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Pacific Northwest
National Laboratory
Operated by Battelle for the
U.S. Department of Energy

PNNL Apatite Investigation at 100-NR-2 Quality Assurance Project Plan

N.J. Fix

March 2008

Prepared for the U.S. Department of Energy
under Contract DE-AC05-76RL01830

DISCLAIMER

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Pacific Northwest National Laboratory
Richland, Washington 99352

PNNL Apatite Investigation at 100-NR-2
Quality Assurance Project Plan

Project # 54475

Prepared by
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3-25-08
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Summary

Efforts to reduce the flux of strontium-90 (Sr-90) to the Columbia River from past-practice liquid waste disposal sites have been underway since the early 1990s in the 100-N Area at the Hanford Site. The remedy specified in the *Interim Remedial Action Record of Decision for the 100-NR-1 and 100-NR-2 Operable Units of the Hanford 100-N Area, Hanford Site, Benton County, Washington* (EPA et al. 1999) included operation of a pump-and-treat system as well as a requirement to evaluate alternative Sr-90 treatment technologies.[1] It was recognized from the onset that pump-and-treat was unlikely to be an effective long-term treatment method because of the geochemical characteristics of Sr-90, the primary contaminant of concern. Subsequent performance monitoring has substantiated this expectation.

In 2004, the U.S. Department of Energy, Fluor Hanford, Inc., Pacific Northwest National Laboratory (PNNL), and the Washington Department of Ecology agreed that the long-term strategy for groundwater remediation at the 100-N Area would include apatite sequestration as the primary treatment, followed by a secondary treatment if necessary (most likely phytoremediation). Since then, the agencies have worked together to agree on which apatite sequestration technology has the greatest chance of reducing Sr-90 flux to the Columbia River at a reasonable cost. Previous injections of a low concentration calcium-citrate-phosphate solution into a series of 10 injection wells at the 100-NR-2 shore line in 2006 and 2007 have provided a preliminary demonstration of the feasibility of establishing an injectable apatite permeable reactive barrier to reduce the flux of Sr-90 to the Columbia River. The scope of the current project covers the technical support needed before, during, and after treatment of the targeted subsurface environment using a new high concentration formulation. A pilot-scale test will be conducted first using this new formulation. Following this test, operational parameters will be finalized for treatment of a series of 16 injection wells at the 100-NR-2 apatite permeable reactive barrier site.

This Quality Assurance Project Plan provides the quality assurance requirements and processes that will be followed by PNNL Apatite Investigation at 100-NR-2 Project staff. This plan is based on the requirements in the *EPA Requirements for Quality Assurance Project Plans (QA-R-5)* (EPA/240/B-01/003[2]) in accordance with the *Hanford Federal Facility Agreement and Consent Order* (commonly referred to as the Tri-Party Agreement [Ecology et al. 1989[3]]); DOE Order Order 414.1C*, Quality Assurance*[4], and 10 *Code of Federal Regulations* 830, Subpart A, "Quality Assurance Requirements.[5]" The *Price-Anderson Amendments Act*[6] also applies to this project.

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[1] EPA – U.S. Environmental Protection Agency, Washington State Department of Ecology, and U.S. Department of Energy. 1999. *Interim Remedial Action Record of Decision for the 100-NR-1 and 100-NR-2 Operable Units of the Hanford 100-N Area, Hanford Site, Benton County, Washington*. Olympia, Washington.

[2]EPA/240/B-01/003. 2001. *EPA Requirements for Quality Assurance Project Plans (QA/R-5)*. U.S. Environmental Protection Agency, Washington, D.C.

[3]Ecology – Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy. 1989, as amended. *Hanford Federal Facility Agreement and Consent Order*. Document No. 89-10, Olympia, Washington.

[4]DOE Order 414.1C. 2005. *Quality Assurance*. U.S. Department of Energy, Washington, D.C.

[5]10 CFR 830, Subpart A, "Quality Assurance Requirements." *U.S. Code of Federal Regulations*.

[6]Price-Anderson Amendments Act. *Energy Policy Act of 2005*. Title VI—Nuclear Matters, Subtitle A – Price-Anderson Act Amendments, Section 601 et. seq. Public Law 109-58, as amended. 42 USC 15801 et seq.

Acronyms and Abbreviations

ASTM	American Society for Testing Materials
ATS	Assessment Tracking System
CAWSRP	*Conducting Analytical Work in Support of Regulatory Programs*
CD	compact disk
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act*
CFR	*Code of Federal Regulations*
CMP	Configuration Management Plan
DOE	U.S. Department of Energy
DOE-RL	U.S. Department of Energy, Richland Operations Office
DQO	data quality objectives
DVD	digital versatile disc
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
ERICA	Electronic Records and Information Capture Architecture
ESL QAP	*Environmental Sciences Laboratory Quality Assurance Plan*
FH	Fluor Hanford, Inc.
FY	fiscal year
GB	gigabytes
HASQARD	*Hanford Analytical Services Quality Assurance Requirements Documents*
HEIS	Hanford Environmental Information System
ICN	Interim Chance Notice
IRI	Information Resource Inventory
LOI	letter of instruction
M&TE	measuring and test equipment
MDA	minimum detectable activity
MDL	method detection limits
MHP	Managed Hardware Program
NQA	Nuclear Quality Assurance
OU	operable unit
OJT	on-the-job-training
PAAA	*Price-Anderson Amendments Act*

PDL	Program Development Language
PNNL	Pacific Northwest National Laboratory
PMP	Project Management Plan
PRB	permeable reactive site
QA	quality assurance
QAPjP	Quality Assurance Project Plan
QC	quality control
RCRA	*Resource Conservation and Recovery Act*
RDR	Review Document Record
RIDS	Records Inventory and Disposition Schedule
RPG	Requirements, Procedures and Guidelines
RTDI	Records Transfer/Data Input Form
SBMS	Standards-Based Management System
SDD	Software Design Description
SOW	statements of work
SRS	Software Requirements Specification
TSD	treatment, storage, and disposal
TRIM	Total Records Information Management
VOC	volatile organic constituent
VVP	Verification and Validation Plan
VVR	Verification and Validation Review
VVPR	Verification and Validation Plan Review
WAC	*Washington Administrative Code*
WBR	workstation backup and restore
WSCF	Waste Sampling and Characterization Facility
WPA	Work Package Authorization

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1.0 Quality Assurance Project Plan Distribution

Pacific Northwest National Laboratory (PNNL) document control will distribute this Quality Assurance Project Plan (QAPjP) internally to PNNL, Fluor Hanford, Inc. (FH), and the U.S. Department of Energy, Richland Operations Office (DOE-RL), as requested. The Project Manager will determine the final PNNL and external distribution list. If external distribution is required, the QAPjP will be published in accordance with the Standards-Based Management System (SBMS) subject area, "Publishing Scientific and Technical Information" (PNNL 2007d).

2.0 Introduction

2.1 Title

The title of this project is as follows: PNNL Apatite Investigation at 100-NR-2. The short title that will be used throughout this document is 100-NR-2 Apatite Project.

2.2 Client

The client is Fluor Hanford, Inc., located in Richland, Washington.

2.3 Authorizing Document

Work has been authorized by Fluor Hanford, Inc. (FH) contract 27647, release number 318. The PNNL project number is 54475.

2.4 Quality Assurance Requirements

The 100 Area is listed in the *Hanford Federal Facility Agreement and Consent Order* (also known as the Tri-Party Agreement; Ecology et al. 1989) and the associated Action Plan (Attachment 2 to the Tri-Party Agreement) as an operable unit (OU) that must be remediated under the *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA). The signatory parties to the Tri-Party Agreement (U.S. Department of Energy [DOE], the U.S. Environmental Protection Agency [EPA], and the Washington State Department of Ecology [Ecology]) have agreed to programmatic requirements associated with Hanford Site remediation. Therefore, project staff shall comply with the requirements in the *EPA Requirements for Quality Assurance Project Plans QA/R-5* (EPA/240/B-01/003) in accordance with the Tri-Party Agreement (Ecology et al. 1989).

The QAPjP is also based on the quality assurance (QA) requirements of DOE Order 414.1C, "Quality Assurance," and 10 *Code of Federal Regulations* (CFR) 830, Subpart A, "Quality Assurance Requirements," as described in the PNNL SBMS. The project is subject to the *Price Anderson Amendments Act* (PAAA) as defined in the PNNL PAAA Program and implemented through the SBMS subject area, "Price-Anderson Amendments Act" (PNNL 2007c). Additionally, project management staff has determined the *Hanford Analytical Services Quality Assurance Requirements Documents* ([HASQARD] DOE/RL-96-68) apply to portions of this project and to the subcontractors involved on an as-needed basis. HASQARD requirements are discussed within applicable sections of this plan. The

PNNL document for implementing HASQARD for portions of this work is *Conducting Analytical Work in Support of Regulatory Programs* (CAWSRP) located at http://etd.pnl.gov/docs/conducting-work/index.stm.

2.5 Special Requirements or Specifications

DOE Orders 435.1, *Radioactive Waste Management*; 5400.5, *Radiation Protection of the Public and Environment*; and 450.1, *Environmental Protection Program*, apply to the project to ensure that activities related to the radioactive materials and samples are protective of human health and the environment and fulfill PNNL environment and stewardship requirements. Compliance and waste cleanup timetables and implementation milestones are established in the Tri-Party Agreement (Ecology et al. 1989) to achieve compliance with remedial action provisions in CERCLA and the treatment, storage, and disposal (TSD) unit regulations and corrective action provisions promulgated under the *Resource Conservation and Recovery Act* (RCRA).

Field experiment and sampling and analysis plans (see Sections 4.0 and 5.0) will be conducted by applying the Data Quality Objectives (DQO) process, in accordance with the *Guidance on Systematic Planning Using the Data Quality Objectives Process (QA/G-4)* (EPA/240/B-06/001). Field experiment and sampling and analysis plans are reviewed and approved at the project level and updated as necessary.

Computer modeling and database activities for the project shall comply with the software requirements as specified in the PNNL's SBMS subject areas, "Software" (PNNL 2007i) and "Safety Software" (PNNL 2007g). Specific safety software and software requirements for the activities are described in Section 17.0 and are based on a graded approach.

2.6 Project Scope

The scope of this QAPjP is to provide PNNL staff with the program-specific planning, execution, assessment of work, and controls necessary to provide products/solutions and services of the highest quality consistent with project risks, PNNL SBMS "Policies and Standards" (PNNL 2006b), and the needs, expectations, and resources of the client.

Management processes, including planning, scheduling/execution, and providing resources for work to provide project deliverables based on risk, safety, life cycle, complexity are described in the *PNNL Apatite Investigation at 100-NR-2 Project Management Plan* (Project No. 54475, current revision).

2.6.1 Project Background

Efforts to reduce the flux of strontium-90 (Sr-90) to the Columbia River from past-practice liquid waste disposal sites have been underway since the early 1990s in the 100-N Area at the Hanford Site. Termination of all liquid discharges to the ground by 1993 was a major step toward meeting this goal. However, Sr-90 adsorbed on aquifer solids beneath the liquid waste disposal sites and extended beneath the near-shore riverbed, remaining as a continual source to groundwater and the Columbia River.

The remedy specified in the *Interim Remedial Action Record of Decision for the 100-NR-1 and 100-NR-2 Operable Units of the Hanford 100-N Area* (Ecology 1999) included operation of a pump-and-treat system, as well as a requirement to evaluate alternative Sr-90 treatment technologies. Since the pump-

and-treat system was installed, it was determined to be an unlikely effective long-term treatment method because of the geochemical characteristics of Sr-90, the primary contaminant of concern. Subsequent performance monitoring has substantiated this determination. Accordingly, the first CERCLA 5-year review reemphasized the need to aggressively pursue alternative methods to reduce impacts to the Columbia River.

With the presentation of the *Letter Report - Evaluation of Strontium-90 Treatment Technologies for the 100 NR-2 Groundwater Operable Unit* (CH2M HILL 2004) at a December 8, 2004, public meeting, the DOE, FH, PNNL, and Ecology agreed that the long-term strategy for groundwater remediation at the 100-N Area would include apatite sequestration as the primary treatment, followed by a secondary treatment—or polishing step—if necessary (most likely phytoremediation). Since then, the agencies have worked together to agree on which apatite sequestration technology has the greatest chance of reducing Sr-90 flux to the Columbia River, for a reasonable cost. In July 2005, aqueous injection, (i.e., the introduction of apatite-forming chemicals into the subsurface) was endorsed as the interim remedy and selected for field testing. Plans are underway to assess the capability of aqueous injection to address both the vadose zone and the shallow aquifer along the 300 ft of shoreline where Sr-90 concentrations are highest.

The 100-N Area is divided into two OUs: 100-NR-1 and 100-NR-2. The 100-NR-1 OU includes 4 TSD units governed under RCRA, 81 source waste sites, and a shoreline site. The groundwater beneath the 100-N Area constitutes the 100-NR-2 OU. Of primary concern in the 100-NR-2 OU is the presence of high levels of Sr-90 in the groundwater and the discharge of Sr-90 contaminated groundwater to the nearby Columbia River through historic riverbank seeps known as “N-Springs.”

2.6.2 Project/Task Description

Previous injections of a low concentration calcium-citrate-phosphate solution in a series of 10 injection wells at the 100-NR-2 shoreline in 2006 and 2007 have provided a preliminary demonstration of the feasibility of establishing an injectable apatite permeable reactive barrier (PRB) to reduce the flux of Sr-90 to the Columbia River. The scope of the current project covers the technical support needed before, during, and after treatment of the targeted subsurface environment using a new high concentration formulation. A pilot-scale test will be conducted first using this new formulation. Following this test, operational parameters will be finalized for treatment of a series of 16 injection wells at the 100-NR-2 Apatite PRB site.

The client, FH, has imposed the following formal deliverables for this project:

- Report documenting the results of the low-concentration apatite injections completed in fiscal years (FY) 2006 and 2007.
- Treatability Test Plan for the high-concentration formulation. The plan will be prepared in accordance with the *EPA Document Guidance for Conducting Treatability Studies Under CERCLA* (EPA/540/R-92/071a).
- Summary report of the pilot-scale field test injection results.
- Field test instruction plan for treatment of the remaining 15 apatite barrier injection wells with the high-concentration formulation.

2.7 Change Control (Scope, Schedule, Budget)

The project scope, schedule, and budget baseline are compiled, tracked, and reported using a project control system in accordance with FH direction.

Changes in work scope, schedule, or budget may be necessary during the year. Changes may be requested of subcontractors by PNNL that will result in a change to the statements of work (SOWs) due to revisions of work scope, schedule, and/or budget. These changes will be documented in revisions or addendums to the existing SOWs and a PNNL Subcontracts Supplement Form shall be completed.

Administrative changes requested of subcontractors that are approved by Task Leaders may be made by verbal or electronic message authorization. Written documentation of the verbal changes and electronic messages should be maintained in the permanent project files. These changes may only be made if technical work scope and budget are not significantly affected.

3.0 Project Organization and Responsibilities

Line authority, QA authority and support within PNNL, and client interfaces are shown in the organization chart in Figure 3.1. The responsibilities of key PNNL personnel are summarized in Section 3.1. Changes to organizational/interface structures shown in Figure 3.1 that do not reflect a change in the overall scope of the activities or a change of requirements will not require a QAPjP revision and will be incorporated into the next required revision of this QAPjP.

3.1 Responsibilities of Key Personnel

- **Project Manager** — Provides overall direction to task managers and project personnel within PNNL necessary to accomplish project objectives; coordinates and executes project controls associated with scope, schedule, and budget baselines; reports on project status; assures the project is staffed with technically qualified personnel; serves as primary client interface to assure that customer expectations are met in terms of quality, cost, and schedule; and assures the QAPjP is implemented.
- **Technology Task Leaders** — Oversees task-specific planning, control, communications, and progress reporting; prepares scope, resource needs, cost baseline, and deliverables; assures quality and timeliness of the work, in accordance to plans, policies, and procedures; provides monthly reports; interfaces with DOE, other contractors, subcontractors, and other Task Leaders.
- **Technology Principal Investigators** — Provides task-specific technical plans, communications, and progress reporting to the Task Leader; prepares technical details of the task plan; assures technical quality of the work; supports the Task Leader to assure work is performed on schedule, within budget, and in accordance to plans, policies, and procedures; assigns and directs work of project staff; and interfaces with DOE, other contractors, subcontractors, and other investigators.
- **Project Quality Engineer** — Provides guidance and direction to Project Manager, Task Leads, and project staff within PNNL on PNNL QA Program requirements; performs assessments to assure quality of the work; develops, updates, and approves QAPjP; and reviews and approves appropriate work plans and procedures.

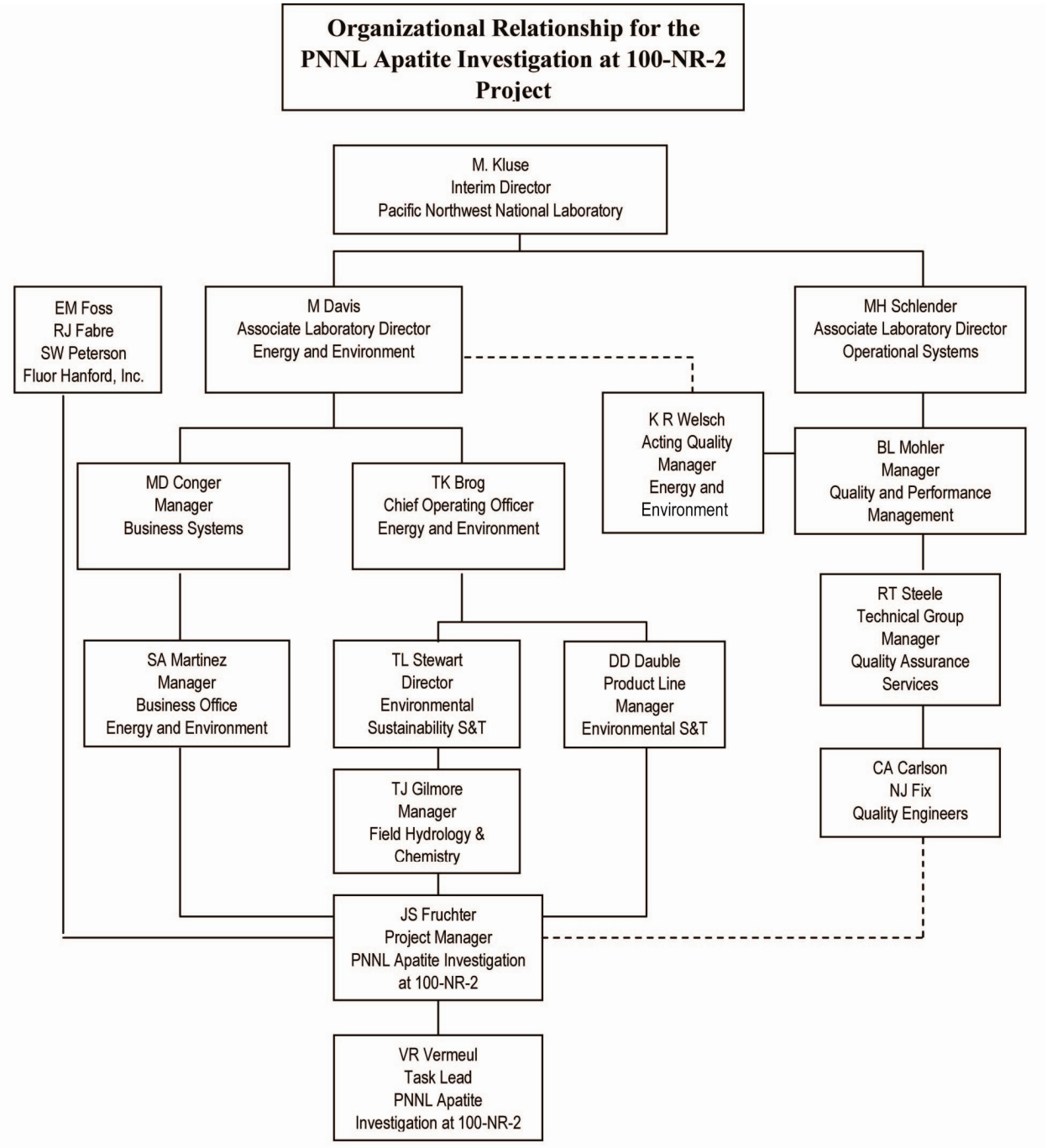

Figure 3.1. Project Interfaces

- **Other Project Staff** — Assures technical quality of the work and that it is performed on schedule, within budget, and in accordance to plans, policies, and procedures; and reports concerns (such as unsafe conditions) and stops work as necessary.

3.2 Other Work Services

Other work services for various portions of project work will obtained through the purchasing process. General work scope, work requirements, specifications, and QA requirements are communicated

via a contracting mechanism to various subcontractors (see Section 15.0). SOWs to subcontractors used for groundwater and sediment sample analysis will require compliance with the HASQARD (DOE/RL-96-68) and/or the *EPA Requirements for Quality Assurance Project Plans* (EPA/240/B-01/003); 10 CFR 830, Subpart A; DOE Order 414.1C; and specific requirements to be achieved by appropriate quality documents. The SOW will include instructions for inspecting/accepting supplies and consumables used for this project.

Subcontracts for drilling, sediment sampling, groundwater sampling, and associated support activities will include the following:

- Fluor Hanford, Inc. (FH) performs drilling, sediment and water sample collection related to drilling; and well construction services.
- Other subcontractors may provide civil surveys, special analytical services, or other services.

3.2.1 Analytical Services

Analytical laboratories, including commercial, onsite, and other DOE national laboratories, are responsible for preparing data reports that summarize the results of analyses and detailed data packages that include the following:

- Sample receipt and tracking documentation, including identification of the organization and individuals performing the analysis; names and signatures of the responsible analysts; sample holding time requirements; references to applicable chain-of-custody procedures; and dates of sample receipt, extraction (if applicable), and analysis.
- Quality control (QC) data, as appropriate for the methods used, including (as applicable) matrix spike/matrix spike duplicate data; recovery percentages, precision and accuracy data; laboratory blank data; and identification of any nonconformance that may have affected the laboratory's measurement system during the time period in which the analysis was performed.
- Analytical results or data deliverables, including reduced data and identification of data qualifiers and contractually defined reporting comments.

These requirements, as well as QA and technical requirements, are specified in the SOW to the analytical laboratories. The requirements for the hard copy and electronic data received from the analytical laboratories are specified in respective analytical subcontractor SOWs.

3.2.2 Sampling Services

The organization collecting soil or water samples, generally PNNL, is responsible for 1) obtaining the samples; 2) delivering samples to the laboratory; and 3) delivering completed paperwork to implement sample tracking. All activities associated with the sample collection, sample handling, sample labeling, and custody of the samples in the field shall be consistent with recommendations and protocols provided in Chapter 4, Section 4.2 through 4.4 in *RCRA Ground Water Monitoring Technical Enforcement Guidance Document* (National Water Well Association 1986), *Test Methods for Evaluating Solid Waste, SW-846* (EPA/SW-846), and the *Handbook for Analytical Quality Control in Water and Wastewater Laboratories* (EPA-600/4-79/019). Activities associated with sample collection, sample handling, sample labeling, and custody of the samples in the field shall be consistent with the SOW.

3.2.3 Well Drilling, Sampling, and Construction Services

FH provides well drilling and construction subcontractors and oversees work performed at the Hanford Site. FH is responsible for the following:

1. Well drilling design specifications and contract management
2. Site preparation and documentation requirements
3. Sediment and water sample collection during drilling
4. Supporting hydrologic tests conducted during drilling
5. Well construction, development, and sample pump installation.

Well construction will meet the requirements of *Washington Administrative Code* 173-160. Well drilling and construction, sediment and water sampling, testing support, and associated quality requirements will be specified in the SOW to FH. FH may subcontract work activities, provided the requirements in the SOW and the FH QA Program are met by subcontractor(s).

3.2.4 Field Measurements

Field measurements during well drilling will be conducted in accordance with FH procedures during well drilling, or other equivalent procedures, and as directed in the SOW. Project-specific test plans that have been reviewed and approved will address procedures during field experiments.

3.2.5 Other Services

Other subcontracted services received from FH or other Hanford Site contractors may include construction of fences and enclosures, geophysical logging, etc.

3.3 Work Conducted by Project Staff

Project staff will perform sampling and measurements according to written and approved internal procedures. Analytical activities conducted by project staff shall be conducted in accordance with written standard operating procedures. Field measurements will be conducted in accordance with in-house operating procedures. Project staff members are responsible for preparing data reports that summarize the results of analyses, QC data for the method used, and identification of data qualifiers. The results and raw data will be included in project records.

Project staff will perform sampling and measurements according to written and approved test plans (Section 5.1), written procedures, or other written direction.

3.4 Field Work

Field work is executed by the treatability study project. Prior to executing field work, project-specific test plans are developed as described in Section 5.0. If supplemental information or individual parameters are needed to perform a test, a test instruction will be developed. The test instruction shall be reviewed by a technical reviewer.

Field work associated with task activities is conducted in accordance with the *Surface Environmental Surveillance Procedures Manual* (PNL-MA-580, current revision). The following procedures in PNL-MA-580 are used:

- Section 4.2 – Columbia River Composite Water Samples
- Section 4.5 – Riverbank Spring Water and Sediment
- Section 4.6 – Specific Conductance
- Section 4.7 – pH Measurement
- Section 4.8 – Filtered Water Samples
- Section 8.1 – Chain-of-Custody.

Sampling aquifer tubes will be conducted in accordance with the procedure entitled "Collecting Environmental Monitoring Waster Samples from Aquifer Tubes" (GC-3) contained in the *Procedures for Ground-Water Investigation Manual* (PNL-MA-567).

4.0 Data Quality Objectives

The QA objectives for measurements generally applicable to technology investigations under the purview of this QAPjP are primarily related to the following: 1) the definition of appropriate methods and analytical precision and accuracy appropriate for chemical analysis of the analyte of interest; and 2) the definition of methods and limits and values for physical measurements associated with the investigation (e.g., column tests). Discussions of aqueous sample analytical objectives and analytical methods with corresponding target values for detection limits, precision, and accuracy are provided in Appendix A of this QAPjP, the *Environmental Sciences Laboratory Quality Assurance Plan* (ESL QAP, current revision), individual test plans, and/or test procedures. The sediment analytical objectives and analytical methods with corresponding target values for detection limits, precision, and accuracy are provided in the ESL QAP, individual test plans, and/or test procedures. DQOs developed in accordance with the *Guidance on Systematic Planning Using the Data Quality Objectives Process (QA/G-4)* (EPA/240/B-06/001) will be applied. Other measurement objectives and methods with corresponding target values for detection limits, precision, and accuracy (as applicable) are provided in the specific work plans and/or the SOW for such activities. Specific data quality needs for individual investigations that are different than the requirements established herein shall be addressed within individual work plans. Other measurement considerations, accuracy requirements, units, and data recording and reporting protocols for instruments supporting stratigraphic characterization, aquifer testing and other types of field investigations shall be as specified in the applicable plans and/or procedures.

5.0 Test Plans and Procedures

Test plans and procedures are used to assure that activities affecting quality are performed consistently and correctly. Test plans are prepared by PNNL staff to conduct a single experiment or test as identified below. Formal procedures will be developed for quality-affecting work activities that are routinely performed. Additional procedures will be developed as needed.

5.1 Test Planning and Performance

Test plans will be used to document a single or related set of experiments or tests (e.g., hydrologic field tests, vertical sampling) work activity.

5.1.1 Developing the Test Plan

The test plan shall contain the following information:

- A title and/or number, including date or revision.
- Dated signatures of the Preparer, Technical Lead, Project Manager or Task Lead, and Quality Representative.
- Individual page identification (page ___ of ___).

The content of each test plan depends on the scope of the test. The following is a brief description of mandatory and optional items to be considered in the preparation of the test plan:

- **Purpose/Description (mandatory)** – Provide a short narrative on the purpose of the experiment/test/activity.

  Example: The purpose of this test is to provide hydrologic property data at polyphosphate treatability injection test wells.

- **Prerequisites (mandatory)** – List items, conditions, or other concerns that must be satisfied prior to beginning the test.

  Example: Prior to beginning the work activity, the staff must complete special training on other plans or procedures that will be used in conjunction with the test plan, special handling or storage requirements, special access or permits, and required records that need to be generated as the result of the work activity.

- **Safety (mandatory)** – Describe the hazards associated with the work such as physical agents (e.g., temperature, pressure, noise, electrical); hazardous environments (e.g., confined spaces, remote locations, heat/cold stress); and hazardous materials (e.g., flammables, corrosives, highly toxic, carcinogens). Describe the methods used to mitigate the hazards that were identified (e.g., personal protective equipment, time periods away from the hazard, alarms, and location of nearest aid station).

- **Materials and Equipment (optional)** – List the materials and equipment necessary to complete the work.

- **Measuring and Test Equipment (mandatory)** – List the equipment that will be used to make the measurements; include the calibration requirements, system checks, and QC checks in this section or in the work instructions section of the test plan.

- **Pretest Verification (mandatory)** – Determine if certain items of a test require verification prior to their use and indicate how the verification will be done.

  Example: A tracer solution containing bromine will be used throughout the test and the initial concentration shall be known. The solution shall be measured by the calibrated probe (as described above) and the concentration shall be recorded prior to injection.

- **Documentation and Reporting (mandatory)** – Describe where the data collected during the test should be documented (e.g., field record forms, laboratory record books, entered into a computer database, downloaded from computer to hardcopy) or entered into the Hanford Environmental Information System (HEIS). Additionally, describe what will be reported, to whom, and the due date(s).
- **Work Instructions (mandatory)** – Provide step-by-step instructions and/or nonsequential instructions (whichever is more appropriate to the activity). Each step or instruction shall be as simple as possible but with sufficient detail so that individuals experienced in the technology or activity involved can easily understand. The following types of information should be considered for inclusion: administrative-control hold points (i.e., where safety, quality, radiological, or other approvals or actions are required before proceeding); cautions that indicate potentially hazardous situations which, if not avoided, may result in death, injury, or damage to facilities or equipment; and notes that call attention to supplemental information that assist the user in making decisions or improving work performance.

5.1.2 Test Performance

Tests will be performed in accordance with test plans, which shall be available at the work location. The Technical Lead is responsible for assuring the current version is used by staff to perform the work.

If changes to the test plan are required during the execution of work, the Technical Lead shall document the deviation and the justification or rationale for the change.

5.2 Procedures

Procedures will be developed in accordance with the SBMS subject area, "Procedures, Permits, and Other Work Instructions" (PNNL 2004). Project staff will perform scheduling, data verification, data processing, and data management as described in Section 6.0 and by following the applicable internal technical procedures or instructions. Also, project staff will perform groundwater sampling, field measurements, water-level measurements, and aquifer testing by following the appropriate internal technical procedures.

5.2.1 Water-Level Procedures

Procedures for water-level measurements shall be written in accordance with industry accepted standards, such as guidelines prepared by the U.S. Geological Survey (1977), and updated as required for the latest advances in measuring equipment.

5.2.2 Analytical Procedures

Specific work plans and/or test plans identify the constituents to be analyzed. As applicable, a PNNL internal procedure generates the sampling package (e.g., chain-of-custody form), which identifies the analytical methods, sample identification, and other information on the chain-of-custody form. The chain-of-custody form and samples are then provided to the appropriate analytical laboratory. Administrative QA processes and procedures (e.g., chain-of-custody, custody logs, sample handling, storage and disposal, and training) will be required of the onsite and offsite analytical laboratories and

will be specified in the SOW. The analytical methods required may be contained within the following references:

- *Test Methods for Evaluating Solid Waste* (EPA/SW-846, as amended)
- *Methods for Chemical Analysis of Water and Wastes* (EPA-600/4-79-020)
- *Methods for the Determination of Organic Compounds in Drinking Water* (EPA-600/4-88-039)
- *Prescribed Procedures for Measurement of Radioactivity in Drinking Water* (EPA-600/4-80-032)
- *Procedures for Radiochemical Analysis of Nuclear Reactor Aqueous Solutions* (EPA-R4-73-014)
- *Radiochemical Analytical Procedures for Analysis of Environmental Samples* (EMSL-LV-0539-17).

Many radiochemical methods have not been standardized, but the procedures are documented in the laboratory-specific standard operating procedures. Aqueous sample chemical and radiological analytical methods and requirements for constituents are specified in the SOW, work plan, or other written direction. Most potential chemical constituents to be analyzed are provided in Appendix A, Table A.3 of this QAPjP and/or the *Environmental Sciences Laboratory Quality Assurance Plan* (ESL QAP, current revision). Sediment and other media constituents to be analyzed and corresponding analytical methods and procedures will be passed on to the analytical laboratory by a SOW, work plan, or other written direction.

Method detection limits (MDLs) shall be determined for all nonradiochemical methods required by the project. Water MDLs shall be determined in accordance with 40 CFR 136, Appendix B, "Definition and Procedure for the Determination of the Method Detection Limit—Revision 1.1." The laboratory provides MDL studies results to PNNL as specified in the SOW. Required detection limits for radiochemical methods are provided in the SOW, work plan, or other written direction.

Sediment constituents to be analyzed for, as well as the corresponding analytical methods and procedures, will be passed on to the analytical laboratory by a SOW. The MDLs for sediment analysis shall be determined using the calculation provided in Chapter One of EPA/SW-846, as amended.

Technical procedures not previously documented will be developed and used as described in CAWSRP, Section 7, "Procedures." If supplemental information or individual parameters are needed to perform a test, a test instruction will be developed. The test instruction shall be reviewed by a technical reviewer and must include the following information:

- A unique numerical designation
- Revision number
- Title
- Effective date
- Instructions - operating parameters and specific test-run information, such as sample size and /or composition, temperature, pH, test duration, etc.
- Reference to controlling procedure or test plan
- Approval by author
- When well-established methods (e.g., American Society for Testing and Materials [ASTM], Soil Science Society of America, or EPA) are used, a PNNL cover page will not be provided unless there is a deviation from the established method.

Appendix B lists additional analyses and measurements with the respective procedures, methods, and other relevant information.

Administrative QA processes and procedures (e.g., chain-of-custody, custody logs, sample handling, storage and disposal, and training) will be required from the onsite and offsite analytical laboratories and will be specified in the SOW.

5.2.3 Calibration Procedures

The requirements for calibrating field and analytical laboratory instruments and maintain traceability to national or international standard (e.g., National Institute of Standards and Technology) is in accordance with *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods* (EPA/SW-846, as amended) and HASQARD (DOE/RL-96-68). These requirements are passed to the subcontractors via a SOW. PNNL will periodically assess the use and effectiveness of procedures and systems for calibration of equipment with the subcontractors.

Measuring and test equipment (M&TE) used by PNNL staff to collect quality-affecting data that are calibrated by the user (Category 2 M&TE) or by an approved external or internal source (Category 1 M&TE) will be in accordance with the SBMS subject area, "Calibration" (PNNL 2005b). Upon receiving calibrated equipment, staff must review the documentation for acceptability and verify the proper operation of the M&TE and check the calibration label.

M&TE shall be controlled as described in CAWSRP, Section 4, "Instrument Calibration," and in accordance with the SBMS subject area, "Calibration" (PNNL 2005b). Externally calibrated M&TE, such as balances, will be calibrated in accordance with manufacturer's tolerances unless other control limits are specified and justification is provided.

Data sheets and log book entries will be used to document pipette performance checks. Calibration reports and other calibration data will be maintained as project records.

Quality control requirements are described in CAWSRP, Section 5, "Quality Control," and in Appendix A of this QAPjP. A few exceptions to CAWSRP requirements are considered necessary for the project, as described in the following paragraphs.

5.2.4 Common Data Quality Calculations

Data quality parameters of precision, accuracy, measures of agreement, detection limits/sensitivity, and uncertainty will be calculated per the formulas in CAWSRP, Section 6, in the exhibit "Calculations for Assessing Data Quality." For radiochemistry analyses, the minimum detectable activity (MDA) is reported as the detection limit.

The CAWSRP exhibit, "Calculations for Assessing Data Quality," is a control charting tool used to monitor an ongoing/continuous process where there are sufficient data points to perform a representative statistical evaluation. The analyses performed within these projects are performed as research functions in which instrumental operating parameters may be changed to accomplish many different objectives. The frequency of instrumental operating changes does not allow accumulation of sufficient data points to properly utilize control charting as a statistical analysis tool. In lieu of control charts, instrument performance is monitored daily by the use of fixed control limits.

5.2.5 Well Drilling and Construction Procedures

FH will obtain drilling services through its procurement process. SOWs to FH specify well drilling, characterization (aquifer and sediment sampling, etc.) and construction requirements. The well drilling, sediment samples collection, groundwater samples collection, water level measurements, and notification to perform geophysical logging/gyroscope well-deviation survey is the responsibility of FH. These activities will be performed in accordance with FH procedures and/or to subcontractor procedures (e.g., conducting geophysical logging/gyroscope well deviation survey). FH Health and Safety, and QA procedures and waste management procedures will be followed during the drilling activity.

5.2.6 Water and Sediment Sample Collection Procedures

Sediment and water samples collected during drilling will be collected by or under the direction of FH, and in accordance with FH or subcontractor procedures. The quality requirements for sampling activities, including chain-of-custody, storage, and records requirements are specified in the work plan or test plan.

5.2.7 Receiving and Handling Samples

Direction for sample receipt, handling, and storage is provided in CAWSRP, Section 3, "Receiving and Handling Samples," and in the SBMS subject area, "Sample Handling, Archival, and Disposal" (PNNL 2007h).

Chain-of-custody for samples will be documented using a chain-of-custody form. An example of a chain-of-custody form is provided as an exhibit in CAWSRP. Each PNNL facility is a secured area, restricted to authorized personnel only. Chain-of-custody will be documented for moving samples from one facility to another, but not for moving samples within a secured facility.

The samples to be received from other PNNL groups are materials from various field investigations. Documentation of unique sample and subsample identifications will be maintained for samples received from other PNNL groups and for other samples generated from tests conducted by the project. The documentation may consist of entries in laboratory record books or data sheets.

Disposition of unused materials may include returning the material to another group at PNNL, the client, or disposal at PNNL. Material returned to the client will be documented by a chain-of-custody form. Material disposed of at PNNL will be documented by standard waste paperwork (forms). See the SBMS subject area, "Waste, Managing" (PNNL, 2007j).

5.2.8 Sediment Physical Analysis Procedures

Sediment physical analyses including moisture content, particle-size distribution, hydraulic conductivity, water retention, water content, bulk density, particle density, and matric potential will be performed as directed in the test plan by PNNL staff. These procedures are contained in the internal *Procedures for Groundwater Investigations* (PNL-MA-567). For some studies, well-established methods, (e.g., ASTM, Soil Science Society of America, or EPA) are sometimes used and additional documentation is not needed unless there is a deviation from the established method.

5.2.9 Sediment Core Analysis Procedures

Sediment core analyses and column experiments will be performed by PNNL staff as directed in the test plan. Procedures are contained in individual test plans, which will either provide a procedure or reference an existing procedure.

6.0 Data Generation and Acquisition

6.1 Experimental Design (Sampling Process Design)

Data generation and data collection designs for each of the treatability study tests are described in the individual work plans and sampling and analysis plans.

Sampling processes to support the treatability studies will be in accordance with the waste management area sampling design, based on the regulatory requirements (e.g., RCRA or CERCLA) and applying the DQO process in accordance with *Guidance on Systematic Planning Using the Data Quality Objectives Process (QA/G-4)* (EPA/240/B-06/001). A description of these processes will be included in sampling and analysis plans along with the number of samples, when to sample, number of sample locations, number of QC samples (field replicates, etc.), analysis methods and QC criteria, and groundwater-level measurements.

6.2 Sampling Methods

Procedures for collecting samples and identifying the sampling methods and equipment, including any implementation requirements, sample preservation requirements, decontamination procedures, and materials needed for projects involving physical sampling are described in the treatability study-specific work plans and procedures. Specific performance requirements for the methods are also described. If a failure in the sampling or measurement system occurs, documentation of and recovery from the failure will be documented in the project-specific laboratory record book. The treatability study Principal Investigator is responsible for ensuring the corrective action is effective and documented.

The preparation and decontamination of sampling equipment, including the disposal of decontamination by-products; the selection and preparation of sample containers, sample volumes, and preservation methods; and maximum holding times to sample extraction and/or analysis is also treatability-study topic specific and will be managed in accordance with EPA-SW-846, as amended, or PNNL-specific procedures, as applicable. Waste generated as a result of the activities will be handled in accordance with SBMS subject areas, "Treatability Studies" (PNNL 1999) and "Waste, Managing" (PNNL 2007j).

Field sample collection, if applicable, will be done by FH Nuclear Chemical Operators under the direction of FH and specific procedures. PNNL will prepare, integrate, and coordinate sample collection schedules and constituent analysis of groundwater samples in accordance with monitoring plans and a specific procedure. The paperwork and instructions provided to the field personnel will include sample authorization forms, chain-of-custody forms, labels, and the groundwater sample reports. PNNL will track, oversee, and interface with the sampling organization to assure the work is completed as specified.

6.3 Sample Handling and Custody

Water samples will be collected in accordance with FH and/or PNNL-approved project-specific procedures. Custody of the samples in the field and receipt at the laboratory will be documented on chain-of custody forms in accordance with PNNL procedures. Shipping and transporting of the samples will be handled by FH in accordance with FH procedures and federal regulations. If PNNL is responsible for shipping and transporting of the samples, the samples will be handled in accordance with PNNL procedures and the SBMS subject area, "Hazardous Materials, Packaging and Shipping" (PNNL 2007a).

6.4 Analytical Methods

The sampling and analysis plan for each site will identify the sample constituents and the analytical method as discussed in section 5.2.2.

7.0 Data Reduction, Verification, and Reporting

7.1 Data Reduction

Data measured during technology project investigations are compiled, evaluated, and documented as described below. Verification of analytical data provided by laboratories is performed in accordance with Appendix A of this QAPjP. Results are reviewed to assure the reliability and validity of the field and laboratory measurements based on accuracy, precision, and detection limits. Representativeness, completeness, and comparability may also be evaluated for overall quality. These parameters are evaluated through laboratory QC checks, replicate sampling and analyses, analysis of blind standards and blanks, and interlaboratory comparison. Acceptance criteria are established for each of these parameters in Appendix A of this QAPjP, the *Environmental Sciences Laboratory Quality Assurance Plan* (ESL QAP, current revision), and/or in specific test plans. When a parameter is outside the criteria, corrective actions are taken to prevent a future occurrence and any data impacted is appropriately flagged. If appropriate, the review will take into account results of the QC evaluation as defined in the internal procedure QC-5, "Groundwater Data Validation and Process" (see PNL-MA-567), and results of the review are documented as stated in the test plan.

When the data review identifies suspect data, those data are investigated to establish whether they reflect true conditions or an error. A Review Document Record (RDR) form is initiated in accordance with the procedure DA-3, "Data Review Procedure" (see PNL-MA-567) or other appropriate project-specific method.

7.2 Sample Data Tracking and Verification

The process for tracking and scheduling sampling and analysis requirements, sampling field activities, chains-of-custody, and laboratory analysis is managed using a variety of electronic data management tools. Groundwater data are reviewed after they are generated to assure the reliability and validity of the field and laboratory measurements for collected groundwater samples. The reliability and validity of the measurements are based on accuracy, precision, and detection limits. Representativeness, completeness, and comparability may also be evaluated for overall quality. These parameters are

evaluated through laboratory QC checks (e.g., matrix spikes, laboratory blanks), replicate sampling and analyses, analysis of blind standards and blanks, and interlaboratory comparison. Acceptance criteria are established for each of these parameters in the appendix of this plan. When a parameter is outside the criteria, corrective actions are taken to prevent a future occurrence and any data impacted are appropriately flagged. Reports documenting the QC evaluation results are discussed in Section 8.0.

7.3 Sample Data and Tracking for Soil and Sediment Samples

Completed data packages for soil and sediment samples will be verified by qualified PNNL personnel. Verification will consist of verifying required deliverables for completeness, required QC results, chain of custody forms, and case narratives that describe any issues related to the sample analyses for all data packages. Verification may also include evaluating and qualifying results based on holding times, method blanks, matrix spikes, laboratory control samples, laboratory duplicates, and chemical and tracer recoveries, as appropriate to the methods used. No other verification/validation or calculation checks will be performed. At least 10% of all data types (i.e., volatile organic constituent [VOC], semi-VOCs, metal, etc.) will be verified. Verification will be documented on checklists to be included in the project files.

7.4 Data Reporting

Data measured during the projects are compiled, evaluated, and documented as described below. When the data review identifies suspect data, those data are investigated to establish whether they reflect true conditions or an error.

Requirements for reporting analytical data are described in CAWSRP, Section 8, "Reporting Analytical Data." All data reported shall be traceable to the M&TE and procedure (including procedure revision) or test plan used, and if the reported results are quantitative, a valid calibration. The analyst shall sign or initial and date the data reports unless the results printed by the instrument include identification of the analyst and date. A staff member other than the person who performed the work, and who is knowledgeable in the area being reviewed, shall review the data before results are reported.

Interpretative data, test results, and reports will be released through the information release process in accordance with the SBMS subject area, "Publishing Scientific and Technical Information" (PNNL 2007d).

8.0 Analytical Quality Control Checks

Analytical QC checks are performed on internal and external samples. A summary of QC check samples is outlined in Appendix A of this QAPjP, the *Environmental Sciences Laboratory Quality Assurance Plan* (ESL QAP, current revision), and/or in specific test plans. Internal QC data are generated when the analytical laboratory prepares QC samples to monitor the quality of their analyses.

The QC activities needed for sampling, laboratory (internal and external) and field analysis, or measurement technique will be defined in the appropriate treatability study test plans. For each required QC activity, the associated method, acceptance criteria, and corrective action will be listed. Also, for the

field and laboratory QC activities included, but not limited too, are the use of blanks, duplicates, matrix spikes, laboratory control samples, and surrogates in the plans. The project-specific QA plans also identify the procedure, formulae, or references for calculating the percent recovery, bias, and precision.

9.0 Assessments

Assessments are performed to gather results that can be evaluated to measure the effectiveness of the quality systems and processes implemented by the project. Assessments will be performed periodically during the year. The following types of assessments may be used at varying frequencies during the year:

- Management self-assessment — an assessment performed by those immediately responsible for overseeing and/or performing the work to establish whether policies, practices, and procedures are adequate for assuring results needed.
- Management independent assessment — an assessment performed by an individual or group independent of the work performed to assure that policies, practices, and procedures are adequate for assuring results needed.
- Technical independent assessment — an assessment performed by an individual or group technically competent to do the work but independent of the work being performed to assure qualitative and quantitative aspects of the work are accomplished according to documented specifications.

Data quality assessments are conducted as project QC checks. The focus of data quality assessments is independent verification of reported results. Data quality is routinely evaluated through technical review. If the complexity and/or significance of the work performed warrants it, the Project Manager will direct the QA representative and/or another staff member to conduct an additional quality assessment. The assessment is documented and retained in the project records. Documentation of the above assessments, as well as any external assessments performed, is maintained as project records. The Project Manager ensures that any deficiencies are corrected in a timely manner.

9.1 Assessment Planning and Documentation

Assessment planning is done by the project management team (includes Project Manager, Task Leaders, Principal Investigator, and appropriate staff) in consultation with the project Quality Engineer. Assessments are in accordance with the SBMS subject area, "Planning, Assessment, and Analysis," Section 2, "Performance Assessment" (PNNL 2007b). The assessor plans the assessment on a Self-Assessment Planning Form (see example in Figure 9.1) where the assessment scope, topic, and supporting references are documented on the plan. A unique identification number is assigned to the plan and entered on an Assessment Log Sheet.

Results of assessments will be documented on a Self-Assessment Results form (see example in Figure 9.2). The corrective action and action owner will be documented on the assessment report. The Task Manager will assign the action owners, and the Project Manager will prioritize the corrective actions. An action item log will be maintained by the project Quality Engineer to track and close out actions, and to finally verify the corrective actions. The Project Manager will sign the assessment report when the corrective actions have been closed. The assessment plan and report will distributed to the appropriate Task Managers, Project Manager, and project records.

9.2 Subcontractor Assessments

If PNNL passes work to subcontractors, periodic assessments of analytical subcontractors are performed as an oversight function or prior to contract award in accordance with internal acquisition quality procedures. Provisions are made in the SOW for oversight assessment activities to be performed as necessary.

The results of all subcontractors' assessments (including surveillances and audits) will be made available to project and line management, individuals contacted, and the client as requested. The corrective action tracking, corrective actions, and closure responses will be in accordance with the internal acquisition quality procedures. The official assessment report files and responses (audits and surveillances) are maintained in the PNNL Suppliers History File by the Quality Assurance Services group.

Periodic assessments of well drilling and construction, drilling and sampling-related activities, and Environmental Sciences Laboratory work may be conducted in accordance with the requirements discussed in this section.

10.0 Preventive Equipment Maintenance

Subcontracted organizations will be required to implement preventive maintenance on their equipment to mitigate the possibility of down time affecting cost and schedule. This will be specified in the SOW to the respective organizations.

11.0 Specific Routine Procedures Used to Assess Data Precision, Accuracy, and Completeness

The evaluation of laboratory precision, accuracy, and completeness is accomplished during the verification process performed upon receipt of data (see Section 7.0 of this plan).

SELF-ASSESSMENT PLANNING FORM

Scope & Location: *(General: Maintenance, Operations)*	**I.D. Number:** *(Assessment tracking system number or other unique tracking number)*
Topic: *(Describe what will be assessed)*	**Date:** *(Date planning form is prepared)*
References: (*Cite source documents for performance expectations;* i.e., Regulation; Environmental Permit; DOE Order; A-Manual; Standards Based Management System [SBMS]; Requirements, Procedures and Guidelines [RPG]).	

Performance Expectations

Criteria developed from source documents that will be applied throughout the assessment. Each criteria/expectation will have the reference enclosed in parenthesis at the end of the criteria/expectation statement (e.g., DOE Order 5480.19, SBMS, RPG). Performance expectations should be limited to six maximum to allow the assessment to remain focused. Additional Planning Forms can be completed to expand the scope of a particular assessment.
1.
2.
3.
4.
5.
6.

Procedure: *(Perform the following as applicable for the assessment)*
Review assessment planning form
- Review applicable procedure/requirements. (Include references.)
- Conduct performance tests and data validation.
- Observe the activity controlled by the procedure.
- Interview appropriate personnel about requirements and practices.
- Record observations based on comparison to plan.
- Document the results after receiving final information on the Self-Assessment Results form.

Basics for the Assessment: [ ] Planned [ ] Lessons Learned [ ] Responsive [ ] Other

Work Package Number (optional):

Assessment Requestor/Authorizing Person:

Assessor(s):

Figure 9.1. Self-Assessment Planning Form

SELF-ASSESSMENT RESULTS

Assessor:	**I.D. Number:**
Assessment Location:	**Date**: (*Date assessment performed*)

Results

(*Related to Associated Performance Expectations*)

(*Use additional pages if necessary.*) Concise and objective statements are the goal. Subjective comments may be added at the end and must be based upon a series of facts that supports the comments. Include strengths and improvement opportunities. Include date the information is obtained and list of line managers or points-of-contact during assessment.
Summary
1.
2.
3.
4.
5.

Subsequent Actions

(*Related to associated results*)

Assigned Action	Action Owner	Due Date
1.		
2.		
3.		
4.		
Actions Assigned By:		**Date**:
Completion (*To be signed by Lead Assessor when assessment is completed.*) **Signature**: **Date**:		
Completion (*To be signed by Manager when assessment is completed and all actions have been entered into ATS*) **Signature**: **Date:**		

Figure 9.2. Self-Assessment Results

12.0 Corrective Action

12.1 Project Corrective Actions Resulting from Assessments

As part of the continuous improvement processes initiated by the project management team, assessments will be tracked and improvement actions identified and prioritized. The Assessment Tracking System (ATS) is the process used by this project for tracking and managing assessments, including determining conditions and developing corrective actions. ATS supports the identification, control, and correction of items, services, and processes that do not meet established requirements. The SBMS subject area, "Assessment Management" (PNNL 2005a) documents this corrective action management process for handling and documenting events and assessments, including those that must be tracked in ATS such as formal project reviews or audits performed by the client or its representative, management-initiated assessments, etc. If immediate corrective action is required, the quality problem will be directly entered into the ATS and actions taken as specified in Section 12.2.

12.2 Unplanned Deviations

Corrective action must be initiated by the Project Manager or cognizant Task Leader when unplanned deviations from procedural, contractual, regulatory requirements, or construction specifications occur. These deviations will be documented by documenting the quality problem information directly into the ATS in accordance with the SBMS subject area, "Quality Problem Reporting" (PNNL 2005c). The assessment must describe the problem, the cause of the deviation, the impact of the problem, and the corrective action needed to remedy the immediate problem and to prevent recurrence.

Subcontractors will be required to have a system in place to identify, correct, and prevent recurrence of contractual, procedural or regulatory requirement(s) deviations, and to notify the PNNL point-of-contact specified when such an event occurs. These requirements will be passed in a SOW to the subcontractors.

12.3 Planned Deviations

Planned deviations from procedure, documented (including justification) and approved by the Project Manager or Task Leader in advance, do not constitute a deficiency and do not require generation of an assessment item. Documentation may consist of a hard copy e-mail or memo to the Project Manager or Task Leader. This documentation must include either an approval signature if on a memo, or electronic approval via a reply to the e-mail indicating such approval.

12.4 Measuring and Test Equipment Calibration Discrepancies

Subcontractors will be required to maintain a system for identifying calibration discrepancies and tracing data or samples that may have been affected. Subcontractors will be required, via a SOW, to notify the PNNL point-of-contact as soon as possible when such an incident occurs. PNNL will perform periodic assessments to assess the effectiveness of subcontractor procedures and processes for calibration control.

Project staff must investigate instruments or equipment found to be operating outside acceptable operating ranges (as specified in the applicable technical procedure or manufacturer's instructions), and issues must be addressed in accordance with the SBMS subject area, "Quality Problem Reporting" (PNNL 2005c). When as-found data on an instrument's calibration report was found to be "Out of Tolerance" during the review and acceptance process of the contract-supplier documents submitted in response to quality requirements, an "Out-of-Tolerance Notification" will be generated using the ATS in accordance with the SBMS subject area, "Assessment Management" (PNNL 2005a). Project staff must then determine if there was any impact on data. When it is determined from calibration verification that Category 1 or 2 M&TE is out of tolerance, proceed with the evaluation to determine impact on data and document the results with justification.

13.0 Quality Assurance Reports to Management

Quality activities such as project improvement efforts, significant deficiencies and associated corrective actions, and a summary of assessment results will be reported to the Project Manager. When major quality problems are identified, they shall be reported to the Project Manager. Surveillance plans and surveillance results are provided to the Project Manager and Task Manager after a surveillance event.

Quality-related problems identified by project personnel must be reported to project management immediately for resolution. Any problems involving data quality, sample integrity, or test measurements will be thoroughly documented by an RDR and/or a problem and discrepancies form and communicated to the appropriate Task Leader and Project Manager for resolution.

Significant quality-related problems that may affect customer satisfaction shall be communicated to the Product Line Manager by the Project Manager.

14.0 Records

14.1 Records Control

SBMS definitions of project records and record material apply to this project. As stated in the SBMS subject area, "Records Management" (PNNL 2007f), project records are any recorded information relating to a specific research project. Record material includes information, regardless of its media (e.g., hard copy, electronic, microfilm), created or received in connection with Pacific Northwest Division business or research activities that documents research and administrative functions, policies, decisions, procedures, operations, or other activities, and which is preserved for its value.

Note: E-mail that is record material must be printed out and maintained as the record copy unless the e-mail is saved directly into the PNNL Total Records Information Management (TRIM) System.

Record material that is not stored in field notebooks or laboratory records books (see Section 19.5 of this QAPjP) or is not electronic data gathered from sensors or instruments in the field and/or laboratory (see Section 14.3 of this QAPjP) such as project-specific field data forms, shall be scanned and managed as PDF files in accordance with Section 14.3. Record material shall be scanned and archived at least

quarterly or more often, such as weekly or monthly, if the accumulation of the material is significant and inadvertent damage or loss would cause irreparable damage to the project.

Records that document the sampling subcontractor activities, analytical results, verification and compliance checks, quarterly and annual reports, test plans and associated results, groundwater monitoring plans, and assessment reports will be maintained as project records. Individual monitoring plans and work plans may identify other records requirements. Project records will be legible, identifiable, and maintained in accordance with the PNNL SBMS subject area, "Records Management" (PNNL 2007f). Test results documented in laboratory record books will be reviewed semi-annually by a technically qualified individual who did not perform the work. The reviewer will verify that there is sufficient detail to retrace the investigation and confirm the results.

The project Records Specialist prepares and submits a Records Inventory and Disposition Schedule (RIDS) file index for review and approval by the records management representative and Quality Engineer. The Records Custodian reviews and updates the RIDS annually at a minimum, or when a major change to the program occurs. Records retention schedules shall be based on requirements in the Tri-Party Agreement (Ecology et al. 1989), which requires the retention of records for 10 years after termination of the Tri-Party Agreement.

14.2 Records Transfer to Storage

On an annual basis, the Records Custodian will transfer to storage inactive records as identified by the project staff as not required for day-to-day operations. Sampling and analysis plans, assessments, and special project correspondences will be maintained by the Record Custodian until the activity or project is complete. The project Records Specialists generates the internal form (e.g., Records Transfer/Data Input [RTDI] form). The records management representative will sign the RTDI form as acknowledging receipt of the records and return a copy of this form to the records custodian. The RTDI form is then placed in project records.

Within 90 days of project completion or termination, records shall be transferred to storage and/or the client. The project Records Specialist completes the appropriate internal form (e.g., RTDI form). The records management representative will sign the RTDI form as acknowledging receipt of the records and return a copy of this form to the Records Custodian, who will file the form in project records.

14.3 Electronic Data/Records Management

Electronic data gathered from sensors or instruments in the field and/or laboratory will be maintained and managed appropriately to allow for reproducible results. Electronic data that are directly delivered and/or used in analysis, that are delivered to the customer, will be maintained as project records in accordance with the requirements of the SBMS subject area, "Records Management" (PNNL 2007f).

Electronic data produced by instrumentation or sensors are usually stored on that instrument and are only usable by the system itself. It is necessary for the electronic data to be transferred, without error, to a form that can be used by a variety of software applications. An example would be to transfer an ASCII file into a Microsoft Excel® file. [1] To ensure that the data transfer process has occurred in an acceptable

[1] Microsoft Excel is a registered trademark of Microsoft Corporation.

manner, a review of a representative sample, of sufficient data points to provide confidence that the data have been transferred properly, shall occur. The review method used and results obtained shall be documented and retained as project records in the Laboratory Record Book, in accordance with section 19.5 of this plan. For retrieval of the data, the staff member shall record the use of the data on the media used to store the raw data and in the project records. The staff member shall ensure that unauthorized modifications are not made to the data during its use. The method of control shall be documented in the project records by the staff member. The staff member shall ensure that a back-up of the data is maintained in the project records. The use of the data in software applications shall be documented, along with the software application name and version number.

Electronic data shall be archived and saved as project records based on the project's record retention period. When the project records are required be maintained for a minimum of 10 years, after the close of the project, saving the raw electronic data files to a CD/DVD is sufficient. When the project's record retention requirements are longer than 10 years, the raw data files should be saved either to magnetic media (TRIM, tape) or optical media (CD, DVD). The Total Records Information Management (TRIM) system is one option for storing raw data files and is approved for projects that have a permanent retention period.

Backup and archive processes shall be followed for maintaining the data during the life of the project. Electronic data backups shall be performed nightly, in accordance with the requirements identified by the PNNL IT Computing Services - InfoSource website. The computer backup procedures identified in the PNNL Infosource website for Data Backup Options shall be followed based on the type of computer or server on which the data are stored. The data backup process is identified in the following sections.

14.3.1 Workstations

PNNL staff members are responsible for ensuring the data on their computers are regularly backed up regularly. There are three options for backing up these data:

1. The staff member can sign up for one of the PNNL workstation backup and restore (WBR) services: WBR Connected DataProtector for Windows®, WBR Mac for Macintosh®, or WBR Networker for all other systems. [2,3] WBR is free to each staff member for one workstation. Additional backup subscriptions are available for a small monthly fee. (See the WBR website for restore instructions.) The maximum backup size is 100 gigabytes (GB) for Windows workstations.
2. A network shared folder may be used to store files on a PNNL network file server. Network shared folders are backed up nightly. To retrieve files from a backup, request a file restore by calling the PNNL Help Desk at 375-6789 or send an email. They will need the complete name of the shared folder (for example, \\pnl10\projects) and the name and date of the file or directory that needs to be restored.
3. Manually copy files to floppy disks, CDs, or DVDs. Most computers purchased through the Managed Hardware Program (MHP) come with large-capacity floppy drives, CD-RW drives, and/or DVD drives. A CD can hold 600 megabytes or more; DVDs 4.7 GB. Either of these methods is suitable for backing up important data files, but not recommended for backing up the entire system.

[2] Windows is a registered trademark of Microsoft Corporation.
[3] Macintosh is a registered trademark of Apple, Inc.

14.3.2 Servers

The data backup options for servers include the following:

1. The Workstation Backup and Restore (WBR) service. For a small monthly fee, WBR performs a full backup of all the project's programs and data. (See the WBR website for restore instructions.)
2. Backing up to Zip disks or to a tape drive connected to the server. If a tape drive connected to the project server is used, refer to the manufacturer's instructions for establishing backup schedules and performing restores.

Data archiving shall occur at least every two 2 weeks. It is recommended archiving occur at least once a week. The electronic data shall be archived to a CD/DVD and kept in the project working files until the electronic data are no longer being used; at that time, the electronic data shall be moved to TRIM when longer storage retention is required by the records requirements.

15.0 Procurement Control

Project staff procuring quality-affecting materials (e.g., calibration standards, chemicals) or services (e.g., calibration, analytical services, or other subcontracts for technical services) will be obtained in accordance with the SBMS subject area, "Purchasing Goods and Services" (PNNL 2007e). For this project, the majority of procurements will result in purchases of services such as drilling, sampling, and analysis. All procurements will be obtained in accordance with the SBMS subject area, "Purchasing Goods and Services" (PNNL 2007e). SOWs for purchasing services shall be reviewed and signed by the project Quality Engineer to assure consistency of QA requirements specified to subcontractors with project quality standards in this plan.

15.1 Groundwater Sampling

Test plans used for field experiments will include requirements for sample collection, sample handling, sample labeling, custody of the samples in the field to delivery to the laboratory or shipper, and water level measurements. The test plan procedure will pass on the requirements of the *EPA Requirements for Quality Assurance Project Plans (QA/R-5)* (EPA/240/B-01/003) and HASQARD (DOE/RL-96-68). A review must be performed by the Quality Engineer during the planning stages and preparation of the test plan procedure.

15.2 Groundwater and/or Sediment Analytical Measurements

If the groundwater or sediment analysis will be conducted by subcontractors or collaborators on the project, requirements will be specified in the SOW or Letter of Instruction (LOI) as applicable, which shall be used to obtain the analytical services. The LOI is the mechanism to be used for work requests to other Hanford Site contractors. An LOI or SOW must accompany each purchase order. A review must be performed by the Quality Engineer during the planning stages and preparation of the SOW/LOI. The SOW must define the data quality and any additional project requirements associated with the service requested. The data quality requirements should include a description of the QC samples for each analysis for determining the level of possible contamination from preparation and analysis. Project

requirements should include information on analysis method, calibration standards traceable to the National Institute of Standards and Technology, sample turnaround time and reporting requirements, and disposal requirements for remaining sample material and any process waste. The LOI/SOW will pass on the requirements of the *EPA Requirements for Quality Assurance Project Plans (QA/R-5)* (EPA/240/B-01/003) and HASQARD (DOE/RL-96-68) to the analyst.

15.3 Other Hanford Site Contractor Services

Other Hanford Site contractor services (e.g., well drilling and construction) will be obtained using the procurement process. An electronic requisition will be generated by project staff accompanied by a work authorization document (LOI or SOW). The work authorization document will describe the requirements for the requested services. The SOW/LOI will pass on the requirements of the *EPA Requirements for Quality Assurance Project Plans (QA/R-5)* (EPA/240/B-01/003) and HASQARD (DOE/RL-96-68) to the subcontractor. A review must be performed by the Quality Engineer during the planning stages and preparation of the SOW/LOI.

15.4 Technical Services from Subcontractors

Technical services from subcontractors will be procured by using a work authorization document (LOI or SOW) accompanied by a work package authorization (WPA) or work orders. The Quality Engineer shall perform a review during the planning stages and preparation of the SOW/LOI. The work authorization document must define the data quality and any additional project requirements associated with the service requested. The data quality requirements should include a description of the QC samples for each analysis for determining the level of possible contamination from preparation and analysis. The project requirements should include information on analysis method, calibration standards traceable to the National Institute of Standards and Technology, sample turnaround time and reporting requirements, and disposal requirements for remaining sample material and process waste. The SOW will pass on the requirements of the *EPA Requirements for Quality Assurance Project Plans (QA/R-5)* (EPA/240/B-01/003) and HASQARD (DOE/RL-96-68) to the subcontractor. Where software is involved, DOE Order 414.1C requirements will be passed on to the subcontractor.

16.0 Staff Training

Staff performing activities affecting quality shall be issued documented training assignments, including applicable project administrative and technical procedures and this plan.

1. Task Leaders and staff members will assess project-specific training needs. The assessment will include evaluating cumulative training records of staff.
2. Task Leaders will assign reading and/or briefings of procedures as needed. If training is assessed and the need for formalized training is identified, the staff member will be scheduled to attend a formal training class.
3. Task Leaders and staff will document training on a Briefing Document, an individual on-the-job training (OJT), a Reading Assignment Documentation form, or a Group OJT or Reading Assignment Documentation form. These forms are available internally to PNNL staff. Documentation shall be

sent to the PNNL Laboratory Training Coordinator for input into the training database. The training database will contain the record copy of project staff training.

Subcontractors are responsible for special training of its staff in accordance with the respective SOW.

Project management shall utilize personnel who are knowledgeable and possess adequate technical, managerial, or professional skills to perform assigned tasks. The Project Manager will identify any additional specific project-related processes that will require project staff training and qualification, and who will be responsible for assuring the project-specific training will be developed, delivered, and changes managed in accordance with the SBMS subject area, "Training Design, Development, Implementation and Evaluation" (PNNL 2002). The project shall maintain training documentation for project-required coursework or OJT training taken by staff that is not capable of being tracked in the Laboratory's training database in accordance with the SBMS subject area, "Training and Qualification for Staff and Non-Staff" (PNNL 2005d).

The Project Manager or assigned delegate shall inform the immediate manager of project staff of his/her requirement to take project-required training and assure that the training has been completed prior to project staff conducting work that requires the training. The immediate manager of project staff, or their delegate, shall record the need for identified project required training and assuring training (and retraining for changes) records (for both Lab-level and project -specific training) will be maintained in accordance with the SBMS subject area, "Training and Qualification for Staff and Non-Staff" (PNNL 2005d).

Software development that requires complex or unfamiliar interactions with users and operators should include a comprehensive plan for training. The training plan should include the following:

a. A description of the populations to be trained, the training objectives for each population, and the content covered in the training
b. An estimate of the amount of resources necessary for training development, delivery, and time expenditures
c. Procedures for evaluating the effectiveness of the training and for making modifications to the training.

The Project Manager has identified the following project-specific training requirements for project core team members:

- Project Management Plan
- QAPjP
- Health and Safety Plan

The project shall maintain training documentation for project-required coursework, or on-the-job training taken by staff, which is not capable of being tracked in the Laboratory's training database in accordance with the SBMS subject area, "Training and Qualification for Staff and Non-Staff" (PNNL 2005d).

17.0 Software Control

Various project tasks require the use of databases and software, which are managed, controlled, and operated by entities outside PNNL. The project also requires the use of databases and software that are developed, managed, controlled, and operated by PNNL. A graded approach is used to establish software QA requirements based on identified risk. Software QA at PNNL is based on DOE O 414.1C, "Quality Assurance," which establishes specific requirements for software related to safety and nuclear facilities.

The project uses databases, custom applications, and configurable software to support various activities. These databases, custom applications, and configurable software (spreadsheets and queries) used to generate reportable results shall be documented in accordance with the SBMS subject area, "Software" (PNNL 200i). This documentation is maintained in project files.

17.1 Safety Software and Software Applications

For the purpose of the projects identified in this plan, software is defined as computer programs, including computer programs embedded in firmware (see the SBMS subject areas, "Safety Software" [PNNL 2007g] or "Software" [PNNL 2007i]). Excluded is software that is an integral part of firmware or equipment, where all software maintenance is performed by the vendor and the software is verified as an integral part of the system (e.g., calibration with known standard materials). Any vendor will be required to follow the NQA-1-2000 standards for software when the software that is part of firmware is identified as safety software. The safety software clause (QA-197a) will be included in any SOWs, at a minimum, and possibly with additional clarification when requested by the vendor, and the software being used or developed has been identified as safety software. The software clause (QA-197b) will be included in any SOWs, at a minimum, and possibly with additional clarification, when requested by the vendor for non-safety applications being developed.

All software applications used for the project under this plan will be reviewed and identified as safety software or software. The grading process for safety software will be recorded and copies for each application will be maintained as project records for each project that falls under this plan. Software applications follow this plan have the potential to be identified as safety software and when graded as such, will follow the SBMS subject area, "Safety Software" (PNNL 2007g) Level C requirements, at a minimum. The SBMS subject area, "Safety Software" (PNNL 2007g) is based on DOE Order 414.1C, which includes the NQA-1-2000 standard.

If applications are not identified as safety software, applications will be documented as software and the documentation will be maintained as project records for each project. Safety software and software applications identified for the projects in this plan will be used by staff to perform the work activities identified below that pertain to custom developed, configurable, acquired/legacy, utility calculations, and commercial design and analysis software.

All safety software applications are required to be identified in the Information Resource Inventory (IRI). All safety software will be identified as safety system software, safety and hazard analysis software and design software, or safety management and administrative controls software. The following will additionally be identified for each software application in the IRI: type of software, graded level, version

of the software, and the scope of the software, for the intended use with the project. The owner and point of contact information will also be identified in the IRI.

17.1.1 Minimum Documentation Requirements

To ensure implementation of the software satisfies requirements, the following documentation is required as a minimum for all safety software applications. These document requirements must be reviewed and processed through the Electronic Records and Information Capture Architecture (ERICA) system for software code being developed as a deliverable. The rigor of the documentation will be decided based on the grading of the safety software application. Refer to the SQA Activity Tailoring exhibit, in the SBMS subject area, "Safety Software" (PNNL 2007g), for guidance on the rigor needed for the documentation requirements. The document requirements will be for each document identified below. Document requirements may be grouped together in one document or may be separated into separate documents identified below:

a. Software Requirements Specifications (SRS)
b. Software Design Description (SDD)
c. Verification and Validation Plan (VVP)
d. Verification and Validation Report (VVR)
e. Configuration Management Plan (CMP).
    1. A problem reporting and corrective action tracking system will be identified with the CMP documentation.
    2. Data management process will also be identified, when applicable.
f. Procurement contractual documentation, when applicable.

17.1.2 Software Requirements Specification

The Software Requirements Specification (SRS) shall clearly and precisely describe each of the essential requirements (functions, performances, design constraints, and attributes) of the software and the external interfaces. Each requirement shall be defined such that its achievement is capable of being objectively verified and validated by a prescribed method (e.g., inspection, analysis, demonstration, or test).

The SRS is subject to the Software Requirements Review (SRR), identified in applicable CMPs when needed, which identifies the QA aspects of work activities.

17.1.3 Software Design Description

The Software Design Description (SDD) shall depict how the software will be structured to satisfy the requirements in the SRS. The design document shall describe the components and subcomponents of the software design, including databases and internal interfaces, and provides a technical description of how the software will meet the requirements established in the requirements specification. Its most important function is to describe a decomposition of the whole system into components (subsystems, segments, etc.) that are complete and well bounded. In addition, it should document the rationale for the more important design decisions to facilitate the understanding of the system structure.

The SDD will document major system features such as databases, diagnostics, external and internal interfaces, as well as the overall structure of the design. It involves descriptions of the operating environment, timing, system throughput, tables, sizing, centralized or distributed processing, extent of parallelism, client/server, reusable objects library, program design language (PDL), prototypes, modeling, simulation, etc. The design description will also document any input and output data that may be required. The QA organizational element can observe demonstrations, which is a more efficient way to review and assess written design documentation.

The SDD will be updated after each significant review. A new version containing a more detailed design description is developed for each subsequent review.

17.1.4 Verification and Validation Plan

The Verification and Validation Plan (VVP) shall identify and describe the methods (e.g., inspection, analysis, demonstration, or test) to be used:

1. To verify that the following:
   - Requirements in the software requirements specifications have been approved by staff with appropriate authority
   - Requirements in the requirements specifications are implemented as described in the SDD
   - Design documented in the SDD is implemented in the code.
2. To validate that the code, when executed, complies with the requirements expressed in the requirements specification.

The VVP describes the overall approach for verification and validation of the software or modeling approach and will be produced and reviewed incrementally, for safety software applications. The tasks, methods, and criteria for verification and validation will be described in the appropriate VVPs for each application.

The VVP will be used for documentation of the testing standards and practices as they are defined in the plan for each application. The VVP will document the scope of the validation testing to ensure the baseline requirements, and describe the stages of development that require customer review and the extent of the verification that will precede such a review.

The VVP will specify minimum test documentation requirements for each test performed. Additionally, a section of each plan will identify a verification matrix where the requirements are listed with their corresponding test. A matrix will be maintained during the life of the software and will be used to verify all the requirements have been met, identified, and tested.

The contents of the VVP will be evaluated at a Verification and Validation Plan Review (VVPR) prior to testing. Such a review will be conducted when significant changes are made to the baseline. The Verification and Validation Plan Review will be used to identify all changes to be tested and to pass on pertinent information to the appropriate testing staff.

17.1.5 Verification and Validation Report

The Verification and Validation Report (VVR) shall describe the results of the execution of the VVPR. The report summarizes the observed status of the software as a result of the execution of the VVP. The report should include the following information:

a. Summary of all life-cycle verification and validation tasks.

b. Summary of task results.

c. Summary of anomalies and resolutions.

d. Assessment of overall software quality.

e. Summary from the verification matrix.

f. Recommendations such as whether the software is, or is not, ready for operational use.

The report may be a full report or a summary (depending upon the grading of the software).

17.1.6 User Documentation

User documentation will be developed for applications where the code is part of the deliverable.

17.1.7 Configuration Management Plan

The Configuration Management Plan (CMP) shall document methods to be used for identifying software items, controlling and implementing changes, and recording and reporting change implementation status. The CMP should describe the tasks, methodology, and tools required to assure that adequate configuration management procedures and controls are documented and are being correctly implemented. If the CMP is not a stand-alone document, and is included in the QAPjP or PMP, it is not necessary that the QA organizational element prepare it; however, it is essential that one exist for each project or set of applications under each project.

The CMP should describe the methods to be used for the following:

a. Identifying all the configuration items (each software item will be identified if it is considered to be safety software or not, if identified as safety software, the level will be identified as well)

b. Controlling and implementing changes.

c. Recording and reporting change and problem reports implementation status.

d. Conducting configuration audits.

e. Identifying review and approval cycle as well as signature authority.

f. Identifying the personnel responsible for maintaining the baselines and distributing the plan.

The CMP shall contain the information identified in the SBMS subject area, "Safety Software" (PNNL 2007g) for the appropriate level of software to which the application was graded. Most software application for the work under this project will be graded at Level C.

17.2 Software Use in Analysis

The use of software of any kind to conduct analyses delivered, or in support of a deliverable, to the customer includes data analysis tools such as spreadsheets and statistical analysis software, databases, modeling, and simulation tools. Excluded are software productivity tools such as word processors and spreadsheets when no automated calculations, macros, or scripts are used. Staff working on projects under this plan shall conduct work in accordance with requirements for the control of software used in analyses as defined in the SBMS subject areas, "Safety Software" (PNNL 2007g) or "Software" (PNNL 2007i) based on how the software being used is graded.

17.3 Utility Calculations

This section defines a uniform method for documenting the QCs in place when using software packages (e.g., Microsoft Excel®, Mathematica®, Matlab®, and Mathcad®, known as Utility Calculations) for calculations that are a significant part of a client deliverable, but not classified as safety software. [4,5,6] As stated above, the safety software classification involves software failure that could result in the loss of life or serious injury, exposure to hazardous materials in excess of standards, serious damage to the environment, or noncompliance with laws or regulations.

Excel or other Utility Calculation analyses that are not used for a significant part of a client deliverable or are only used to recheck information are exempt from these instructions. These instructions apply to the use of scripts and/or macros, within Excel, as well as Excel basic calculations. Portions of this project that have been identified as containing safety software must follow the SBMS subject area, "Utility Calculations Guidance" identified in "Safety Software" (PNNL 2007g). For additional information, refer to the SBMS "Software" (PNNL 2007i) subject area, "Section 7 – Using Software to Conduct Analyses."

Note: Excel is used as the example in these instructions; however, the process is the same for all other Utility Calculations.

These requirements and instructions apply to Project Managers and staff who will use Excel to conduct analysis to be delivered to the client, or to conduct analyses in support of a deliverable to the client. The process shall be implemented as follows:

- Requirements and Risk Identification: Plan out the analysis that will be performed and assess the risk associated with the failure of the software. Document the associated risk and the analysis to be performed (this could be one paragraph in a Microsoft Word® document or on another tab in the Excel spreadsheet). [7] (See risk examples in Table 17.1.)
- Design and Validation Planning: Prepare and document how the Excel file will be validated/reviewed and tested by an independent technical reviewer. Identify and document who will perform the independent technical review. (Identify what problem is trying to be solved and what actual calculations are being performed to solve the problem. This information will be useful for the

[4] Mathematica is a registered trademark of Wolfram Research, Inc.
[5] Mathcad is a registered trademark of Parametric Technology Corporation
[6] Matlab is a registered trademark of The MathWorks, Inc.
[7] Microsoft Word is a registered trademark of the Microsoft Corporation.

independent technical reviewer. This could be one paragraph in a Word document or on another tab in the Excel spreadsheet.)

- Implementation: Conduct the analysis using the Excel spreadsheet with the appropriate calculations based on the planning previously performed. (If the implementation of the analysis has changed, go back and update the risk associated with the analysis and the documentation to be used for the validation, if applicable.)
- Verification: Review/verify the results of the analysis. Review the results produced from the analysis. Determine if the analysis and results support the problem that is trying to be solved. Document the verification/review step. (Documenting this step can be done with one paragraph, in a Word document, or on another tab in the Excel spreadsheet itself, of what was reviewed, and identify if the outcome was acceptable or if additional work needs to be done.)
- Validation: Conduct independent review of results and validation. Provide the identified independent technical reviewer the Excel spreadsheet and Word document, if applicable. (The reviewer needs to have all the information regarding the requirements, risk, design and review expectations to perform the review.)

Table 17.1. Software Risk Management Examples

Identified Risk	Overall Risk to Project	Preventive Action	Contingency Action	Trigger	Owner
Changing requirements after starting design/ development.	Medium	Customer approval of requirements before design/development, flexible design, and configuration management process.	Changes affect either schedule or resource allocation.	Customer request.	Battelle / Customer
Incomplete input Data.	High	Identify appropriate sources of validation data.	Manual updates to input tables are tracked through the change control process.	Appropriate input tables not available.	Battelle / Customer
Change in project budget or/or schedule.	Low	Define and implement new process.	Continue current process.	Coordination issues with customer.	Battelle / Customer
Invalid regulatory products that rely on calculations performed with this software.	Low	Development and execution of a software test plan to cover all calculations in the system.	Identify critical calculations and test based on use of the system.	Software codes are required to be reviewed with a customer QA/QC process.	Customer
Overall risk rating is *Medium*.					

- Independent Technical Review: Reviewer performs the review per the instructions provided, and documents any additional checks performed on the file that extended outside the original scope of the review and the method used to review the results. The reviewer documents the outcome of the review. (The documentation can be one paragraph in a Word document or on another tab in the Excel spreadsheet.)
  - The results shall be determined based on using an alternate method to perform the analysis. Typical alternate methods include: literature review, empirical data, hand-calculations, executing the analysis on a comparable but different tool.
- Documentation: Print the Excel spreadsheet with the analysis/results and attach the Word document or the tab in the Excel spreadsheet itself that contains the identified requirements, risk, design, validation steps, verification, and independent technical review steps and results. Have the independent technical reviewer sign the document. The verifier needs to sign the verification step. Place this signed document in project records.

18.0 Nonconformances and Deficiencies

For procured materials found to be in nonconformance with specifications or where the quality of an activity is found not to be in compliance, the quality problem will be documented in the ATS in accordance with the SBMS subject area, "Quality Problem Reporting" (PNNL 2005c). Corrective actions are documented in ATS in accordance with the SBMS subject area, "Assessment Management" (PNNL 2005a).

If a deficiency is found where a procedure or process is not followed or the activity is not in compliance with a procedure or process, the deficiency will be documented into the ATS in accordance with the SBMS subject area, "Quality Problem Reporting" (PNNL 2005c). Corrective action will be documented using ATS in accordance with the SBMS subject area, "Assessment Management" (PNNL 2005a).

Subcontractors will be required to have a system to identify and disposition nonconforming items, procedure deficiencies, processes not followed, or activities not in compliance with a procedure or a process. This requirement will be specified in a SOW.

19.0 Document Control

19.1 Quality Assurance Project Plan Control

Distribution and control of this QAPjP shall be performed in accordance with the SBMS subject area, "Publishing Scientific and Technical Information" (PNNL 2007d). Modifications to this plan shall be made either by revision or by issuing an Interim Change Notice (ICN). (See Figure 19.1 for the ICN form and instructions.) This plan will be revised after four ICNs, or a major change in project scope or requirements. Any PNNL staff member may request a change to this QAPjP by submitting the requested change in writing to the Project Manager and Quality Engineer. All reviewers listed on the signature page and affected by the change will approve the revision. The ICN will be placed in front of the signature

page and the individual pages will be replaced, or the necessary correction will be lined out with the correction added with the appropriate initials and date. The QAPjP will be reviewed at least every 2 years.

19.2 Technical Procedure Control

Technical procedures referenced by this QAPjP and used by PNNL staff will be contained in a PNNL internal procedure manual, *Procedures for Ground-Water Investigations* (PNL-MA-567) or other procedure manuals as appropriate. Technical procedures will be distributed and controlled in accordance with the SBMS subject area, "Document Control" (PNNL 2006a). Modifications to any of the internal procedures shall be made either by revision or by issuance of an ICN.

Procedures will be revised after two major ICNs, or if the procedure format has changed. Any PNNL staff member may request a change to procedures at any time by submitting the requested change in writing to the author. The author, technical reviewer, groundwater project Task Manager, and project Quality Engineer will review and approve the ICN. The ICN will be placed in front of the signature page and the individual pages will be placed or the necessary correction will be lined out and corrections added with the appropriate initial and date. Contact the Project Quality Engineer for the electronic copy of the ICN. New or revised technical procedures, whether they will be included in the internal procedures manual or not, must be developed in accordance with the SBMS subject area, "Procedures, Permits, and Other Work Instructions" (PNNL 2004). The procedure owner is required to review the procedure at least every 2 years.

19.3 Administrative Procedure /Instruction Preparation and Control

Administrative procedures/instructions used by PNNL staff will be developed, approved, and controlled to ensure consistent application by staff performing the defined task(s). These procedures/instructions will be developed, approved, and controlled in a manner that has been approved by appropriate the Project Manager and Quality Engineer.

19.4 Test Plans and Other Work Documents

Test plans and other work instructions used by PNNL staff will be developed, approved, and controlled to ensure consistent application by those staff performing the defined task(s). These procedures/instructions will be developed, approved, and controlled in a manner that has been approved by the appropriate Project Manager and Quality Engineer. Distribution and control of test plans and other plans shall be performed in accordance with the SBMS subject area, "Publishing Scientific and Technical Information" (PNNL 2007d).

INSTRUCTIONS FOR ICN FORM

HEADER:

The ICN number is identified as ICN No.-____.

For a published document, each page of the ICN shall have a header on the right upper corner that includes the report number, the date and the pagination. The number of the ICN must be placed after the PNNL number. The second line of the header should show the date and pagination. The cover sheet needs to identify how many pages in the ICN packet.

Example header: PNNL-xxxxx-ICN-x
Month, day, year; Page x of xx

SECTION A.

Self-explanatory.

SECTION B.

Include all actions that the document holder must take to update the procedure or instruction. Possible actions include: replacing pages of the document with pages that are distributed with the ICN and marking up the document (in ink) to reflect the changes identified on the ICN or attach the ICN cover sheet to the front of the document.

For a "Published" groundwater monitoring plan include the following statement: "Attach this ICN to the front of the document, just before the title page."

SECTION C.

Identify, by title, all personnel whose job functions will be affected by the change and include a brief description of the effect. If there is no effect on personnel (e.g., the change was made to clarify the intent of the procedure or to correct a typographical error) this block should be marked "N/A."

SECTION D.

State the reason for the change followed by a description of the change (including the affected paragraph, information which is deleted, and the actual wording of any replacement test) for each change included on the ICN.

SECTION E.

The Cognizant Manager shall document the reason for not obtaining original reviewers approval and/or any other decisions that must be documented. Additionally, list the individuals who will receive the document (distribution list).

SECTION F.

Identify type of change and document required approvals.

Figure 19.1. Interim Change Notice

INTERIM CHANGE NOTICE (ICN)

Page ___ of ___

A. Document No.: **Revision No.:** **Document Title:** **Document's Original Author:**	**Implementation Date of ICN: / /** **Change Requested By:**
B. Action:	
C. Effect of Change:	
D. Reason for Change/Description of Change: **Reason for Change:** **Description of Change**:	
E. Document Management Decisions:	
F. Groundwater Monitoring Task Manager Approval Signatures (Please Sign and Date)	

Project Quality Engineer Approval: _____Date: _____

Author Approval: _____Date: _____

Other Approvals: _____Date: _____

Figure 19.1. (contd)

19.5 Field Notebooks and Laboratory Record Books

Field notebooks and laboratory record books used by the 100-NR-2 Apatite Project staff will be managed, controlled, and reviewed in accordance with the SBMS subject area, "Laboratory Record Books" (PNNL 2000).

The Project Manager shall ensure that all field notebooks and laboratory record books are reviewed at least twice yearly. The reviewer, a qualified individual, confirms there is sufficient detail to trace the investigation and confirm the test results or repeat the investigation and achieve comparable results, without recourse to the original investigator.

Non-PNNL project staff, such as subcontractors and/or collaborators shall comply with the following procedural steps regarding laboratory records books, or a project-approved equivalent:

1. Use laboratory record books with beige-colored binding.
2. The initial laboratory record book custodian shall complete the title, author, and period covered sections of the information block (first sheet inside the cover). If the laboratory record book is transferred, the new custodian shall enter their name, payroll number, location, and date received to the lower portion of the information block.
3. If persons other than the custodian make entries, the custodian shall list above or below the information block on the first sheet inside the cover, the names of those persons and obtain sample signature and initials from each.
4. Use the following procedure as new project number and project or activities are initiated.
   - Record the starting page, the project or activity title in the table of contents.
   - Record as the first entry the research activity title, the project or work authorization number, and a brief description of the objectives and planned approach.
   - Record observations/data chronologically. Describe (narrative or sketch) experimental apparatus, equipment, and any procedures, data sheets, etc., that are used.
5. Date and sign each page. List person(s) who performed the work.
6. Record information only in permanent ink, line out unused portions of pages, and keep pages intact.
7. Do not erase or obliterate entries. Mark out errors or corrections with single lines. Initial and date all changes other than editorial corrections. If the change is substantive, record the reason for it.
8. Use the following steps if it is necessary to attach a loose sheet.
   a. Attach the sheet to an unused page of the laboratory record book by tape or glue.
   b. Write the laboratory record book and page numbers on the attached sheet (in case it comes loose).
   c. Make an entry in the laboratory record book to introduce or describe the attached sheet.
9. Maintain a list in the project or activity file identifying the laboratory record book numbers, custodians, and locations.
10. Record as the last entry for a project or activity a statement noting completion of the work or, if appropriate, reference to a subsequent laboratory record book.

11. Store laboratory record books in metal file cabinets or receptacles that prevent physical damage or access by unauthorized persons when not in use, and allow easy retrieval for periodic inventory.
12. Notify Document Control in writing when laboratory record books are reassigned.
13. Return laboratory record books to Document Control when complete or when the project ends. Users may copy appropriate pages for their personal files and future reference. If the staff member for future reference retains the laboratory record books, they must be protected from physical damage or access by unauthorized persons and made available for periodic inventory.
14. Return laboratory record books to Document Control or request reassignment when the custodian terminates employment.
15. Make copies of laboratory record books, or applicable pages, for inclusion in project files, when appropriate.

20.0 References

10 CFR 830, Subpart A, "Quality Assurance Requirements." *U.S. Code of Federal Regulations*.

40 CFR 136, Chapter 1, Appendix B (7/1/01). U.S. Environmental Protection Agency. "Guidelines Establishing Test Procedures for the Analysis of Pollutants." *U.S. Code of Federal Regulations*.

40 CFR 264. "Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities." *U.S. Code of Federal Regulations*.

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Appendix A

PNNL Apatite Investigation at 100-NR-2 Quality Control Plan

Appendix A

PNNL Apatite Investigation at 100-NR-2 Quality Control Plan

A.1 Introduction

This appendix describes the basic methods and procedures to implement a quality control (QC) task for sampling and analysis conducted in association with the 100-NR-2 Apatite Project. The QC practices described in this plan help to evaluate whether samples free of contamination are obtained during sampling, and that the laboratory performed sample analyses within the accuracy and precision limits required by the project.

Most of the information in this appendix applies only to groundwater samples. QC practices and requirements that pertain to soil and sediment samples are described in Section A.5.

The primary objectives of this plan are as follows:

1. Identify the QC elements selected for the 100-NR-2 Apatite Project
2. Provide data quality objectives (DQO) for reporting limits, precision, accuracy, and completeness
3. Indicate actions that are to be taken for out of tolerance data.

A.2 Technical Requirements

The technical requirements for QC are divided into two types – components that provide checks on field and laboratory activities (Field QC) and factors that help monitor laboratory performance (laboratory QC). Each type of QC sample has required frequencies and acceptance criteria.

The following guidance documents were used as aids in determining the QC elements necessary for the 100-NR-2 Apatite Project:

1. *Quality Assurance Manual for the Waste Management Branch Investigations* (EPA 910/9-86-00)
2. *Resource Conservation and Recovery Act (RCRA) Groundwater Monitoring Technical Enforcement Guidance Document* (EPA/OSWER-9950.1)
3. *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, SW-846, Third Edition* (EPA/SW-846, as amended)
4. *Handbook for Analytical Quality Control in Water and Wastewater Laboratories* (EPA-600/4-79-019)
5. *Hanford Analytical Services Quality Assurance Requirements Documents* ([HASQARD] DOE/RL-96-68).

QC elements were selected based on the needs of the project and value that results from each type of sample added to the database.

A.2.1 Field Quality Control

To indicate whether samples are collected in a consistent manner and are properly preserved, three types of QC samples will be collected before or during sampling:

1. **Sampling Event Blanks** — These samples will be prepared by the sampling team before traveling to a sampling site. A preserved bottle set, identical to the set that will be used for sample collection in the field, will be filled with reagent water (carbon free, deionized water). Dead water from well 699-S11-E12AP is used for sampling low-level tritium. The bottles will be sealed by the sampling team and transported unopened to the field in the same storage container used for the samples collected that day. These samples will be typically analyzed for the same constituents as the samples from the associated well.
2. **Equipment Blanks** —Reagent water will be passed through the pump or manifold after decontamination (sometimes just prior to sampling) to collect blank samples identical to a set that will be collected in the field. Preserved bottles will be used. The equipment blank bottles will be placed in the same container as the associated field samples and not removed from the container until delivery to the laboratory.
3. **Field Duplicates** — A replicate sample that is collected at one well. After each type of bottle is filled, a second identical bottle will be filled for each type of analysis as directed by chain-of-custody requirements. Both sets of samples will be stored and transported together.

Using several types of field blank samples provides checks on bottle cleanliness, preservative purity, equipment decontamination, proper storage and transport of samples, and reveals whether or not samples may have been contaminated during collection. Sampling in replicate provides information about sampling reproducibility. Field QC sample frequencies are shown in Table A.1. In addition to the evaluation characteristics described in Table A.1, the field QC samples also provide a check on the analytical results. The field QC data are designed to give an overall impression of the performance of the sampling and analysis of the 100-NR-2 Apatite Project; however, individual data points associated with field QC samples that are outside of the acceptance criteria are flagged in the database.

Table A.1. Quality Control Samples

Sample Type	Primary Characteristics Evaluated	Frequency
Sample Event Blank	Contamination from containers or transportation	1 per 20 wells sampled
Equipment Blank	Contamination from non-dedicated equipment	As needed(a)
Replicate/Duplicate Samples	Reproducibility	1 per 20 wells sampled
Laboratory Quality Control		
Sample Type	Primary Characteristics Evaluated	Frequency
Method Blanks	Laboratory Contamination	1 per batch
Lab Duplicates	Laboratory Reproducibility	(b)
Matrix Spikes	Matrix Effect and Laboratory Accuracy	(b)
Matrix Spike Duplicates	Laboratory Reproducibility/Accuracy	(b)
Surrogates	Recovery/Yield	(b)
Laboratory Control Samples	Method Accuracy	1 per batch

(a) For portable Grundfos pumps, equipment blanks are collected one per ten well trips. Whenever a new type of non-dedicated equipment is used, an equipment blank shall be collected every time sampling occurs until it can be shown that less frequent collection of equipment blanks is adequate to monitor the decontamination procedure for the non-dedicated equipment.
(b) As defined in the laboratory contract or QA plan and/or analysis procedures.
QA = Quality assurance.
QC = Quality control.

The results of each type of field QC sample are evaluated according to criteria defined in Table A.2.

Table A.2. Field and Laboratory QC Elements and Acceptance Criteria

Method	QC Element	Acceptance Criteria	Corrective Action
General Chemical Parameters			
Alkalinity – EPA 600 Series, 310.1	MB(a)	< MDL	Flagged with "C"
Chemical Oxygen Demand – EPA 600 Series, 410.4	LCS	80-120% recovery(b)	Data reviewed(c)
Conductivity – EPA 600 Series, 120.1	DUP	± 20% RPD(b)	Data reviewed(c)
Oil and Grease – EPA 600 Series, 413.1	MS(d)	75-125% recovery(b)	Flagged with "N"
pH – EPA 600 Series, 150.1	EB, FTB	< 2X MDL	Flagged with "Q"
Total Dissolved Solids – EPA 600 Series, 160.1	Field Duplicate	± 20% RPD(e)	Flagged with "Q"
Total Organic Carbon – EPA/SW-846, as amended, 9060			
Total Organic Halides – EPA/SW-846, as amended, 9020			
Ammonia and Anions			
Ammonia – EPA 600 Series, 350.1	MB	< MDL	Flagged with "C"
Anions by IC – EPA 600 Series, 300.0	LCS	80-120% recovery(b)	Data reviewed(c)
Cyanide – EPA/SW-846, as amended, 9012	DUP	± 20% RPD(b)	Data reviewed(c)
	MS	75-125% recovery(b)	Flagged with "N"
	EB, FTB	< 2X MDL	Flagged with "Q"
	Field Duplicate	± 20% RPD(e)	Flagged with "Q"
Metals			
Arsenic – EPA/SW-846, as amended, 7060	MB	< CRDL	Flagged with "C"
Cadmium – EPA/SW-846, as amended, 7131	LCS	80-120% recovery(b)	Data reviewed(c)
Chromium – EPA/SW-846, as amended, 7191	MS	75-125% recovery(b)	Flagged with "N"
Lead – EPA/SW-846, as amended, 7421	MSD	± 20% RPD(b)	Data reviewed(c)
Mercury – EPA/SW-846, as amended, 7470	EB, FTB	< 2X MDL	Flagged with "Q"
Selenium – EPA/SW-846, as amended, 7740	Field Duplicate	± 20% RPD(e)	Flagged with "Q"
Thallium – EPA/SW-846, as amended, 7841			
ICP Metals – EPA/SW-846, as amended, 6010			
ICP/MS Metals – EPA/SW-846, as amended, 6020			

Bias will be assessed by comparing a measured value to a known or accepted reference value or the recovery of a known amount of spiked contaminant into a sample (i.e., a matrix spike). For a matrix spike (MS) bias caused by matrix effects will be calculated as follows in Equation (A.1):

$$B = (X_s - X_u) - K \qquad \text{A.1}$$

Where

X_s = measured value of spiked sample
X_u = sample or miscellaneous contribution
K = known value of spike

Using Equation (A.2) yields percent recovery (%R):

$$\%R = 100\ (X_s - X_u)/\ K \qquad \text{A.2}$$

Analytical precision will be determined by analyzing duplicates (field or lab). Precision is expressed as either percent relative standard deviation (RSD) or relative percent difference (RPD). Duplicate results will be flagged if the results of both samples are quantifiable (i.e., the result is greater than the 5 times the instrument detection limit [IDL]/method detection limit [MDL]/minimum detectable activity [MDA]) and the RPD is greater than 20%. The RPD is calculated as follows in Equation (A.3):

$$RPD = \frac{D_1 - D_2}{(D_1 + D_2)/2} \times 100 \qquad \text{A.3}$$

Where

D_1 = original sample value
D_2 = duplicate sample value

When more than two data values are present, precision is calculated by the RSD as shown in Equation (A.4):

$$RSD = \frac{\text{standard deviation}}{\text{mean}} \times 100 \qquad \text{A.4}$$

A.2.2 Quality Control in the Laboratory

The ability to perform sample analyses within the limits established by the 100-NR-2 Apatite Project will be monitored in several ways. This QAPjP governs laboratory work performed by staff participating in the 100-NR-2 Apatite Project. The work activities in the laboratories will be periodically reviewed, including selected laboratories of subcontracted 100-NR-2 Apatite Project collaborators. The laboratory QA effort includes a comprehensive quality control program, which includes the use of matrix spikes, matrix duplicates, matrix spike duplicates, laboratory control samples, surrogates, tracers, and blanks. These samples are recommended in the guidance documents and are required by U.S. Environmental Protection Agency (EPA) protocol.

Matrix Duplicate — An intra-laboratory split sample used to evaluate the precision of a method in a given sample matrix.

Matrix Spike — An aliquot of a sample spiked with a known concentration of target analyte(s). The matrix spike will be used to assess the bias of a method in a given sample matrix. Spiking will be done prior to sample preparation and analysis.

Matrix Spike Duplicate — A replicate spiked aliquot of a sample subjected to the entire sample preparation and analytical process. The results from these samples will be used to determine the bias and precision of a method in a given sample matrix.

Laboratory Control Sample — A control matrix spike (e.g., deionized water) spiked with analytes representative of the target analytes or a certified reference material used to evaluate laboratory accuracy.

Method Blank — An analyte-free matrix to which all reagents are added in the same volumes or proportions as used in sample processing. The method blank will be carried through the complete sample preparations and analytical procedure and used to quantify contamination resulting from the analytical process.

Tracers — A tracer is a known quantity of a chemical or radioactive isotope that is different from that of the isotope of interest but is expected to behave similarly and is added to an aliquot of sample. Sample results are generally corrected based on tracer recovery.

The samples are analyzed within the holding times specified by the analysis procedure. In some instances, constituents in samples not analyzed within the holding time may be compromised by volatilization, decomposition, or other chemical changes. Data from samples analyzed outside the holding time are flagged in the HEIS database with an "H." The holding times for constituents analyzed by the 100-NR-2 Apatite Project are listed in Table A.3.

Other tools are used by the project to evaluate analytical work. Double-blind standards of the constituents of concern will be used to evaluate laboratory performance. Because the results of double-blind standards provide information on laboratory precision and accuracy, these standards are useful tools to verify the project DQOs are being met. Table A.4 lists the typical blind-standard constituents. The list of constituents is subject to change based on need. Specific information about the constituents used and their spiking levels will be maintained in the project files.

Table A.3. 100-NR-2 Apatite Project Holding Times

Constituents	Methods[(a)]	Holding Times
ICP metals	SW-846, 6010	6 months
ICP-MS	SW-846, 6020	6 months
Arsenic	SW-846, 7060	6 months
Lead	SW-846, 7421	6 months
Mercury	SW-846, 7470/7471	28 days
Selenium	SW-846, 7740	6 months
Thallium	SW-846, 7841	6 months
Alkalinity	EPA 600 Series, 310.1	14 days
Cyanide	SW-846, 9010/9012	14 days
Bromide	EPA 600 Series, 300.0	28 days

Table A.3. (contd)

Constituents	Methods[(a)]	Holding Times
Chloride	EPA 600 Series, 300.0	28 days
Fluoride	EPA 600 Series, 300.0	28 days
Nitrate	EPA 600 Series, 300.0	48 hours
Nitrite	EPA 600 Series, 300.0	48 hours
Phosphate	EPA 600 Series, 300.0	48 hours
Sulfate	EPA 600 Series, 300.0	28 days
Total organic carbon	SW-846, 9060	28 days
Total organic halides	SW-846, 9020	28 days
Chemical oxygen demand	EPA 600 Series, 410.4	28 days

(a) EPA/SW-846, as amended.
ICP = Inductively coupled plasma
ICP/MS = Inductively coupled plasma-mass spectrometry.

Table A.4. Blind-Standard Constituents and Schedule

Constituents	**Recommended Recovery (%)(a)**	**Precision (%RSD)(a)**
Fluoride	±25 %	±25 %
Nitrate	±25 %	±25 %
Cyanide	±25 %	±25 %
Chromium	±20 %	±20 %
Total Organic Carbon(b)	Varies according to spiking compound	Varies according to spiking compound
Total Organic Halides(c)	Varies according to spiking compound	Varies according to spiking compound
Gross alpha(d)	70 – 130 %	±20 %
Gross beta(e)	70 – 130 %	±20 %
Tritium	70 – 130 %	±20 %
Tritium (low level)	70 – 130 %	±20 %
Cobalt-60	70 – 130 %	±20 %
Strontium-90	70 – 130 %	±20 %
Technetium-99	70 – 130 %	±20 %
Iodine-129	70 – 130 %	±20 %
Cesium-137	70 – 130 %	±20 %
Uranium	70 – 130 %	±20 %
Plutonium-239/240	70 – 130 %	±20 %

Blind standards are prepared by spiking matrix groundwater and deionized water with known concentrations of constituents of interest. Spiking concentrations range from MDA or MDL, depending on the constituent measured, to the upper limit of concentration determined in groundwater on the Hanford Site. The matrix groundwater wells chosen are 699-49-100C for radiochemical analytes, and total organic halides (TOX); and 699-19-88 for cyanide, anions, inductively coupled plasma (ICP) metals, and total organic carbon (TOC). Deionized water is used to prepare VOCs. Well 699-49-100C is located to the west of the Hanford Site. Well 699-19-88 is a southern boundary well. Both wells are considered

free of the contaminant migration zone. Dead water from well 699-S11-E12AP is used to prepare low-level tritium blind standards.

Blind-standard results are evaluated by comparing the laboratory results to the actual spike values. Laboratory precision is also considered as the samples are sent to the laboratory in replicate. Laboratory results are evaluated based on the recovery and precision criteria listed in Table A.4. Results outside of these control limits are investigated and appropriate actions are taken, if necessary.

A.3 Data Quality Objectives

DQOs are defined for reporting limits, precision, accuracy, and completeness. Groundwater monitoring plans or sampling analysis plans specify whether or not a particular site has more stringent DQOs than those specified in this plan.

Limits for precision and accuracy for chemical analyses are based on criteria stipulated in the methods (e.g., EPA/SW-846, as amended, EPA 600 series). Precision and accuracy limits for radiochemical results are specified in the laboratory contract.

Completeness is defined as the percentage of data points judged to be valid. The percent complete for each quarter should be at least 85%.

Reporting limits for radiochemical constituents are defined in individual test plans. Reporting limits will be based on the research needs, but regulatory reporting limits and actual reporting limits are listed in Table A.5 for radiochemical constituents as a reference point. For chemical constituents, MDLs as low as one-third the EPA drinking water standards are preferred. In some cases, MDLs that are one-third the regulatory limit are not feasible (e.g., pentachlorophenol and cadmium). Because MDLs change frequently, these values are not provided in this document.

Table A.5. Reporting Limits for Radiochemical Constituents

Constituent of Concern	Method	CAS #	DWS	1/3 DWS	RDL
Gross Alpha	Gross Alpha - GA	12587-46-1	15 pCi/L*	5 pCi/L*	3 pCi/L
Gross Beta	Gross Beta - GB	12587-47-2	N/A	N/A	4 pCi/L
Cobalt-60	Gamma Spec	10198-40-0	100 pCi/L	33 pCi/L	25 pCi/L
Cesium-137	--	10045-97-3	200 pCi/L	67 pCi/L	15 pCi/L
Europium-152	--	--	--	--	50 pCi/L
Europium-154	--	--	200 pCi/L	67 pCi/L	50 pCi/L
Europium-155	--	--	600 pCi/L	200 pCi/L	50 pCi/L
Tritium	H-3	10028-17-8	20,000 pCi/L	6700 pCi/L	400 pCi/L
Tritium	H-3 (LL)	N/A	N/A	N/A	10 pCi/L
Iodine-129	I-129	10043-66-0	1 pCi/L	0.33 pCi/L	5 pCi/L

Table A.5. (contd)

Constituent of Concern	Method	CAS #	DWS	1/3 DWS	RDL
Iodine-129	I-129 (LL)	N/A	N/A	N/A	1 pCi/L
Strontium-90	Sr-89/Sr-90	10098-97-2	8 pCi/L	2.7 pCi/L	2 pCi/L
Technetium-99	Tc-99	14133-76-7	900 pCi/L	300 pCi/L	15 pCi/L
Plutonium-238	Isotopic Plutonium	--	1.6 pCi/L	0.5 pCi/L	1 pCi/L
Plutonium-239/240	Pu-AEA	--	1.2 pCi/l	0.4 pCi/L	1 pCi/L
Uranium-233	Isotopic Uranium	13968-55-3	20 pCi/L	6.7 pCi/L	1 pCi/L
Uranium-234	Isotopic Uranium	13966-29-5	20 pCi/L	6.7 pCi/L	1 pCi/L
Uranium-235	Uranium-AEA	15117-96-1	24 pCi/L	8 pCi/L	1 pCi/L
Uranium-238		U-238	24 pCi/L	8 pCi/L	1 pCi/L
Total alpha energy emitted from Radium	Total Radium	N/A	N/A	N/A	1 pCi/L
Uranium (elemental)	Total Uranium	N/A	30 μg/L	10 μg/L	0.1 μg/L

* Excluding uranium
CAS# = Chemical abstract service number.
DWS = Drinking water standard.
N/A = Not applicable.
RDL = Required detection limit.

A.4 Reporting and Deliverables Requirements

The results of the blind standards and the field QC samples will be provided through current analytical reporting procedures. The QC analytical results will be reviewed and compiled in the 100-NR-2 Apatite Project database.

All project records associated with quality control are maintained in accordance with the RIDS for the 100-NR-2 Apatite Project.

A.5 Requirements for Soil and Sediment Samples

The 100-NR-2 Apatite Project will analyze sediment samples in support of site-characterization activities. The nature of this work precludes specification of many of the requirements listed previously for groundwater samples. Therefore, the types, quantities, and acceptance criteria for field and/or laboratory QC samples are specified in the characterization plan and specific test plans for individual experiments. Table A.6 lists the maximum recommended holding times for common analytes in soils. Radionuclides are not included in the table.

Table A.6. Holding Times for Sediment Analyses

Constituents	Methods[(a)]	Holding Times
ICP metals	SW-846, 6010	6 months
ICP-MS	SW-846, 6020	6 months
Arsenic	SW-846, 7060	6 months
Lead	SW-846, 7421	6 months
Mercury	SW-846, 7470/7471	28 days
Selenium	SW-846, 7740	6 months
Thallium	SW-846, 7841	6 months
Alkalinity	EPA 600 Series, 310.1	14 days
Cyanide	SW-846, 9010/9012	14 days
Bromide	EPA 600 Series, 300.0	28 days
Chloride	EPA 600 Series, 300.0	28 days
Fluoride	EPA 600 Series, 300.0	28 days
Nitrate	EPA 600 Series, 300.0	48 hours
Nitrite	EPA 600 Series, 300.0	48 hours
Phosphate	EPA 600 Series, 300.0	48 hours
Sulfate	EPA 600 Series, 300.0	28 days
Total organic carbon	SW-846, 9060	28 days
Total organic halides	SW-846, 9020	28 days
Chemical oxygen demand	EPA 600 Series, 410.4	28 days
(a) EPA/SW-846, as amended.		

A.6 References

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Appendix B

Experimental and Modeling Procedures for the 100-NR-2 Apatite Project

Appendix B

Experimental and Modeling Procedures for the 100-NR-2 Apatite Project

Method	Analysis	Document Number	Procedure Title
Conduct of Routine Laboratory Operations	General	RPL-OP-001	"Routine Research Operations," Section 31, tab 3 of *RPL Laboratory Handbook*
Inductively Coupled Plasma-Optical Emission Spectroscopy (ICP-OES)*	Ca, K, Mg, P, Sr, Na, Si, Cu, Fe, Mn, S, and Ti in water in ppb or moles/L	PNNL-AGG-ICP-AES*	Inductively Couple Plasma – Optical Emission Spectrometry (ICP-OES) Analysis
Inductively Coupled Plasma-Mass Spectroscopy (ICP-MS)	Re, Tc	PNNL-AGG-415	Inductively Coupled Plasma Mass Spectrometric (ICP-MS) Analysis
Ion Chromatography	F, Cl, NO_2, NO_3, CO_3, SO_4, PO_4, PO_4 in water in ppm or moles/L	*PNNL-AGG-IC-001	Determinations by Ion Chromatography (IC)
ICP/MS	Cu, Fe in water in ppb or moles/L	PNL-SAND-3.1 (needs to be updated)	--
KPA	U in water in ppb or moles/L	Liu et al. (2004)	--
Spectrophotometer	Fe(II) and total Fe in ppb	Kukkadapu et al. (2004)	--
LSC	Sr-90, Tc-99, I-129, in dpm/mL	*PNNL-AGG-RRL-002; Procedures vary slightly for different radioisotopes; McKinley et al. (2006) for Sr-90	--
Solid-State pH Electrode and Meter	pH, Bromide	AGG-PH-001	pH Measurement
X-ray Diffraction (XRD)	Mineralogy	RPL-XRD-PIP	Operation of Scintag Pad-V X-Ray Diffractor (RGD #62)
Scanning Electron Microscopy/ Energy-Dispersive X-ray Spectrometry (SEM/EDS)	Particle morphology, size, and qualitative elemental analysis	PNL-SP-3	Scanning Electron Microscopy/Energy Dispersive Spectrometry

Method	Analysis	Document Number	Procedure Title
Particle Size Distribution	--	PNL-MA-567, SA-3	Particle-size analysis (pipette or hydrometer method); wet-sieve analysis will be used to remove sand-size particles
Hydraulic Conductivity	--	PNL-MA-567, SA-5	Falling head hydraulic conductivity
Water Retention	--	UFA-SK-01	Determination of water retention as a function of water content using open-flow centrifugation techniques
Water Content	--	PNL-MA-567, SA-7	Water content
Bulk Density	--	PNL-MA-567, SA-8	Clod density/bulk density
Particle Density	--	PNL-MA-567, SA-9	Determining particle density; necessary for constant head hydraulic conductivity
Column Packing	--	WHC-IP-0635, GEL-3 Rev.3	Moisture relationships of soils; necessary for constant head hydraulic conductivity
pH/EC	--	PNL-G-5-pH/EC	Measuring pH/EC of low-level radioactive solutions
Saturated column experiments	--	AGG-SAT-COL-001	Conducting saturated column experiments
Batch experiments	--	AGG-BSE-001	Batch sorption experiments
Surface Area	--	AGG-SA-001	Measuring surface area
TIC/TOC	Inorganic C, organic C, total C	*PNNL-AGG-TOC-001	--
X-ray Fluorescence	Total analyses of sediments including Al, Si, K, Ca, Mg, Sr, Ti, Fe, Mn, Cu, Ni, Cr, Cs, U, and others.	*PNNL-AGG-OP-RGD74-001	--
Conventional Powder X-ray Diffraction	Mineral identity (% distribution)	Qafoku et al. (2005)	--
Digital Autoradiography	Identify locations of radioactivity in sediment thin section and mixtures of sand and silt-sized particles.	Zeissler et al. (2001); McKinley et al. (2001)	--

Method	Analysis	Document Number	Procedure Title
Scanning Electron Microscopy with WDS	High resolution imaging of particle morphology and atomic mass generally in sediment thin section; semi quantitative imaging of chemical distribution.	McKinley et al. (2005)	--
Transmission Electron Microscopy with Selected Area Diffraction (SAED)	Very high resolution of single mineral grains in cross section; local morphology, structure and atomic arrangement.	Zachara et al. (2006). Selected area diffraction patterns are interpreted using the JADE software (see below) using x-ray powder diffraction data (PDF) retrieved from a standards library (ICDD 2003)	--
Electron microprobe	Quantitative, intermediate sensitivity chemical mapping in thin sections. Chemical transects across grain/particle boundaries.	Wang et al. (2005b); Catalano et al. (2006)	--
X-ray fluorescence microprobe	High sensitivity, semi quantitative mapping of element distributions in sediment thin sections at scales of 10 μm.	Liu et al. (2004); Fredrickson et al. (2004)	--
X-ray absorption spectroscopy	Determination of element coordination structure, nearest neighbors, and bond distances in contaminated sediment.	Catalano et al. (2004); Catalano et al. (2006) Basic experimental synchrotron measurements are modeled with FEFF, FEFFIT, and IFEFFIT (see below) to extract molecular information.	--
Synchrotron diffraction	Identification of mineral structures In sediment thin sections.	Catalano et al. (2004). Mineral structures are derived by application of the FIT2D software (see below).	--

Method	Analysis	Document Number	Procedure Title
Cryogenic laser induced fluorescence spectroscopy (CLIFS)	Vibronic spectra of U(VI) in water and solids to establish molecular and mineralogic environment.	Wang et al. (2004) (for aqueous solutions); Wang et al. (2005a) (for solids). Data analysis is performed using the IGOR and Globals programs (see below).	--
Batch kinetic desorption experiments	Sediments are bathed in electrolyte of known composition and the time-variant release of contaminants and other solid associated ions are monitored by aqueous phase analyses.	Procedures vary as per element and its concentration. Examples include Liu et al. (2003) (Cs-137); Liu et al. (2004) (U); McKinley et al. (2005) (Sr-90). Kinetic rate laws and rate constants are calculated from the data using microscopic, diffusion based transport models (See below). Steady state values can be used to establish thermodynamic parameters, such as the solubility product of a precipitated contaminant phase (e.g., Ilton et al. 2006).	--
Batch adsorption experiments	Sediments are bathed in electrolyte of know composition that has been spiked with a contaminant of interest. The adsorption of the contaminant is monitored as a function of pH, ionic strength, or ion composition.	Example procedures are equilibrium -Turner et al. 1996 (U) and Zachara et al. 2002 (Cs); kinetic – Liu et al. 2003 (Cs), Liu et al. 2004 (U), and McKinley et al. 2006 (Sr). Experimental results are fitted with various geochemical models (MINTEQ; Geochemists Workbench; GMIN; or FITEQL see below) to identify suites of adsorption reactions (ion exchange or surface complexation).	--

Method	Analysis	Document Number	Procedure Title
Column experiments	Sediment (<2 mm or < 4 mm) is packed into a cylindrical plastic, glass, or stainless steel column. Electrolyte with or without a contaminant tracer is applied to the column to study the release (from contaminated sediment) or sorption/retardation (for uncontaminated sediments) of key contaminants of concern.	Qafoku et al. 2005. The basic experimental data that is in the form of chemical concentration as a function of leaching volume of fluid, must be modeled with various commercial and research codes to yield useable information. CXTFIT is used to fit physical transport parameters such as the dispersivity, while other models are linked with a solver of the advective-dispersion equation to describe 1-dimensional reactive transport. The reactive transport models include a commercial one (the Geochemists Workbench) and others assembled by the research team including the Distributed Rate Model (DRM) and the Dual Continuum Model (DCM). These are described below.	--
MINTEQA2 Version 4	Commercial software used to calculate aqueous speciation, precipitation/dissolution, and adsorption/desorption equilibria for low to intermediate-strength solutions.	Code published by Allison et al. 1991 and 1998 linked to a thermodynamic data base of our own synthesis (see below).	--
Geochemists Workbench	Commercial software to calculate geochemical equilibria, reaction network modeling, and reactive transport.	Geochemists Workbench Release 6. from Craig Bethke, Hydrogeology Program, University of Illinois	--
CXTFIT	Commercial software for fitting column effluent data.	Toride et al. (1999)	--

Method	Analysis	Document Number	Procedure Title
FITEQL (V 4.0)	Commercial software used to calculate equilibrium constants and their statistics for aqueous, surface and precipitated phases from batch experimental data.	Herbelin and Westall (1999)	--
GMIN	An equilibrium geochemical model used to calculate aqueous speciation, precipitation/ dissolution, and adsorption desorption equilibria for high ionic strength solutions. Maintained by PNNL.	Felmy (1995)	--
Spectral Fitting Software	Commercial software used to fit fluorescence emission spectra on U(VI) derived from CLIFS analyses. The fitting allows determination of the precise spectral wavelengths and deconvolutes spectral signatures resulting from multiple fundamental species.	Beechem et al. (1991)	--
Phase Identification for Powder Diffraction (JADE+, V 5)	Commercial software used to manipulate powder diffraction files are for comparison with reference spectra in for mineral identification.	Materials Data Inc., Livermore, CA; ICDD, (2003)	--

Method	Analysis	Document Number	Procedure Title
Reactive Transport Modeling	The Dual Continuum Model (DCM) is used to model the reactive transport of contaminants 1-dimensional laboratory columns and in multidimensional field simulations. The model is a reaction-based simulator and requires significant parameterization using batch and column data, and physical measurements of sediment characteristics. Maintained by LANL.	Lichtner et al. (2000); Lichtner et al. (2001)	--
Empirical Kinetic Modeling	The distributed rate model (DRM) is used to empirically describe complex kinetic desorption/dissolution phenomena in sediment that is controlled by chemical kinetics or diffuse mass transport. The basic model describes kinetic phenomena using a statistical distribution of first order rate constants. Maintained at PNNL.	Culver et al. (1997)	--
Surface Complexation Model	The surface complexation model (SCM) is used to describe the surface chemical reactions of U(VI) that are responsible for its adsorption to vadose zone and aquifer sediments. Maintained by USGS.	Davis et al. (2004)	--

Method	Analysis	Document Number	Procedure Title
Thermodynamic Data Base	A large thermodynamic data base is maintained and constantly updated based on literature advances. The data base describes stability constants for aqueous complexes and solubility products for precipitated phases relevant to S&T research and issues. This data base is used in almost every S&T geochemical study. There are many hundreds of entries in the data base for a variety of contaminants that is used in MINTEQA@; Geochemists Workbench, and all of the reactive transport codes. Maintained at PNNL.	The data base relies on the following and many other sources: Grenthe et al. 1992 (U); Guillaumount et al. 2003 (U); Rard (1999) (Tc).	--
* The document number states ICP-AES, but the instrument in use is an ICP-OES. ICP-AES and ICP-OES are equivalent and refer to the same analytical technique. PNNL-AGG referenced procedures are from PNNL's Applied Geochemistry Group.			

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