination and planning of the experiments by the modelers and experimentalists are essential. The output from this task will consist of a mathematical model and supporting database that will be implemented by the Integrated Source-term Modeling Task.

3. Standards

There are no relevant standards in this area. However, guidance from the DOE Peer Review Panel and from the NRC staff will be used.

4. Quality Assurance

Work at PNL will be conducted in accordance with PNL-MA-70, "PNL Quality Assurance Program Manual". PNL's quality assurance program responds to 10 CFR 830.120 and conforms to the requirements of ASME NQA-1, "1989 Quality Assurance Requirements for Nuclear Facilities", as interpreted by Parts 1 and 3 of PNL-MA-70. PNL uses a graded methodology for implementing the management controls used on projects and discrete work activities. The quality assurance plan (ETC-001) for PNL support to TWRS vitrification activities provides detailed information regarding the grading selection (impact level) and project specific requirements applicable to PNL Vitrification Technology Development Project work activities.

5. Schedule

The task will start October 1, 1997 and be completed March 30, 1999.

6. Cost

FY 1998 - 0.10 professional FTE at \$180,000/FTE = \$18,000

FY 1999 - 0.30 professional FTE at \$180,000/FTE = \$54,000

C. Integrated Source-Term Modeling

1. Detailed Description

Radionuclide release from glass waste forms is highly dependent upon the composition of the glass, the chemistry of the water contacting the glass and aqueous chemistry of the particular radionuclide, temperature, and the local hydrologic conditions. Because the glass waste package will be surrounded by soil and most likely other engineered materials, these materials will affect the aforementioned parameters and impact release rates from the glass and overall release from the engineered system.

The objective of this task is to develop and/or adapt a model that is a reasonable and defensible representation of the engineered system. The integrated model will incorporate the mechanistic model developed for the corrosion of low-level waste glass, and models that describe the important physical, chemical, and hydrological properties of the other engineered materials planned for the disposal system. Output from the integrated model will be time-dependent fluxes for radionuclides exiting the engineered disposal system which will be used as inputs for far-field transport and dose assessment modeling (Activity 3.5).

2. Interfaces

Inputs to this task will come from virtually every task on the Hanford Low-Level Tank Waste project that is responsible for characterizing the physical and chemical properties of the site and the engineered materials being developed for the disposal system. The main outputs will be to the tasks responsible for far-field transport and dose assessments.

3. Standards

There are no relevant standards in this area.

4. Quality Assurance

Work at PNL will be conducted in accordance with PNL-MA-70, "PNL Quality Assurance Program Manual". PNL's quality assurance program responds to 10 CFR 830.120 and conforms to the requirements of ASME NQA-1, "1989 Quality Assurance Requirements for Nuclear Facilities", as interpreted by Parts 1 and 3 of PNL-MA-70. PNL uses a graded methodology for implementing the management controls used on projects and discrete work activities. The quality assurance plan (ETC-001) for PNL support to TWRS vitrification activities provides detailed information regarding the grading selection (impact level) and project specific requirements applicable to PNL Vitrification Technology

Development Project work activities.

5. Schedule

The task will start October 1, 1997 and be completed June 30, 1999.

6. Cost

FY 1998 - 1.00 professional FTE at \$180,000/FTE = \$180,000
FY 1999 - 1.00 professional FTE at \$180,000/FTE = \$180,000

D. Source-Term Model Verification and Certification

1. Detailed Description

The integrated source-term model developed under the Integrated Source-Term Modeling Task will be subjected to verification and certification testing to build confidence in the reliability of the model for calculating release rates from the engineered disposal system. Verification testing will consist of checking code outputs against standard analytical solutions and against benchmark cases run with other computer codes. Verification testing will be performed routinely during model development in accordance with software control procedures.

Certification tests will consist of controlled laboratory experiments designed to test release and migration predictions of radionuclide contaminants through idealizations of the engineered disposal system. The laboratory tests will primarily involve long duration, unsaturated, flow-through tests in columns packed with low-level waste glass, engineered barrier materials and/or Hanford soils.

The main contributors to this task will be Clark Lindenmeier, Richard Holdren, Jeff Serne, and Pete McGrail of PNL.

2. Interfaces

Inputs to this task will come from virtually every task on the Hanford Low-Level Tank Waste project associated with development and application of engineered materials for processing and final disposal of Hanford low-level tank waste. Additionally, this task will be closely coordinated with the Integrated Source-Term Modeling Task to help define the test configurations and test parameters that will best evaluate the underlying assumptions and theories incorporated in the integrated source-term model.

3. Standards

There are no relevant standards in this area.

4. Quality Assurance

Work at PNL will be conducted in accordance with PNL-MA-70, "PNL Quality Assurance Program Manual". PNL's quality assurance program responds to 10 CFR 830.120 and conforms to the requirements of ASME NQA-1, "1989 Quality Assurance Requirements for Nuclear Facilities", as interpreted by Parts 1 and 3 of PNL-MA-70. PNL uses a graded methodology for implementing the management controls used on projects and discrete work activities. The quality assurance plan (ETC-001) for PNL support to TWRS vitrification activities provides detailed information regarding the grading selection (impact level) and project specific requirements applicable to PNL Vitrification Technology Development Project work activities.

5. Schedule

The task will start October 1, 1997 and be completed September 30, 1999.

6. Cost

FY 1998 - (Funding is provided under 3.1.6)

FY 1999 - 1.00 professional FTE at \$180,000/FTE = \$180,000

0.25 tech. serv. FTE at \$160,000/FTE = \$40,000

E. Advise

1. Description

Participate in steering group meetings and provide assistance/advise to other tasks.

2. Interfaces

Coordinate with related programs.

3. Schedule

Task is a continuing activity.

4. Cost

Cost is contained in above tasks.

3.4.7 Waste Package Materials Interaction

I. SUMMARY

This activity focuses on the testing and results of the interactions of materials in the waste package. The waste package consists of the waste form and the canister holding the waste form. To model the source term, the mechanisms of the material interactions and long-term material performance of the waste package need to be known.

II. GENERALA. Background

The waste package will be a composite consisting of vitrified low-level tank waste, a canister containing the vitrified waste, and currently, a matrix material integrated with the vitrified waste. Each material in the composite will degrade over the life of the disposal system. Each material and reacted components will interact with each other, changing local environments (e.g., pH) and material properties. A basic understanding of the chemistry, physics, and thermodynamics of the material's interaction and the changing local environment is needed for producing a defensible mechanistic source-term model. Experiments will support the source-term modeling by providing insight to the degradation processes and the interactions between the materials.

Work on the packaging material started in FY 1995. The PNL Vitrification Technology Development Project is funding testing on the matrix material and matrix material/glass interaction (Low-Level Waste Process Product Development Task, Product Package Evaluation, Investigation Plan, PVTD C95-02). This activity assumes that work on matrix materials has continued (Activity 3.1.7). This activity will build on the previous work.

B. Organization

The responsible organization will be the Environmental Modeling Section of the Westinghouse Hanford Company, Nick Anderson, Manager. The cognizant scientist will be Fred Mann. The cognizant engineer performing the tasks will be Cheryl Eiholzer of TWRS Disposal Engineering, Process Design Section, John Garfield, Manager.

Direction of required testing for the performance assessment objectives will be closely integrated with Pete McGrail (Activity 3.4.6) and the low-level waste performance assessment personnel. TWRS low-level waste disposal Program Office personnel and the processor of the waste packages will also provide information. Work supporting the testing activities will be performed through the PNL, other DOE contractors, and outside contractors to take advantage of expertise within the Department of Energy Complex and the commercial sector.

C. Vision

To understand the chemical, physical, and thermodynamics of the materials and material interactions of the waste package to support the source-term modeling effort for the performance assessment.

D. Objectives

The main objective is to understand the behavior of the materials in the waste package and how these materials interact with each other. This understanding will be used to develop and support the mechanistic source term model. The main objective can be achieved by the following:

- 1) To continue following ongoing waste package material testing. The work stated in Activity 3.1.7 should continue if there is information from these tests which support the final performance assessment.
- 2) To obtain more information on matrix material for the final performance assessment.
- 3) To obtain more information on other waste package material interaction for the final performance assessment.
- 4) To summarize for the final performance assessment the current understanding of the relationship between the waste package materials.

E. Deliverables

- 1) Internal memo identifying performance assessment waste materials testing needs and strategies for FY 1999. (March 31, 1998)
- 2) Status reports on waste material testing. Delivery need to be determined.
- 3) A letter report summarizing for the final performance assessment the current understanding of the relationship between the waste package materials.
- 4) Conduct a workshop on matrix material in FY 1998.

III. TASK DESCRIPTIONSA. Summary List of Activities

- 1) Continue communications with organizations related to the ongoing waste package materials testing.
- 2) Matrix material testing.
- 3) Other waste packaging material testing.
- 4) Current understanding of waste package materials summary.

- 5) Matrix material workshop.
- 6) Advise and steering group participation.

B. Continue Communications with Organization Related to Ongoing Waste Package Materials Testing

1. Detailed Description

Various programs for materials testing were identified or started in Activity 3.1.7. These programs may not stop after providing data for the preliminary performance assessment. Some long-term tests would require testing for a few years. In some cases, more data may be required for the final performance assessment.

The scope of this task consists of continuing interfacing with the organizations conducting the ongoing testing on waste packaging materials. The focus of all testing would be to support the source-term modeling and provide data for the final performance assessment.

The major contributor performing this interfacing task will be Cheryl Eiholzer.

2. Interfaces

The input to this task consists of information from the TWRS Program Office, PNL Technology Development, TWRS Engineering, the Performance Assessment team, the architect engineer, and contributing testing organizations. Pete McGrail of the Performance Assessment team will provide the specific data requirements for the source-term modeling activity (Activity 3.4.6). The contributing testing organizations will provide progress reports and final reports. Outside concerns (Activity 1.4) will also provide input.

The output from this task will be information on testing that is being done on the Hanford low-level waste package materials. These data will be used by the modelers for the near-field and source term calculations for the final performance assessment (Activity 3.5).

3. Standards

The tests will be required to follow appropriate standards. Standards will be decided on a case-by-case basis.

4. Quality Assurance

The tests will be required to have the appropriate quality assurance for data used for decision making. Scoping tests could have a lesser quality assurance level. The quality assurance level will be decided on a case-by-case basis.

5. Schedule

This coordination task begins October 1, 1997 and will continue through March 31, 1999. The performance assessment team will be updated on the testing at performance assessment meetings. Materials testing needs and strategy for FY 1999 and FY 2000 will be produced by March 31, 1998 and March 31, 1999, respectively.

6. Costs

The following cost breakdown, in FY 1995 dollars, includes engineering time and secretary support.

FY 1998: 2.75 man-months at \$130,000/man-year - \$29,800

FY 1999: 1.4 man-months at \$130,000/man-year - \$15,200

Time estimates are based on previous experience need for interfacing with organizations, advising the performance assessment team, and writing memos.

C. Matrix Material Data

1. Detailed Description of Task

The current TWRS Engineering design of the waste package includes a matrix material to enhance the performance of the vitrified low-level waste. The current design focuses on sulfur polymer cement as a chemical barrier. Thus the current focus of matrix material development is on sulfur polymer cement (SPC). However, other matrix materials have been considered and work may be performed on such materials.

The scope of this task is to obtain additional data on the matrix material or the matrix material/glass composite for the final performance assessment. Ongoing experiments followed in the previous task will be scrutinized to identify if any other information is required for the final performance assessment.

Cheryl Eiholzer will be coordinating and following the experiments. Also contributing will be contractors inside and outside Hanford to take advantage of expertise within the Department of Energy Complex and the commercial sector.

2. Interfaces

Input for this task is information from the performance assessment team especially Pete McGrail on additional information needed on the matrix material for a defensible source-term and near-field model. Also information (concerns and doubts) from the public (Activity 1.4) and the DOE Peer Review Panel (Activity 3.3) will be used for input.

Output from this task will be defensible data and an understanding of the mechanisms for the matrix material and matrix material/glass interaction. These data will be used for the

source term modeling (Activity 3.4.6) and the final performance assessment (Activity 3.5).

3. Standards

The tests will be required to follow appropriate standards. Standards will be decided on a case-by-case basis.

4. Quality Assurance

The tests will be required to have the appropriate quality assurance for data used for decision making. Scoping tests could have a lesser quality assurance level. The quality assurance level will be decided on a case-by-case basis.

5. Schedule

This coordination task begins October 1, 1997 and will continue through March 31, 1999. The performance assessment team will be updated on the testing at performance assessment meetings. Reports on testing initiated by the performance assessment team will be written by the testing organization. Each testing organization will write a summary report each fiscal year. Other reports if required will depend on the contract. However, final reports from the testing organizations would be needed by January 1, 1999 for input to Task E of this activity.

6. Costs

The following cost breakdown, in FY 1995 dollars, is:

FY 1998:

staff - 2 man-months at \$130,000/man-year = \$21,666
testing - \$200,000 (estimated)

FY 1999:

staff - 1 man-month at \$130,000/man-year = \$10,833
testing - \$80,000 (estimated)

Costs do not include any contingency money for additional needed testing identified during any of the fiscal years. The costs include engineering time for oversight of the tests. The tests proposed in this task are supplemental to PNL Technology Development testing on matrix materials.

D. Other Waste Packaging Materials Interaction

1. Detailed Description

The waste package will consist of other materials besides glass and matrix material such as steel. Currently carbon steel has been selected as the container material. The current container design also shows steel inside the container. Thus, testing on

the influence of carbon steel on the glass, matrix material, or glass/matrix material must be done.

The scope of this task is to obtain additional data on the steel, steel/matrix material or the steel/matrix material/glass composite for the final performance assessment. Ongoing experiments followed in Activity 3.1.7 will be continued and followed as needed for the required data for the final performance assessment. If new testing is required for performance assessment data on the influence of non-matrix material waste package materials, then the tests will be initiated under this task.

The main contributor to the task is Cheryl Eiholzer who will be coordinating the task. Contributors to the testing tasks will be contractors inside and outside Hanford to take advantage of expertise within the Department of Energy Complex and in the commercial sector.

2. Interfaces

Input for this task is information from the performance assessment team especially Pete McGrail on additional information needed on the packaging material for a defensible source-term and near-field model. Also input from the public (Activity 1.4) and the Peer Review Panel (Activity 3.3) will be considered.

Output from this task will be defensible data and an understanding of the mechanisms and influence of the non-matrix material component of the waste package. These data will be used for the source-term modeling (Activity 3.4.6) and the final performance assessment (Activity 3.5).

3. Standards

Any tests will be required to follow appropriate standards. Standards will be decided on a case-by-case basis.

4. Quality Assurance

Tests will be required to have the appropriate quality assurance for data used for decision making. Scoping tests could have a lesser quality assurance level. The quality assurance level will be decided on a case-by-case basis.

5. Schedule

This coordination task begins October 1, 1997 and will continue through March 31, 1999. The performance assessment team will be updated on the testing at performance assessment meetings. Reports on testing initiated by the performance assessment team will be written by the testing organization. A fiscal year summary report on the testing will be required. Final reports from the testing organizations would be needed for Task E of this activity by January 1, 1999. Delivery of other reports will be determined during the contractual phase.

6. Costs

The following cost breakdown, in FY 1995 dollars, is:

FY 1998:

staff - 1 man-month at \$130,000/man-year = \$10,833
testing - \$100,000 (estimated)

FY 1999:

staff - 0.5 man-month at \$130,000/man-year = \$5,417
testing - \$50,000 (estimated)

The cost includes times for engineering oversight and for some testing on metal/waste-form interactions.

E. Summary of Waste Package Material Testing

1. Detailed Description

The scope of this task is to write a data report on the most current understanding of the interaction between the materials in the waste package. The data report will be for the final performance assessment data package. The reason for the report is to summarize the testing results in one document for the modelers.

2. Interfaces

The input data needed are the status and final reports from the testing organizations.

The output data will be a report to be used by the performance assessment personnel for the modeling efforts for the final performance assessment (Activity 3.5).

3. Standards

There are no relevant standards in this area.

4. Quality Assurance

All reports will be reviewed before issuance.

5. Schedule

This task will start by January 1, 1999 when writing of the material interaction data package will start. The data package will be issued by March 31, 1999.

6. Costs

The following cost breakdown, in FY 1995 dollars, includes engineering time and secretarial support.

FY 1998: \$0

FY 1999: 2 man-month at \$130,000/man-year - \$21,667

The cost is based on experience producing supporting documents.

F. Matrix Material Workshop

1. Detailed Description

The scope of this task is to organize a workshop on the matrix material. A workshop would provide peer assessment and input to the testing and data being obtained on the matrix material. Topics would be determined during the initial development stage of organizing the workshop which is in Task F of activity 3.1.7. The workshop will probably be held during the 1998 calendar year.

The main contributor to the task will be Cheryl Eiholzer.

2. Interfaces

The input to this task would be from the performance assessment team especially Pete McGrail and the organizations performing tests on the matrix material.

The output of this task will be data, suggestions, direction, and opinions on the matrix material.

3. Standards

None.

4. Quality Assurance

None.

5. Schedule

This activity will start October 1, 1997. The activity will end 3 months after the workshop which will be some time in calendar year 1998. Actual date to be determined (Task F, Activity 3.1.7).

6. Cost

The estimated cost, in FY 1995 dollars, of the workshop is as follows:

FY 1998:

staff: 1.3 man-months at \$130,000/man-year - \$14,083
PNL: \$16,000
Other: \$35,000

FY 1999: none

The cost is based on the cost of the recharge workshop held in May 1995.

G. Advise

1. Description

Participate in steering group meetings and provide assistance/advise to other tasks.

2. Interfaces

Coordinate with related programs.

3. Schedule

Task is a continuing activity.

4. Cost

Cost is contained in above tasks.

IV. OTHER CONSIDERATIONS

This task is based on the current preliminary conceptual design for the waste package. If the approved baseline design or the architect engineer's design uses significantly different materials from the preliminary conceptual design, this task will be rewritten to reflect these changes.

3.4.8 Hydrologic Data and Conceptual Model Testings

I. SUMMARY

This activity is designed to determine site-specific hydrologic data needed for materials within and near the low-level tank waste disposal facility (near-field media) and for materials within the vadose zone (far-field media). Note that glass release rate, recharge rate, and retardation factors are covered in other activities. Experiments will be designed to identify the appropriate conceptual model(s) for simulation of flow and transport in the vadose zone and to provide the parameters necessary for simulations.

II. GENERAL**A. Background**

The Peer Review Panel (the group selected by the Department of Energy to judge whether a performance assessment is technically adequate) has mandated that site-specific data used in the analyses of water flow and contaminant transport be selected and justified. Such selection and justification can be based on expert judgement, available literature, or project-specific experiments.

The hydraulic properties of backfill materials (matrix) emplaced as part of engineered disposal system require a close study. The materials selected might present very different flow fields to the contaminant transport. To examine the effect on the contaminant transport, conceptual models have to be developed and evaluated by numerical models. Methods for dealing with characteristics of fractures will be explored, if the material that is selected may experience fracturing.

Vadose zone flow and transport models are recognized as necessary tools for baseline risk assessments. The purpose of these models is, in part, to evaluate the potential migration of contaminants within vadose zone soils to the water table. Confidence in the predictions of these models improves progressively as they are repeatedly shown to represent reality.

The proposed experiments are designed to help resolve outstanding technical issues related to current vadose zone flow and transport modeling at Hanford such as:

- 1) How to resolve differences between field and laboratory measurements of water retention characteristics and unsaturated hydraulic conductivities ?
- 2) How representative are laboratory measurements of unsaturated hydraulic conductivity determined using centrifugation techniques relative to estimates obtained using other methods?
- 3) How to address the issue of scale and increase confidence in the predictions of the vadose zone flow and transport models?

B. Organization

The cognizant organization is the Environmental Modeling Section of Westinghouse Hanford Company; Nick Anderson, Manager. The cognizant scientist is Allen Lu. Supporting this effort will be the Environmental Technology Division of the Pacific Northwest Laboratory (in particular, M.L. Rockhold, M.J. Fayer, R.R. Kirkham, C.T. Kincaid, A.L. Ward, and M.P. Bergeron will provide technical coordination and interface for this task for the PNL Vittrification Technology Department (PVTD) Program).

C. Vision

This task will contribute to understanding the low-level tank waste disposal facility and it's behavior in Hanford sediments. The task will improve the ability to simulate the flow of fluids and transport of contaminants within the facility and in the surrounding vadose zone through the measurement of physical and hydraulic properties and the study of alternate constitutive models.

D. Objectives

The objectives of this task are to identify the appropriate conceptual model(s) for simulation of flow and transport in the vadose zone and to provide the parameters necessary for simulations.

E. Deliverables

- 1) A data package containing data, parameter estimates, and description statistics will be delivered eight months after field experiments get underway in the excavation pit.
- 2) A journal manuscript describing the results of field experiments and laboratory analyses will be submitted to a peer-reviewed journal twelve months after field experiments are initiated.
- 3) An interim report summarizing the field data and analysis of the controlled experiment will be prepared by September 30, 1998.
- 4) One or more journal manuscripts describing the field experiment data analysis will be submitted to a journal by September 30, 1999.
- 5) A final report summarizing the development and use of model verification data sets will be published by September 30, 1998.
- 6) A topical report presenting methods and measurements of physical and hydraulic properties of intact and degraded near field materials will be issued by September 30, 1998.
- 7) A topical report on the physical and hydraulic properties, specimens drawn from stockpiled materials (backfill media, construction materials), and of specimens of the waste form that have undergone accelerated aging tests will be issued by March 30, 1999.

III. TASK DESCRIPTIONS

A. Summary List of Activities

- 1) Field measurement of unsaturated hydraulic conductivities using a modified Instantaneous Profile Method (IPM).
- 2) Controlled field testing of flow and transport models.
- 3) Disposal site testing of flow and transport model.
- 4) Development of conceptual models for flow in the near field.
- 5) Determination of hydraulic properties of matrix materials.

B. Field Measurement of Unsaturated Hydraulic Conductivities using Modified IPM

1. Detailed Description

The primary objective of this task is to conduct field experiments to obtain justifiable and defensible parameter estimates, based on site-specific data, to support unsaturated water flow and solute transport modeling for the performance assessment. A second objective is to generate a sufficient quantity of high quality data so that spatial correlation lengths can be estimated for flow and transport parameters. Quantifying spatial correlation structure is important because this structure influences the anisotropy of hydraulic conductivity and the potential dispersion of contaminants. Quantification of spatial structure is also required to effectively upscale unsaturated hydraulic properties determined from small point measurements to the larger grid block sizes typically used in numerical simulation models.

A series of field experiments will be conducted within the excavation selected for the low-level tank waste disposal facility. The experiments will be based on a modification of the instantaneous profile method for estimating unsaturated hydraulic properties, as described by Rockhold (1995) and demonstrated through field application during fiscal years 1995, 1996, and 1997. The precise data (i.e., fiscal year) when this activity would begin is contingent on the initiation of excavation for disposal facility construction.

It would be beneficial to conduct IPM experiments as the low-level tank waste disposal facility is excavated to obtain more information about spatial variability in the vertical direction. The need for any additional work related to FY 1996 and 1997 activities under the IPM task will be evaluated at that time.

Field plots in the excavated pit will be instrumented with segmented, remote diode-shorting (Time Domain Reflectometer) TDR probes and multi-depth tensiometers for measuring soil-water contents and tensions, respectively. The tensiometers will be equipped with transducers and the TDR/tensiometer system will be

automated and multiplexed for continuous, near real-time data acquisition. Water will be ponded on the surface of the field plots until the plots are wetted to the deepest depth of interest. Water contents and tensions will be monitored during the infiltration and drainage phases of the experiments. *In situ* water retention characteristics and unsaturated hydraulic conductivities will be estimated from the water content and hydraulic head profiles. Details on the method and data reduction procedures are given by Rockhold (1995) and will be documented in fiscal year 1996 and 1997 research reports.

Each field plot will be instrumented with multiple TDR probes and tensiometers. These instruments will be arranged to maximize the number of lag pairs available for quantifying the autocorrelation structure of the unsaturated hydraulic properties and estimating correlation lengths. In addition, *in situ* measurements of saturated and unsaturated hydraulic conductivity will be made using ponded and tension infiltrometers. Because of the portability and low water-use requirements of infiltrometers, they are ideally suited for spatial variability studies.

After the IPM experiments have been conducted, core samples will be collected from the field plots to determine bulk densities, porosities, particle-size distributions, water retention characteristics, and saturated hydraulic conductivities using standard laboratory methods. All laboratory analyses will be conducted by the WHC Geotechnical Engineering Laboratory (WHC-GEL). In addition, unsaturated hydraulic conductivities may be directly measured on subsamples of some of the cores using a centrifuge technique (Conca and Wright 1990). Data from the field experiments and laboratory analyses will be analyzed and compared. The data generated will simultaneously provide site-specific hydraulic properties that are needed for flow and transport modeling in the performance assessment, estimates of spatial variability and parameter uncertainty that are needed to evaluate the uncertainty associated with performance assessment predictions, and field-scale experimental data for model testing and confirmation exercises.

2. Interfaces

Allen Lu (WHC) will oversee the task. The principal investigators from PNL are Mark Rockhold and Andy Ward, with some support provided by Mike Fayer and Randy Kirkham for data acquisition and analysis activities. John Relyea and Paula Heller (WHC-GEL) will provide support for laboratory measurements of physical and hydraulic properties. Jim Conca (WSU - Tri-Cities) would provide support for centrifuge measurements.

Results will be presented to the technical community and reviews and comments will be solicited. The findings will be provided to the vadose zone modeling team so they may use the data for the final performance assessment.

3. Standards

There are no standards in this area. However, past experience with risk and performance assessments will be used to guide activities. Standard laboratory techniques will be used to process any collected samples. If new techniques are developed, replicable procedures will be prepared and documented.

4. Quality Assurance

Periodic reviews will be conducted of work in progress. Topical reports will be subjected to PNL and WHC peer review before being issued.

Work at PNL will be conducted in accordance with PNL-MA-70, "PNL Quality Assurance Program Manual". PNL's quality assurance program responds to 10 CFR 830.120 and conforms to the requirements of ASME NQA-1, "1989 Quality Assurance Requirements for Nuclear Facilities", as interpreted by Parts 1 and 3 of PNL-MA-70. PNL uses a graded methodology for implementing the management controls used on projects and discrete work activities. The quality assurance plan (ETC-001) for PNL support to TWRS vitrification activities provides detailed information regarding the grading selection (impact level) and project specific requirements applicable to PNL Vitrification Technology Development Project work activities.

5. Schedule

FY 1998-1999: These activities of the IPM task beyond FY 1997 are contingent upon the excavation for construction of disposal facilities.

6. Cost

Costs are shown in FY 1998 and FY 1999. This assumes excavation begins in mid FY 1998 and that data reduction continues into FY 1999. These costs are based on the similarity of the work to that being conducted during FY 1996-FY 1997, and the resources needed to perform that work. Accordingly, better estimates of the resources needed to perform this out-year study will be available after FY 1996 work is completed.

FY 1998: Approximately 15 man-months of professional time is anticipated for PNL, costing approximately \$200,000.

Approximately \$50,000 is anticipated for the WHC-GEL for laboratory sample analyses.

Sixteen thousand dollars (\$16,000) is required for WHC professional time (1.47 man-months at \$130,000 per man-year) to oversee the activity.

FY 1999: Approximately 4 man-months of professional time costing \$50,000 is anticipated for PNL to prepare reports and journal manuscripts, and participate in peer-review meeting.

\$16,000 is required for WHC professional time (1.47 man-months at \$130,000 per man-year).

7. Deliverables

- a) A data package will be prepared for use in the final performance assessment. It will contain data and parameter estimates, and descriptive statistics (mean, variance, distribution type) and estimates of spatial correlation lengths for each of the hydraulic parameters. This data package will be delivered 8 months after field experiments in the excavation pit begin.
- b) A journal manuscript describing the results of the field experiments and laboratory analyses will be submitted to a peer-reviewed journal 12 months after field experiments are initiated.

8. References

Conca, J.L., and J. Wright, 1990. "Diffusion Coefficients in Gravel Under Unsaturated Conditions", Water Resources Research 26:1055-1066.

Rockhold, M. L., 1995. Experimental Determination of Unsaturated Hydraulic Properties for Near-Surface Sediments - (FY95) Test Plan, PVTD-C95-04.02A, Rev.0, Pacific Northwest Laboratory, Richland, Washington.

C. Controlled Field Testing of Flow and Transport Models

1. Detailed Description

The objective of this task is to build confidence in the predictions of the vadose zone flow and transport models.

A new injection experiment will be designed with objectives oriented to the needs of the low-level tank waste performance assessment project. Data collected from this experiment will be used to test several aspects of the conceptual model as well as demonstrate overall model performance.

The injection experiment will involve the introducing to the subsurface water and one or more solutes with characteristics similar to the contaminants expected to be found in the vitrified waste. Such experiments provide useful information in a short time, but the sediments are usually wetter than expected around the disposal facility. The experiments are generally unable to provide data under drier conditions in a reasonable amount of time. To overcome this limitation, heat may be added following

injection. The heat will be used to redistribute water in both the liquid and vapor phases to provide flow and transport data for drier conditions.

Monitoring equipment today is vastly improved. Instruments such as TDR probes enable more or less instantaneous measurements of water content distributions, something that is not possible with the neutron probe method. TDR measurements can also be taken at a much higher spatial and temporal frequency than the neutron probe. Logging tools such as the RLS spectral gamma-ray tool can be used to measure and discriminate minute quantities of radionuclides:

Post-experiment sampling of the sediments will occur if detailed measurement of the water and contaminant distributions are deemed necessary.

2. Interfaces

Allen Lu (WHC) will oversee the task. Principal investigators from PNL include Mike Fayer, Mark Rockhold, Dan Kaplan, and Rick Lewis.

This work will be conducted in collaboration with three other tasks: instantaneous profile measurements (IPM), disposal site testing, and chemical retardation factors. The IPM task is developing TDR and tensiometer techniques for high-speed measurements of water contents, matrix potentials, and electrical conductivity. These techniques will be used for the new field test. The disposal site test will provide a large-scale data set for model testing. Coordination with the disposal task will ensure that the controlled field and the disposal tests will be complementary and that issues that cannot be addressed at the large scale will be addressed by the controlled field tests. The chemical retardation activity (3.4.9) will be involved in the planning and analysis of the controlled field test to ensure that chemical aspects of the test are appropriate (e.g., Glass-specific primary contaminants, competition for sorption sites, etc.).

Results will be presented to the technical community and reviews and comments will be solicited. The findings will be provided to the vadose zone modeling team so the results may be used in the final performance assessment.

3. Standards

There are no standards in this area. However, past experience with risk and performance assessments will be used to guide activities. Standard laboratory techniques will be used to process any collected samples. If new techniques are developed, replicable procedures will be prepared and documented.

4. Quality Assurance

Periodic reviews will be conducted of work in progress. Topical reports will be subjected to PNL and WHC peer review before being issued.

Work at PNL will be conducted in accordance with PNL-MA-70, "PNL Quality Assurance Program Manual". PNL's quality assurance program responds to 10 CFR 830.120 and conforms to the requirements of ASME NQA-1, "1989 Quality Assurance Requirements for Nuclear Facilities", as interpreted by Parts 1 and 3 of PNL-MA-70. PNL uses a graded methodology for implementing the management controls used on projects and discrete work activities. The quality assurance plan (ETC-001) for PNL support to TWRS vitrification activities provides detailed information regarding the grading selection (impact level) and project specific requirements applicable to PNL Vitrification Technology Development Project work activities.

5. Schedule

FY 1998: The site of the controlled field test will be instrumented and monitoring will begin. An interim report summarizing the field data and analysis will be prepared by September 30, 1998.

FY 1999: Monitoring of the controlled field test will be completed, although the site will be left intact for further testing and monitoring. A final report summarizing the field data and analysis will be prepared for submittal to a peer review journal(s) by September 30, 1999.

6. Cost

These costs are based on past experience on this project, (e.g., logging wells, and collecting and analyzing samples at the Sisson and Lu experimental site).

FY 1998: PNL costs are \$315,000 for 20 man-months (includes instrumenting test site, logging wells, and collecting and analyzing samples).

\$16,000 is required for WHC professional time (1.47 man-months at \$130,000 per man-year) to oversee the activity.

FY 1999: PNL costs are \$135,000 for 8.5 man-months.

\$16,000 is required for WHC professional time (1.47 man-months at \$130,000 per man-year) to oversee the activity.

7. Deliverables

- a) An interim report summarizing the field data and analysis of the controlled experiment adjacent to the low-level tank waste disposal facility will be prepared by September 30, 1998.
- b) A final report summarizing the field data and analysis will be prepared for submittal to a peer review journal(s) by

September 30, 1999.

D. Disposal Site Testing of Flow and Transport Model

1. Detailed Description

The objective of this task is to use field data from past releases of contaminants from existing disposal sites to increase confidence in the predictions of vadose zone flow and transport models. The accidental releases and planned low-level burial practices of the early 60's provide natural field experiments with 30 years of equilibration time. Development of these data sets will supplement the companion tasks by providing data sets with a greater temporal and spacial scales.

As with past disposal practices, the vitrification program will most likely be subjected to continued review. Model validation will remain a critical area continually open to examination by regulatory agencies and the public. This task develops a defensible data set that can be used to validate transport models. Model validation is defined here to mean the ability to predict infiltration of water and/or contaminants using realistic values of parameters that control redistribution of water and radionuclides in the geologic media surrounding the waste material.

Onsite data sets of actual contaminant plumes are limited and generally describe only sites (e.g., "wet" sites) where contaminants have been released in association with large amounts of water.

This task will further develop the existing data set describing a "wet" site and develop a new data set for a "dry" site which has been exposed to near natural rates of infiltration. This will allow model performance to be bracketed by a worst case and a scenario more representative of the low-level tank waste disposal site. Data sets to be generated include down well high resolution gamma-ray scans (Koizumi et al 1994), water balance data for the study sites, and soil samples for radionuclide content.

2. Interfaces

Allen Lu (WHC) will oversee the task. A summary document/paper will be presented to the technical community. All data sets generated will be made available via Internet servers or electromagnetic media to the vadose zone modeling team for performance assessment modeling. PNL principal investigators are Randy Kirkham, Charles Kincaid, Mike Fayer, Mark Rockhold, Dan Kaplan, and Rick Lewis. The WHC-GEL will be involved with sample characterization.

3. Standards

There are no standards in this area. However, past experience with risk and performance assessments will be used to guide

activities. Standard laboratory techniques will be used to process any collected samples. If new techniques are developed, replicable procedures will be prepared and documented.

4. Quality Assurance

Periodic reviews will be conducted of work in progress. Topical reports will be subjected to PNL and WHC peer review before being issued.

Work at PNL will be conducted in accordance with PNL-MA-70, "PNL Quality Assurance Program Manual". PNL's quality assurance program responds to 10 CFR 830.120 and conforms to the requirements of ASME NQA-1, "1989 Quality Assurance Requirements for Nuclear Facilities", as interpreted by Parts 1 and 3 of PNL-MA-70. PNL uses a graded methodology for implementing the management controls used on projects and discrete work activities. The quality assurance plan (ETC-001) for PNL support to TWRS vitrification activities provides detailed information regarding the grading selection (impact level) and project specific requirements applicable to PNL Vitrification Technology Development Project work activities.

5. Schedule

FY 1998 A final report will be prepared describing the "wet" and "dry" sites, respective data sets, and the comparison of measured data with model simulations. The emphasis of these simulations will be to examine if transport phenomena are appropriately described at the expected hydrologic conditions "dry" and at a worst-case scenario "wet".

6. Cost

These cost estimates are based on cost and effort required to perform work on this task during FY 1995 and to perform well logging and data reduction at the Sisson and Lu experiment site.

FY 1998 4 man-months of PNL labor (\$64,000) includes scientific staff and support from clerical and editing staff, graphical/photography.

\$16,000 is required for WHC professional time (1.47 man-months at \$130,000 per man-year).

7. Deliverables

- a) A final report summarizing the development and use of model verification data sets will be published by September 30, 1998.

8. References

Koizumi, C.J., Brodeur, J.R., Price, R.K., Meisner, J.E., and Stromswold, D.C., 1994. "High-resolution Gamma-ray Spectrometry Logging for Contamination Assessment". Nuclear Geophysics, Vol. 8 no. 2, 149-164.

E. Development of Conceptual Models for Flow in the Near Field

(note, Item 5 (Determination of Hydraulic Properties) has been incorporated into item 4; the conceptual model development is highly linked to hydraulic property measurement)

1. Detailed Description

a. This study of near-field conceptual and constitutive models needs to continue until the final performance assessment is completed. Past programs have shown that changes in both the waste form and key near-field materials can occur quite late in the performance assessment schedule, and therefore, an assessment of hydraulic properties of new materials and new disposal engineering systems may be required late in the performance assessment cycle. Initial conceptual, constitutive models and hydraulic properties of materials will have been provided by the close of FY 1995 for use in the interim performance assessment. These models and data will have been updated by the close of FY 1997 for use in the preliminary performance assessment, and finally updated by the close of FY 1998 for use in the final performance assessment. This study will continue over the duration of performance assessment preparation activities because final decisions on materials have not been made for the waste form, the near-field matrix, or the engineered structures. Accordingly, degradation of engineered materials and systems will require some form of accelerated aging experiments followed by material hydraulic property tests. These property measurements, and associated conceptual and constitutive models will be critical to long-term estimates of the performance of the glass/matrix and engineered disposal system.

b. General Description of the Near-Field Task

This task deals with the development of scientifically defensible conceptual and constitutive models for the flow of fluids in the near-field environment of the low-level tank waste disposal facility. Several program elements will decide the materials of interest and the configuration of candidate glass, matrix, structures, and barriers. As materials are identified for potential use in the near-field environment, the purpose of the task is to:

- Improve our basic understanding of and ability to simulate the flow of fluids in the near-field through the measurement of physical and hydraulic properties

and studies of alternate constitutive models.

- Assist in the simulation of the near-field release of contaminants from the combined glass/matrix materials, and the overall engineered system (bounded below by the natural environment and laterally by backfill soil) by providing conceptual and constitutive models of water flow in the near-field environment (i.e., waste, matrix, and engineered system components).
- Assist in the simulation of the far-field migration and fate of contaminants by providing conceptual and constitutive models of the near-field hydraulics and associated physical and hydraulic properties.
- Resolve issues (if they arise) involving the physical and computational scales and associated model parameters necessary to perform mass conserving and accurate simulations in both the near- and far-field for flow and contaminant release from the glass waste form.

Experiments and measurement protocols will be designed to resolve outstanding technical issues related to the conceptual model and physical or hydraulic properties. These measurements will be made on matrix materials proposed to surround or be mixed with the low-level radioactive waste glass, materials proposed for use in engineered structure and barriers, and the backfill soil. The experiments and measurements will be designed to address or discriminate between,

- Alternate constitutive models (e.g., equivalent-porous media models, dual-porosity models, or discrete fractured media models).
- Alternate constitutive models for the unsaturated hydraulic properties of matrix media, (i.e., backfill soil, backfill soil with favorable geochemical additives, air, and sulfur polymer cement), and structural materials, (i.e., concrete, gravel, clay).
- Alternate constitutive models for degraded matrix and structural materials.
- Influences of laboratory- and field-scale instruments on measured property values.
- Issues of spatial and temporal scale-up (laboratory-specimen to disposal-system scales) related to the accuracy of both near- and far-field hydraulic models.

Use will be made of laboratory instruments, measurement protocols, and sample preparation capabilities established under other tasks. This activity will be coordinated with

those tasks performing laboratory-scale measurements for characterization of near-field geochemical reactions and unsaturated hydraulic properties.

As final decisions are made on (a) the matrix, structural, and barrier materials, (b) the material, size, and shape of the "retrievable" waste package, and (c) the design of the engineered storage/disposal system, characterization of the unsaturated hydraulic properties of prototype materials will proceed and final constitutive and conceptual models will be presented for use in the final performance assessment.

For the purposes of this task, the near-field is defined as including all engineered elements of the disposal facility and barriers. This includes the

- Glass/matrix storage/disposal zone.
- The structural components of the engineered disposal facility (e.g., catchment basins, floor, walls, drains, interim covers).
- Engineered barriers surrounding the facility (e.g., capillary barriers).
- Backfill soils/sediments immediately surrounding the facility.

The study of conceptual and constitutive hydraulic models for the near-field environment will consider the behavior of intact and degraded materials. Toward that end, the probable mechanisms leading to degradation will be identified, the resulting form of physical or chemical degradation will be discussed, and the influence of degradation on the hydraulic conceptual and constitutive models will be described and, if possible, quantified.

Measurements of hydraulic properties (e.g., saturated hydraulic conductivity, water retention, and relative permeability) need to be performed at the scale appropriate to accurately simulate releases from the near-field. Whenever possible, the material specimens used in measurements of physical and hydraulic properties are to be of the actual materials proposed for the waste disposal system (i.e., representative specimens collected from engineering or vendor stockpiles).

Experiments that involve materials that have been fractured or otherwise degraded to represent possible future physical states, and their hydraulic properties will continue to be monitored. In other cases, where the aging process has been accelerated but is still relatively slow, experiments designed to test aged materials and determine their hydraulic properties will be continued. These experiments may be multiyear experiments designed to determine

intermediate steps in aging and associated hydraulic properties.

The performance of a gravel capillary barrier over the waste disposal zone has been identified as a key hydraulic barrier for both interim and long-term disposal. Glendon Gee has been involved in review and assistance to WHC during the spring of 1995. Under the near-field task, Glendon Gee will continue to advise and support the effort to design functional hydraulic barriers for the disposal system. The application of a capillary barrier (permanent moisture barrier) for the low-level tank waste disposal facility requires an analysis of capillary barrier performance under conditions that have not been tested previously. Issues that need resolution are identified below.

- Will the designed capillary barrier to be constructed withstand 1000-year storm events at the Hanford Site?
- What failure modes can be expected for a large-area (several hundred square meters or more) layered barrier that has a relatively low slope (less than 5%)? What hydraulic instabilities might exist at the interface of the capillary barriers?
- Are standard construction practices consistent with the required interface continuity (e.g., smoothness of slope) associated with a capillary break?

To resolve these issues and others that arise, Glendon Gee will use the existing literature and analyses to assist and advise the program.

In FY 1999 and perhaps beyond, in preparation for the final performance assessment and subsequent operation of the disposal facility, samples from contractor material stockpiles for the matrix, engineered structures and barriers will be tested to provide assurance that conceptual and constitutive hydraulic models used in the performance assessment are supported by the hydraulic properties of stockpiled materials and waste form packaging to be present in the final engineered facility.

c. Detailed Description of the Near-Field Task

Under this task the principle investigators, Charles Kincaid (Near-Field Conceptual Model and Hydraulics) and Glendon Gee (Capillary Barriers), will develop conceptual and constitutive models of the near-field by determining hydraulic properties of materials of interest, evaluating alternate constitutive models, and posing consistent conceptual models for near- and far-field simulations.

Under the near-field task, Glendon Gee has provided the program expert assistance and advice on the potential for a capillary barrier composed of gravel overlain by fine soils to wick deep drainage away from the waste form.

During FY 1998 this multiyear activity will,

- i. Prepare a topical report presenting methods and measurements of physical and unsaturated hydraulic properties of intact and degraded near-field materials selected for use in the final performance assessment.

During FY 1999 this multiyear activity will,

- i. Prepare a topical report presenting confirmatory physical and unsaturated hydraulic property measurements for the final performance assessment on near-field material specimens from material stockpiles (associated with engineered facility operation), and on specimens being tested under accelerated aging tests to determine long-term degradation effects on hydraulic properties.

2. Interfaces

Productive effort on this task is largely driven by decisions on candidate materials and designs for both the waste form and the engineered disposal facility. Candidate materials designs have been identified and do not currently pose a limitation to the conduct of work. However, as decisions change on waste form and engineered disposal system, so too does the scope of work, i.e., additional waste form and system design concepts would need to be explored.

The output of this task will be state-of-the-art conceptual and constitutive models, and measured values of physical and unsaturated hydraulic properties to be used in release rate calculations for the final performance assessments. This information will also feed to the design of engineered systems. The dates for which the information is needed correspond to dates for which specific performance assessment calculation and design tasks are performed.

Allen Lu (WHC) will oversee the task. Allen Lu is the cognizant scientist for the activity and he resides within the Environmental Modeling Section of WHC. Charles Kincaid, PNL, is the principle investigator. Other PNL participants include Glendon Gee, and other technical staff as determined necessary to support hydraulic and physical property measurements and confirmatory constitutive modeling.

Primary interfaces consist of the WHC participants, (i.e., Allen Lu, Frank Schmittroth, and Fred Mann), and B. Pete McGrail (PNL) who is performing release-rate calculations (Activities 3.4.6 and 3.5). The PNL interface for sulfur polymer cement and other.

matrix materials is P. Sliva.

3. Standards

No single specific standard is relevant to the topic of developing the conceptual model of hydraulic characteristics for a disposal facility. However, guidance documents from the DOE (including the DOE/HQ Peer Review Panel) on performance assessment of low-level waste disposal, and from the Nuclear Regulatory Commission for site selection and licensing of low-level waste sites will be used. ASTM standards on vadose zone investigations and modeling of the subsurface will also be reviewed and used where applicable to conceptual model development. The measurement of hydraulic and physical properties of candidate near-field materials will follow established standards where they exist, and will follow accepted methods for the measurement of especially difficult materials, e.g., hydraulic conductivity of highly impermeable materials such as sulfur polymer cement.

4. Quality Assurance

Topical reports will be subjected to PNL and WHC peer review before being issued. Periodic reviews will be conducted of work in progress.

Work at PNL will be conducted in accordance with PNL-MA-70, "PNL Quality Assurance Program Manual". PNL's quality assurance program responds to 10 CFR 830.120 and conforms to the requirements of ASME NQA-1, "1989 Quality Assurance Requirements for Nuclear Facilities", as interpreted by Parts 1 and 3 of PNL-MA-70. PNL uses a graded methodology for implementing the management controls used on projects and discrete work activities. The quality assurance plan (ETC-001) for PNL support to TWRS vitrification activities provides detailed information regarding the grading selection (impact level) and project specific requirements applicable to PNL Vitrification Technology Development Project work activities.

5. Schedule

- Prepare a topical report presenting methods and measurements of physical and unsaturated hydraulic properties of near-field materials selected for use in the final performance assessment. (start October 1, 1997; end September 30, 1999)
- Prepare a topical report presenting confirmatory physical and unsaturated hydraulic property measurements for the final performance assessment on near-field material specimens from material stockpiles (associated with engineered facility operation), and on specimens being tested under accelerated aging tests to determine long-term degradation effects on hydraulic properties. (start October 1, 1998; end March 30, 1999)

6. Cost

The cost estimates for this task are based on the effort and cost associated with determining hydraulic properties for the Hanford Site performance assessment and barrier technology programs, and for private industry. Costs of hydraulic property measurements for near-field materials may need to be reevaluated depending upon where these analyses are performed. Until the necessary measurements are known and initial measurements made, funding for measurements may be best held in an "other" or a "contingency" category. Once materials are defined (i.e., either simply of interest or selected for use) and it is determined that published hydraulic and physical properties are not available or representative, the measurements will need to be made. Therefore, the funding doesn't really represent a contingency fund.

FY-1998: Total itemized below: Expense \$266,000

Near-field conceptual model & hydraulics; \$150,000 (0.6 FTE Charles Kincaid, ~\$124,000; few hours from supporting scientific staff including Mark Rockhold, Mike Fayer, and Mark White, ~ 126,000).

Hydraulic property measurements; estimated \$50,000 (funding requirement for measurements will depend heavily on the materials and methods)

Gravel Capillary Barrier; Expense \$50,000; 0.2 FTE Glendon Gee.

\$16,000 is required for WHC professional time (1.47 man-months at \$130,000 per man-year) to oversee the activity.

FY-1999: Total itemized below: Expense \$276,000

Near-field conceptual model & hydraulics; \$160,000 (0.6 FTE Charles Kincaid, ~\$130,000; about 0.05 FTE each from supporting staff including Mark Rockhold, Mike Fayer, and Mark White, ~ \$30,000).

Hydraulic property measurements; estimated \$50,000 (funding requirement for measurements will depend heavily on the materials and methods; e.g., measurements of hydraulic properties for intact and degraded sulfur polymer cement may be expensive).

Gravel Capillary Barrier: \$50,000 for 0.2 FTE - Glendon Gee.

\$16,000 is required for WHC professional time (1.47 man-months at \$130,000 per man-year) to oversee the activity.

F. Determination of Hydraulic Properties

See Task E, just above.

3.4.9 Recharge

Generating defensible estimates of recharge rates at the Hanford Site for use in the final performance assessment.

See Activity 3.1.9

3.4.A Determination of Geochemical Data for the Final Performance Assessment

I. SUMMARY

The purpose of this task is to determine and quantify, through the use of existing data and laboratory experiments, the geochemical parameters important to the final performance assessment. This work includes determining the effects of sorption and solubility on contaminant transport through the waste matrix, the vadose zone, and the aquifer. This activity also includes identifying geochemical codes for use in the performance assessment, increasing the technical defensibility of the final performance assessment through natural analog studies, and resolving geochemical issues raised during review of the preliminary performance assessment.

II. GENERALA. Background

The Hanford low-level tank waste performance assessment requires knowledge of the site-specific geochemical parameters that will influence the transport of contaminants after leaching from the glass waste form. Chemical retardation of the contaminants through native sediments and engineered barriers emplaced in the near-field will be quantified in this activity. The data will be obtained through literature review, bench-scale laboratory testing, and mechanistic and empirical modeling. Long-term confirmation analyses will be attempted using critical analyses of available thermodynamic and natural analogue information gleaned from the literature. The major activity will be empirical laboratory testing using traditional batch and column techniques and the newly developed UFA (unsaturated flow apparatus) to generate site-specific and waste-form-specific chemical retardation data compatible with the needs of near- and far-field transport computer codes. The emphasis for the final performance assessment will be on obtaining accurate measurements of distribution coefficients (K_d) for Tc, I, Np, and U and other identified important radionuclides in Hanford soils and engineered waste-form materials/barriers. The empirical data will be generated in an iterative fashion such that some chemical retardation data of key contaminants will be available to other groups at each time that the performance assessment calculations are planned. Chemical and mineralogical characterization of test samples from the site will be carried out to aid in understanding of sorption results with these samples.

Solubility values will be determined under a range of conditions for several key radionuclides to determine to what degree the precipitation of solid phases may limit the source term for contaminant release. These solubility determinations will also indicate to what degree geochemical conditioners, placed beneath the waste vaults, may be effective in slowing the transport of contaminants.

The extrapolation of laboratory data to the required containment time is a problem that must be addressed. In this task a combination of thermodynamic analysis and data from natural analogue systems will be used to give technical defensibility to this necessary extrapolation.

The geochemical conditions that may exist along a contaminant flow path will be complex and it is impossible to duplicate all of them in laboratory experiments. Thus, it is important to identify geochemical codes that can, in conjunction with laboratory data, quantify important transport parameters such as solubility and speciation. This task will examine available geochemical codes and determine which is most useful for application to contaminant transport in the low-level tank waste performance assessment.

B. Organization

The responsible organization will be the Groundwater Management Section of the Westinghouse Hanford Company, J. S. Schmid, Manager. The cognizant scientist will be F. N. Hodges. The lead contact at PNL will be D. I. Kaplan and for WSU-TC will be J. Conca.

C. Vision

Estimations of the potential range of contaminant releases from the disposal facility to the accessible environment are key to the low-level tank waste performance assessment. The purpose of this activity is to provide the geochemical data that will allow estimation of contaminant transport rates through the waste package, the vadose zone, and the aquifer in the far-field. This transport data, coupled with the source terms, will allow the necessary modeling of contaminant release.

D. Objectives

The objectives of this activity are:

- 1) Provide high quality K_d and solubility values for use in the final performance assessment for engineered barrier, vadose zone, and aquifer contaminant transport.
- 2) Use thermodynamics and natural analogues to provide technical defensibility for data used in the final performance assessment.
- 3) To analyze and resolve geochemical issues that result from review of the preliminary performance assessment.
- 4) Finalize identification of geochemical codes for use in the final performance assessment.

E. Deliverables

- 1) Progress letter reports on geochemical data measurements in September 1998.
- 2) PNL Letter report on the site specific K_d values of studied contaminants and of the results of expert opinion on lesser contaminants in July 1998.
- 3) A topical paper on "Technical Rationale for Chemical Retardation Values Used in Final Performance Assessment" in January 1999.

- 4) A topical paper on "Use of Natural Analogues and Thermodynamics to Defend Long-term Extrapolation of Laboratory Chemical Retardation Data" in November 1997.
- 5) A topical paper on "Applicability of Mechanistic Adsorption Models for Key Contaminants in Hanford Low-Level Tank waste Disposal" September 1998.

III. TASK DESCRIPTIONS

A. Summary List of Task

- 1) Advise.
- 2) Determine K_d 's and solubilities for key radionuclides.
- 3) Geochemical codes.
- 4) Determine fate of water in concretes.
- 5) Natural analogue/technical defensibility.

B. Advise

1. Detailed Description

This task provides coordination between the geochemistry data effort and other parts of the low-level tank waste performance assessment effort and provides project management with needed information concerning project needs and progress. It also provides for review of documentation and oversight of work performed at PNL and WSU. The principal contributor will be F. N. Hodges

2. Interfaces

This task interfaces with project management, other steering panel members, and organizations carrying out work in this area, including PNL and WSU.

3. Standards

There are no applicable standards in this area.

4. Quality Assurance

not applicable

5. Schedule

Work will be done to meet the schedules of the steering panel.

6. Costs

\$32,500 is budgeted for each of FY 1998 and FY 1999.

C. Determination of Sorption K_d and Solubilities of Key Radionuclides

1. Detailed Description

Batch adsorption tests, which are performed at high water to solid ratios, are an important source of K_d data; however, these tests may not accurately measure small K_d values in the zero to one range, which is a very important (sensitive) range for performance assessment results. The use of column studies to measure breakthrough curves of key species is a way to indirectly obtain K_d values. The column breakthrough curve provides a retardation factor, which is the ratio of groundwater velocity to species velocity. The K_d value can be calculated from the retardation factor.

Radionuclide retardation is strongly dependent on the chemistry of the mobile (groundwater) and immobile (sediment) phases, the degree of saturation, and the unique solubility/precipitation and adsorption properties of each contaminant. No single K_d can adequately describe the partitioning of a contaminant in the range of environmental conditions likely present in both the near- and far-fields of the Hanford low-level tank waste site. To address this issue, "variable K_d s" will be developed that vary with the aqueous and solid phase conditions along the flow path. Variable K_d s will be developed through a systematic series of bench-scale laboratory studies by determining the empirical relationships between K_d values and various important geochemical parameters, such as ionic strength, complexants, competing ions, Eh, pH, number of sorption sites, etc. (thus variable $K_d = f[\text{ionic strength, complexants, competing ions, Eh, pH, number of sorption sites, etc.}]$).

Batch tests will continue with previously used Hanford sediment samples and will be supplemented with column tests. These tests will be phased over to site-specific test materials as samples from the characterization well become available.

The solubility of some contaminants of interest may be sufficiently low that release from the barrier material will be limited by a precipitated solid phase. If so, the maximum solution concentration is time invariant (assuming chemical conditions remain constant in the area where precipitation has occurred) and determined by the equilibrium reaction between the solid phase and whatever water is available. The equilibrium solution concentration can, in this case, be used as the source-term for release from the waste matrix. The affect of geochemical variables such as Eh and pH on solubilities will be key in determining the viability of geochemical barriers beneath the disposal facility. At a different level solubility data are necessary for the proper interpretation of sorption tests. In order to perform sorption experiments unambiguously, it is necessary to ensure that initial radionuclide or contaminant concentrations do not exceed solubility. If concentrations exceed solubility, sorption effects cannot be distinguished from precipitation effects when the element is removed from the aqueous

phase.

A critical literature review of solubility data will be carried out to identify solubility data usable in the performance assessment. This literature review will be used as a basis for determining what solubility tests should be carried out in support of the performance assessment. Following the literature review a limited number of solubility determinations will be carried out to fill gaps in the existing data. The determinations will be carried out in expected fluid compositions both with and without matrix solids present. The solubility values will, to the extent possible, be approached from both the solid and solution side (reversed) to help insure that equilibrium solubility values are obtained. They will also be carried out at several pH and Eh values to allow an estimate of the range of conditions under which these solubility values represent a reasonable source term.

The main contributors to this task will be R. J. Serne and D. I. Kaplan, of PNL and J. A. Conca of the WSU-TC.

2. Interfaces

Interfaces will be maintained with other team members dealing with parameters not covered in this task to understand the possible range of interactions. Interfaces will also be maintained with the geologists who are responsible for getting sediment cores for testing, with the engineers in charge of choosing barrier materials, and with the glass release source-term effort to ensure that the retardation studies use waters that cover the range of actual glass leachate compositions. This task will contribute K_d (or retardation) and solubility data to the vadose and groundwater transport tasks and will provide sorption and solubility values to the engineers designing the barrier systems. This task may also contribute to and perhaps perform laboratory tests on integrated systems should activity integrated testing become a key activity.

3. Standards

There are no laboratory standards per se in this area to follow. Past experience with chemical retardation aspects of risk and performance assessments will be used to guide activities (Serne et al., 1973; Serne et al., 1990).

4. Quality Assurance

Work at PNL will be conducted in accordance with PNL-MA-70, "PNL Quality Assurance Program Manual". PNL's quality assurance program responds to 10 CFR 830.120 and conforms to the requirements of ASME NQA-1, "1989 Quality Assurance Requirements for Nuclear Facilities", as interpreted by Parts 1 and 3 of PNL-MA-70. PNL uses a graded methodology for implementing the management controls used on projects and discrete work activities. The quality assurance plan (ETC-001) for PNL support to TWRS vitrification activities provides detailed information regarding the grading selection (impact level) and project specific

requirements applicable to PNL Vittrification Technology Development Project work activities.

5. Schedule

Progress letter reports on geochemical data measurements will be produced in September 1998. A letter report of the site-specific K_d values of studied contaminants and of the results of expert opinion on lesser contaminants will be prepared in July 1998, and a topical paper of "Technical Rationale for Chemical Retardation Values Used in Final Performance Assessment" will be prepared in January 1999. In addition, a topical paper of "Applicability of Mechanistic Adsorption Models for Key Contaminants in Hanford LLW Glass Disposal" September 1998.

6. Cost

\$150,000 is budgeted for FY 1998 and \$50,000 is budgeted for FY 1999.

D. Geochemical Code Identification

1. Detailed Description

The transport properties of many key radionuclides, including both their K_d and solubility, depend strongly on their oxidation state and speciation. In order to understand the behavior of these radionuclides, it is necessary to identify geochemical codes, for application in both the near- and far-fields, that can predict oxidation state, speciation, and solubilities under various geochemical conditions that may exist within the vadose zone and aquifer beneath the low-level waste disposal site.

The choice of geochemical code will depend on several factors, such as what data bases can it access, what data bases are available, kinetics or equilibrium assumptions, hydraulic capability or hydraulic interface, etc. This task will survey the available geochemical codes that are available (there is no intent to do development here) and the corresponding data bases, document the pros and cons of each code, weigh the needs of the low-level tank waste performance assessment and choose a code that best fits the needs of the performance assessment. With the variable K_d being developed by PNL, a geochemical code that will predict and keep track of the variables (pH, competing ions, etc.) that the variable K_d needs, will be useful. As the factors that affect K_d values change over time and space, the K_d will change accordingly.

2. Interfaces

WHC staff will coordinate with PNL and other geochemists at outside laboratories who have experience in using geochemical codes and their linking with flow/transport codes. Within the geochemistry task, WHC personnel will interface with the staff involved in the sorption and solubility work. Within the performance assessment project it will interface with the vadose

and groundwater transport tasks.

3. Standards

Not applicable.

4. Quality Assurance

Only codes with complete, publicly available user's guides that address code verification exercises will be considered.

5. Schedule

To be determined.

6. Cost

\$40,000 is budgeted for FY 1998 and \$20,000 is budgeted for FY 1999.

E. Determine fate of water in concrete

1. Detailed Description

Concrete or cement contains a high percentage of water after setting. Given the large quantity of concrete that will exist within the disposal facility the fate of this water is important to the overall performance of the waste disposal system. In the short term concrete normally acts as a sink for water because of unreacted clinkers of anhydrous calcium-aluminum silicates within the concrete. However, the reaction between clinkers and water produces a hydrous calcium-aluminum silicate gel that is inherently unstable from a thermodynamic point of view. The important question over the long-term is whether the phases that eventually crystallize from the gels are hydrous or anhydrous. If the phases are anhydrous, or less hydrous than the gels, the excluded water may be released into the waste vault environment.

Principal contributors will be R. J. Serne of PNL and F. N. Hodges of WHC.

2. Interfaces

This will interface with the design engineering function and the source term task (Activity 3.4.6).

3. Standards

Not applicable.

4. Quality Assurance

Work at PNL will be conducted in accordance with PNL-MA-70, "PNL Quality Assurance Program Manual". PNL's quality assurance program responds to 10 CFR 830.120 and conforms to the

requirements of ASME NQA-1, "1989 Quality Assurance Requirements for Nuclear Facilities", as interpreted by Parts 1 and 3 of PNL-MA-70. PNL uses a graded methodology for implementing the management controls used on projects and discrete work activities. The quality assurance plan (ETC-001) for PNL support to TWRS vitrification activities provides detailed information regarding the grading selection (impact level) and project specific requirements applicable to PNL Vitrification Technology Development Project work activities.

5. Schedule

A topical report setting forth the long-term stability of water in concrete will be prepared in July 1998.

6. Cost

This task is funded for \$50,000 in FY 1998 and \$0 in FY 1999.

F. Natural Analog and Technical Defensibility

1. Detailed Description

This task will provide technical defensibility for the use of short-term laboratory through thermodynamic analysis and data from natural analogue systems. These geochemical issues that emanate from the reviewers of the performance assessments will be addressed using letter reports or topical reports that draw from literature and project specific laboratory studies.

The main contributors to this task will be F. N. Hodges, V. G. Jonson, S. R. Reidel and J. W. Shade of WHC and R. J. Serne, K. M. Krupka, D. I. Kaplan, J. M. Zachara, and D. Rai of PNL.

2. Interfaces

This task will interface with other tasks and with reviewers of the preliminary performance assessment.

3. Standards

To be determined.

4. Quality Assurance

To be determined.

5. Schedule

To be determined.

6. Cost

\$175,000 is budgeted for FY 1998 and \$200,000 is budgeted for FY 1999.

3.4.B Groundwater Data for Final Performance Assessment

I. SUMMARY

Refine the conceptual model of groundwater flow and contaminant transport in the vicinity of the low-level tank waste disposal site and obtain the groundwater site-specific data needed to perform flow and transport calculations for the final performance assessment.

II. GENERALA. Background

A generalized Hanford site-wide groundwater flow model is needed to (1) develop a conceptual model of groundwater flow and contaminant transport in the vicinity of the low-level tank waste disposal site, (2) provide boundary or reference conditions for site specific models, and (3) evaluate potential plume mixing. Furthermore, because of the variability within similar sediment types displayed across the Hanford site, it is necessary to gather site specific data if a site specific decisions and models are to be made.

Numerical flow and transport codes such as PORFLOW, VAM3D, and CFEST are available for assessing flow and transport in both vadose zone and aquifer. VAM3D has also been used for site-wide groundwater study. The study was funded by the Environmental Restoration program (WHC) and the Liquid Effluent/Groundwater Impact Program (WHC) over the past several years. An initial calibration (subject to change) of the flow model for a two-layer geologic system was completed at the end of FY 1994. The two-layer system consists of a high-conductivity layer representing the pre-Missoula/Hanford, where it exists, over a low-conductivity layer representing the "E" sequence of the Ringold. Responsibility for continued calibration of the model has been transferred to Bechtel Hanford. However, in recognition of the need for applying the model to evaluating consequences of disposing effluents of waste management facilities and obtaining field scale parameters, WHC will continue the effort to refine site-wide flow and transport models.

B. Organization

The cognizant organization is Environmental Modeling. The cognizant scientist will be Allen Lu. Key investigators will be Allen Lu, Frank Schmittroth, Gene Freeman, and Dave Langford.

C. Vision

Defence of groundwater flow and contaminant transport modeling depends on the appropriate conceptual model and acquisition and implementation of adequate and appropriate data.

D. Objectives

Refine the conceptual model of groundwater flow and contaminant transport in the vicinity of the low-level tank waste disposal site and obtain the groundwater site-specific data needed to perform flow and

transport calculations for the final performance assessment.

E. Deliverables

- 1) A letter report describing further data collection and analysis. The letter report will be written by August 1, 1998 and issued by September 30, 1998 (after peer review).
- 2) A letter report describing the further data collection and analysis. The letter report will be written by August 1, 1999 and issuance by September 30, 1999 (after peer review).

III. TASK DESCRIPTIONS

A. Summary List of Activities

- 1) Model testing and calibration.
- 2) Obtain groundwater data for final performance assessment.
- 3) Visualization.
- 4) Identify groundwater field testing location and approach.
- 5) Advise and steering group participation.

B. Groundwater Model Testing and Calibration

1. Detailed Description

A large amount of data has been collected at Hanford that can be used to check flow and transport models. Work is continuing in this area. There is a need to better coordinate these efforts and to consolidate past efforts into a more coherent framework. The site-wide model would be a useful tool for integrating these efforts. Model testing and calibration process will enhance the understanding and interpretation of these data.

2. Schedule

FY 1998	Continue testing and calibration of the site-wide transport model with other contaminant plumes. Establish clear and consistent interpretation of the existing plumes. Continue to document the findings.
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3. Costs

FY 1998	0.35 FTE is anticipated for WHC scientists, costing approximately \$46,000 at \$130,000 per FTE.
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C. Obtain Groundwater Data for Final Performance Assessment

1. Detailed Description

Describe tasks which will help define physical parameters at work beneath the low-level tank waste disposal site. These physical parameters are primarily associated with hydraulic flow and contaminant transport properties. Parameters of interest include (1) hydraulic conductivity distribution, (2) storativity, (3)

boundary values, (4) distribution coefficients (K_d), and (5) dispersivity.

Dispersivity is the spread of a contaminant plume about its center of mass due to redistribution of contaminant mass along peripheral flow channels in the porous media. One potential method for defining the dispersivity is by the using spatial moments analysis. Spatial moments were used in previous studies by Freyburg (1986), Garabedian et al. (1991), Knox (1993), and Farrell et al. (1994) to define plume characteristics. By using the spatial moments method, the mass of the plume is calculated by the zeroth moment. The center of mass is calculated from the first spatial moment. The variance (dispersivity) about the center of mass is calculated from the second spatial moment.

By applying the spatial moments technique to contaminant distributions measured at monitoring wells, it is hoped that the dispersivity can be derived from the second spatial moment. Additionally, the flow path can be derived from first spatial moment (center of mass) at different time steps. Use of this method for a reactive constituent in conjunction with a nonreactive constituent will provide a means of calculating the distribution coefficient of the reactive contaminant plume.

2. Schedule

FY 1998

Data generated during tracer test experiments in FY 1997 will hopefully yield vertically distributed constituent data. These data will be used as input to the spatial moments model to define vertical dispersivity within the stratigraphic profile. Conceptualization of a 3-D plume will be developed from the tracer test data and FY 1996 results. Collation of data and integration into the spatial moments model will take 3 to four weeks. Report preparation will take four to six weeks.

FY 1999

The spatial moments test will be applied to other plumes onsite to determine spatially distributed dispersivity at Hanford. Collection of data at each additional site will take eight to twelve weeks. Report preparation will require four to six weeks.

3. Costs

FY 1998

0.3 FTE is anticipated for WHC scientists, costing approximately \$46,000; \$26,000 is anticipated for data access support (other scientist).

FY 1999

\$ 70,000 is anticipated.

4. References:

Farrell, D.A. and A.D. Wood, 1994, "The 1978 Borden Tracer Experiment: Analysis of the Spatial Moments", Water Resources Research, Vol. 30, No. 11, pp 3213-3223.

Freyburg D.L., 1986, "A Natural Gradient Experiment on Solute Transport in a Sand Aquifer, 2. Spatial Moments and the Advection and Dispersion of Nonreactive Tracers", Water Resources Research, Vol. 22, No.13, pp. 2031-2046.

Garabedian, S.P., D.R. LeBlanc, L.W. Gelhar, and M.A. Celia, 1991, "Large Scale Gradient Tracer Test in Sand and Gravel, Cape Cod, Massachusetts, 2. Analysis of Spatial Moments for a Nonreactive Tracer", Water Resources Research, Vol. 27, No. 5, pp. 911-924.

Knox, R.C., 1993, "Spatial Moments Analysis of Mass Balance Calculations and Tracking Movement of a Subsurface Hydrocarbon Mound", Groundwater Monitoring and Remediation, Summer, pp. 139-147.

D. Visualization

1. Detailed Description

It may prove helpful to input the measured data into a package which will provide visualization in three dimensions. This process will allow evaluation and identification of areas at the site which require (a) additional conceptualization (data gaps), (b) parameter distributions, and (c) show spatial distribution of sampling points. The advantage of visualization is that the data is viewed as an ensemble package with all components of the physical system present. This software is designed to represent geologic structures, hydrologic features, and contaminant distributions. Well locations and screen intervals can be shown. While the program is active, physical and chemical properties of the wells can be defined by clicking on each select well. Plume dimensions are calculated from the scatter data using a minimum tension gridding routine. Plume dimensions can then be plotted and contaminant volumes for user define concentration isopleths can be calculated.

2. Schedule

FY 1998

Incorporation of vertical constituent distributions collected through tracer tests (FY 1997), which will allow more complete 3-D visualization of the groundwater system.

FY 1999

Continue to add data to the visualization database. Generate an animation to show how the contaminant plume has been evolving during the previous years. Add pre-1996 data of contaminant concentrations. This will allow an extended view of plume dynamics.

3. Costs

FY 1998 \$5,000 is anticipated.

FY 1999 \$18,000 is anticipated.

E. Identify Groundwater Field Testing Location and Approach

1. Detailed Description

The conceptual model will identify those areas requiring field work to collect necessary information. Plans to perform field work to collect data must be written, approved, and implemented. Certain areas may require drilling, if no wells currently exist in the area of concern, or the existing wells are unsuitable. Expert consultation will be used to assist in the test plan and enhance the credibility of the test results.

2. Schedule

FY 1998

Continuation of tracer tests. May use a reactive constituent to determine distribution coefficient. Perform data analysis and interpretation. Report preparation of tracer test results.

3. Costs

FY 1998 \$28,000 is anticipated for WHC scientist; \$26,000 is anticipated for other support.

F. Advise

1. Description

Participate in steering group meetings and provide assistance/advise to other tasks.

2. Interfaces

Coordinate with related programs.

3. Schedule

Task is a continuing activity.

4. Cost

Cost is contained in above tasks.

3.4.C Dose Modeling Data for the Final Performance Assessment

I. SUMMARY

Continue upgrades to the food chain data base used for performance assessment calculations. Areas of specific interest are stochastic methods for dose determination.

II. GENERALA. Background

Sensitivity studies rely on the parameter distributions to evaluate the range of possible dose consequences. From the sensitivity studies, it is possible to decide which parameters are most important in determining the projected doses. The validity of these key parameters determines the validity of the overall results.

B. Organization

The responsible organization will be the Environmental Modeling Section of the Westinghouse Hanford Company, Nick Anderson, Manager. The cognizant scientist will be Paul Rittmann.

C. Vision

The goal of the performance assessment is to provide "reasonable assurance" that the disposal activities will protect long-term human health and safety. The ranges of parameter values must be considered to justify the use of the word "reasonable".

D. Objectives

This activity will determine the ranges of the parameters used in the calculations for the final performance assessment.

E. Deliverable

Letter report providing parameter ranges and distributions for the final performance assessment (March 31, 1999).

III. TASK DESCRIPTIONSA. Summary List of Tasks

- 1) Determine parameter distributions
- 2) Advise and steering group participation

B. Determine Parameter Distributions

1. Detailed Description

Based upon relevant literature searches the distributions will be identified and documented.

The main contributor to this task will be Paul D. Rittmann.

2. Interfaces

The inputs for this task will be technical literature and the opinions of individuals with first-hand knowledge of the problem, such as Bruce Napier of PNL.

The output of this task will determine the parameter ranges and distributions for dosimetry parameters. The letter report will be formally reviewed by the standing low-level waste performance assessment review groups.

3. Standards

There are no relevant standards in this area. However, guidance from the DOE Peer Review Panel and from the NRC staff will be used.

4. Quality Assurance

The letter report will be reviewed internally before issuance.

5. Schedule

The task will formally start October 1, 1997 with the letter report written by March 31, 1999.

6. Cost

0.5 FTE of WHC professional time costing \$130,000 per FTE for a total of \$65,000 will be required each of the fiscal years 1998 and 1999.

C. Advise

1. Description

Participate in steering group meetings and provide assistance/advise to other tasks.

2. Interface

Coordinate with related programs.

3. Schedule

Task is a continuing activity.

4. Cost

Cost is contained in above tasks.

3.4.D Integrated Borehole

see Activity 3.1.D

3.4.E Integrated Testing of the Low-Level Waste Package and Disposal System

I. SUMMARY

This activity focuses on the integrated testing of the waste package and disposal system performance. Establishing the release rates of radioactive waste constituents and hazardous constituents from the engineered low-level tank waste disposal system and establishing how these materials move in the environment are critical to assessing the long-term performance of the disposal system.

II. GENERALA. Background

An assessment of the long-term performance of the low-level tanks waste disposal system is being developed as required by DOE Order 5820.2A. This Order establishes the requirements for preparing and maintaining a site-specific performance assessment. The performance assessment needs to show that the engineered disposal system and the natural environment work together to protect the health and safety of the public by preventing excessive release of contaminants determined by State, Local, and Federal regulations and ALARA principles. To show this protection, measurements, experiments, and analyses on the waste disposal system are necessary. Among the key inputs required to support the performance assessment are experimental data, physical models, and computational models.

A long-term effort is needed to develop computational and physical models that describe the release of the constituents from the disposal system. The computational models for the performance assessment describe the release of the constituents from the low-level waste package and the influence of various design features incorporated into the engineered disposal system. To validate these computational models, physical models closely approximating the conditions expected in the low-level waste disposal system are needed. Testing protocols are also needed to reflect the conditions in the disposal system. This activity is directed at meeting these programmatic needs by continuing the integrated testing of the engineered disposal system.

B. Organization

The responsible organization will be the Environmental Modeling Section of the Westinghouse Hanford Company, Nick Anderson, Manager. The cognizant scientist will be Fred Mann. The cognizant engineer performing the tasks will be Cheryl Eiholzer of TWRS Disposal Engineering, Process Design Section, John Garfield, Manager.

C. Vision

To develop and execute tests simulating the disposal system for understanding the behavior of the system and for obtaining data for performance assessment computer models.

D. Objectives

The objective of this activity is to initiate and coordinate testing activities directed at the development and validation of the constituent release models for the disposal system. The focus of the integrated testing will be on the interaction of the waste package and the components of the engineered disposal system, the engineered components, and the release rate from the disposal system.

E. Deliverables

- 1) Semiannual internal memos summarizing the testing progress will be issued to the performance assessment team. (Due at mid-fiscal year and at the end of the fiscal year.)
- 2) Annual testing summaries will be issued by the testing organization at the end of the fiscal year and at the end of this activity if the activity does not stop at the end of a fiscal year.
- 3) Internal memos updating the needs and plans for the integrated testing. The updates will be used for the following year's fiscal planning.
- 4) A letter report containing the most recent understanding of the performance of the disposal systems. This data report will be used for the final performance assessment.

III. TASK DESCRIPTIONS**A. Summary List of Tasks**

- 1) Implementation and coordination of the testing.
- 2) Summary of the current understanding of waste disposal system release rate.
- 3) Advise and steering group participation.

B. Implementation and Coordination of the Testing**1. Detailed Description**

Programs for assessing the long-term performance of the low-level waste disposal facility were started in Activity 3.1.E. These integrated tests may not stop after providing data for the preliminary performance assessment. The duration of some long-term tests is a few years. Data for the preliminary performance assessment may also indicate additional areas of testing for data for the final performance assessment.

The scope of this task consists of continuing coordinations of needed existing tests and implementing needed new tests.

2. Interfaces

Input will be from PNL and WHC staff responsible for the waste package development, the engineered barrier development, and the performance assessment activities. There will also be interfaces between the cognizant engineer and the contracts personnel and the organization performing the work.

The main output from this task is data to use or verify computational models being used for the performance assessment. (Activities 3.1.6, 3.2, 3.4.6, and 3.5).

3. Standards

The tests will be required to follow appropriate standards. Standards will be decided on a case-by-case basis.

4. Quality Assurance

Tests will be required to have the appropriate quality assurance for data used for decision making. Scoping tests could have a lesser quality assurance level. The quality assurance level will be decided on a case-by-case basis.

5. Schedule

This task will start on October 1, 1997. This coordination task will end March 31, 1999. Internal memos summarizing the progress of the testing for the performance assessment will be issued. These memos will be due March 31, and September 30 of each fiscal year. The performance assessment needs and direction for the testing will be reevaluated every fiscal year for planning the following fiscal year. The needs and directions will be documented in internal memos due March 31, 1999. Organizations performing the testing will be required to submit end of the fiscal year summaries. Updates of these summary reports for information to be used for the final performance assessment will be required by December 31, 1998.

6. Cost

The estimated cost, in FY 1995 dollars, is:

FY 1998:	3.5 man-months at \$130,000/man-year - \$37,920
	testing: \$200,000 (estimated)
FY 1999:	2.2 man-months at \$130,000/man-year - \$23,833
	testing \$75,000 (estimate)

The cost is based on time needed for interfacing, writing internal memos, documenting mid- and end-of-year testing status, interfacing with the testing organizations, and advising the performance assessment team. All costs are based on previous experience. The testing cost is based on one focused experiment.

C. Summary of the Current Understanding of Waste Disposal System Release Rate

1. Detailed Description

The scope for this task is to write a data report on the most recent understanding of the disposal system performance based on the ongoing test(s). The data report will be for the final performance assessment data package. The reason for the report is to summarize the testing results in one document in order to document assumptions that will be made for the final performance assessment.

2. Interfaces

The input data needed are the status and final reports from the testing organizations.

The output data will be used by the performance assessment team for the modeling efforts for the final performance assessment (Activity 3.5).

3. Standards

There are no relevant standards in this area.

4. Quality Assurance

All reports will be reviewed before issuance.

5. Schedule

The task will start on January 1, 1999 when writing on the disposal system data package will start. The data package will be issued by March 31, 1999.

6. Costs

The following cost breakdown, in FY 1995 dollars, includes engineering time and secretary support.

FY 1998: 0 none

FY 1999: 2 man-months at \$130,000/man-year - \$21,667

The cost is based on producing a supporting document. Time is based on writing, secretarial support, graphic support, and document control. Time is based on experience of producing other supporting documents.

D. Advise

1. Description

Participate in steering group meetings and provide assistance/advise to other tasks, especially the modeling tasks.

2. Interfaces

Coordinate with related programs.

3. Schedule

Task is a continuing activity.

4. Cost

Cost is contained in above tasks.

3.4.F Sensitivity

I. SUMMARY

Develop uncertainty/sensitivity strategies and implement conceptual and summary models suitable for analysis and presentation of uncertainties.

II. GENERAL

A. Background

Uncertainties arise from scenario selections, conceptual models, data uncertainties, extrapolation to future times, and integration of these issues in numerical computer models. This task supports the Performance Assessment by providing independent and supporting justification for the selected methods and models.

Preliminary work has included a review of regulatory papers and work by others that will assist in developing an acceptable strategy for treating uncertainties. It is recognized that while formal uncertainty analyses may be required, there may well be aspects of the Performance Assessment that are not amenable to these approaches. In these situations, it is deemed imperative that the sources of uncertainty or ambiguity be clearly stated such that independent reviewers and stakeholders are fully informed with the best attainable data.

B. Organization

The responsible organization is the Environmental Modeling Section. The cognizant scientist is F. Schmittroth with support from the Environmental Modeling Staff.

C. Deliverables

Letter report documenting uncertainty analysis for representative tasks.

III. TASK DESCRIPTIONSA. Summary list of tasks

- 1) Conceptual models.
- 2) Simplified mathematical representations of conceptual model.
- 3) Advise.

B. Conceptual Models

1. Description

This task shall provide independent assessments of the validity and appropriateness of the supporting methodologies and models selected for the Performance Assessment tasks.

Critical independent assessments of conceptual models

supporting the Performance Assessment are needed to obtain a defensible analysis. Many aspects of the Performance Assessment models depend on expert judgments where contrasting approaches and viewpoints are beneficial and necessary. The importance of an independent perspective is emphasized by inherent difficulties in directly validating the results of a Performance Assessment.

2. Interfaces

Close coordination with the respective Performance Assessment team tasks required.

3. Schedule

The scope will be determined in 3.1.F.B, due in FY 1996.

4. Cost

Thirty thousand dollars (\$30,000) (about 2.8 man-months at \$130,000 per man-year) in FY 1998 and \$30,000 in FY 1999. These costs are based on past experience.

C. Simplified mathematical representation of conceptual model.

1. Description

Develop simple alternative models representative of both global and individual processes that support more complex calculations but that transparently represent the fundamental processes.

This task represents one specific alternative to complex numerically-based models. The initial work will focus on the feasibility of the approach using simple models to represent source terms, release rates, and transport through the vadose zone and unconfined aquifer. Continuing work will further develop the consequences of these simple models.

2. Interfaces

Application of alternative models requires close coordination with the respective Performance Assessment team tasks.

3. Schedule

Scope will be determined in 3.1.F.C, due in FY 1996.

4. Cost

Sixty thousand dollars (\$60,000) (about 5.5 man-months at \$130,000 per man-year) in FY 1998 and in FY 1999. These costs are based on past experience.

D. Advise

1. Description

Advise and coordinate independent uncertainty assessments in this task with those performed directly within the respective tasks.

2. Interfaces

Application of alternative models requires close coordination with the respective Performance Assessment team tasks.

3. Schedule

Continuing activity

4. Cost

Thirty thousand dollars (\$30,000) (about 2.8 man-months at \$130,000 per man-year) in FY 1998 and in FY 1999. These costs are based on past experience.

3.5 Calculate Results and Write Final Performance Assessment

I. SUMMARY

This activity consists of performing the actual calculations and analyses that appear in the final performance assessment and writing the document.

II. GENERALA. Background

Earlier activities (3.4.X) produced the data and methods to be used in the final performance assessment.

B. Organization

The responsible organization will be the Environmental Modeling Section of the Westinghouse Hanford Company, Nick Anderson, Manager. The cognizant scientist will be Fred Mann.

C. Vision

The final performance assessment is the document required by DOE Order 5820.2A to allow waste disposal.

D. Objectives

This activity will produce the final performance assessment.

E. Deliverables

- 1) Final Performance Assessment as a letter report will be sent to the Program Office (June 30, 1999).

III. TASK DESCRIPTIONSA. Summary list of tasks

- 1) Write final performance assessment.

B. Write Final Performance Assessment

1. Detailed Description

All calculations and analyses that will appear in the final performance assessment will be performed.

The final performance assessment (including required background information, integration, and interpretation) will be written.

The main contributors to this task will be the entire performance assessment team.

2. Interfaces

The input for this task was generated in 3.4.X tasks.

The output of this task will be the final performance assessment ready for review by the program office, RL, and other internal Hanford reviews.

3. Standards

There are no relevant standards in this area. However, guidance from the DOE Peer Review Panel and from the NRC staff will be used.

4. Quality Assurance

The letter report will be reviewed by the performance assessment team before issuance.

5. Schedule

The task will start three months before the data packages are ready. It will take six months to complete. The due date is June 30, 1999.

6. Cost (FY 1999)

0.75 FTE of WHC professional time will required for calculation, writing, and editing. Using \$130,000 per FTE, the total cost is \$97,500.

This estimate is based on having only minor revisions from the preliminary performance assessment due to the review of the Peer Review Panel and to new data. Work will include (about equally) time for analyses, writing, and editing.

3.6 PRP/HQ Review and Approval

I. SUMMARY

The Peer Review Panel and DOE-Headquarters are to review and approve the final performance assessment.

II. GENERALA. Background

The final performance assessment is the regulatory document allowing the disposal of radioactive waste in a disposal facility. By DOE Order 5820.2A, both the Peer Review Panel and DOE Headquarters must review and approve the final performance assessment before disposal occurs.

B. Organization

The responsible organization will be the Environmental Modeling Section of the Westinghouse Hanford Company, Nick Anderson, Manager. The cognizant scientist will be Fred Mann.

C. Vision

The final performance assessment should withstand any attacks on its methods, data, or interpretations.

D. Objectives

This activity consists of interfacing with the groups which will review and approval the final performance assessment.

E. Deliverables

- 1) Communications from review bodies on the adequacy of the final performance assessment (June 30, 2000).

III. TASK DESCRIPTIONSA. Summary list of tasks

- 1) PRP/DOE Review/Approval of the final performance assessment.

B. PRP/DOE Review/Approval of the final performance assessment

1. Detailed Description

The Peer Review Panel and DOE will review and approve the final performance assessment. If changes to the document are required, they will be made by the performance assessment team.

The main interface to the reviewers will be Fred Mann.

2. Interfaces

The input for this task is the final performance assessment generated in activity 3.5 (and possibly modified because of the review occurring in 3.6).

The output of this task will be approval to disposed of radioactive waste in the disposal facility.

3. Standards

There are no relevant standards in this area.

4. Quality Assurance

The review groups will establish their own quality assurance.

5. Schedule

The task will start once the Final Performance Assessment is written. It is expected to take 12 months to obtain Peer Review Panel and headquarters approval.

6. Cost

Cost will be covered in the management task (Activity 1.3).

4.1 Maintain Interface with Operations

I. SUMMARY

Obtain information from operations and construction activities in order to revise performance assessment.

II. GENERALA. Background

DOE Order 5820.2A requires periodic updates based on new information. An important source of new information is the information concerning the disposal facility in its as-built condition and inventory actual placed into the waste form.

B. Organization

The responsible organization will be the Environmental Modeling Section of the Westinghouse Hanford Company, Nick Anderson, Manager. The cognizant scientist will be Fred Mann.

C. Vision

The final performance assessment should withstand any attacks on its methods, data, or interpretations.

D. Objectives

This activity will gather the information from operations for maintaining the performance assessment.

E. Deliverables

none in this time period

III. TASK DESCRIPTIONS

The estimate cost for these activities per year is 0.67 FTE or \$87,000, assuming \$130,000 per FTE.

A. Summary list of tasks

- 1) Obtain as-built disposal facility information.
- 2) Obtain actual glass inventory.

B. Obtain As-Built Facility InformationC. Obtain Actual Glass Inventory

4.2 Obtain Experimental Data for Performance Assessment Maintenance

I. SUMMARY

Obtain information from experiments in order to revise performance assessment.

II. GENERALA. Background

DOE Order 5820.2A requires periodic updates based on new information. An important source of new information is the information from on-going experiments.

B. Organization

The responsible organization will be the Environmental Modeling Section of the Westinghouse Hanford Company, Nick Anderson, Manager. The cognizant scientist will be Fred Mann.

C. Vision

The final performance assessment should withstand any attacks on its methods, data, or interpretations.

D. Objectives

This activity will gather the information from experiments for maintaining the performance assessment.

E. Deliverables

none in this time period

III. TASK DESCRIPTIONS

The estimate cost for these activities per year is estimated to be \$1,000,000. Better estimates will be made as the project matures.

A. Summary list of tasks

- 1) Perform glass release rate experiments.
- 2) Perform integrated waste package experiments.
- 3) Perform other experiments.

B. Perform Glass Release Rate ExperimentsC. Perform Integrated Waste Package ExperimentsD. Perform Other Experiments

APPENDIX A
PA ACTIVITIES

(underline indicates activity done by end of FY 1995)
(start dates are beginning of month, end dates are at end of month)

	Constant Funding
1.0 Guidance Using Performance Assessment Activities	
1.1 Provide Guidance for Early Activities	<u>1/94- 7/94</u>
1.2 Provide Guidance for Interim Activities	<u>8/94- 9/95</u>
1.3 Management of PA Activities	10/95-
1.4 External Review	10/95-
2.0 Interim PA	12/93- 6/97
2.1 Obtain data	<u>12/93- 9/95</u>
2.1.1 Performance objectives	<u>1/94- 1/95</u>
2.1.2 Scenarios and pathways (including land use)	<u>3/94- 3/95</u>
2.1.3 Tool selection and verification	<u>5/94- 6/95</u>
2.1.4 Inventory	<u>12/93- 9/95</u>
2.1.5 Disposal Facility	<u>12/93- 9/95</u>
2.1.6 Release Rates	<u>12/93- 9/95</u>
2.1.7 Far field transport data	<u>12/93- 9/95</u>
2.2 Calculate responses and document	10/95- 9/96
2.3 Define contingencies	10/96- 3/97
2.4 Have internal review	10/96-12/96
(1.4) External Review with public input	1/97- 6/97
3.0 Performance Assessment	
3.1 Obtain data for preliminary PA	1/94- 9/97
3.1.1 update performance objectives	10/96- 6/97
3.1.2 update scenarios and pathways	10/96- 6/97
3.1.3 Tool selection, verification, and certification	7/95- 9/97
3.1.4 Inventory	10/95- 9/97
3.1.5 Disposal Facility	10/95- 9/97
3.1.6 Release Rates	1/94- 9/97
3.1.7 Matrix Interactions	1/95- 9/97
3.1.8 Geologic/hydrologic Data	10/94- 9/97
3.1.9 Recharge Data	1/94- 9/97
3.1.A Chemical Retardation Data (K_d)	10/94- 9/97
3.1.B Saturated Flow Data	10/94- 9/97
3.1.C Dosimetry and air transport data	10/94- 9/97
3.1.D Integrated Borehole	10/94- 9/97
3.1.E Integrated Tests	10/94- 9/97
3.1.F Sensitivity	1/94- 9/97
3.1.G TWRS Complex Characterization	10/94- 9/97
3.2 Calculate Response and document for Preliminary PA	10/97- 3/98
3.3 PRP review of Preliminary PA	4/98- 9/98

3.4	Obtain data for final PA	9/97- 3/99
3.4.1	Update performance objectives	10/98-12/98
3.4.2	Update scenarios and pathways	10/98-12/98
3.4.3	Update tools	10/97- 3/99
3.4.4	Inventory	10/97- 3/99
3.4.5	Disposal Facility	10/97- 3/99
3.4.6	Release Rates	10/97- 3/99
3.4.7	Matrix Interaction	10/97- 3/99
3.4.8	Hydrologic data	10/97- 3/99
3.4.9	Recharge Data	10/97- 3/99
3.4.A	Chemical retardation data (K_d)	10/97- 3/99
3.4.B	Saturated Flow Data	10/97- 3/99
3.4.C	Dosimetry and Air Transport data	10/97- 3/99
3.4.D	Integrated borehole	10/97- 3/99
3.4.E	Integrated Testing	10/97- 3/99
3.4.F	Sensitivity	10/97- 3/99
3.4.G	TWRS Complex characterization	10/97- 3/99
3.5	Calculate responses and document for final PA	1/99- 6/99
3.6	PRP/HQ review and approval	7/99- 6/00
4.0	Long-term Maintenance	
4.1	Monitor Operations	4/99-
4.2	Long-term experiments	4/99-
4.3	Write revision of performance assessment	9/03-
4.4	Review revision	9/04-

APPENDIX B
FORMAT and CONTENTS

I. SUMMARY

Include a one paragraph statement which summarizes the effort for which the statement of work is to become the management plan document.

II. GENERAL

A. Background

- 1) Identify need for this activity.
- 2) Describe previous work including studies, functions and requirements, design criteria, etc. The criteria to be met by the end product must either be referenced or contained in the statement of work. If the criteria is not available, specify that end product criteria must be generated as one of the tasks.

B. Organization

Define the cognizant organization and all supporting organizations responsible for completing the work. Identify the responsible manager and the cognizant scientist/engineer. Identify the responsible manager or contributor from each support group.

C. Vision

Provide an overview of how the proposed activity relates to long-range objectives of the low-level waste performance assessment activity.

D. Objectives

Provide a detailed listing of the objectives of the activity.

E. Deliverables

Provide a listing of the deliverable products and when they will be completed. These products typically include documents, analyses, workshops, major reviews, and presentation/attendance at major meetings.

III. TASK DESCRIPTIONS

A. Summary List of Tasks

All tasks under this activity should be listed even those completed.

B -> N. Task by Task Description

"I".1 Detailed Description of Task

- a) Prepare a description of each task to be (or was) performed.
- b) Define the scope of the task.
- c) Provide the reason for performing the task.
- d) For computer software development, identify computer software life-cycles to be used.
- e) List special requirements to be observed in the performance of the task, such as reporting requirements, documentation requirements.
- f) List all major contributors to the task including organization and the extent of their contributions as well as the limit of their responsibilities.
- g) For tasks on which work has already been performed, describe qualitatively results, schedule, and costs.

"I".2 Interfaces

Describe needed data, information, documents, or other inputs for this task that will be derived from other tasks in this activity, from other activities in the performance assessment effort, or from other efforts. The dates on which these inputs are needed should also be specified.

The users of the output information, data, documents, analyses, etc. should also be identified and the need dates for these items identified.

"I".3 Standards

State any applicable codes and standards which must be used in the task and define the limits of their applicability. Included should be references to WHC Standard Engineering Practices.

"I".4 Quality Assurance

- a) Define the planned points in the task at which critical reviews will be conducted. Define the selected method of verification to be applied at each review point and also the documentation to be included in each review stage.
- b) For computer software application, identify how the computer software was or will be verified.

- c) Identify the applicable company standards (for example, PNL QA plan and impact level, WHC quality-affecting class) for the task and the basis for the determination.

"I".5 Schedule

- a) Provide a schedule showing a detailed breakout of major sub-tier tasks, intermediate and final milestones and deliverables, start and completion dates, as well as review and approval cycles. All prerequisite conditions and inputs for proceeding with any phase of the task should be identified and appropriately labelled with "HOLD" or "DECISION" point flags.
- b) Describe any special assumptions upon which the plan is predicated. Identify a fall-back position in the event the precursor work does not materialize.
- c) List tasks providing input to the task and which tasks receive output of this task.
- d) Provide alternative dates for each task whose milestone date changes depending on the funding scenario. If a slip in all milestone dates is the appropriate answer, then a simple statement to that effect is sufficient.
- e) If a task cannot be done on the desired schedule, state reasons why.

"I".6 Costs

- a) Provide the total cost estimate for the task, broken out by cost element (labor [man-months and totally burdened dollars for each responsible person and/or supporting group], contracts, and other; each cost element must be justified (see b). Preferably the cost element should be further broken down to the individual level.
- b) Identify the major assumptions used in compiling the estimate, particularly those driving significant portions of the cost or schedule.
- c) Identify the potential need for contingency funding, if applicable, and the recommended percentage to be allowed. Identify any recommended project hold points for criteria and cost estimate review or reconciliation.
- d) Note any cost changes (total and timing) due to accelerating or decelerating the schedule and

- e) Include any cost for capital equipment (ie CENTRC).

"I".7 Other Sections

Add other sections (e.g., deliverables for this tasks, references) as appropriate.

IV. OTHER CONSIDERATIONS

Provide other items important for the activity, including strategic considerations, staffing and facility considerations, technology needs and development considerations, as well as strengths and weaknesses of the proposal.

APPENDIX C
DELIVERABLES

FY 1995

- 1) Letter report providing performance objectives for the interim performance assessment: WHC-EP-0826, Rev. 0, "Performance Objectives of the Tank Waste Remediation Systems Low-Level Waste Disposal Program", issued
- 2) Letter report providing performance objectives for the interim performance assessment: WHC-EP-0828, Rev. 0, "Scenarios of the TWRS Low-Level Waste Disposal Program", issued
- 3) Letter reports justifying selection of tools in each analysis area: WHC-SD-WM-CSWD-073, Rev. 0, "Selection of Flow and Transport Code for the Hanford Tank Low-Level Waste Interim Performance Assessment", issued
- 4) Letter report justifying selection of a computational tool for LLW glass source-term calculations for the interim performance assessment: PNL report, PVTD-C95-04.01E, Rev. 1, "Selection of a Computer Code for Hanford Low-Level Waste Engineered-System Performance Assessment", issued
- 5) Letter report documenting comments from review boards on the performance objectives as well as responses to comments. WHC-EP-0826, Rev. 1, "Performance Objectives of the Tank Waste Remediation Systems Low-Level Waste Disposal Program", issued
- 6) Letter report documenting comments from review boards on the scenarios as well as responses to those comments. WHC-EP-0628, Rev. 1, "Scenarios of the TWRS Low-Level Waste Disposal Program", issued
- 7) Letter report defining geometry and volume of waste form. WHC-SD-WM-RPT-159, Rev. 0, "Disposal Facility Data for the Interim Performance Assessment", issued
- 8) Letter report defining important barriers used in design. Facility design has not progressed to provide meaningful report.
- 9) The DQO methodology will be employed to develop an integrated characterization plan for site geology and hydrology. The plan will address the needs of the Performance Assessment as well as the needs to the site licensing activities. As of the end of May, WHC-SD-WM-SE-021, "TWRS Complex Site Characterization Plan", is undergoing review
- 10) Letter reports documenting verification efforts on the selected codes. WHC report, "WHC-SD-WM-UM-019, Rev. 0, "The Grout/Glass Performance Assessment Code System (GPACS) with Verification and Benchmarking", issued. The PNL report will be issued at the end of June.
- 11) Letter report documenting the total inventory expected to be the glass waste form. As of the end of May, WHC-SD-WM-RPT-164, Rev. 0 "Inventories for Low-Level Waste Interim Performance Assessment", is being reviewed.

- 12) Letter report documenting the highest level of important materials to be in a single vault. As of the end of May, WHC-SD-WM-RPT-163, Rev. 0, "Consequence Ranking of Radionuclides in Hanford Tank Waste", is being reviewed.
- 13) Letter report documenting methods for verification and certification of the computational tool selected for LLW glass source-term calculations. see item 10
- 14) A report on conceptual model of hydraulic properties from literature and description of evaluation and output of flow field for preliminary performance assessment. As of the end of May, WHC-SD-WM-RPT-165, Rev. 0, "A Compilation of Geohydraulic Parameters for Low-Level Glass Waste Disposal Performance Assessment", is being reviewed
- 15) A plan for testing the integrated performance of the disposal system will be developed following the selection of a reference and backup disposal system design. Facility design and waste package design has not yet reached a position for a meaningful plan to be developed
- 16) Letter report determining parameters for transport through important barriers. Facility design has not progress sufficiently for a meaningful report
- 17) Letter report documenting advice concerning important parameters [groundwater flow, prior contamination, and quality of existing hydrologic parameters] in site selection. Presentation and support material given to site selection board.
- 18) Letter report documenting advice concerning important parameters [release rate, recharge, vault barriers] in the engineered system. due in revision 1 of WHC-EP-0810, "Impacts of Disposal System Design Options on Low-Level Glass Waste Disposal System Performance" to be issued in September, 1995.
- 19) Letter report documenting advice concerning important parameters [size, shape, temporal release rate] in glass specifications. due in revision 1 of WHC-EP-0810, "Impacts of Disposal System Design Options on Low-Level Glass Waste Disposal System Performance" to be issued in September, 1995.
- 20) Letter report documenting advice concerning important parameters [K_d , hydrologic parameters] in matrix specifications. due in revision 1 of WHC-EP-0810, "Impacts of Disposal System Design Options on Low-Level Glass Waste Disposal System Performance" to be issued in September, 1995.
- 21) Letter report documenting advice concerning important parameters [critical isotopes and their maximum amounts] in inventory and chemical/physical processing. As of the end of May, WHC-SD-WM-RPT-163, "Consequence Ranking of Radionuclides in Hanford Tank Waste", is undergoing review

- 22) Letter report discussing status of the sensitivity of uncertainties to results coming from calculations. due in revision 1 of WHC-EP-0810, "Impacts of Disposal System Design Options on Low-Level Glass Waste Disposal System Performance" to be issued in September, 1995.
- 23) Letter report describing preliminary model for hydrolysis and contaminant release from LLW glass. PNL report undergoing review
- 24) Letter report documenting LLW glass release source-term for interim performance assessment. PNL report undergoing review
- 25) Letter report documenting compilation and interpretation of vadose zone flow and transport properties for soils in the 200 Areas plateau. As of the end of May, WHC-EP-WM-RPT-165, "A Compilation of Geohydraulic Parameters for Low-Level Glass Waste Disposal Performance Assessment", is being reviewed
- 26) A letter report describing the methodology of the field experiment and the results of the hydraulic property measurements. PNL report undergoing review
- 27) Letter report describing the entire process, from data collection to model prediction of the Injection Site (Sisson and Lu, 1984). PNL report to be written
- 28) A letter report describing increased capabilities at the Geotechnical Engineering Laboratory. Funding not used for upgrade
- 29) Proceedings from the recharge workshop. As of May, workshop held with draft having been written.
- 30) WHC report (or letter report) on geochemical software needs and availability. postponed
- 31) A letter report will be prepared describing the groundwater modeling task, the information currently available, and the data collection necessary for the low-level waste performance assessment. Task redirected to integrated groundwater model, due to Defense Nuclear Facility Safety Board recommendation 94-2.

FY 1996

- 1) An internal memo identifying and summarizing ongoing and planned waste package material studies (November 30, 1995). (Activity 3.1.7)
- 2) Submit to clearance by January 12, 1996 a topical report on the conceptual and constitutive models, and model parameters for unsaturated hydraulic properties of near field materials. (Activity 3.1.8)
- 3) WHC report on geochemical issues and their resolutions: Conclusions from the Geochemical Workshop (January 1996) (Activity 3.1.A)
- 4) Submit to clearance by March 29, 1996 a test plan for measurements of hydraulic properties of near field materials. (Activity 3.1.8)
- 5) Test plan on low-level tank waste site field monitoring instrumentation due March 30, 1996. (Activity 3.1.9)
- 6) Semiannual internal memos summarizing the testing progress will be issued to the performance assessment team (Due March 30, 1996). (Activity 3.1.E)
- 7) Internal memo identifying performance assessment waste materials testing needs and strategies for FY 1997 (March 31, 1996). (Activity 3.1.7)
- 8) A topical paper on "Proper Treatment of Reactive Contaminant Diffusion in Partially Saturated Matrix Material and Sediments" (March 1996). (Activity 3.1.A)
- 9) Radionuclide Release Rate Calculations and Supporting Data for Interim Performance Assessment ready as a letter report for internal review (April 29, 1996). (Activity 2.1.6)
- 10) A letter report containing aquifer test plan (April 1996). (Activity 3.1.G)
- 11) Geophysical logging data report (3 months after completion of borehole BH-1 (May 1996). (Activity 3.1.D)
- 12) A letter report containing analog studies (May 1996). (Activity 3.1.G)
- 13) Statement of Work for FY 1997 to 2002 due to program office June 15, 1996. (Activity 1.3.B)
- 14) Report on Unsaturated, Pressurized Column test results ready for internal review (June 28, 1996). (Activity 3.1.6)
- 15) Borehole completion package (4 months after completion of borehole, BH-1, June 1996). (Activity 3.1.D)
- 16) Sampling and analysis data package (BH-1, June 1996 part of borehole completion package). (Activity 3.1.D)
- 17) A letter report containing preoperational monitoring plan (June 1996). (Activity 3.1.G)

- 18) A letter report containing the updated vadose monitoring system plan (June 1996). (Activity 3.1.G)
- 19) A data package containing the data and parameter estimates, including descriptive statistics and estimates of spatial correlation lengths for each of the hydraulic parameters, will be provided for use in the performance assessment calculations by July 15, 1996. (Activity 3.1.8)
- 20) Journal article on AREST-CT Model Description ready for review (July 29, 1996). (Activity 3.1.6)
- 21) Journal article on AREST-CT Model Application ready for review (July 29, 1996). (Activity 3.1.6)
- 22) A topical paper on "Importance of Colloid-facilitated Transport of Contaminants for Hanford LLW Performance Assessment" (July 1996). (Activity 3.1.A)
- 23) A letter report describing geologic map for interim performance assessment (July 1996) (Activity 3.1.G)
- 24) A topical paper on "Influences of Moisture Content on Measured K_d Values" (August 1996). (Activity 3.1.A)
- 25) A topical paper on "The Long-term Fate of Water in Concrete" (August 1996). (Activity 3.1.A)
- 26) Interim Performance Assessment as a letter report ready for internal review (September 30, 1996). (Activity 2.2)
- 27) Letter report evaluating the current leading candidate matrix material (sulfur polymer cement) as an engineering barrier (September 30, 1996). (Activity 3.1.7)
- 28) A draft manuscript describing the field measurement experiments using the modified instantaneous profile method and field results will be prepared by September 30, 1996. (Activity 3.1.8)
- 29) A "wet" site validation data set will be published on CD-ROM by September 30, 1996. The CD-ROM will include 3-dimensional site drawings, radionuclide, soil characteristics and weather data sets. (Activity 3.1.8)
- 30) Submit a letter report by September 30, 1996 describing the results of field testing of the PORFLOW code. (Activity 3.1.8)
- 31) Letter report on the status of tracer experiments (September 30, 1996). (Activity 3.1.9)
- 32) Interim status report on integrated recharge estimation due September 30, 1996. (Activity 3.1.9)
- 33) Progress letter report on geochemical data measurements (September, 1996). (Activity 3.1.A)

- 34) A letter report describing the groundwater flow modeling development, results of testing and calibration, and the data collection and analysis. The letter report will be written by August 1, 1996 and issuance by September 30, 1996 (after peer review).
- 35) A letter report describing the groundwater flow modeling development, results of testing and calibration, and the data collection and analysis. The letter report will be written by August 1, 1996 and issuance by September 30, 1996 (after peer review). (Activity 3.1.B)
- 36) Semiannual internal memos summarizing the testing progress will be issued to the performance assessment team (September 30, 1996). (Activity 3.1.E)
- 37) A letter report containing preliminary evaluation of surface structures and contamination (September 1996). (Activity 3.1.G)
- 38) A letter report containing preliminary ground penetrating radar/EMI survey report (September 1996). (Activity 3.1.G)

FY 1997

- 1) A letter report on results of initial geochemical code evaluation (November 1996). (Activity 3.1.A)
- 2) Communications from review bodies on the adequacy of the interim performance assessment (December 31, 1996). (Activity 2.4)
- 3) Letter report reviewing and modifying (if necessary) code selection used for interim performance assessment for applicability to the preliminary performance assessment (December 31, 1996). (Activity 3.1.3)
- 4) Submit to WHC by September 30, 1996 a progress report on measured unsaturated hydraulic and physical properties of near-field materials. (Activity 3.1.8)
- 5) Letter report providing suggested changes in approach and design to overcome possible problems revealed in the interim performance assessment (March 30, 1997). (Activity 2.3)
- 6) Letter report providing performance objectives for the preliminary performance assessment (March 30, 1997). (Activity 3.1.1)
- 7) Letter report providing scenarios for the preliminary performance assessment (March 30, 1997). (Activity 3.1.2)
- 8) Letter reports justifying selection of tools in each analysis area (March 30, 1997). (Activity 3.1.3)
- 9) Semiannual internal memos summarizing the testing progress will be issued to the performance assessment team (Due March 30, 1997). (Activity 3.1.E)
- 10) Internal memo identifying performance assessment waste materials testing needs and strategies for FY 1998. (March 31, 1997) (Activity 3.1.7)
- 11) A journal manuscript describing results of both field and laboratory analyses will be submitted to a peer reviewed journal by April 30, 1997. (Activity 3.1.8)
- 12) Geophysical logging data report (3 months after completion of borehole BH-2, May 1997. (Activity 3.1.D)
- 13) Statement of Work for FY 1998 to 2003 due to program office June 15, 1997. (Activity 1.3.B)
- 14) Letter report documenting comments from review boards on the performance objectives as well as responses to comments (June 30, 1997). (Activity 3.1.1)
- 15) Letter report documenting comments from review boards on the scenarios as well as responses to comments (June 30, 1997). (Activity 3.1.2)

- 16) A topical paper on "Technical Rationale for Chemical Retardation Values Used in the Preliminary Performance Assessment" containing an updated pedigreed data set of saturated and unsaturated K_d values will be issued for the preliminary performance assessment (June 1997). (Activity 3.1.A)
- 17) Borehole completion package (4 months after completion of borehole, BH-2, June 1997). (Activity 3.1.D)
- 18) Sampling and analysis data package (BH-2, June 1997 part of borehole completion package). (Activity 3.1.D)
- 19) Annual testing summaries will be issued by the testing organization at the end of the fiscal year and at the end of this activity if the activity does not stop at the end of a fiscal year. The later is due on July 1, 1997. (Activity 3.1.E)
- 20) Communications from the external review groups on the quality of the interim performance assessment (September 30, 1997). (Activity 1.4)
- 21) Letter reports documenting verification efforts on the selected codes (September 30, 1997). (Activity 3.1.3)
- 22) Letter reports documenting strategy for certifying codes (September 30, 1997). (Activity 3.1.3)
- 23) Letter report documenting gross tank inventories suitable for the Preliminary Performance Assessment (September 30, 1997). (Activity 3.1.4)
- 24) Letter report defining waste package and disposal facility designs to be used for the preliminary performance assessment (September 30, 1997). (Activity 3.1.5)
- 25) A letter report describing the present understanding of the interactions of the waste package materials. This data package will be used for the preliminary performance assessment (September 30, 1997). (Activity 3.1.7)
- 26) An interim report summarizing site selection, model simulations for experimental design purposes, and instrumentation selection and calibration for the controlled field test to be conducted adjacent to the tank low-level waste disposal facility will be prepared by September 30, 1997. (activity 3.1.8)
- 27) A "dry" site validation data set will be published on CD-ROM by September 30, 1997. The CD-ROM will include radionuclide, soil characteristics and weather data sets. (Activity 3.1.8)
- 28) Submit to clearance by September 30, 1997 a topical report on the conceptual and constitutive models, and model parameters for unsaturated hydraulic and physical properties supporting the preliminary performance assessment. (Activity 3.1.8)
- 29) Letter report on the status of tracer experiments (September 30, 1997). (Activity 3.1.9)

- 30) Interim status report on integrated recharge estimation due September 30, 1997. (Activity 3.1.9)
- 31) A letter report describing the groundwater flow modeling development, results of testing and calibration, and the data collection and analysis. The letter report will be written by August 1, 1997 and issuance by September 30, 1997 (after peer review). (Activity 3.1.B)
- 32) Letter report providing parameters for the preliminary performance assessment (September 30, 1997). (Activity 3.1.C)
- 33) A letter report containing the most recent understanding of the disposal systems performance. This data report will be used for the preliminary performance assessment (September 30, 1997). (Activity 3.1.E)

FY 1998

- 1) A topical paper on "Use of Natural Analogues and Thermodynamics to Defend Long-term Extrapolation of Laboratory Chemical Retardation Data" in November 1997. (Activity 3.4.A)
- 2) Letter report documenting status of work on detailed tank inventories (December 30, 1997). (Activity 3.4.4)
- 3) Topical Report: Laboratory Confirmation Tests in Support of Integrated Source-Term Modeling (December 31, 1997). (Activity 3.4.6)
- 4) Topical Report: An Integrated Source-Term Model for the Hanford Low-Level Waste Engineered Disposal System (March 30, 1998). (Activity 3.4.6)
- 5) Internal memo identifying performance assessment waste materials testing needs and strategies for FY 1999. (March 31, 1998). (Activity 3.4.7)
- 6) Topical Report: Source-Term Calculations for Radionuclide Release from the Hanford Low-Level Waste Engineered Disposal System (March 30, 1998) (Activity 3.4.6)
- 7) Preliminary Performance Assessment as a letter report ready for review (March 30, 1998). (Activity 3.2)
- 8) Geophysical logging data report (3 months after completion of borehole BH-3, May 1998. (Activity 3.1.D)
- 9) Statement of Work for FY 1999 to 2004 due to program office June 15, 1998. (Activity 1.3.B)
- 10) Manuscript on plant behavior due June 30, 1998. (Activity 3.1.9)
- 11) Borehole completion package (4 months after completion of borehole, BH-3, June 1998). (Activity 3.1.D)
- 12) Sampling and analysis data package (BH-3, June 1998 part of borehole completion package). (Activity 3.1.D)
- 13) Manuscript on climate record due July 31, 1998. (Activity 3.1.9)
- 14) PNL Letter report on the site specific K_d values of studied contaminants and of the results of expert opinion on lesser contaminants in July, 1998. (Activity 3.4.A)
- 15) Manuscript on plant/soil variability due August 31, 1998. (Activity 3.1.9)
- 16) Letter report on the status of tracer experiments (September 30, 1998). (Activity 3.1.9)
- 17) Interim status report on integrated recharge estimation due September 30, 1998. (Activity 3.1.9)

- 18) Communications from review bodies on the adequacy of the preliminary performance assessment (September 30, 1998). (Activity 3.3)
- 19) An interim report summarizing the field data and analysis of the controlled experiment will be prepared by September 30, 1998. (Activity 3.4.8)
- 20) A final report summarizing the development and use of model verification data sets will be published by September 30, 1998. (Activity 3.4.8)
- 21) By September 30, 1998 a topical report will be issued presenting methods and measurements of physical and hydraulic properties of intact and degraded near field materials. (Activity 3.4.8)
- 22) Progress letter reports on geochemical data measurements in September 1998. (Activity 3.4.A)
- 23) A topical paper on "Applicability of Mechanistic Adsorption Models for Key Contaminants in Hanford Low-Level Glass Waste Disposal" September 1998. (Activity 3.4.A)
- 24) A letter report describing further data collection and analysis on groundwater flow site-specific data. The letter report will be written by August 1, 1998 and issuance by September 30, 1998 (after peer review). (Activity 3.4.B)

FY 1999

- 1) Letter report justifying selection of performance objectives for the final performance assessment (December 31, 1998). (Activity 3.4.1)
- 2) A topical paper on "Technical Rationale for Chemical Retardation Values Used in Final Performance Assessment" in January 1999. (Activity 3.4.A)
- 3) Letter report justifying selection of scenarios for the final performance assessment (December 31, 1998). (Activity 3.4.2)
- 4) Letter report on completion of tracer experiments for final performance assessment (March 30, 1999). (Activity 3.1.9)
- 5) Final Report: Laboratory Confirmation Tests in Support of Integrated Source-Term Modeling ready for internal review March 30, 1999. (Activity 3.4.6)
- 6) by March 30, 1999 a topical report will be issued on the physical and hydraulic properties, specimens drawn from stockpiled materials (backfill media, construction materials), and of specimens of the waste form that have undergone accelerated aging tests. (Activity 3.4.8)
- 7) Final Report: Source-Term Calculations for Radionuclide Release from the Hanford Low-Level Waste Engineered Disposal System ready for internal review March 30, 1999. (Activity 3.4.6)
- 8) Final report with recharge estimates for all scenarios due March 30, 1999. (Activity 3.1.9)
- 9) Letter report updating the inventories to be use in the final performance assessment (March 31, 1999). (Activity 3.4.4)
- 10) Letter report defining the disposal facility and waste package designs to be used for the final performance assessment (March 31, 1999). (Activity 3.4.5)
- 11) Letter report providing parameter ranges and distributions for the calculation of radiation dose in the final performance assessment (March 31, 1999). (Activity 3.4.C)
- 12) Statement of Work for FY 2000 to 2005 due to program office June 15, 1999. (Activity 1.3.B)
- 13) Final documentation of UNSAT-H code due July 30, 1999 (Activity 3.1.9)
- 14) Final Performance Assessment as a letter report will be sent to the Program Office (June 30, 1999). (Activity 3.5)
- 15) One or more journal manuscripts describing the field experiment data analysis will be submitted to a journal by September 30, 1999. (Activity 3.4.8)
- 16) Progress letter reports on geochemical data measurements in September 1999. (Activity 3.4.A)

- 17) A letter report describing the further data collection and analysis. The letter report will be written by August 1, 1999 and issuance by September 30, 1999 (after peer review). (Activity 3.4.B)

FY 2000

- 1) Statement of Work for FY 2001 to 2006 due to program office June 15, 2000. (Activity 1.3.B)
- 2) Communications from review bodies on the adequacy of the final performance assessment (June 30, 2000). (Activity 3.6)

APPENDIX D
BUDGETS

Detailed Expense Budget

		FY96	FY97	FY98	FY99	FY00	FY01	sum
1.3.B	<u>WHC Management</u>	122.0	122.0	122.0	122.0	122.0	122.0	732.0
1.3.C	<u>PNL Management</u>	270.0	270.0	270.0	270.0	0.0	0.0	1080.0
1.3.D	<u>PATT/PRP</u>	42.7	42.7	42.7	42.7	42.7	42.7	256.2
1.3.E	<u>Program Overhead</u>	171.0	161.0	161.0	161.0	161.0	161.0	976.0
1.3	<u>Management</u>	605.7	595.7	595.7	595.7	324.7	324.7	3044.2
1.4	<u>Review</u>	56.0	56.0	28.0	28.0	x	x	168.0
1		661.7	651.7	623.7	623.7	324.7	324.7	3212.2
2.1.6	<u>Update Corrosion rates</u>	36.0	x	x	x	x	x	36.0
2.2	<u>Write IPA</u>	262.5	x	x	x	x	x	262.5
2.3	<u>Define Contingencies</u>	x	43.4	x	x	x	x	43.4
2	<u>IPA</u>	298.5	43.4	x	x	x	x	341.9
3.1.1.B	<u>Update P0s</u>	0.0	19.5	x	x	x	x	19.5
3.1.1.C	<u>Respond to Comments</u>	0.0	5.2	x	x	x	x	5.2
3.1.1	<u>Determine PPA P0s</u>	0.0	24.7	x	x	x	x	24.7
3.1.2.B	<u>Update Scenarios</u>	0.0	19.5	x	x	x	x	19.5

		FY96	FY97	FY98	FY99	FY00	FY01	Sum.
3.1.2.C	Respond to Comments	0.0	5.2	x	x	x	x	5.2
3.1.2	<u>PPA Scenarios</u>	0.0	24.7	x	x	x	x	24.7
3.1.3	<u>Codes</u>	0.0	0.0	x	x	x	x	0.0
3.1.4.B	total inventory	110.0	60.0	x	x	x	x	170.0
3.1.4.C	Individual tank inventories	120.0	120.0	x	x	x	x	240.0
3.1.4.D	Advise -Inventories	10.0	10.0	x	x	x	x	20.0
3.1.4	<u>Inventory</u>	240.0	190.0	x	x	x	x	430.0
3.1.5.B	Waste Package Design	28.2	27.1	x	x	x	x	55.2
3.1.5.C	Waste Facility Design	19.5	18.4	x	x	x	x	37.9
3.1.5.D	Data Package for PPA	0.0	24.4	x	x	x	x	24.4
3.1.5.E	Advise - Disposal	0.0	0.0	x	x	x	x	0.0
3.1.5	<u>Disposal Facility</u>	47.7	69.9	x	x	x	x	117.6
3.1.6.B	prepare model	50.0	58.0	36.0	x	x	x	144.0
3.1.6.C	Glass Modelling	242.0	280.0	90.0	x	x	x	612.0
3.1.6.D	Model certification	233.0	280.0	326.0	x	x	x	839.0
3.1.6.E	Advise-glass	0.0	0.0	0.0	x	x	x	0.0
3.1.6	<u>Glass Release</u>	525.0	618.0	452.0	x	x	x	1595.0
3.1.7.B	identify testing	38.2	36.7	x	x	x	x	74.9

		FY96	FY97	FY98	FY99	FY00	FY01	Sum
3.1.7.C	perform testing	362.5	331.7	X	X	X	X	694.2
3.1.7.D	other testing	104.3	104.3	X	X	X	X	208.7
3.1.7.E	package summary	21.7	21.7	X	X	X	X	43.3
3.1.7.F	Matrix workshop	0.0	10.8	X	X	X	X	10.8
3.1.7.G	Advise-matrix	0.0	0.0	X	X	X	X	0.0
3.1.7	<u>Matrix</u>	526.7	505.2	X	X	X	X	1031.9
3.1.8.B	IPM	260.0	55.0	X	X	X	X	315.0
3.1.8.C	Control Field testing	48.0	166.0	X	X	X	X	214.0
3.1.8.D	Disposal Site Testing	96.0	516.0	X	X	X	X	612.0
3.1.8.E	Near Field	196.0	256.0	X	X	X	X	452.0
3.1.8.F	matrix	50.0	55.0	X	X	X	X	105.0
3.1.8.G	model testing	97.0	0.0	X	X	X	X	97.0
3.1.8.H	Hydraulic - advise	0.0	0.0	X	X	X	X	0.0
3.1.8	<u>Hydraulic</u>	747.0	1048.0	X	X	X	X	1795.0
3.1.9.B	Tracer	272.0	260.0	X	X	X	X	532.0
3.1.9.C.1	Monitoring	192.0	162.0	X	X	X	X	354.0
3.1.9.C.2	Variability	52.0	120.0	X	X	X	X	172.0
3.1.9.C.3	Modeling	32.0	56.0	X	X	X	X	88.0
3.1.9.C.4	Estimation	32.0	32.0	X	X	X	X	64.0
3.1.9.D	WHC involvement	20.0	20.0	X	X	X	X	40.0
3.1.9	<u>Recharge</u>	600.0	650.0	X	X	X	X	1250.0

		FY96	FY97	FY98	FY99	FY00	FY01	Sum
3.1.A.B	Advise - chemical	32.5	32.5	X	X	X	X	65.0
3.1.A.C	geochemical workshop	40.0	0.0	X	X	X	X	40.0
3.1.A.D	sample characterization	8.0	8.0	12.0	X	X	X	28.0
3.1.A.E	Software identification	47.5	0.0	X	X	X	X	47.5
3.1.A.F	water in concrete	55.0	X	X	X	X	X	55.0
3.1.A.G	K _d and solubility	400.0	400.0	X	X	X	X	800.0
3.1.A.H	K _d moisture dependence	150.0	150.0	X	X	X	X	300.0
3.1.A.I	Diffusion constants	25.0	0.0	X	X	X	X	25.0
3.1.A.J	Colloidal transport	50.0	50.0	X	X	X	X	100.0
3.1.A.K	Tech def	0.00	170.0	X	X	X	X	170.0
3.1.A	Chemical	808.0	810.5	12.0	X	X	X	1630.5
3.1.B.B	Model Development	108.0	138.0	X	X	X	X	246.0
3.1.B.C	Model Testing	44.0	44.0	X	X	X	X	88.0
3.1.B.D	Data Collection	70.0	70.0	X	X	X	X	140.0
3.1.B.E	Visualization	26.0	18.0	X	X	X	X	44.0
3.1.B.F	Field Testing	33.0	54.0	X	X	X	X	87.0
3.1.B.G	GW-advise	0.0	0.0	X	X	X	X	0.0
3.1.B	Groundwater	281.0	324.0	X	X	X	X	605.0
3.1.C	Dosimetry	65.0	65.0	X	X	X	X	130.0

		FY96	FY97	FY98	FY99	FY00	FY01	Sum
3.1.D.B	drill wells	237.3	226.3	226.30	x	x	x	689.9
3.1.D.C	sample sediments	47.6	38.4	38.4	10.0	x	x	134.4
3.1.D.D	log boreholes	12.0	12.0	12.0	6.0	x	x	42.0
3.1.D.E	drill shallow holes	20.0	10.0	x	x	x	x	30.0
3.1.D.F	aquifer	12.0	24.0	24.0	24.0	24.0	24.0	132.0
3.1.D.G	contaminant sampling	3.0	2.0	2.0	x	x	x	7.0
3.1.D.H	advise - IBH	65.0	32.5	25.0	25.0	25.0	25.0	197.5
3.1.D	<u>Integrated Borehole</u>	396.9	345.2	327.7	65.0	49.0	49.0	1232.8
3.1.E.B	develop test plan	19.5	13.6	x	x	x	x	33.1
3.1.E.C	implement test plan	193.3	220.5	x	x	x	x	413.8
3.1.E.D	document results	0.0	21.7	x	x	x	x	21.7
3.1.E.E	advise - IT	0.0	0.0	x	x	x	x	0.0
3.1.E	<u>Integrated Tests</u>	212.8	255.8	x	x	x	x	468.6
3.1.F.B	Conceptual	30.0	30.0	x	x	x	x	60.0
3.1.F.C	Mathematical	60.0	60.0	x	x	x	x	120.0
3.1.F.D	advise - sensitivity	20.0	20.0	x	x	x	x	40.0
3.1.F	<u>Sensitivity</u>	110.0	110.0	x	x	x	x	220.0
3.1.G.B	Geologic mapping	21.7	21.7	21.7	x	x	x	65.1
3.1.G.C	Soil sampling	0.0	31.0	10.0	10.0	x	x	51.0

		FY96	FY97	FY98	FY99	FY00	FY01	Sum
3.1.G.D	GPR/EMI	300.0	325.0	130.0	x	x	x	755.0
3.1.G.E	Literature Survey/Reports	32.5	65.0	130.0	x	x	x	227.5
3.1.G.F	Planning / Implementation	86.7	200.0	325.0	250.0	150.0	50.0	1061.7
3.1.G.G	Advise	50.0	32.0	25.0	25.0	25.0	25.0	182.0
3.1.G	<u>TWRS Complex Characterization</u>	490.9	674.7	641.7	285.0	175.0	75.0	2342.3
3.1	<u>data for PPA</u>	5051.0	5715.7	1433.4	350.0	224.0	124.0	12898.1
3.2	<u>Write PPA</u>	0.0	200.0	255.0	x	x	x	455.0
3.1+3.2	<u>PPA</u>	5051.0	5915.7	1688.4	350.0	224.0	124.0	13353.1
3.4.1	<u>Determine FPA POs</u>	x	x	x	5.2	x	x	5.2
3.4.2	<u>FPA Scenarios</u>	x	x	x	5.2	x	x	5.2
3.4.4.B	Total inventory	x	x	50.0	50.0	x	x	100.0
3.4.4.C	Individual tank inventory	x	x	100.0	50.0	x	x	150.0
3.3.4.D	Advise - inventory	x	x	10.0	10.0	30.0	x	50.0
3.4.4	<u>Inventory</u>	x	x	160.0	110.0	30.0	x	300.0
3.4.5.B	waste package	x	x	19.0	8.1	x	x	27.1
3.4.5.C	facility design	x	x	19.5	8.5	x	x	28.0
3.4.5.D	data package	x	x	0.0	24.4	x	x	24.4
3.4.5.E	facility-advice	x	x	0.0	0.0	x	x	0.0
3.4.5	<u>Disposal Facility</u>	x	x	38.5	41.0	x	x	79.5

		FY96	FY97	FY98	FY99	FY00	FY01	Sum
3.4.6.B	prepare model	x	x	18.0	54.0	x	x	72.0
3.4.6.C	integrated modelling	x	x	180.0	180.0	x	x	360.0
3.4.6.D	model certification	x	x	0.0	220.0	x	x	220.0
3.4.6.E	Glass-advise	x	x	0.0	0.0	x	x	0.0
3.4.6	<u>Glass Release</u>	x	x	198.0	454.0	x	x	652.0
3.4.7.B	monitor	x	x	29.8	15.2	x	x	45.0
3.4.7.C	matrix testing	x	x	221.6	90.8	x	x	312.4
3.4.7.D	waste form testing	x	x	110.8	55.4	x	x	166.2
3.4.7.E	data package	x	x	0.0	21.7	x	x	21.7
3.4.7.F	workshop	x	x	65.1	0.0	x	x	65.1
3.4.7.G	matrix - advice	x	x	0.0	0.0	x	x	0.0
3.4.7	<u>Matrix</u>	x	x	427.3	183.1	x	x	610.4
3.4.8.B	IPM	x	x	266.0	66.0	x	x	332.0
3.4.8.C	Controlled Field Testing	x	x	331.0	151.0	x	x	482.0
3.4.8.C	Disposal Site Testing	x	x	80.0	0.0	x	x	80.0
3.4.8.D	Near-Field Conceptual	x	x	216.0	226.0	x	x	442.0
3.4.8.E	Matrix	x	x	50.0	50.0	x	x	100.0
3.4.8.F	advise	x	x	0.0	0.0	x	x	0.0
3.4.8	<u>Hydraulic Parameters</u>	x	x	943.0	493.0	x	x	1436.0

		FY96	FY97	FY98	FY99	FY00	FY01	Sum
3.4.9.A	Tracer	x	x	240.0	140.0	x	x	380.0
3.4.9.B	Monitoring	x	x	112.0	112.0	x	x	224.0
3.4.9.C	Variability	x	x	96.0	16.0	x	x	112.0
3.4.9.D	Modeling	x	x	48.0	64.0	x	x	112.0
3.4.9.E	Estimation	x	x	32.0	64.0	x	x	96.0
3.4.9.F	WHC involvement	x	x	20.0	20.0	x	x	40.0
3.4.9	<u>Recharge</u>	x	x	548.0	416.0	x	x	964.0
3.4.A.B	Advise - chemical	x	x	32.5	32.5	x	x	65.0
3.4.A.C	K _a and solubility	x	x	150.0	50.0	x	x	200.0
3.4.A.D	Software identification	x	x	40.0	20.0	x	x	60.0
3.4.A.E	water in concrete	x	x	50.0	0.0	x	x	50.0
3.4.A.F	Technical def.	x	x	175.0	200.0	x	x	375.0
3.4.A	<u>Chemical</u>	x	x	447.5	302.5	x	x	750.0
3.4.B.B	Model Testing	x	x	46.0	0.0	x	x	46.0
3.4.B.C	Data Collection	x	x	72.0	70.0	x	x	142.0
3.4.B.D	Visualization	x	x	50.0	18.0	x	x	68.0
3.4.B.E	Field Testing	x	x	54.0		x	x	54.0
3.4.B	<u>Groundwater</u>	x	x	222.0	88.0	x	x	310.0
3.4.C	<u>Dosimetry</u>	x	x	65.0	65.0	x	x	130.0
3.4.D	<u>Integrated Borehole</u>	x	x	x	x	x	x	0.0
3.4.E.B	Implement Testing	x	x	237.9	98.8	x	x	336.7

		FY96	FY97	FY98	FY99	FY00	FY01	Sum
3.4.E.C	Document testing	X	X	0.0	21.7	X	X	21.7
3.4.E.D	Advise	X	X	0.0	0.0	X	X	0.0
3.4.E	<u>Integrated Tests</u>	X	X	237.9	120.5	X	X	358.4
3.4.F.B	Conceptual	X	X	30.0	30.00	X	X	60.0
3.4.F.C	Mathematical	X	X	60.0	60.00	X	X	120.0
3.4.F.D	Advise	X	X	30.0	30.00	30.0	X	90.0
3.4.F	Sensitivity	X	X	120.0	120.0	30.0	X	270.0
3.4	<u>data for FPA</u>	0.0	0.0	3407.2	2403.5	60.0	0.0	5870.7
3.5	<u>Write FPA</u>	X	X	X	97.5	X	X	97.5
3.4+3.5	<u>FPA</u>	0.0	0.0	3407.2	2501.0	60.0	0.0	5968.2
4.1	<u>Operations</u>	X	X	X	X	87.5	87.5	175.0
4.2	<u>Experiments</u>	X	X	X	X	1000.0	1000.0	2000.0
4.3	<u>Write Revision</u>	X	X	X	X	X	X	0.0
4.4	<u>Review</u>	X	X	X	X	X	X	0.0
4	<u>Maintenance</u>	X	X	X	X	1087.5	1087.5	2175.0
	TOTAL	6011.2	6610.8	5719.3	3474.7	1697.2	1537.2	25050.4

Capital Requests

Task	Org.	FY 96	FY 97	FY 98	FY 99	FY 00	FY 01	Sum
1.3.E	WHC	100.	25.	25.	100.	25.	25.	300.
3.1.6.D	PNL	35.						35.
3.1.A.G	PNL	55.						55.
3.1.D.B	WHC	unknown	unknown					unknown
3.1.G.D	WHC	39.						39.
Total		229.	25.	25.	100.	25.	25.	429.

The "unknown" entry in task 3.1.D.B reflects the uncertainty over the split in drilling costs between expense and capital. At present, all drilling costs are being expensed. The actual split will be determined only after the costs are incurred.

Non-WHC Expense Funds

Task	Org.	FY 96	FY 97	FY 98	FY 99	sum
1.3.C	PNL	270.	270.	270.	270.	1080.
1.3.D	PNL	16.7	16.7	16.7	16.7	66.8
1.4	PNL	30.	30.	15.	15.	90.
2.1.6	PNL	36.	x	x	x	36.
2.2	PNL	50.	x	x	x	50.
3.1.6.B	PNL	50.	58.	36.	x	144.
3.1.6.C	PNL	242.	280.	90.	x	612.
3.1.6.D	PNL	233.	280.	326.	x	839.
3.1.7.C	PNL	80.	20.	x	x	100.
	SWRI	250.	290.	x	x	540.
3.1.7.D	unknown	100.	100.	x	x	200.
3.1.8.B	PNL	204.	55.	x	x	259.
	WHC-GEL	40.	x	x	x	40.
3.1.8.C	PNL	32.	150.	x	x	182.
3.1.8.D	PNL	80.	100.	x	x	180.
	unknown		400.	x	x	400.
3.1.8.E	PNL	180.	230.	x	x	410.
	unknown	50.	55.	x	x	105.
3.1.9.B	PNL	292.	140.	240.	140.	812.
	U. Oregon	22.	23.	25.	x	70.
3.1.9.C	PNL	236.	347.	263.	256.	1102.
3.1.A.C	PNL	10.	x	x	x	10.
3.1.A.F	PNL	37.	x	x	x	37.
3.1.A.G	PNL/WSU	400.	400.	x	x	800.
3.1.A.H	PNL	100.	100.	x	x	200.
	WSU	50.	50.	x	x	100.
3.1.A.I	WSU	25.	x	x	x	25
3.1.A.J	PNL	50.	50.	x	x	100.
3.1.E.C	Unknown	150.	200.	x	x	350.
3.4.6.B	PNL	x	x	18.	54.	72.

Task	Org.	FY96	FY97	FY98	FY99	Sum
3.4.6.C	PNL	x	x	180.	180.	360.
3.4.6.D	PNL	x	x	x	220.	220.
3.4.7.C	unknown	x	x	200.0	80.0	280.
3.4.7.D	unknown	x	x	100.0	50.0	150.
3.4.7.F	PNL	x	x	16.	x	16.
	unknown	x	x	35.	x	35.
3.4.8.B	PNL	x	x	200.	50.	250.
	WHC-GEL	x	x	50.	x	50.
3.4.8.C	PNL	x	x	315.	135.	450.
3.4.8.D	PNL	x	x	64.	x	64.
3.4.8.E	PNL	x	x	180.	60.	240.
3.4.8.F	PNL	x	x	50.	50.	100.
3.4.9.B	PNL	x	x	240.	140.	380.
3.4.A.C	PNL/WSU	x	x	150.	50.	200.
3.4.E.C	unknown	x	x	200.	75.	275.
total	PNL	2629.	2527.	2670.	1637.	9463.
	WHC-GEL	40.	x	50.	x	90.
	SWRI	250.	290.	x	x	540.
	WSU	75.	50.	x	x	125.
	U. Oregon	22.	23.	25.	x	70.
	unknown	300.	755.	535.	205.	1795.
	total	3316.	3645.	3280.	1842.	12083.