Environmental Protection Department
Environmental Restoration Division

UCRL-AR-103160 Rev. 2

Quality Assurance Project Plan

Livermore Site and Site 300 Environmental Restoration Projects

Author

V. Dibley

Technical Contributors

R. Bainer
R. Blake
T. Carlsen
S. Chamberlain
R. Ferry*
D. MacQueen

Contributors

L. Berg
R. Depue

March 1999

***Weiss Associates, Emeryville, California**

Lawrence Livermore National Laboratory
University of California • Livermore, California 94551

Work performed under the auspices of the U. S. Department of Energy by Lawrence Livermore National Laboratory under Contract W-7405-Eng-48.

LLNL Environmental Restoration Division

Quality Assurance Project Plan

Livermore Site and Site 300 Environmental Restoration Projects

Author

V. Dibley

Technical Contributors

R. Bainer
R. Blake
S. Chamberlain
R. Ferry*
D. MacQueen

Contributors

L. Berg
R. Depue

March 1999

*Weiss Associates, Emeryville, California

Concurrence by: _____ 4-9-99
J. Merrigan — Date
EPD Quality Assurance Manager

Approved by: Albert L Lamarre 4-6-99
A. L. Lamarre — Date
ERD Division Leader

Approved by: Robert W Bainer 4/6/99
R. W. Bainer — Date
ERD Livermore Site Project Leader

Approved by: _____ 4-6-99
J. P. Ziagos — Date
ERD Site 300 Project Leader

LLNL Environmental Restoration Division

Quality Assurance Project Plan

Livermore Site and Site 300 Environmental Restoration Projects

Author

V. Dibley

Technical Contributors

R. Bainer
R. Blake
S. Chamberlain
R. Ferry*
D. MacQueen

Contributors

L. Berg
R. Depue

March 1999

*Weiss Associates, Emeryville, California

Concurrence by: _____ 3-21-99
V. Fong — Date
EPA Quality Assurance Manager

Concurrence by: _____ 3-21-99
K. Setian — Date
EPA Remedial Project Manager

cc:
Admin. Record (2 copies)
ERD Personnel
K. Angleberger, DOE
M. Brown, DOE
J. Chou, RWQCB
V. Fong, EPA
C. Garcia, ORAD
M. Gill, EPA
J. Littlejohn, DOE
J. Merrigan, EPD
M. Kelley, TVC
M. Piros, DTSC
K. Setian, EPA
P. Strauss, TVC
D. Sutherland, DOE
S. Timm, RWQCB

Table of Contents

List of Figures

List of Tables

Appendices

Foreword

The U.S. Environmental Protection Agency (U.S. EPA) requires that a Quality Assurance Project Plan (QAPP) be developed for environmental data operations to ensure that decisions are based on the correct data that were collected properly the first time. The complexity of environmental data operations demands that a systematic process and structure for quality be established so that decision makers will have confidence in the quality of the data that support their decisions. The QAPP documents how quality assurance (QA) and quality control (QC) are applied to an environmental data operation to assure that the results obtained are of the type and quality needed and expected. For clarification, the following EPA definitions are given:

Environmental Data

Environmental data include any parameters or pieces of information collected or produced from measurements, analyses, or models of environmental processes or conditions and effects of pollutants on human health and the ecology, including results from laboratory analyses, or from experimental systems representing such processes and conditions.

Quality Assurance

An integrated system of management activities involving planning, implementation, assessment, reporting, and quality improvement to ensure that a process, item, or service is of the type and quality needed and expected by the client.

Quality Control

The overall system of technical activities that measure the attributes and performance of a process, item, or service against defined standards to verify that they meet the stated requirements established by the customer; operational techniques and activities that are used to fulfill requirements for quality.

This QAPP was prepared for the Lawrence Livermore National Laboratory (LLNL) Site 300 and Livermore Site Environmental Restoration Projects (ERPs) to ensure that the precision, accuracy, completeness, comparability, and representativeness of project data are known and are of acceptable quality. In addition, this QAPP documents how environmental data operations are planned, implemented, and assessed during the life cycle of these projects.

All ERP environmental monitoring and measurement activities are covered by this QAPP. Such activities include but are not limited to, investigations, experiments, routine ground water monitoring and remedial treatment facility monitoring. This plan was prepared following the guidelines and specifications offered by the U.S. EPA (U.S. EPA, 1980; 1987; 1994a,b; 1997). This QAPP is intended to be used in conjunction with the LLNL Livermore Site and Site 300

Environmental Restoration Project Standard Operating Procedures (SOPs), the Site Safety Plan (SSP) for Site 300 CERCLA Investigations, the SSP for Livermore Site CERCLA Investigations, the ERD treatment facility Operations and Maintenance (O&M) Manuals, and the LLNL Environmental Protection Department Quality Assurance Management Plan (EPD QAMP). Because QA is an ongoing task, ERD QA documents will undergo revision as necessary.

1. Project Management

1.1. Project Organization

The Site 300 and Livermore Site Environmental Restoration Projects (ERPs) are part of the Environmental Restoration Program and Division (ERD) which belongs to the Lawrence Livermore National Laboratory (LLNL) Environmental Protection Department (EPD). LLNL is operated by the University of California for the U.S. Department of Energy (DOE). Project organization and responsibility is divided among the DOE, LLNL, and LLNL contractors. Figure 1 shows the ERP's organization and line of authority. Figure 2 shows the ERPs relationship to EPD, LLNL, DOE, the regulating agencies, and the ERP subcontractors. Specific responsibilities of key groups and individuals are discussed in the following Sections.

1.1.1. Department of Energy Oakland Operations Office

The DOE office is responsible for oversight of all environmental programs within DOE Oakland Operations, including LLNL.

1.1.2. Regulating Agencies

The ERPs regulating agencies include: the U.S. Environmental Protection Agency (EPA)–Region IX, Regional Water Quality Control Board (RWQCB)–San Francisco (Livermore Site) and Central Valley (Site 300) Regions, Department of Toxic Substances Control (DTSC), Bay Area Air Quality Management District (BAAQMD) (Livermore Site), and San Joaquin Valley Unified Air Pollution Control District (SJVUAPCD) (Site 300).

1.1.3. Lawrence Livermore National Laboratory Site Manager for Laboratory Site Operations

The Laboratory Site Operations office has administrative responsibility for the LLNL departments of Hazards Control, Health Services, Plant Engineering, Safeguards and Security, and Environmental Protection.

1.1.4. Environmental Protection Department

EPD ensures that LLNL meets its environmental responsibilities as set by environmental legislation, DOE orders, and other applicable regulations and speaks for LLNL on environmental regulatory matters.

1.1.5. Environmental Restoration Division

ERD investigates and remediates environmental releases at LLNL through DOE's Environmental Restoration Program.

1.1.6. Site 300 Environmental Restoration Project

Site 300 ERP conducts environmental investigation and remediation actions associated with Site 300 and maintains direct communications with regulatory agencies with respect to Site 300 activities.

1.1.7. Livermore Site Environmental Restoration Project

Livermore Site ERP conducts environmental investigation and remediation actions associated with the Livermore Site and maintains direct communications with regulatory agencies with respect to Livermore Site activities.

1.1.8. Project Leader

The Project Leader is responsible for overall management of the project.

1.1.9. Division Quality Assurance Implementation Coordinator

The Division Quality Assurance Implementation Coordinator (QAIC) administers the implementation of ERD's QA program. This includes monitoring and reviewing the procedures used to perform all aspects of the environmental investigations (e.g., data collection, analytical services, and report generation).

1.1.10. Environmental Chemistry and Biology Group

The Environmental Chemistry and Biology Group (ECBG) provides general chemistry support to the ERPs. The Sampling Coordinators (SCs) within the ECBG coordinate the

chemical sampling and water level measurement of wells, schedule the presampling preventive maintenance of field equipment and instruments, and report well information (e.g., well name, location, completion depth and screened interval, ground elevation, pump type and discharge rate, and contaminant types and concentrations) to the Data Management Team (DMT). The Quality Control (QC) Chemists within ECBG assist on the preparation of sampling plans, review and qualify project data, monitor laboratory performance, and interact with the analytical laboratories.

1.1.11. Hydrogeology Group

The Hydrogeology Group administers the installation and development of wells; plan and implement soil sampling and soil vapor surveys; analyze and interpret geologic, hydraulic, and chemical data; develop conceptual and computer models; and coordinates and supervises hydrogeologic, geophysical, and drilling contractors.

1.1.12. Engineering Group

The Engineering Group conducts engineering functions in connection with remedial actions, and designs remediation systems to clean up contaminants in conformance with QA objectives.

1.1.13. Information Systems Management Group

The DMT stores data and sampling plans generated for the ERPs, controls field logbooks, ensures that pertinent sampling information is recorded and that chain-of-custody (CoC) forms are properly used, and maintains the project relational database. The Information Systems and Computer Support Team plans, designs, and maintains computerized information systems, hardware, and software, in support of all ERP activities.

1.1.14. Environmental Restoration Project Subcontractors

ERP subcontractors generating data for the ERP activities are responsible for implementing and documenting procedures to ensure precision, accuracy, completeness, and representativeness of their data as required by EPD. The ERPs have used various analytical laboratories and geotechnical services, both internal and external to LLNL over the course of the projects. Appendix A lists the organizations that have provided environmental services in support of the ERPs. The contract analytical laboratories provide services as specified in LLNL service agreements. These agreements specify the QA requirements required by ERD. The agreements are reviewed each year and renewed every three years.

1.1.15. Task Leader

Task Leaders report administratively to one of the Group Leaders but have technical and budgetary leadership for one or more activities or tasks supporting an ERP. They must understand all the resource needs and requirements to implement or perform the assigned activity or task (e.g., scope of task-specific activity, schedules for work). Task Leaders prepare activity and task plans, budget estimates using established tools and protocols, implement the activity and task plan that is approved by the project leader, track and control task progress and costs against the plan, and oversee and participate in performing activity and task work (e.g., obtain/evaluate hydrogeologic information, design treatment systems).

1.2. Problem Definition

Both the LLNL Livermore Site and Site 300 are Superfund sites under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA). ERD has the responsibility to investigate and remediate environmental contamination at the LLNL Livermore Site and at LLNL's Site 300 test facility in accordance with CERCLA and applicable CERCLA guidance and policy, the National Contingency Plan, pertinent provisions of the Resource Conservation and Recovery Act (RCRA) and applicable RCRA guidance and policy, and applicable state laws and regulations.

LLNL Site 300 is a High Explosives (HE) testing facility used primarily for support of the LLNL Weapons Program Mission in research, development, and testing nonnuclear components associated with the national defense program. This work began in 1955 and includes explosives processing; preparation of new explosives; and pressing, machining, and assembly of explosives components. Contamination of the soil and ground water has resulted from these activities.

LLNL Livermore Site is a research and development facility owned by the U.S. DOE and operated by the University of California (UC). Initial releases of hazardous materials to the

environment occurred in the mid- to late- 1940s when the Livermore Site was used by the U.S. Navy as a Naval Air Station. From 1950 to 1954 California Research and Development Company, a subsidiary of Standard Oil, occupied the southern portion of the site. LLNL has occupied the site since 1952. Since 1950, additional releases have occurred due to localized spills, landfills, surface impoundments, and leaking tanks.

1.3. Project Background

Figure 3 shows the locations of the Livermore Site and Site 300. Site descriptions and project history are discussed below.

1.3.1. Site 300 Site Description

LLNL operates the Site 300 experimental test facility in support of DOE's national defense programs. Operations at Site 300 support four programmatic activities: (1) hydrodynamic testing; (2) charged particle beam research; (3) physical, environmental, and dynamic testing; and (4) high explosives (HE) formulation and fabrication. Located in a remote region of the Altamont Hills portion of the Coast Range about 100 kilometers (62 miles) east-southeast of San Francisco, California, the site covers approximately 11 square miles of ridge and canyon terrain adjacent to California's Central Valley. Local relief is on the order of 100 to 200 meters (328 to 656 ft). The climate at Site 300 is semiarid; average rainfall is about 25 centimeters (9.8 in.) per year. No perennial streams exist within or near the site. About 80% of Site 300 is in San Joaquin County, the remainder is in Alameda County. Population around the site is sparse in that most of the surrounding land is used for grazing cattle and sheep. Detailed descriptions of Site 300, climate, drainage conditions, and general environmental monitoring programs are described in Lentzner et al. (1995).

The geology and hydrogeology of Site 300 are detailed in the Final Site-Wide Remedial Investigation Report (Webster-Scholten et al., 1994). The site is underlain by bedrock of interbedded sandstone, siltstone, claystone, and conglomerate which is generally overlain by colluvial and valley fill deposits, as well as alluvial and terrace deposits. Ground water occurs largely within the sandstone and conglomerate beds, and moves through both pores and fractures.

1.3.2. Site 300 Project History

LLNL initiated environmental investigations at Site 300 in 1981 to evaluate the impacts of past operations and waste disposal practices on soils and ground water. Early restoration work was conducted under the oversight of the San Joaquin RWQCB. Seven environmental Study Areas have been defined at Site 300, and are shown on Figure 4. These are:

1. The Building 832 Canyon Study Area
2. The Building 834 Complex Study Area
3. The East and West Firing Areas (EWFA) Study Area
4. The Pit 6 Study Area

5. HE Process Area Study Area
6. General Services Area (GSA) Study Area
7. Building 854 Complex

Early hydrogeologic investigations of Site 300 included the installation and sampling of 17 monitor wells in 1982 to investigate the impact to the area ground water by the operation of 8 solid waste landfills, Pits 1 through 8 (Raber and Carpenter, 1983). In addition, water samples were obtained from 12 springs or seeps and 10 existing wells at Site 300. Samples were analyzed for major ions, physical parameters, metals, radionuclides, HE compounds, volatile organic compounds (VOCs), semi-volatile priority pollutants, pesticides, polychlorinated biphenyls, phenolics, total organic halide, and total organic carbon. No degradation of the ground water from the landfills was observed, and routine monitoring of the wells around the landfills was established to meet RCRA ground water monitoring requirements.

Also in 1982, an assessment was begun to determine the extent of trichloroethylene (TCE) contamination of soil, rock, and ground water at Site 300. An examination of past practices in the handling and use of TCE revealed several areas where leakage to the ground had occurred. TCE was used in large quantities at Site 300 as a heat exchange fluid. Results of this assessment were reported in Carpenter et al. (1983). Twenty-three exploratory and soil-sampling boreholes were drilled and five monitor wells were completed. TCE was detected in a perched ground-water body under the Building 834 Area in concentrations up to 160,000 micrograms per liter [µg/L, or parts per billion (ppb)]. TCE was also detected in soil and rock samples from the Buildings 854 and 830 areas. Water-supply well 7 in the GSA also contained detectable amounts of TCE (up to 52 µg/L [ppb]), although no TCE was found in nearby soil, rock, or ground water samples.

In 1984, tritium in excess of the State of California Maximum Contaminant Levels (MCLs) for drinking water (20,000 picocuries per liter [pCi/L]) was detected during the RCRA monitoring around the Pit 7 Complex of landfills (the "Pit 7 Complex") in the northwest part of the site. A major investigation was launched in 1985, which initially included drilling over 50 boreholes, a records search of tritium uses, and a survey of tritium levels in soil, vegetation, and water in the area. A maximum tritium concentration of slightly less than 10^6 pCi/L was detected in the ground water, with similar levels detected in soil moisture. Elevated tritium concentrations were also detected near Building 850. Conclusions reported in Buddemeier (1985) indicated the tritium release from the Pit 7 Complex was caused when the inactive Landfills 3 and 5 were inundated due to an elevated water table caused by excessive rainfall during the 1982 and 1983 water years. The cause of the tritium release near Building 850 was the result of the mobilization of tritium contamination in the firing table from explosive tests through the use of water for dust suppression.

In 1985, an investigation began to support the proposed closure of several inactive, unlined lagoons in the HE Process Area of Site 300. These lagoons had been used to receive rinse water that had been produced by the HE processing. The unlined lagoons were replaced with two double-lined surface impoundments. Eight shallow boreholes and a deeper monitor well were drilled to obtain soil and rock samples. The HE compounds HMX, RDX, and small amounts of

trinitrotoluene (TNT) were detected in the borehole samples. Only one monitor well had small amounts of RDX in ground water (Crow et al., 1986).

Results from the ongoing TCE, tritium, and HE investigations have been reported through the use of the topical reports referenced above. Beginning with the first quarter of 1987 and continuing through the second quarter of 1991, LLNL Site 300 Environmental Investigation Quarterly reports were prepared. These reports detailed progress on existing and new investigations. The reports were sent to the RWQCB–Central Valley Region, EPA, DTSC, and other interested regulatory agencies or individuals.

Since 1987, TCE has also been detected in the GSA, the HE Process Area, the Pit 8 Landfill area, and the Pit 6 Landfill area. Currently, over 400 monitor wells, piezometers, barcads, lysimeters, and neutron probe access tubes are in place both onsite and offsite.

As a result of the discovery of high concentrations of VOCs (up to 800,000 ppb TCE) in ground water beneath the Building 834 Complex, the EPA evaluated the site using its Hazard Ranking System. The resulting score of 31.6 caused the site to be named to the EPA National Priorities List (NPL) in 1990. A Federal Facilities Agreement (FFA) pursuant to the CERCLA was signed by DOE, EPA, the RWQCB, and DTSC. Work has continued under CERCLA.

Currently, investigations at Site 300 are being conducted in areas where VOCs (primarily trichloroethylene), metals, uranium, tritium, and/or the HE compounds have been detected in the soil, rock, and/or ground water. To date, only small amounts of TCE and tetrachloroethylene (PCE) have been detected offsite in ground water samples collected from monitor wells drilled adjacent to the southeastern part of the site. Three private drinking water wells lie within 1,000 ft of the identified TCE plumes in this area. Concurrent with the remedial investigation of the site, a number of cleanup activities have been conducted. The completed remedial actions at Site 300 include: capping of Pits 1, 7, and 6, removal of firing table gravel at six locations, closure of nine HE rinse water lagoons, closure of numerous dry well sumps, enhanced bioremediation of diesel-contaminated soil, and sealing and abandonment of old water-supply wells. Other remedial actions presently in progress include: Building 834, eastern GSA, and central GSA soil vapor and ground water extraction. Soil vapor and ground water cleanup operations at the central and eastern GSA are being conducted under a CERCLA Record of Decision (ROD). To date, several Feasibility Studies (FSs), Proposed Plans (PPs), Engineering Evaluations and Cost Analysis (EE/CA) reports, and an Interim and Final ROD have been completed. Table 1 lists the Site 300 contaminants of concern (COCs) and their action limits.

1.3.3. Livermore Site Description

The LLNL Livermore Site comprises approximately 800 acres. It is situated in the southeast portion of the Livermore Valley, approximately 3 miles east of the downtown area of the City of Livermore, California. The site is heavily developed with large-scale experimental research and support facilities. Land immediately north of the site is zoned for industrial uses. Sandia National Laboratory is located to the south of the site in an area zoned for industrial development. Land to the east is zoned for agriculture and is currently used as pasture land, and to the west of the site is zoned for residential housing. Land to the west is primarily residential.

The ground surface of the site slopes approximately 2.5% from southeast to northwest. The area is underlain by complexly interbedded alluvial sediments filling a structural depression that cuts across the Diablo Range in Central California. The interstratified clays, silts, sands, and gravels of late Tertiary and Quaternary age comprise a sedimentary body of alluvial fans, terraces, and flood-plain deposits. The site is drained by two ephemeral streams, Arroyo Seco and Arroyo Las Positas.

1.3.4. Livermore Site History

In 1983, ground water contamination was discovered on the Livermore Site and offsite by LLNL. In 1987, LLNL was added to the U.S. EPA NPL. To date, a Remedial Investigation (RI), a Feasibility Study (FS), a Proposed Remedial Action Plan (PRAP), a Baseline Public Health Assessment (BPHA), a Record of Decision (ROD), a Remedial Action Implementation Plan (RAIP), a Compliance Monitoring Plan (CMP), a Draft Contingency Plan (CP), and five Remedial Design (RD) reports, which detail our treatment facilities and associated wellfields have been completed.

The ground water and vadose zone contaminants of primary concern are VOCs, tritium, and metals that exceed State and Federal regulatory limits. VOCs, predominantly PCE and TCE are the most widespread contaminants of concern in the LLNL study area. The VOCs occur in ground water in relatively low concentrations up to a maximum of about 40,000 ppb with the majority less than 1,000 ppb underlying about 85% of the site, some of which has migrated offsite, encompassing a total area of about 1.4 square miles. The calculated volume of VOCs in the sub-surface as of 1996 is approximately 226 gallons. The vertical thickness of the VOC ground water plumes vary from about 30 ft to the east to 150 ft to the west. VOCs are seldom found beneath a depth of about 200 ft from the surface.

Fuel hydrocarbons were confined to the immediate vicinity of an onsite gasoline fuel tank leak. The fuel components initially spread about 500 ft horizontally of the spill, but have been successfully remediated. Chromium is found in excess of drinking water standards in about 15 wells scattered around the site. Cadmium has been detected above its drinking water standard only from bailed water samples from a few undeveloped boreholes around the site. Tritium exceeds its drinking water standard at one location onsite. Table 2 lists the Livermore Site COCs and their action limits.

The LLNL Livermore Site remedial activities include the design, construction, and operation of ground water and vapor extraction facilities for treatment of the contaminants of concern. In addition, excavation and disposal of contaminated sediments have been accomplished.

Construction of treatment facilities to date include: Treatment Facility A (TFA), Treatment Facility B (TFB), Treatment Facility C (TFC), TFC-Southeast (TFC-SE), Treatment Facility D (TFD), TFD-East, TFD-West, Treatment Facility E-East (TFE-E), Treatment Facility F (TFF), Treatment Facility 406 (TF406), Treatment Facility G-1 (TFG-1), and Vapor Treatment Facility 518 (VTF518) (Fig. 5). These treatment facilities utilize ultraviolet light/hydrogen peroxide (H_2O_2) oxidation, air stripping, and carbon adsorption to treat VOCs. Ion exchange and carbon dioxide (CO_2) (which reduces the pH) are used to treat chromium when necessary.

1.4. Project Description

1.4.1. Applicable Quality Standards

The DOE initiated DOE Order 5700.6C in 1991 to improve the safety and reliability of the Department's programs, projects, and facilities. The 10 criteria of DOE Order 5700.6C direct organizations to develop, implement, and maintain a written quality assurance program. The DOE requires LLNL to maintain quality assurance programs to the requirements of DOE Order 5700.6C. The EPD QAMP is written to these requirements. The EPD QAMP ensures that EPD management provides planning, organization, direction, control, and support to achieve EPD's objectives; that the line organizations achieve quality; and that overall performance is reviewed and evaluated using a thorough assessment program. Because ERD is a division of EPD, it must comply with all the QA requirements of EPD. ERPs must comply with all the QA requirements of EPD since they are part of ERD. Figure 6 shows ERD's QA Document Hierarchy. In addition, ERD must comply with the various QA requirements of the regulating agencies: U.S. EPA—Region IX, RWQCB–Central Valley and San Francisco Regions, DTSC, BAAQMD, and SJVUAPCD.

1.4.2. Data to be Collected

The types of data required are varied and often interrelated. Table 3 summarizes the types of data to be collected. The primary investigative techniques used to define the lateral and vertical extent of the contaminants of concern in ground water and soils, and to locate release sites are: (1) completion of ground water and unsaturated zone sampling installations (such as wells, Flutes, Barcads, lysimeters, and soil vapor points), (2) saturated and unsaturated sediment and ground water sampling, and (3) chemical analyses. The primary investigative techniques used to understand the hydrogeologic characteristics of the area include: (1) development of a three-dimensional representation of subsurface geology derived from hydrogeologic studies of the area, (2) determination of aquifer characteristics by conducting pumping and slug tests, and (3) determination of water table configuration. Analytic and numerical models have been developed and used to aid in source definition, evaluation of remedial alternatives, and risk assessment. Saturated and unsaturated soil samples are routinely taken to: (1) estimate physical properties of the soil underlying the sites, (2) evaluate the distribution of hazardous materials in the vadose and saturated zones, (3) select intervals for completion of wells, (4) evaluate potential sources of hazardous materials and characterize known sources, (5) evaluate exposure pathways of hazardous materials for assessing public health and safety, and (6) design remediation procedures. Ground water is the medium of greatest concern. Other pathways for contaminant migration (i.e., soils, surface waters, and air) are investigated by the ERPs as appropriate for the evaluation of all contaminants at, or originating from, the sites.

1.4.3. Anticipated Use of the Data

The types of data collected during the ERPs ground water, soil, and rock investigations and their uses are summarized in Table 3. Data are required to: (1) assess the lateral and vertical extent of contamination on and off the sites, (2) understand the hydrogeologic characteristics under the Livermore Site and Site 300 and adjacent affected areas, (3) determine the nature and

location of possible sources of contamination, (4) develop public health and ecological assessments, (5) model contaminant fate and transport, (6) evaluate potential remedial action alternatives and engineering designs, and (7) characterize baseline conditions. The data use categories are briefly described below:

- Site Characterization—Data are used to determine the nature and extent of contamination at a site. This category is usually the one that requires the most data collection. Site waste sources characterization data are generated through the sampling and analysis of waste sources and environmental media.
- Risk Assessment—Data are used to evaluate the threat posed by a site to public health and the environment. Risk Assessment data are generated through the sampling and analysis of environmental and biological media, particularly where the potential for human exposure is great.
- Evaluation of Alternatives—Data are used to evaluate various remedial technologies. Engineering data are collected in support of remedial alternatives evaluation and to develop cost estimates. This may involve performing bench scale studies to determine if a particular process or material may be effective in mitigating site contamination.
- Engineering Design of Alternatives—Data are used for engineering design purposes to develop a preliminary database in reference to the performance of various remedial technologies.
- Monitoring During Remedial Action—During the remedial action, samples can be taken to assess the effectiveness of the action. Based on the analysis of these samples, corrective measures may be taken.

The data categories required for each data type and use are described in Section 1.5.

1.4.4. Personnel and Equipment

There are no special personnel and equipment needs. All personnel and equipment for the ERPs will be provided by LLNL or its subcontractors.

1.4.5. Assessment Tools

The ERPs undergo numerous technical and peer reviews from independent organizations throughout the life of the projects. For example, LLNL's Hazards Control Department performs environmental safety and health (ES&H) assessments of the ERPs facilities and the EPD conducts QA audits to assess the implementation of the EPD QAMP requirements. In addition, ERD performs operational, management and QA self-assessments. Chapter 3 discusses assessments and oversight in more detail.

1.4.6. Work Schedule

Work is to continue until the Livermore Site and Site 300 achieve cleanup standards as agreed to by DOE and the regulatory agencies.

1.4.7. Project Reports

The ERPs must provide DOE and the regulatory agencies various reports per each site's FFA. The type of reports required depends on the work being performed and the agreements reached between the ERPs, DOE, and the regulatory agencies. Examples of "primary" documents that are required are listed below:

1. RI and FS work plans
2. Community relations plans
3. Engineering/Evaluation Cost Analysis (EE/CA)
4. Operable unit (OU) work plans
5. RI/FS reports
6. QAPPs and SOPs
7. Proposed plans (PPs)
8. Records of decisions (RODs)
9. Remedial design workplans
10. Preliminary remedial designs
11. Final remedial designs
12. Remedial action work plans
13. Contingency plans (CPs)
14. Project closeout reports
15. Operation and maintenance (O&M) plans
16. Compliance Monitoring Plans

1.4.8. Project Quality Assurance Records

The ERD's DMT archives the projects' QA records. Such records include analytical and QC results from the analysis of environmental media, ground water sampling data forms, geologist field logs, CoC forms, water level data sheets, completed controlled field logbooks, and hydraulic test data. Other QA records managed by the ERD QAIC are corrective action reports, controlled document distribution lists, and self assessment reports and completed checklists.

1.5. Quality Objectives and Criteria for Measurement Data

The Projects must collect data to support the decisions necessary to meet their end goal of site cleanup. To do this, the data must be of a known and sufficient quality level as required for their intended purpose. Table 3 summarizes the types of data collected by the Projects and the intended uses. Table 3 also indicates the data category, either screening or definitive, that is required for each use. These two data categories are associated with specific quality assurance

and quality control elements and may be generated using a wide range of analytical methods. EPA has provided the following definitions:

Definition of Screening Data

Screening data are generated by rapid, less precise methods of analysis with less rigorous sample preparation. Sample preparation steps may be restricted to simple procedures such as dilution with s solvent, instead of elaborate extraction/digestion and cleanup. Screening data provide analyte identification ad quantification, although the quantification may be relatively imprecise. At least 10% of the screening data are confirmed using analytical methods and QA/QC procedures and criteria associated with definitive data. Screening data without associated confirmation data are not considered to be data of known quality.

Definition of Definitive Data

Definitive data are generated using rigorous analytical methods, such as approved EPA reference methods. Data are analyte-specific, with confirmation of analyte identity and concentration. Methods produce tangible raw data (e.g., chromatograms, spectra, digital values, etc.) in the form of paper printouts or computer-generated electronic files. Data may be generated at the site or at an offsite location, as long as the QA/QC requirements are satisfied. For the data to be definitive, either analytical or total measurement error must be determined.

These definitions are easily applied to the chemical and radiological analysis data types indicated in Table 3.

When data are received by the DMT, they are put into one of the two EPA Superfund descriptive data categories. The DMT make this determination based on the type of data, how and where the data was generated, and the associated QC data accompanying the data.

Analytical laboratories may send two types of data reports: official and preliminary. The official hardcopy report contains all required information, requested analyses, QC results, and is certified by the laboratory manager. A preliminary report may be verbal, facsimile, or e-mail results usually reported before any peer reviews, confirmation analyses, or QC sample results have been performed. Preliminary results are not certified by the laboratory and may change once the QC and confirmation information are reviewed. Although past history indicates this does not happen frequently, this data must be considered screening data and be used only with the understanding of the potential consequences of making decisions based on inaccurate preliminary results that may be revised in later official results. Laboratories that are not State of California certified or that do not report the extensive QA/QC as required in Section 1.7 should be considered for use as a screening tool only.

Preliminary or screening data are acceptable for decision making purposes:

- During drilling activities when the cost of waiting for the official results out-weigh the potential consequences of using inaccurate or low quality data to make drilling decisions.
- When sample results are used for low cost optimization of existing treatment facilities.
- Treatability studies used to test new technology before implementation (pre-design phase).

Definitive, official validated data must be used for decision making purposes when consequence of failure is high:

- Risk assessment and site characterization samples.
- Self-monitoring compliance samples.
- Proof of system tests performed during initial phase of start-up as required by permit to determine whether system operates and treats as planned.

The EPA has not defined screening or definitive categories for the non-analytical data types collected for the ERPs. Therefore, these data collected using ERP SOPs or standard industry practices (i.e., surveying, physical property analysis) will be considered definitive. Any questions regarding whether data are appropriate for use will be directed to the ERP Leader.

1.6. Training

Personnel supporting the ERPs are trained to ensure that they have the skills and knowledge necessary to perform their work assignments in a safe, competent, uniform, and environmentally sound manner. ERD complies with the EPD Training Plan, Laboratory Site Operations Training Implementation Plan, and LLNL Training Program Manual. In addition to the regulatory driven training such as hazardous waste operations and emergency response certification, Superfund Amendments and Reauthorization Act/Occupational Safety and Health Administration (SARA/OSHA), and the ES&H courses provided by LLNL, ERP personnel also receive on-the-job training for their specific work tasks. All training is tracked and recorded by the EPD Training Section.

1.7. Documentation Requirements for Analytical Data

The documentation requirements for the ERPs analytical data are defined and communicated to the analytical laboratories via Analytical Services Statement of Work (SOW).

1.7.1. Case Narrative

A case narrative, on subcontractor letterhead, shall include:

- LLNL's sample identification and corresponding subcontractor identification.
- Analysis as requested by LLNL on the CoC for each sample and the methodology used.
- Detailed description of all problems encountered.
- Discussion of possible reasons for any QA/QC criteria outside acceptance limits.
- Observations regarding any occurrence that may affect sample integrity or data quality.
- Indication of whether holding times were exceeded.
- Authorization by the subcontractor manager for release of the data.

When any of the hard copy deliverables have been revised, the case narrative shall also indicate why and under whose direction the revision was done, and what changes were made.

1.7.2. Chain-of-Custody Documentation

A legible copy of the completed CoC documentation shall be included as part of the hard copy deliverables. The CoC shall indicate:

- The appropriate receiving and relinquishing signatures and dates.
- The observed sample condition at the time of receipt, described either on the CoC or on the subcontractor's sample receipt form.

1.7.3. Summary of Sample Results

Hard copy reports shall be identical to the electronic report generated from a common data source (see Section 1.7.6 below) and shall include for each sample:

- LLNL's sample identification (ID) and the corresponding subcontractor ID.
- Sample matrix.
- Date/time and method used for sample extraction, if applicable.
- California State, Certification Number, where applicable.
- Analysis method and LLNL analysis method code.
- Date/time of analysis.
- ID of the instrument used for analysis.
- Dilution or concentration factor of the samples.
- The reporting limit as indicated in the SOW.
- Definitions for any data qualifiers used.
- Analyte name.
- Analytical results (concentration or activity detected in the sample) in units as indicated in the SOW.
- LLNL code for each parameter.
- The analytical chemist's ID.
- Sample collection date and date the subcontractor received the sample.
- Project CoC ID.
- Sample QC batch number.
- Analytical uncertainty (error) a the sigma deviating where applicable, in units as indicated in the SOW.
- Calculated value where applicable.
- Any applicable notes or comments.

1.7.4. Summary of Quality Control Sample Results

A summary of QC sample results shall be provided for each sample and shall include:

- Method blank results and reporting limits, matrix, units, batch number, date/time of analysis, instrument ID number, analyst ID, and method code.
- Surrogate or tracer yield recoveries, if applicable.
- Sample duplicate results, and relative percent difference (%RPD), if applicable.
- Matrix spike (MS), matrix spike duplicate (MSD) recoveries and %RPDs, batch number, date/time of analysis, instrument ID number, analyst ID, matrix, method code, and sample result when indicated by the method.
- Laboratory control sample (LCS) recoveries, batch number, date/time of analysis, instrument ID, analyst ID, matrix, and method code.
- QC control limits for LCS, MS/MSD, surrogate, and tracer yield recoveries, and %RPDs.

In addition, the Subcontractor shall provide upon request all supporting documentation used to generate reported results, including, but not limited to:

- Initial instrument calibration data.
- Continuing calibration data.
- Retention time window determinations.
- Run logs and standard preparation logs.
- Method detection limit determinations.
- Laboratory QC control charts.
- Gas chromatography/mass spectrophotometry (GC/MS) tune data.

Data packages will be validated at LLNL by the ERD QC Chemists. For results that cannot be validated through the standard report package, the subcontractor shall submit additional related documentation, such as raw data, to LLNL upon request.

1.7.5. Hard Copy Retention

All raw sample and QC hard copy data are considered QA records and must be maintained for the life of LLNL. The subcontractor shall retain all related project information for a minimum of three years, and afterwards, may turn it over to LLNL for storage.

1.7.6. Electronic Data Deliverables

Electronic data deliverables (EDDs) are electronic versions of sample, analytical, and related QC data that shall be delivered to LLNL. The hard copy reports must be identical to the Felectronic copy, i.e., generated from a common electronic data source. By “common electronic data source” LLNL means data generated directly from the subcontractor’s Laboratory Information Management System (LIMS) or some other original data source, eliminating insofar as possible manual secondary data entry.

Specifications for a transmission batch are continually being improved by the ERD DMT to meet new data generation and reporting requirements. Each transmission batch shall include four files:

- Sample File, containing descriptive information about the collected sample, as provided by LLNL on the CoC form.
- Analysis File, containing information about the analysis performed on the samples, including methods used and results obtained.
- QA/QC File, containing information about the QC samples and their analytes.
- Batch Number Reference File, containing batch numbers and corresponding laboratory log numbers for samples supported by that batch.

All analytical work shall be delivered electronically in this four-file format, with the exception of specialty analyses whose results do not lend themselves to the specified format (e.g., EPA 1002 Gross Algae Test, EPA 1003 Water Flea Test).

1.7.7. Turnaround Times

Turnaround time (TAT) is calculated beginning at 24 hours after LLNL's notification for sample pickup or the verified time of sample receipt at the lab facility, whichever comes first. If samples are shipped, the TAT calculation starts 24 hours after the samples leave the LLNL facility or the verified time of sample receipt at the lab facility, whichever comes first. Sample pickup commences the count for 24-hour or less TAT.

The TATs for official hard copy data packages and preliminary results are specified in the agreement/contract between LLNL and the subcontractor. The official hard copy result includes the sample results with the subcontractor's signature and accompanying QA/QC results. The turnaround times for preliminary/unofficial packages are the schedules when LLNL must receive preliminary results by fax, e-mail, or verbally, as requested on the CoC. Only receipt of the official report shall constitute the basis for payment. TATs are defined in working days.

2. Measurement/Data Acquisition

2.1. Sampling Process Design

Presently, the investigations at the Livermore Site and Site 300 require the sampling and analyses of more then 450 monitor wells at each site for various parameters with the emphasis on VOCs, inorganics, HE compounds, and radionuclides, using methods and procedures functionally equivalent to the methods and procedures used in the EPA Contract Laboratory Program (CLP) and the California DTSC Certified Laboratory Program whenever possible. ERD SOP 2.11, "Developing Ground Water Monitoring Sampling Schedules" describes how routine ground water sampling locations, sampling frequency, and requested analyses are determined by the Task Leader. The specific locations and frequency of soil sampling are determined by the Task Leader. The analytical methods used for soil samples are selected on the basis of: (1) results of analysis of soil and ground water from nearby boreholes and wells; and

(2) data on the use, storage, and disposal of hazardous material at nearby locations. A soil sampling plan for each borehole or excavation is developed prior to collection of the samples. All sampling plans are reviewed by the QC Chemists for inclusion of proper QA/QC samples and are archived by the DMT.

2.2. Sampling Methods

The ERD SOPs (Dibley and Depue, Eds., February 1999) describe how ERD collects samples in support of the Environmental Restoration Projects. The ERD SOPs applicable to sampling are:

SOP-1.1 Field Borehole Logging

SOP-1.2 Borehole Sampling of Unconsolidated Sediments and Rock

SOP-1.3 Drilling

SOP-1.5 Monitor Well Development

SOP-1.6 Borehole Geophysical Logging

SOP-1.8 Disposal of Investigation-Derived Wastes (Drill Cuttings, Core Samples, and Drilling Mud)

SOP-1.9 Lysimeter Soil Moisture Sampling

SOP-1.10 Soil Vapor Surveys

SOP-1.11 Soil Surface Flux Monitoring of Gaseous Emission

SOP-1.12 Surface Soil Sampling

SOP-1.14 Final Well Development/Specific Capacity Tests at LLNL Livermore Site

SOP-1.15 Well Site Core Handling

SOP-2.1 Presample Purging of Wells

SOP-2.2 Field Measurements on Surface and Ground Waters

SOP-2.3 Sampling Monitor Wells with Bladder and Electric Submersible Pumps

SOP-2.4 Sampling Monitor Wells with a Bailer

SOP-2.5 Surface Water Sampling

SOP-2.6 Sampling for Volatile Organic Compounds

SOP-2.7 Presample Purging and Sampling of Low-Yielding Monitor Wells

SOP-2.8 Installation of Dedicated Sampling Pumps

SOP-2.9 Sampling for Tritium in Ground Water

SOP-2.10 Well Disinfection and Coliform Bacteria Sampling

SOP-2.11 Developing Ground Water Monitoring Sampling Schedules

SOP-2.12 Ground Water Monitor Well and Equipment Maintenance

SOP-2.13 Barcad Sampling

SOP-3.1 Water Level Measurement

SOP-3.2 Pressure Transducer Calibration

SOP-3.3 Hydraulic Testing (Slug/Bail)

SOP-3.4 Hydraulic Testing (Pumping)

SOP-4.1 General Instructions for Field Personnel

SOP-4.2 Sample Control and Documentation

SOP-4.3 Sample Containers and Preservation

SOP-4.4 Guide to the Handling, Packaging, and Shipping of Samples

SOP-4.5 General Equipment Decontamination

SOP-4.7A Livermore Site Treatment and Disposal of Well Development and Well Purge Fluids

SOP-4.7B Site 300 Treatment and Disposal of Well Development and Well Purge Fluids

SOP-4.8 Calibration/Verification and Maintenance of Measuring and Test Equipment (M&TE).

SOP-4.9 Collection of Field QC Samples

A complete list of ERD SOPs can be found in Appendix B. The SOP manual as a whole undergoes an annual review. Procedures are revised whenever a procedural change is needed; therefore, reviews and revisions may occur more frequently.

Sampling performed by ERD personnel in support of the ERPs remedial activities follow the ERD SOPs when applicable to the work being performed. O&M Manuals developed for the ERD treatment facilities are used in conjunction with the ERD SOPs.

The O&M manuals are reviewed annually and revised when necessary.

The corrective actions to be taken when problems related to sampling occur are described below in Section 2.11.

2.3. Sample Handling and Custody

Sample custody procedures are described in ERD SOP 4.2, “Sample Control and Documentation.” This SOP describes the methodology of sample control and documentation applicable to field logbooks, sampling data collection forms, CoC records, and sample identification labels. ERD SOP 4.3, “Sample Containers and Preservation,” contains holding time information, as well as the appropriate sample volume, container, and preservation techniques. Additional sample handling and shipping information can be found in ERD SOP 4.4, “Guide to the Handling, Packaging, and Shipping of Samples.”

2.4. Analytical Methods

ERD submits environmental samples produced during environmental investigations and remedial activities to onsite and offsite (subcontract) analytical laboratories for analyses. ERD requires EPA-based methodology whenever possible. ERD requires that any of its subcontractor analytical laboratories and any approved sub-subcontractors maintain a DHS Environmental Laboratory Accreditation Program (ELAP) certification for analytical tests provided to LLNL for which the DHS offers certification. During the contract pre-award audit, copies of State and Federal certificates and any analytical procedures to be used by the subcontract laboratories are reviewed. In addition, all relevant method detection limit (MDL) studies are reviewed to verify that the laboratories performance-based MDLs are as low or lower than the required ERP reporting limits (See Section 3.1.1 for more information on analytical laboratory audits). The ERPs do not accept results from a laboratory that have MDLs higher than the reporting limits. MDL studies are performed by analyzing seven replicates per 40 CFR, part 136 App. B. Copies of the certificates, MDL studies, and subcontract analytical laboratories operating procedures are maintained by the EPD QA Manager.

The requested analyses are selected based on the COC. The ERPs require reporting limits lower than the action limits for the COCs whenever technically feasible. Appendix C lists the analytical methods and reporting limits required for the ERP COCs. This list is continually being modified as alternative methodology and technology is introduced. The reporting limits are subject to change due to high analyte concentrations and matrix effects requiring dilution. The analyses performed by onsite laboratories for the ERPs are either nonstandard analyses or noncritical (information only) samples that require a rapid turnaround time. All critical samples requiring standard methodology are sent offsite to a DHS certified laboratory.

The corrective actions to be taken when problems related to analytical laboratory analyses occur are described below in Section 2.11.

2.5. Quality Control

2.5.1. Field Quality Control

There are many measures that need be taken to ensure the quality of the sampling and analysis effort. The QC checks that ERD has implemented are the collection of equipment blanks to check the effectiveness of decontamination procedures, trip blanks and field blanks which identify contamination that occurs during sample collection and transportation, and the collection of collocated samples. Ten percent of ERD samples will be collocated (5% intralaboratory and 5% interlaboratory). When collocated samples are collected, processed, and analyzed by the same organization, they provide intra-laboratory precision information for the entire measurement system including sample acquisition, homogeneity, handling, shipping, storage, preparation and analysis. When collected, processed, and analyzed by different organizations, these QC checks provide inter-laboratory precision information for the entire measurement system. Additional information regarding these type of QC checks including QC sample collection frequency can be found in ERD SOP 4.9, “Collection of Field QC Samples.”

2.5.2. Analytical Quality Control

The analytical laboratories that analyze samples for the ERPs are required to perform and document certain internal QC checks. These checks will vary according to the specific analytical method and level of desired data quality. For a high-quality result, the QC usually consists of the analysis of one method blank, MS and MSD or sample duplicate, and an LCS per batch of twenty samples. In addition, initial instrument calibration data, continuing calibration data, extraction blank data, surrogate recoveries, retention time windows, method detection limit determinations, laboratory QC control charts, and GC/MS tune data may also be reported. At a minimum, these items are kept at the laboratory and reviewed upon request or during an audit of the analytical laboratory facilities. Analytical QC checks required by ERD are explained in ERD SOP 4.6, "Validation and Verification of Nonradiological Data Generated by Analytical Laboratories" and SOP 4.11, "Validation and Verification of Radiological Data Generated by Analytical Laboratories." Assessment of the analytical QC is described in Chapter 3. Table 4 shows the methods used to analyze the COCs, the QC elements, frequency of analysis, and acceptance criteria. The analytical laboratories set internal QC limits based on EPA methodology whenever it exists. These limits may be tighter or wider than the criteria listed in Table 4; therefore, the QC Chemists base their data review and qualification of data on the internal control limits provided by the laboratories. Table 5 lists the corrective action for QC failure.

2.6. Instrument/Equipment Maintenance

ERD field instruments are maintained as directed by the manufacturer. The maintenance procedures and required documentation are described in ERD SOP 4.8, "Calibration/Verification and Maintenance of Measuring and Test Equipment (M&TE)."

ERD ground water monitor wells and related equipment are maintained according to ERD SOP 2.12, "Ground Water Monitor Well and Equipment Maintenance."

The subcontract analytical laboratories have internal procedures that describe the maintenance and corrective actions performed for analytical instrumentation. Before a subcontract laboratory is used by ERD, maintenance procedures are assessed as part of a comprehensive laboratory audit.

2.7. Instrument Calibration and Frequency

ERD SOP 4.8 describes ERD field equipment calibration procedures and frequency. This SOP also describes the corrective action steps required when an instrument is outside of acceptance criteria.

The subcontract analytical laboratories' internal calibration procedures include frequency of calibration and calibration standards for the calibration of their analytical instrumentation. Before a subcontract laboratory is to be used by ERD, maintenance procedures are assessed as part of a comprehensive laboratory audit.

2.8. Inspection and Acceptance Testing

All supplies and consumables required by the ERPs are procured by the ERD Resource Managers per LLNL procurement regulations. ERD personnel order the materials or equipment from the ERD Technical Release Representatives (TRRs) and specify the technical and quality requirements. When the order is received, ERD personnel determine if the item meets the specified requirements. The graded approach is used to determine the level of testing required.

2.9. Non-Measurement Data Acquisition

Data from non-measurement sources, such as literature files, and computer databases and programs, are essential elements of project implementation and decision making. Use of these data are managed in accordance with the policy presented in this section. Management of databases is described in Section 2.10 of this document. Financial information follows the LLNL Business Services and Finance Regulations.

The need to assemble pertinent information previously developed by others will be determined. This is typically considered during the task planning stages. The scope of any resulting survey will be based on the needs of the project. Acquired information may include:

- Applicable Federal, State, and local regulations and rulings
- Program/site status
- History/background
- Future plans
- Requirements/schedule
- Methodologies available for field exploration, monitoring, testing, and sampling
- Laboratory testing
- Processing and volume reduction of radioactive/hazardous material
- Isolation and disposal of radioactive/hazardous material
- Numerical analysis and design
- Existing data generated for the specific region or site
- Demographical
- Geological (surface and subsurface)
- Hydrological/meteorological (e.g., ground water distribution and usage)
- Geochemical
- Geophysical
- Geotechnical
- Facility development and practices (past, present, and future)

- Type, volume, and extent of contamination
- Physical layout of man-made facilities
- Data generated on specific wastes, materials, or chemical compounds of interest
- Processing
- Physical
- Chemical
- Radiological
- Mechanical
- Thermomechanical
- Toxicity/hazards and protection
- Treatability
- Previous or concurrent surveys, studies, analyses, and designs of a similar or parallel nature.

Sources for the above information may include:

- Government and private regulations, standards, guidelines, journals, periodicals, and data compilations
- Textbooks and maps
- Reports and manuals previously issued by the LLNL, DOE, EPA, or other organizations
- Results of currently ongoing investigations by government and private agencies, corporations, and research facilities
- Personal communications
- Aerial photographs and satellite imagery

Information collected will be documented to indicate its source. Documentation will, as appropriate, include author or individual contacted; source title; identification of periodical or journal; standard, guideline, or report number; identification of publisher or originating organization; page location; and date. Documentation must be sufficient to allow other individuals to easily obtain or verify the information.

Whenever possible, complete copies of articles, data compilations, maps, reports, and photographs will be included in the project files. If this is not feasible, copies of title pages and pertinent sections should be included with complete source documentation. Regulations, standards, guidelines, and textbooks, which are generally not project specific, may be obtained and kept in the project library if they are of a unique nature.

Personal communications, such as interviews or correspondence, will be documented in the form of trip reports, meeting notes, or memoranda, and the resulting documentation included in the project files. Documentation will provide, as appropriate, the date and the name, organization, address, telephone number, and credentials of individuals contacted. A request

should be made for formal written confirmation of critical data obtained verbally to serve as final documentation.

As necessary, an estimation of the quality/credibility of the information will be made. The collection of information must be consistent with the quality objectives of the project. Particular attention should be given to information that is collected that is not published from a peer reviewed source, or collected under the controls of a documented quality assurance program. This may include, but is not limited to, personal interviews, internal reports and memoranda, or newspaper articles. Any limitations or potential reservations for the accuracy or credibility of acquired information that could affect project quality should be clearly identified.

Computer software documentation, such as reference manuals and users' guides, are maintained and easily accessible to users. Computer hardware/software configurations are installed, tested, and maintained as described in the EPD Computer Security Plan. Quality affecting software developed or modified for the project is documented and tested according to EPD's Software Quality Assurance (SQA) policy.

Quality assurance (QA) in data interpretation and software application consists of using appropriate data, data analysis and methods, and administrative procedures. In general, the quality of a study is determined by the expertise of the technical and quality assessment teams.

To ensure consistent and reproducible results, QA in software application should address the following issues (van der Heijde et al., 1988):

- Formulation of problems
- Definition of objectives
- Methodologies and procedures
- Conceptualization of physical system and processes
- Description of assumptions, simplifications, and limitations
- Data acquisition, interpretation, and uncertainties
- Software selected and applied
- Validity of parameter values, and protocols for estimations, interpolations, and calibration
- Sensitivity analyses
- Validation of results
- Establishment of appropriate performance targets
- Presentation and documentation of results
- Evaluation and applicability of results
- Assessment and technical review

The findings of technical and/or administrative reviews should be documented and distributed to all members of technical staff. If necessary, additional work or corrective action in response to review comments should also be documented.

2.10. Data Management

The DMT has developed a data management system of data storage based on projected retrieval needs of the data users. The data elements needed by the data users are captured to produce a consistent data set of a specified data quality available to all users. The key goal of the system is to provide project personnel with timely access to the data while ensuring safe archival storage. This section will describe the structure and flow of data in the data management system used by the ERD to store and archive data.

2.10.1. Structure and Flow of Data Through the Data Management System

The structure is based on a relational database, named EPDData. EPDData stores discrete data including sample tracking, sample location, media, analytical results, and some geological information as shown in Figure 7. This production database is currently maintained on a Sun MicroSystems SPARC station 20 with OpenIngres relational database management software. Applications are developed and tested on a separate Sun Sparc Workstation before implementation in the production database. Two read-only, date-stamped, archive copies of the database are served from a separate Sun Sparc 20. These two read-only databases are updated from the production database twice a week. Gemini is a read-only date stamped database that is a copy of EPD data.

The flow of data, both hard copy and electronic, follows a model which tracks information from sampling plan through storage to archiving. The process of the data management includes CoC tracking of the sample, analytical result receipt, the application of quality control procedures, and the facilitation of the electronic use of data in analyses and decision making.

A sampling plan is developed to establish the frequency, method and location of samples to be taken. Field log books and CoC forms confirm the collection of samples as dictated by the plan. A document control number is assigned to the samples based on the field log book used. A carefully controlled system of field log book labeling permits electronic tracking of an environmental sample from field collection through analytical result receipt as well as tracing back to the log book for any given analyte, should details of sampling conditions be needed. Samples are sent on to analytical laboratories where they are assigned unique log numbers. A collection of related tables, Sample Planning and CoC Tracking (SPACT), tracks the flow of the sampling information (Fig. 8). The key fields in each SPACT record are document control number, analytical laboratory, analytical lab log number, sampling location identification, sampling date, and the analysis requested. Additional dates tracked include: receipt of sample and analytical results, and date of entry. SPACT also tracks invoice information. SPACT records are updated according to the receipt of official printed analytical results and invoices based on the document control number and sampling location. A data record is marked complete only when all analytical results have been received. Thus, completion of a record confirms that all requested analyses have been performed and reported.

Analytical results are stored in separate, but correlated, relational database tables based on sampling location, log number, and date. These tables are accessed by the MONITOR application (Fig. 9) and are related to SPACT tables by identical fields: document control number, sampling location, sampling date, analytical laboratory and requested analysis.

Additional information collected for each sample and analyte includes requestor, project, sample media, sample type, and method, units, error, detection limit, dilution factor, and dates of extraction, analysis, and entry, together with any comments or special notes.

Sources of data in these database tables include geologic borehole logs, surveyor reports, field measurements, laboratory measurements, calculated or reduced data, and test conclusions. Types of data to be stored have included descriptive sample location information, such as coordinates, elevations, lithology, and screened intervals of monitoring installations, as well as measurements and analytical information, including physical and chemical parameters, media identification, and ground water elevation measurements.

Data verification and validation are achieved through a combination of methods. Hand entered data are run through a series of computerized verifications that check for duplication, empty fields, and reported results not consistent with reported detection limits. Data are also thoroughly checked by a second person before being formally added to the database. Electronically delivered laboratory data are verified and standardized by filling in empty fields and ensuring internal consistency in fields such as sample location, project, media, and type. Computerized verifications are also run on electronic data and a second person checks sample descriptor fields before data are formally added to the database. Random audits are done to verify electronically delivered results against official printed results. Analytical results in the database are reviewed and validated by the QC Chemists. Original hard copies of data are stored by laboratory and log number for easy access.

Data elements related to quality control are also captured electronically. Such fields include flags indicating analytical result qualification and data quality level. The qualifier flags are absent from a routine report, but may be included to indicate sample dilution, compound detection in method blanks, or any of several other quality affecting conditions. Data quality levels can range from EPA approved methods performed by a certified laboratory to quick, approximate field analyses.

The database, originally recorded only analytical results and operated on other platforms in other database management software systems. Additional tables were created to serve the sample tracking needs. In 1993, the databases were merged into one database, EPDData, accessed by multiple software applications. In 1996, the database was brought up and run in the UNIX operating system.

The integrated centralized data management system has many advantages. The use of such a system promotes and provides a consistent data set of known quality, which is available to all. Single entry for multiple use allows quality assurance and quality control to be performed equally for all data.

The ERD SOPs applicable to Data Management are:

SOP-5.1 Data Management Printed Analytical Result Receipt and Processing

SOP-5.2 Data Management Chain-of-Custody Receipt and Processing

SOP-5.3 Data Management Electronic Analytical Results Receipt and Processing for Sample and Analysis Data

SOP-5.4 Data Management Hand Entry of Analytical Results

SOP-5.5 Data Management Revision Receipt and Processing

SOP-5.6 Data Management Data Review Request Processing

SOP-5.7 Data Management Sample Location Entry

SOP-5.8 Data Management Controlled Field Log Books Issue and Use

SOP-5.10 Data Management Receipt and Processing of Lithology

SOP-5.11 Data Management Verification of Format and Quality of Electronic Data Deliverables

SOP-5.12 Data Management Update of Analysis Data Quality Flags

SOP-5.13 Data Management Receipt and Processing of Quality Improvement Forms (QIFs)

SOP-5.14 Data Management Verification of Analytical Data Quality Flags

SOP-5.15 Data Management Processing of Water Elevation Data

SOP-5.16 Data Management Electronic Field Chain-of-Custody Receipt and Processing

SOP-5.17 Data Management Reference Report Preparation and Distribution

SOP-5.18 World Wide Web Custodianship

SOP-5.19 EPDData Copy Over Software Operating Procedure

SOP-5.20 Statistical Outliers

SOP-5.21 Cost Effective Sampling Algorithm Preparation

2.11. Corrective Actions

Corrective actions are necessary to rectify or resolve nonconformances to preclude repetition. A nonconformance is a deficiency in characteristic, documentation, or procedure that renders the quality of an item or activity unacceptable or indeterminate. The manner in which ERD and the subcontract laboratories handle corrective actions depends on the surrounding circumstance. The following description of corrective actions is not all encompassing. Situations may arise not covered here. These are handled as the need arises.

2.11.1. Corrective Actions Performed by Analytical Laboratories

The analytical laboratories used by the ERPs perform formal nonconformance and corrective action reporting as part of their overall QA Program. During the comprehensive laboratory audit, the implementation of the nonconformance and corrective action reporting is verified and the documented corrective action procedures are reviewed.

2.11.2. Corrective Actions Performed by LLNL Personnel

ERD follows different procedures for isolated and other, possibly systematic data problems. A Data Review Request (DRR) form is used to document corrective action for isolated problematic analytical data, while QIF is used for documenting all other types of problems as well as continuing or systematic analytical data problems such as:

- Cost savings suggestions.
- Quality improvement suggestions.
- Requested changes to the database (requiring a paper trail).
- To identify the problems commonly addressed each day.
- Receipt of broken or inadequate materials from vendors.
- Sampling and analysis error identification and correction.
- Broken equipment requiring repair.
- Treatment facility permit exceedences.

Instructions for using DRRs may be found in SOP 4.6 and SOP 4.11 and QIFs usage is described in SOP 4.12, "Quality Improvement Forms (QIFs)."

3. Assessment/Oversight

3.1. Assessments and Response Actions

3.1.1. System Audits

The system audit consists of evaluation of all components of the measurement systems to determine their proper selection and use. This audit includes a careful evaluation of both field and laboratory QC procedures and is regularly scheduled for the lifetime of the projects.

ERD performs self-assessments of quality-affecting activities including sampling, data management, drilling, and operations at ERD ground water treatment facilities. Management assessments of these activities are also performed by using a combination of checklists and including a member of ERD Management on the assessment team. Most self-assessments are performed triennially. The frequency may vary based on past findings. ERD self-assessments are coordinated and tracked by the ERD QAIC. The Personnel responsible for the assessed activities respond to any assessment findings. The results of the assessments and the responses are reported to the ERD Division Management. The ERD QAIC maintains the ERD Self-assessment Schedule and establishes whether any necessary follow up need be performed.

Independent audits of ERD activities are performed by auditors outside of ERD throughout the life of the projects. QA audits of ERD operations are performed by the EPD QA Manager. The EPD QA Manager determines the frequency and the subject of audits. ES&H assessments and safety inspections are performed by the LLNL Hazards Control Department Safety Teams. Findings from these ES&H assessments are reported and tracked by the LLNL deficiency tracking database called Deftrack. Findings are assigned a number and a closure date. ERD activities are also reviewed by other outside organizations such as the DOE, DTSC, EPA, RWQCB–San Francisco and Central Valley Regions, and various LLNL organizations. All audits are recorded in an assessment database maintained by the ERD QAIC.

ERD requires that the operations and QA program of the laboratories that provide analytical services in support of the ERPs be reviewed before contract award, then annually thereafter. This review is usually an onsite audit using checklists developed based on EPA SW-846 requirements, good laboratory practices and any contractual agreements between LLNL and the laboratory. However, if an analytical laboratory meets all requirements without findings, it may not be subjected to an onsite audit in the subsequent year if deemed appropriate by the Analytical Contract Management Team (ACMT). A laboratory audit includes:

- Analysis
- Assessments
- Calibration
- Client services
- Computer files
- Corrective action and reporting
- Data validation and reporting
- Document control
- Glassware
- Instrumentation
- Laboratory notebooks
- Maintenance
- MDL studies
- QA program and documentation
- Reagents
- Record archival
- Sample control
- Sample login and distribution
- Sample preparation
- Segregation
- Standard operating procedures
- Standard preparation
- Subcontracting
- Training
- Waste storage and disposal

The EPD QA Manager qualifies lead auditors, approves all checklists, and follows up on any findings.

3.1.2. Performance Audits

Performance audits are conducted periodically to determine the accuracy of the total measurement system. ERD conducts performance audits by requiring the collection of field QC samples and the analysis of performance evaluation samples.

Performance evaluation (PE) samples are used to monitor analytical laboratory performance and data quality. ERD requires that any subcontractor analytical laboratories participate, as applicable, in California-, Utah-, DOE- and/or EPA-approved inter-laboratory QA programs such as those sponsored by Environmental Monitoring Systems Laboratory, Environmental Measurements Laboratory, Water Pollution, or Drinking Water Pollution. Subcontractors and any sub-subcontractors provide the EPD QA Manager with:

- The unique laboratory identification codes for each approved inter-laboratory comparison program in which the subcontractor and sub-subcontractors participate.
- A hard copy report of the results of each inter-laboratory comparison study within 30 calendar days of its publication.
- A written explanation for any unacceptable results identified by the inter-comparison programs within 30 calendar days of the publication of the results. The explanation must include a determination of the root cause and a schedule of corrective action to be taken to resolve the problem and prevent its recurrence.
- Names and phone numbers, upon request, of agency contacts for all PE studies, so that the LLNL user group may contact them for verification of report accuracy when required.
- Copies of correspondence sent to any state or federal Performance Evaluation program due to unsatisfactory performance.

In addition, the LLNL EPD PE Committee conducts certified double-blind performance evaluation sample programs for each of the laboratories utilized by ERD. The frequency, matrix, and methodology for the PE samples vary based on need and available budget. The PE Committee informs the laboratories of any non-performance and requests corrective action. The EPD QA Manager monitors the PE Committee actions and determines if the corrective action are acceptable. All subcontract analytical laboratories must perform adequate analysis of pre-award double blind PE samples.

To evaluate the quality of the sampling and analysis effort, ERD has implemented the following QC checks: equipment blanks, field blanks, trip blanks, and collocated samples as described in Section 2.5.1. The collocated samples are evaluated as described in Section 4.2. The blank samples are evaluated per SOP 4.6 and SOP 4.11.

3.1.3. Data Quality Assessment

Analytical laboratories are required to assess the quality of their data using such methods as QC sample analysis, control charting, internal PE samples, and analyst proficiency testing. The ERPs use equipment blanks, field blanks, trip blanks, collocated samples, and all the supporting analytical data (as described in Section 1.7) provided by the analytical laboratories to assess data quality.

3.1.3.1. Accuracy

The analytical laboratories analyze QC samples to assess precision and accuracy. Accuracy is defined by the degree of agreement between measured value and true or known value. It is a measure of the bias in the measurement system. The laboratories assess accuracy, expressed as %RCV, by the analysis of MSs and LCSs. The %RCV is compared to set control limits to determine acceptability. The %RCV is calculated as follows:

$$\%RCV = \frac{A - B}{T} \text{ X } (100),$$

where:

A = Concentration actually determined in matrix spiked sample.

B = Concentration determined on original unspiked sample.

T = True concentration of the spike in the spiked sample.

3.1.3.2. Precision

Precision is determined by the degree of agreement between duplicate analyses of the same parameter in a given sample. It is an indicator of how well a laboratory can reproduce it's work under a given set of conditions. Precision is expressed as %RPD and is determined by the laboratory by the analysis of MSDs, sample duplicates, or LCS duplicates. The %RPD is compared to set control limits to determine acceptability. ERD also assesses precision by the analysis of intralaboratory and interlaboratory collocated samples. The %RPD is calculated as follows:

$$\%RPD = \frac{|R1 - R2|}{(R1 + R2)/2} \text{ X } (100),$$

where:

R1 = Measured analyte concentration in first aliquot or sample.

R2 = Measured analyte concentration in second aliquot or sample duplicate.

Another way to assess precision is by calculating the percent relative standard deviation (%RSD). The %RSD is calculated as follows:

$$\%RSD = \left(\frac{100}{\sqrt{2}}\right) * \left[\frac{2|R1 - R2|}{(R1 + R2)}\right],$$

where:

R1 and R2 = The reported concentrations for each duplicate sample.

The %RPD of laboratory generated duplicates is compared to the laboratory specific control limits. The %RPD of collocated samples is compared to the QA Objectives for measurement data as defined in Chapter 4 to determine if the Projects have been receiving data of the appropriate quality.

3.1.3.3. Completeness

The ERD annual QA Report will summarize completeness by determining the completeness of the data set in terms of the number of valid results obtained for the number of analyses planned.

It will be calculated by counting the number of routine ground water analyses planned (SP), the number actual sampled (AS), the analyses received back from the laboratories (R), and those analyses that are valid and usable (V).

In theory, we will collect less samples than planned due to well dry outs or logistic problems (SP>AS). The number of samples received back from the laboratories may be less than actually collected due to sample breakage in shipment or other sample losses (AS>R). Finally, it is expected that some results received will not be usable due to laboratory problems or QC sample failure (R> V). Completeness will be based on the ERPs COCs.

Completeness equation:

$$\text{Completeness} = \frac{V}{SP}(100)$$

V = Valid, usable results.

SP = Samples planned.

The Livermore and Site 300 ERPs completeness objective is 90%. If completeness is not met, additional samples will be collected.

3.1.3.4. Representativeness

Representativeness is a measure of the degree to which data accurately and precisely represent a characteristic of a population parameter at a sampling point or for a process condition or environmental condition. Representativeness is a qualitative term that determines whether in situ and other measurements are made and physical samples collected in such a manner that the resulting data appropriately reflect the media and phenomenon measured or studied. ERD uses various models to select monitoring locations. In addition, ERD uses sampling techniques and EPA prescribed sample preservation to ensure that the samples are representative of the media of interest.

3.1.3.5. Comparability

Comparability is the measure of the confidence with which one data set or method can be compared to another. ERD ensures comparability by performing periodic statistical analyses on all the data in the database to identify outliers. ERD has developed a computer software program

that identifies time trend outliers and flags them as such in the database. The QC Chemists review the recommended outlier identification and accept or reject it based on professional judgment (i.e., does the outlier fit the model?). An outlier is defined as "an observation that does not conform to the pattern established by other observations." Outliers may arise from mistakes such as transcription, keypunch, or data coding errors. They may also arise as a result of instrument breakdowns, calibration problems, or carry-over from prior analyses. In addition, outliers may be manifestations of a greater amount of inherent spatial or temporal variability than expected for a given value. Outliers may also be an indication of unsuspected factors of practical importance. The outlier program is described in ERD SOP 5.20, “Statistical Outliers.”

3.1.4. Management Reviews

The ERD’s management of the ERPs is continually being assessed by DOE and other organizations enlisted by DOE (e.g., Corp. of Engineers). DOE reviews the budgeting process, project progress and scope at least annually. Cost-quality Management Assessments are performed annually by DOE to assess the quality of ERD’s budget estimate. In addition, ERD internally reviews the management of the projects weekly at the ERD Management Team meetings.

3.2. Reports to Management

3.2.1. Project Status Reports

Reporting of the projects status occurs in various ways. For example, the ERP personnel report biweekly to the ERP Leader during the Project Task Leader Meetings. Project status reports are given to the Division Leader during the ERD Management Team meeting. ERD Management reports to DOE weekly. DOE also requires a written Project Tracking System (PTS) report monthly. ERD must also provide DOE mid-year and year-end reports of the progress of the projects.

3.2.2. Quality Assurance Reporting

The ERD QAIC will submit an annual QA report to the ERD Division Leader. This report will summarize the performance of QA/QC measures and data quality for sampling and analysis activities, for the year as reported by the analytical laboratories for the Livermore Site and Site 300 ERPs. The report will review laboratory performance for the analysis of method, trip, equipment, and field blanks, collocated samples, LCSs, MS, MSDs, and sample duplicates. Performance of QA/QC measures are reported in terms of precision as %RPD, accuracy as %RCV, and completeness. In addition, the report will summarize the Data Qualifier Flags used to qualify ERD data, any documented nonconformances, results of any self-assessments, analytical laboratory performance evaluations, independent audits, and laboratory audits.

4. Data Validation and Usability

4.1. Data Review, Validation, and Verification

The ERD QC Chemists review 100% of the analytical results immediately upon receipt from the analytical laboratories as shown in Figure 10. During this review, the QC Chemists verify that the analytical laboratories internal QC data is within acceptance limits, blanks are clean, dilutions, units and reporting limits are correct. The ERP Task Leaders review the analytical results against historical information when this information exists. The ERD's data validation procedures ERD SOP 4.6 and SOP 4.11 (Dibley and Depue, Eds., 1997), were prepared using the EPA's Functional Guidelines (U.S. EPA, 1985; 1994c,d). The offsite commercial laboratories are contractually required to provide method blank, laboratory control sample, matrix spike, and matrix spike or sample duplicate results with every analysis. The acceptance limits used are the analytical laboratories' internal control limits.

The ERD QC Chemist initiates Data Qualifier Flags for analytical data that is suspect, outside acceptance criteria, or requires additional qualification (see Appendix D for a list of Data Qualifier Flags and some general rules for use). The analytical sample results are qualified based on the associated QC data and other information that accompany the results. All data are identified in the database as either screening or definitive data as described in Chapter 1 of this report. The QC Chemist works with the laboratories to identify and correct any problems with data or service. When necessary, problems are elevated to the EPD Analytical Forum for discussion. The Forum is made up of representatives from each analytical laboratory user group. If the Forum cannot solve a problem, it is sent to the EPD ACMT for resolution.

An electronic data qualifier flag software program developed by LLNL reviews the QC data and generates flags. Certain flags are automatically applied as identified by Attachment E. For example, data that is generated after the EPA holding time requirements expire are automatically flagged with an "H." The data qualifier flags used by ERD were adapted from the Contract Laboratory Program data qualifier flags. The flags that the QC Chemist applies to the data are compared to the electronic program output to identify discrepancies.

Calibration information is made available upon the request of the QC chemist. As described in Chapter 2, the analytical laboratories archive all calibration, QC, and raw data. The ERD QC Chemists perform an annual evaluation of all QA/QC data, including calibration information and raw data validation on representative data packages. The number of data packages reviewed is determined based on analytical laboratory performance. This data is also reviewed during the annual assessment of the analytical laboratories as described in Chapter 3.

4.2. Data Quality Objectives

The QC chemists determine whether data that is generated by the analytical laboratories are contractually acceptable based on compliance with the service agreements between LLNL and the laboratories. The QC Chemists also determine the quality of the data based on the performance of associated QC data provided with the results. In addition, the data is reviewed for outliers against historical data as described in Section 3.1.3.5.

Data may be considered usable if it is outside QC control limits but within historical variance. Usability of data outside of QC criteria is determined by the end user on a case-by-case basis.

The entire data set for the year is reviewed to determine if the data as a whole is of adequate quality for its intended purpose. At the time of data review, the laboratory generated QC data is compared to laboratory specific control limits. These control limits are generated by the laboratories and provided to LLNL. These limits are subject to approval by LLNL. The Annual ERD QA Report (Chapter 3) summarizes the past year's laboratory QC results compared to the acceptance limits for trending purposes.

The collocated sample results acceptance criteria or data quality objective (DQO) has been established by the ERPs Statistician and QC Chemists based on past analytical laboratory performance. Acceptance criteria have been established for a subset of the analyses and analytes generally performed for the ERPs. The selection of analyses was based on the most frequently requested analyses and the Projects contaminants of concern.

The DQOs were established for five groups of chemicals: explosive compounds (Table 6), metals (Table 7), nutrients (Table 8), radiologicals (Table 9), and volatile organics (Table 10). In soil, the metals group is subdivided into soluble metals and total metals. The radiologicals group is subdivided into tritium and others. In Tables 6 through 10, the analyte groups are abbreviated as follows: explosives—HE, metals—Met, soluble metals—Smet, total metals—Tmet, radiologicals—3H or RAD, and volatile organics—VOC. DQOs are established only when there are at least ten collocated pairs in which both results are above the analytical contract reporting limit.

The DQOs established in this section are for precision, as measured by the %RPD between collocated sample pairs. The %RPD for each pair is defined as:

$$\%RPD = \frac{|R1 - R2|}{(R1 + R2)/2} \text{ X } (100),$$

where R1 and R2 are the reported concentration results from the collocated sample pair. The %RPD is calculated for pairs in which both results are above the analytical contract reporting limit.

Recent years have seen substantial improvements in QC screening and qualification of ERD analytical data. The goal of this DQO is to ensure that future data will be comparable in quality to recent data. This DQO uses data from 1992 through 1995 as a baseline for comparison with subsequent data.

Variability is inherent in the sampling and analytical processes. Even when all processes are under control and performing well, there will be occasional large differences within collocated sample pairs. Therefore, acceptable performance consists of a mixture of results such that much of the time the %RPD is small, some of the time it is moderate, and occasionally it is large. Poor performance is indicated by the presence of too many large values for %RPD.

Performance as described above is best measured by a tabulation of the percentiles of the distribution of %RPD values. Target percentile distributions are presented in Tables 11 through

14. For example, Table 11 shows that 50% of the intralaboratory collocated ground water pairs analyzed for VOCs should have %RPD less than or equal to 7.9%, and 90% of the pairs should have %RPD ≤ 31.1% as they did in 1992 through 1995. The last row in each table gives the number of collocated pairs used in the analysis. The data in Tables 11 through 14 are presented in Figures 11 through 27. Note that data sets with more pairs tend to have smoother curves.

Starting with 1996, the annual distribution of %RPD will be compared with the curves defined in Tables 8 through 11. The comparison may be either tabular or graphical. For a graphical comparison, performance is better than the DQO if a given year's curve is to the left of the DQO curve. For a tabular comparison, performance is better than the DQO if the %RPD associated with a percentile is less than the %RPD listed in the appropriate DQO table.

4.3. Validation and Verification History

In 1986, environmental investigations, routine environmental surveillance, and routine environmental monitoring were consolidated in the EPD of LLNL. By 1987, all soil, rock, and ground water investigations were performed by what is now the ERPs. A major effort was also underway to consolidate and centralize all environmental chemical analytical data collected previously. All hard copy reports of analytical chemical data were collected. Assisted by ERD chemists and geologists, all historical analytical reports were verified, ensuring that proper sampling, handling, and analytical protocols were followed, and that proper documentation concerning the sample was available. After verification was complete, the data were entered into the centralized database. Analytical results failing such verification were excluded from the database or properly annotated. Samples were analyzed by onsite LLNL laboratories and offsite commercial laboratories. The ERPs started receiving QA/QC documentation from the offsite analytical laboratories in 1989. The QC data generated by onsite LLNL laboratories continue to be archived by them and are available for review by the ERD QC chemists.

Prior to 1989, reports from offsite analytical laboratories contained minimal QC information. Reports always included LLNL sample identification, analytical laboratory identification, sample matrix, date sampled, date analyzed, and analytical results. Generally, the reports also included the analytical method, reporting detection limit, and certification by the laboratory manager. If the validity of a particular result was questioned, the laboratory was requested to provide all associated QC data for review by ERD QC chemist. Data acceptance into the central database was based on all relevant and available information.

By 1992, many quality improvements and implementation of new quality affecting procedures were instituted. For example, rigorous QA/QC requirements were established for analytical laboratory contracts. The offsite laboratory must be California state certified, and pass an EPD onsite audit of their QA program and operating procedures. The audit verifies that the laboratory is in compliance with its internal procedures and QA program, and that all DOE and EPD requirements are met. New contracts required delivery of QA/QC documentation with results and stricter penalties for nonperformance. Other improvements to the ERD QA program included the QC Chemist functional guideline checklist review and qualification of data generated by analytical laboratories as well as a field QC sample procedure.

While the majority of the data collected prior to 1989 was not reviewed by a QC chemist for compliance with MS, MSD, and LCS precision and accuracy acceptance limits, the data in most cases were analyzed by California State certified laboratories using standard analytical methods. Since the laboratories were certified by California State and met its strict criteria, we assumed that the analytical laboratory chemists had already reviewed the data for quality and technical adequacy. The restoration project data produced since 1989 are legally reproducible, defensible, and of known quality. The pre-1989 data were compared to the usable current data, looking for variances and anomalous trends. On the basis of this examination and comparison, the ERPs have determined that the majority of the pre-1989 data is internally consistent with the post-1992 data. Therefore, historical data will be used along with more recent data of known quality for delineation of the nature and extent of contamination at the Livermore Site and Site 300, and for use in the baseline quantitative risk assessment.

4.4. Reconciliation with User Requirements

Once the data has been reviewed and qualified by the QC Chemist and stored electronically, it is ready for use by the end user. The end users of the data must specify to DMT the types and quality of data they need extracted from the database for their intended purpose. DMT will then exclude those data that do not meet the stated criteria. Data that should be excluded from uses requiring a high level of quality and confidence, for example, may include data that has exceeded its hold time, identified as a statistical outlier, flagged with an "S," "J," or "R" qualifier flag, or is screening data. The annual ERD QA Report (see Chapter 3) summarizes the overall quality of the project data. The end user will evaluate whether they are of sufficient quality and quantity to support decisions to meet the ERP's remedial strategies. If there is any question whether the data quality is sufficient for a specific use, the project leader will be consulted.

References

Belsley, D. A., E. Kuh, and R. E. Welsh (1980), *Regression Diagnostics*, John Wiley and Sons, New York, NY.

Buddemeier, R. W. (1985), *Investigation of Tritium in Ground Water at Site 300,* Lawrence Livermore National Laboratory, Livermore, Calif. (UCID-20600).

Buddemeier, R. W., M. R. Ruggieri, and J. A. Oberdorfer (1987), *Tritium in Ground Water at Site 300*, Lawrence Livermore National Laboratory, Livermore, Calif. (UCID-21031).

Carlsen, T. M. (1991), *LLNL Site 300 Environmental Investigations Quarterly, April–June 1991,* Lawrence Livermore National Laboratory, Livermore, Calif. (UCAR-10194-91-2).

Carpenter, D. W., R. Stone, R. C. Ragaini, W. A. McConachie, N. B. Crow, and R. Elwood (1983), *Assessment of the Extent of Trichloroethylene Contamination of Soil and Water at Lawrence Livermore National Laboratory Site 300,* Lawrence Livermore National Laboratory, Livermore, Calif. (UCID-19945).

Carpenter, D. W., R. Elwood, and L. G. Gross (1986), *Assessment of the Extent of Trichloroethylene in Soil and Water At Lawrence Livermore National Laboratory Site 300,* Lawrence Livermore National Laboratory, Livermore, Calif. (UCID-20774).

Crow, N., R. Elwood, and P. Webster-Scholten (1986), *Distribution of High Explosives Compounds in Soil and Water in the 806/807 Lagoons, HE Process Area, LLNL, Site 300,* Lawrence Livermore National Laboratory, Livermore, Calif. (UCAR-10169).

Dibley, V. and R. Depue (Eds.) (1997), *LLNL Livermore Site and Site 300 Environmental Restoration Project Standard Operating Procedures (SOPs),* Lawrence Livermore National Laboratory, Livermore, Calif. (UCAR-MA-109115 Rev. 3).

Dibblee, T. W., Jr. (1980), *A Preliminary Map of the Midway Quadrangle, Alameda and San Joaquin Counties, California*, U.S. Geological Survey, Menlo Park, Calif. (USGS Open-File Report 80-535).

Gilbert, R. O. (1988), *Statistical Methods for Environmental Pollution Monitoring,* Van Nostrand Reinhold Co., New York, NY, 320 pp.

Kilmer, J. (1997), *Site Safety Plan for LLNL CERCLA Investigations at Site 300,* Lawrence Livermore National Laboratory, Livermore, Calif. (UCRL-21172 Rev. 2).

Lentzner, H. L. (Ed.) (1995), Environmental Report 1995, Lawrence Livermore National Laboraroty, Livermore, Calif. (UCRL-50027-95).

McConachie, W. A., Homan, D. N., and D. W. Rice, Jr. (1988), *Quality Control Experiments on Organics in Ground Water at the Lawrence Livermore National Laboratory, Calif.,* Lawrence Livermore National Laboratory, Livermore, Calif. (UCRL-97737).

Raber, E., and D. W. Carpenter (Eds.) (1983), *An Evaluation of the Hydrogeology and Ground Water Chemistry Associated with Landfills at LLNL's Site 300*, Lawrence Livermore National Laboratory, Livermore, Calif. (UCRL-53416).

Raymond, L. A. (1969), *The Stratigraphy and Structural Geology of the Northern Lone Tree Creek and Southern Tracy Quadrangles*, California, M.S. thesis, San Jose State University, San Jose, Calif.

Taffet, M. J., J. A. Oberdorfer, and W. A. McIlvride (1989), *Remedial Investigation and Feasibility Study for the Lawrence Livermore National Laboratory Site 300 Pit 7 Complex*, Lawrence Livermore National Laboratory, Livermore, Calif. (UCID-21685).

U.S. Environmental Protection Agency (EPA) (1980), *Interim Guidelines and Specifications for Preparing Quality Assurance Project Plans*, Office of Monitoring Systems and Quality Assurance, U.S. Environmental Protection Agency, Washington, D.C. (QAMS-005/80).

U.S. EPA (1985), *Functional Guidelines for Evaluating Pesticide/PCB Analyses*, Office of Emergency and Remedial Response, U.S. Environmental Protection Agency, Washington, D.C. (EPA Tech. Doc. No. HQ-8410-01 [R-582-5-5-01]).

U.S. EPA (1986), Test Methods for Evaluating Solid Waste, U.S. Environmental Protection Agency, Washington, D.C. (SW-846).

U.S. EPA (1987), *Data Quality Objectives For Remedial Response Activities*, Office of Emergency Response and Office of Waste Programs Enforcement, Washington, D.C.

U.S. EPA (1993), *Data Quality Objectives Process for Superfund*, Office of Emergency Response and Office of Waste Programs Enforcement, Washington, D.C. (EPA/540/G-93/071).

U.S. EPA (1994a), *Interim Final EPA Requirements for Quality Assurance Project Plans for Environmental Data Operations*, U.S. Environmental Protection Agency Quality Assurance Division, Washington, D.C. (EPA QA/R-5).

U.S. EPA (1994b), *Guidance for the Data Quality Objective Process*, U.S. Environmental Protecton Agency, Washington, D.C. (EPA QA/G-4).

U.S. EPA (1994c), *Contract Laboratory Program (CLP) National Functional Guidelines for Inorganic Data Review*, U.S. Environmental Protecton Agency, Washington, D.C. (EPA-540/R-94-013).

U.S. EPA (1994d), *Contract Laboratory Program National Functional Guidelines for Organic Data Review*, U.S. Environmental Protecton Agency, Washington, D.C. (EPA-540/R-94-012).

U.S. EPA (1997), *EPA Guidance for Quality Assurance Project Plans*, U.S. Environmental Protecton Agency, Office of Research and Development, Washington, D.C. (EPA QA/G-5).

van der Heijde, P. K. M., A. I. El-Kadi, and S. A. Williams (1988), *Groundwater Modeling: An Overview and Status Report*, U.S. Environmental Protection Agency, R. S. Kerr Environmental Research Laboratory, Office of Research and Development, Ada, Oklahoma (EPA/600/2-89/028)

Webster-Scholten, C. P. (Ed.) (1994), *Final Site-Wide Remedial Investigation Lawrence Livermore National Laboratory Site 300*, Lawrence Livermore National Laboratory, Livermore, Calif. (UCRL-AR-21010).

Figures

ENVIRONMENTAL RESTORATION DIVISION

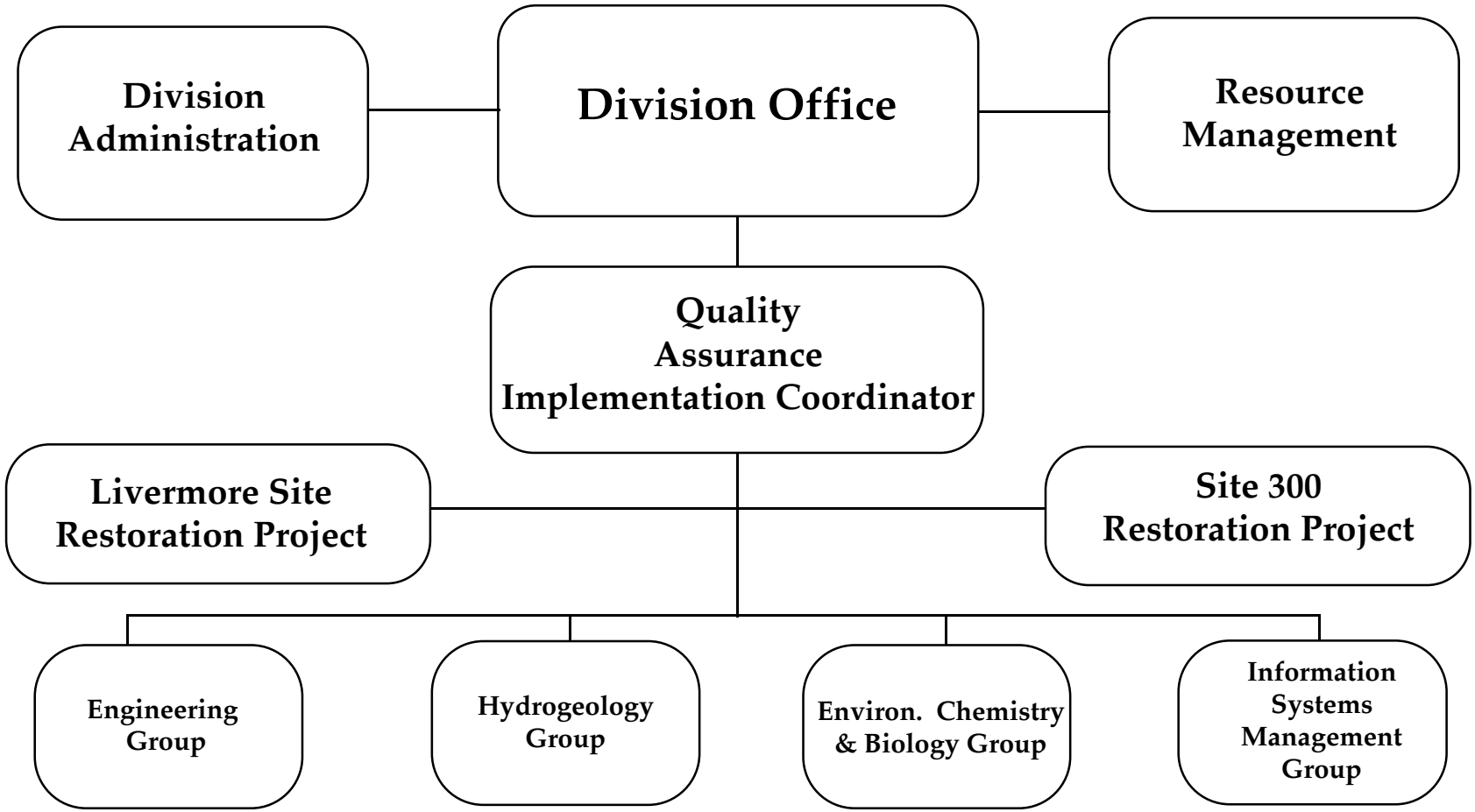

Figure 1. Environmental Restoration Division personnel organization chart.

3-99/ERD QAPP:rtd

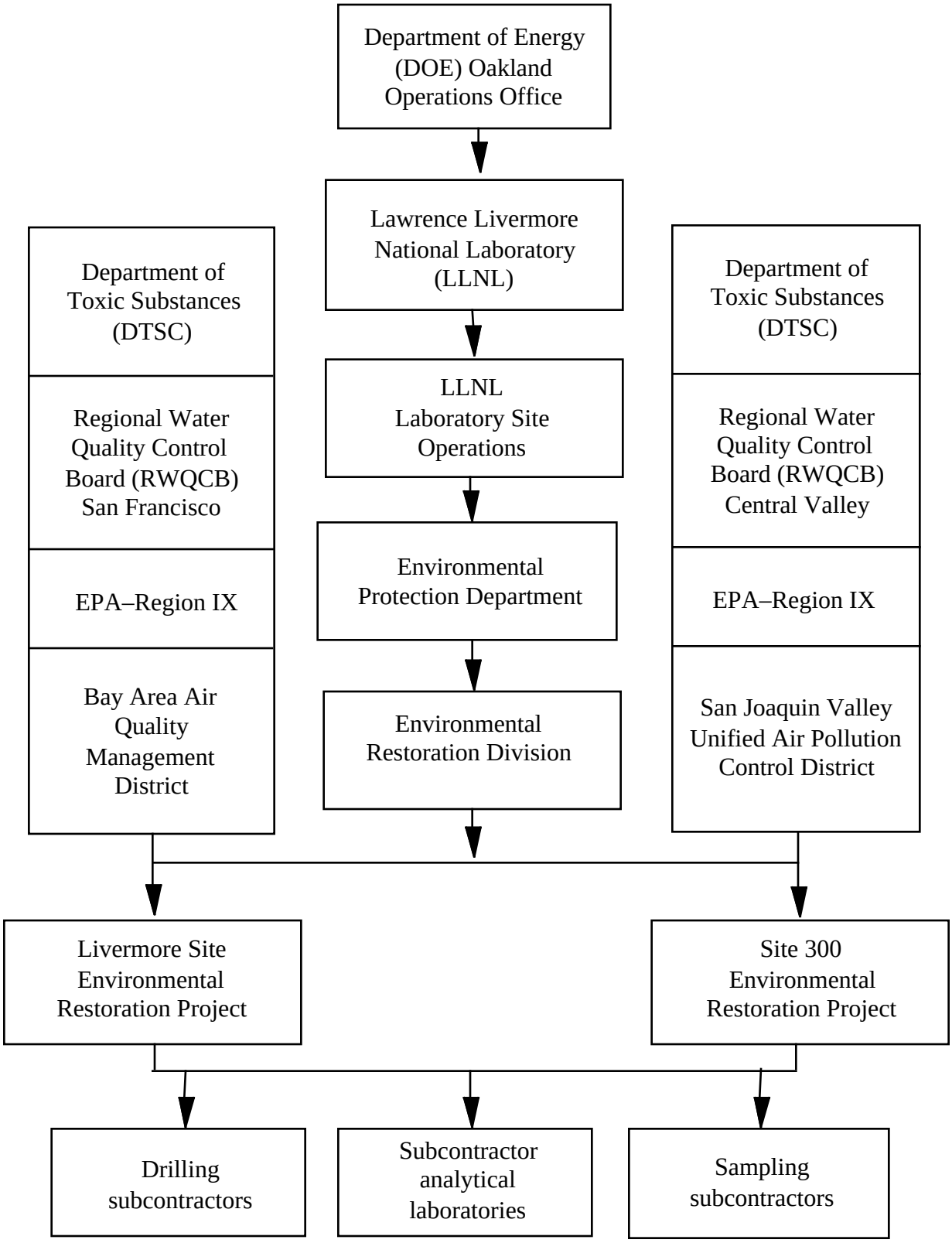

Figure 2. Environmental Restoration Project relationships.

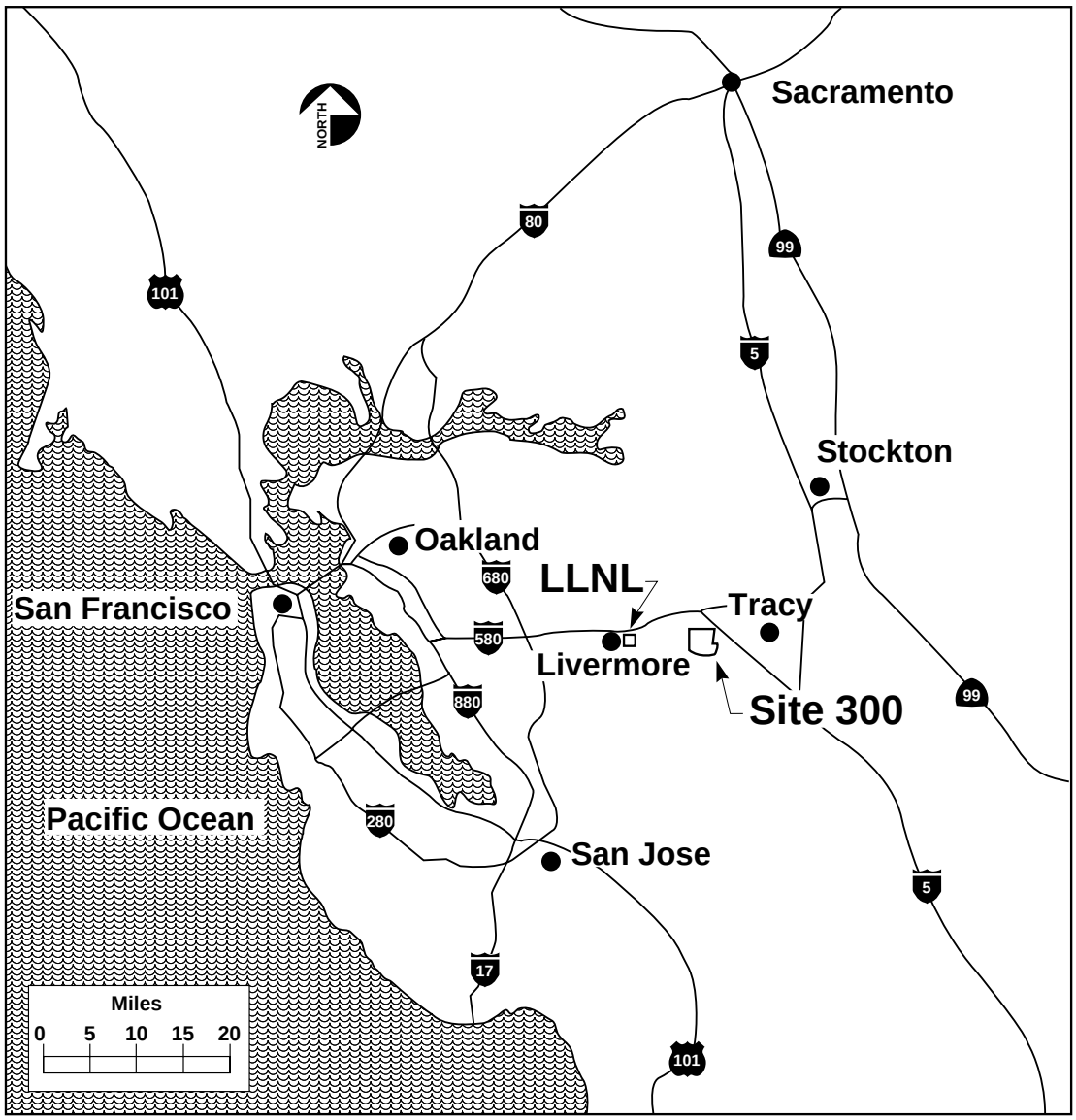

Figure 3. Locations of the Livermore Site and Site 300.

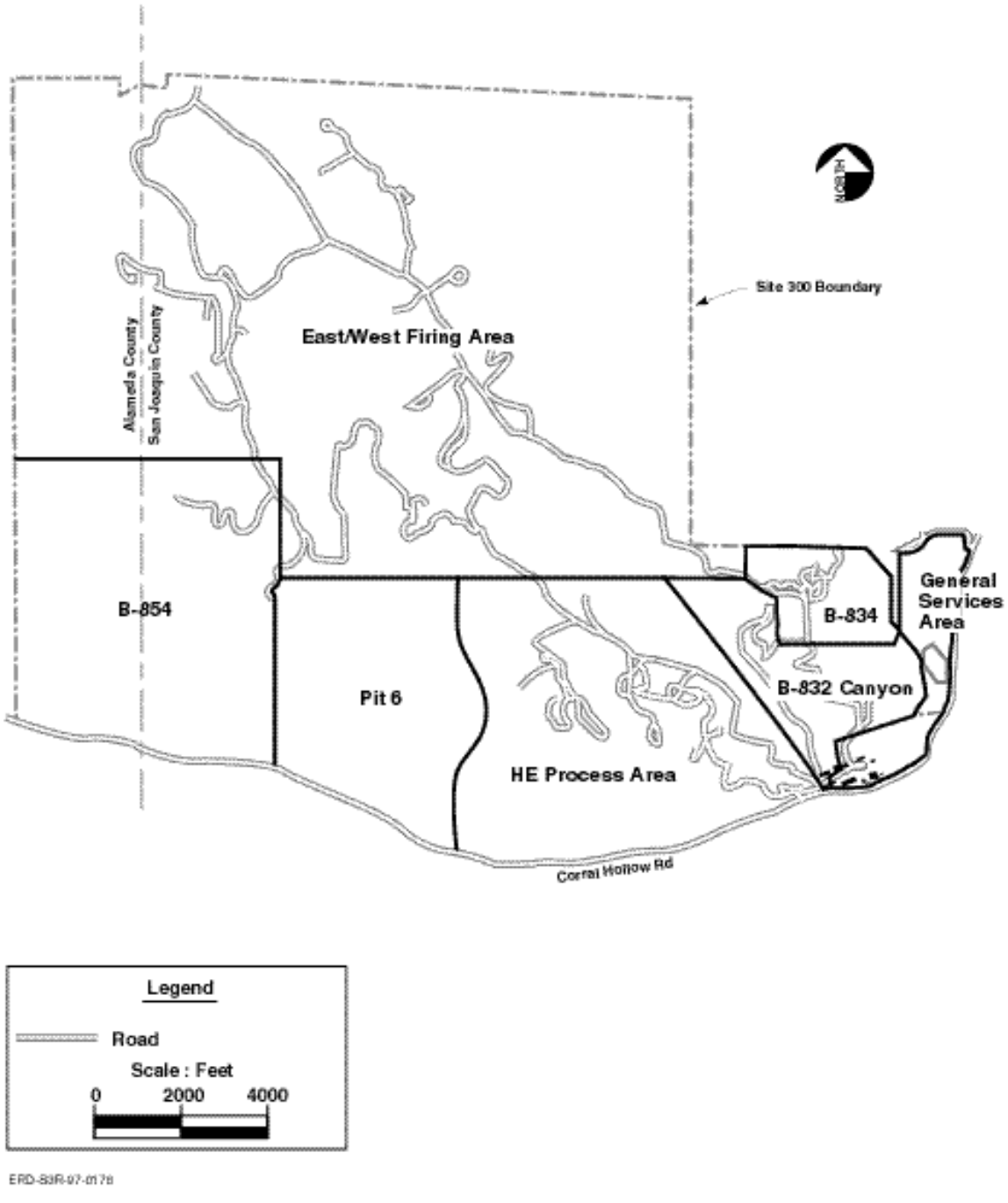

Figure 4. Study areas at LLNL Site 300.

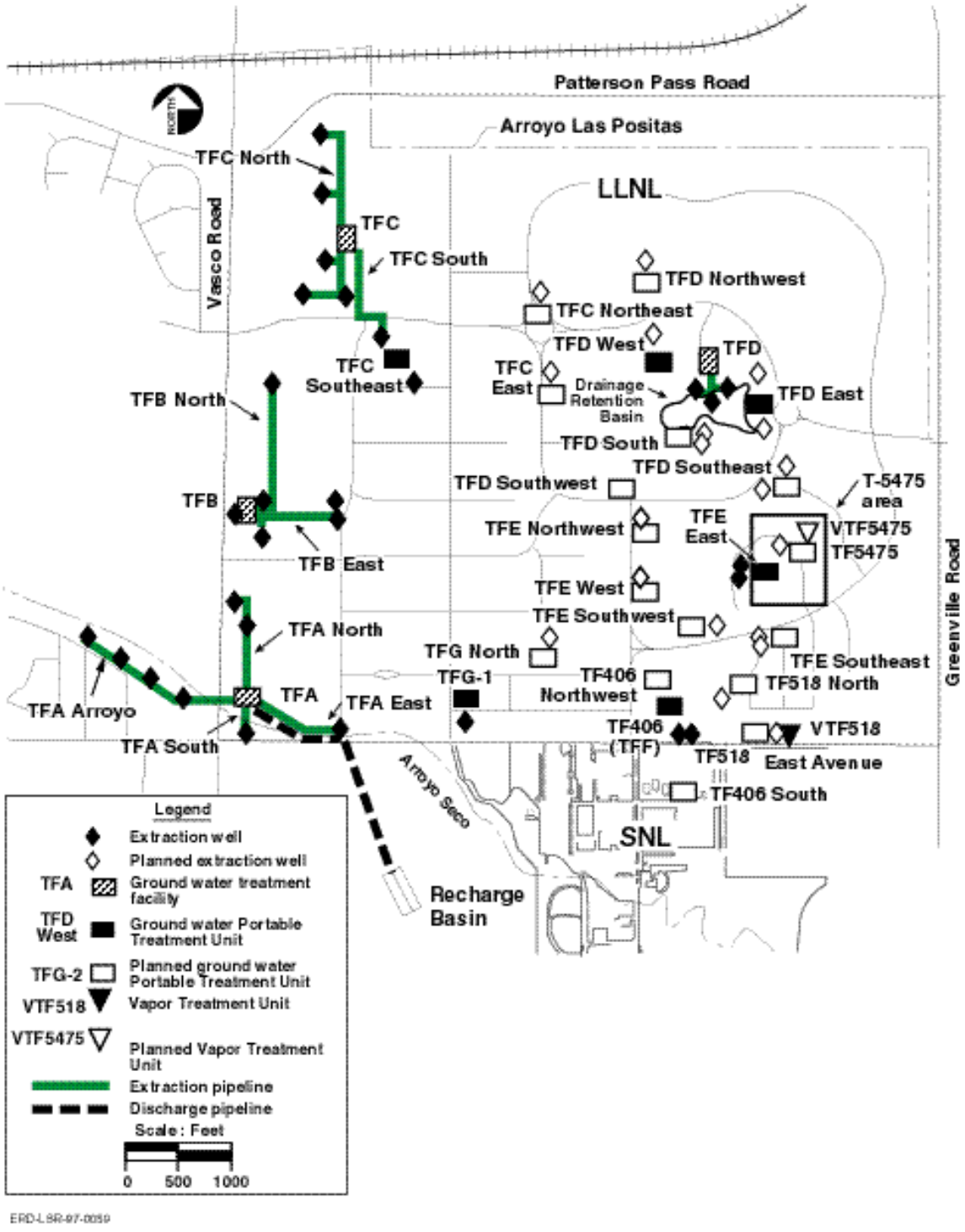

Figure 5. Map of Livermore Site showing location of task areas.

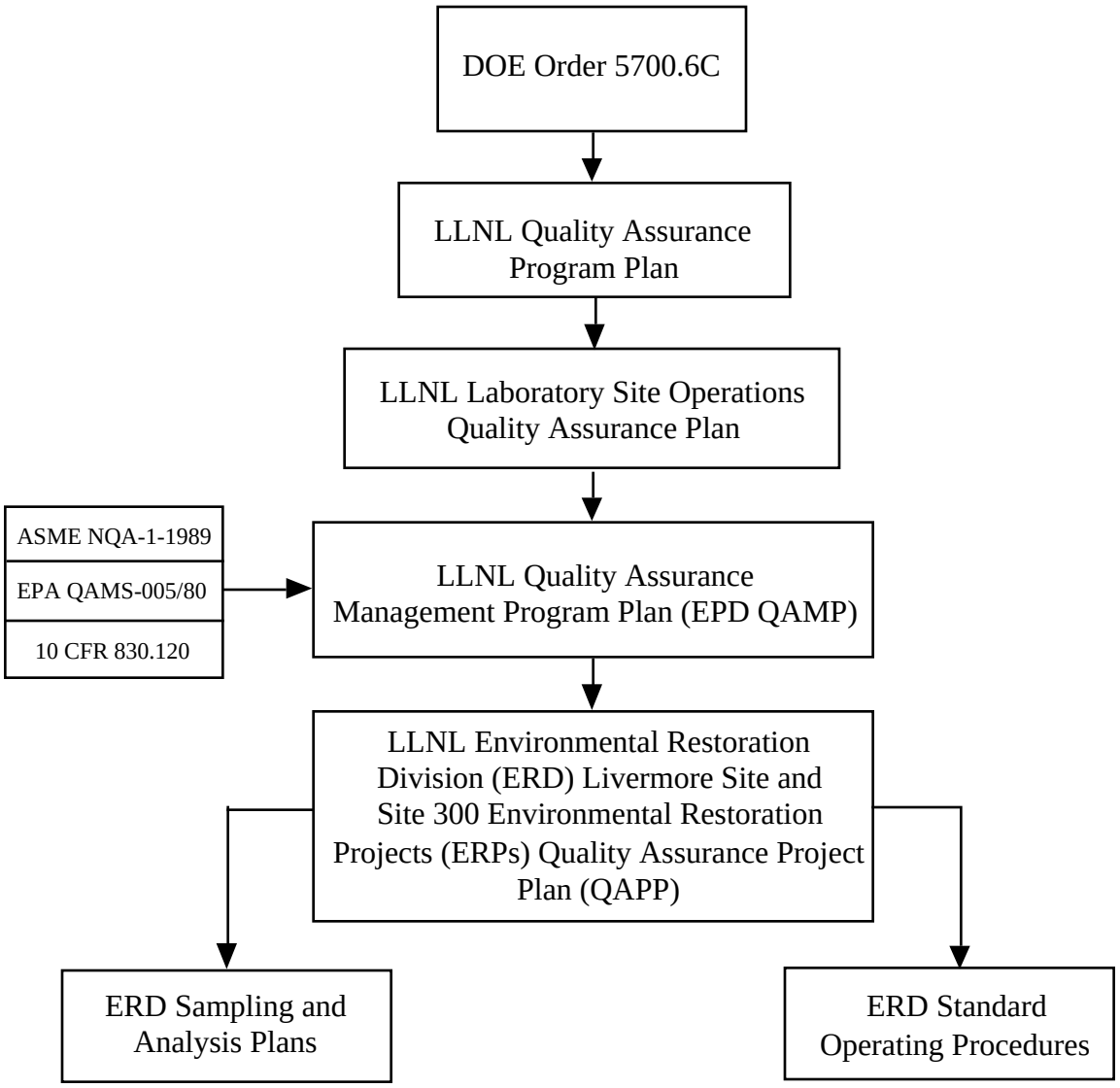

Figure 6. Quality Assurance document hierarchy.

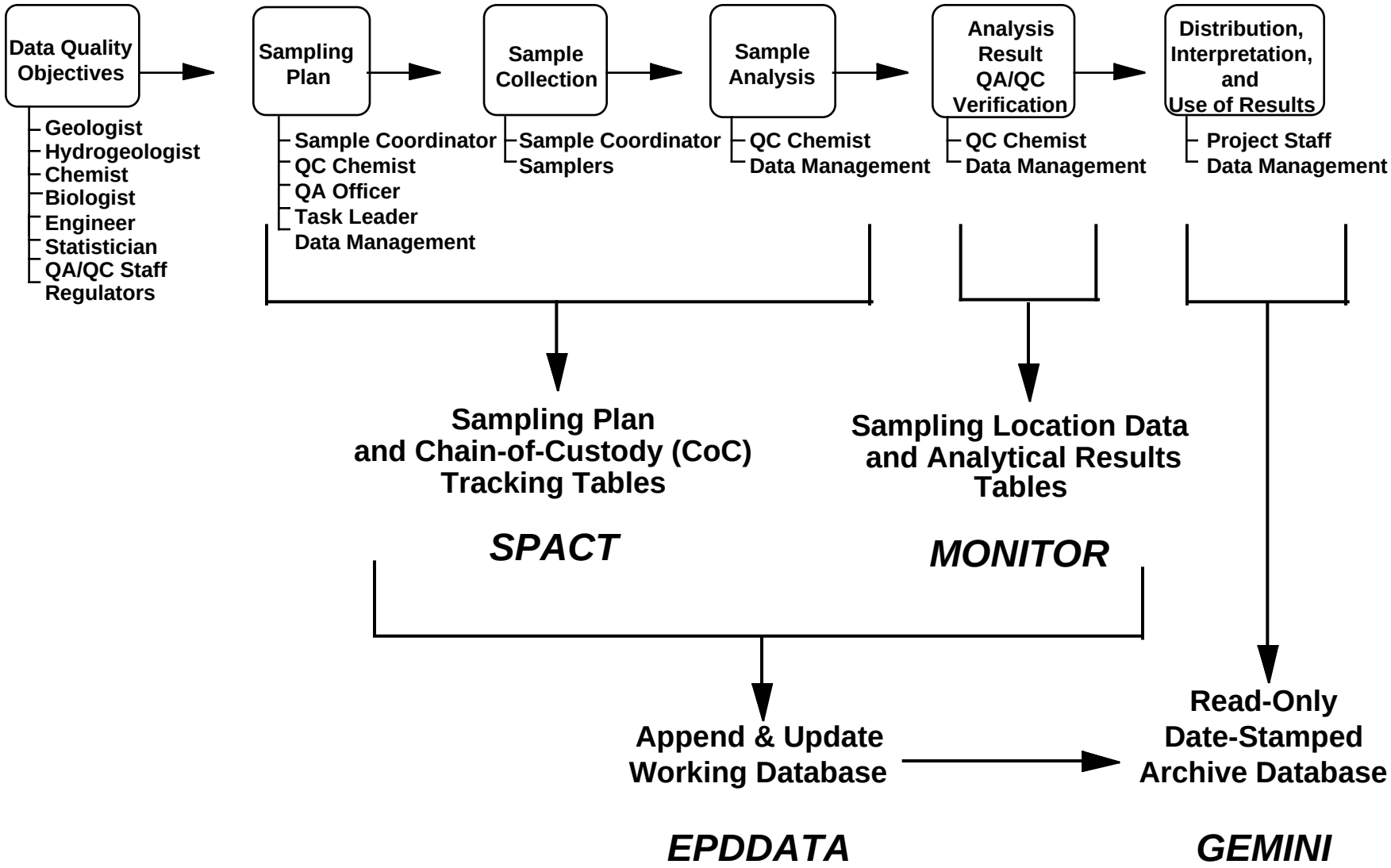

Figure 7. Environmental data flow - overview.

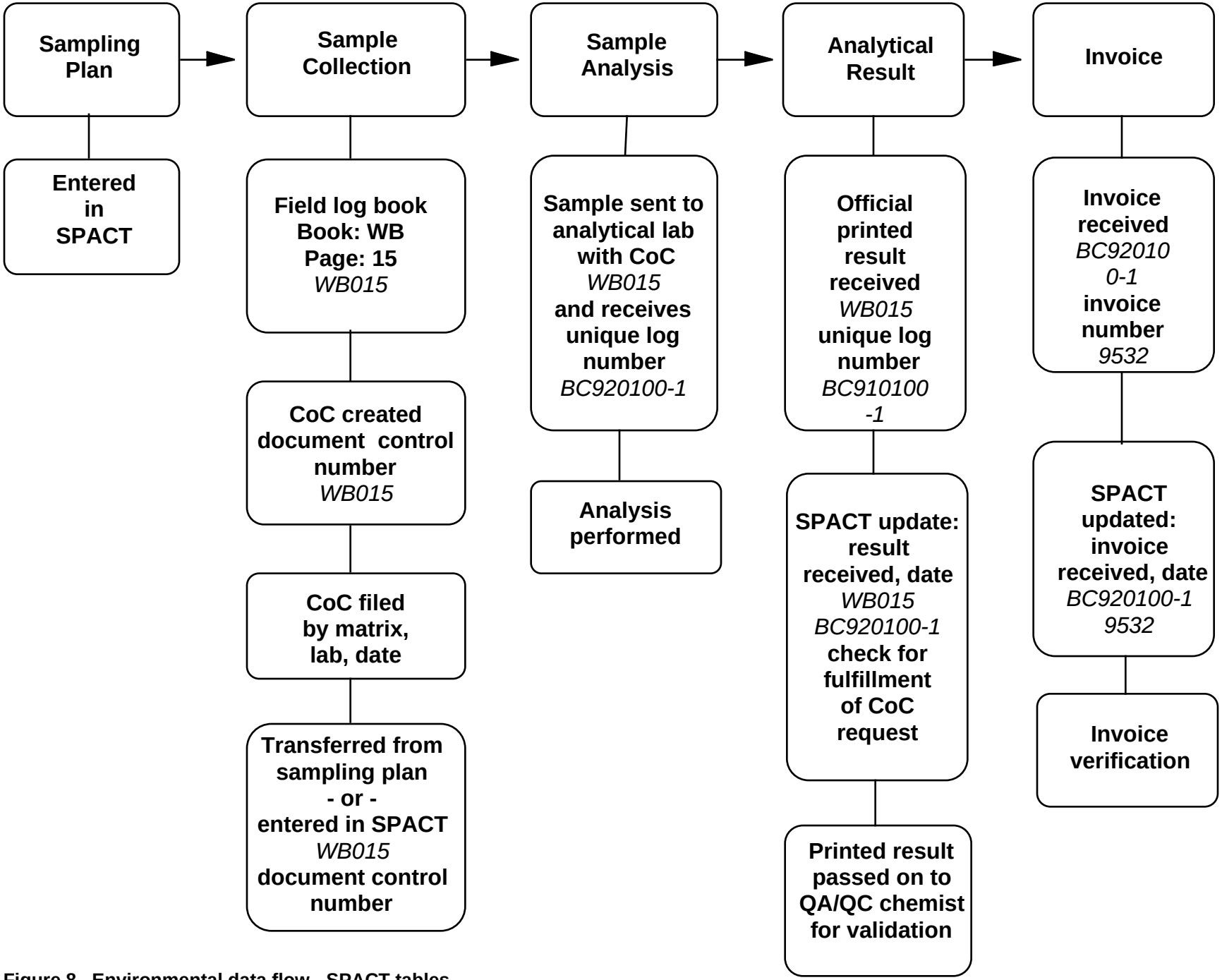

Figure 8. Environmental data flow - SPACT tables.

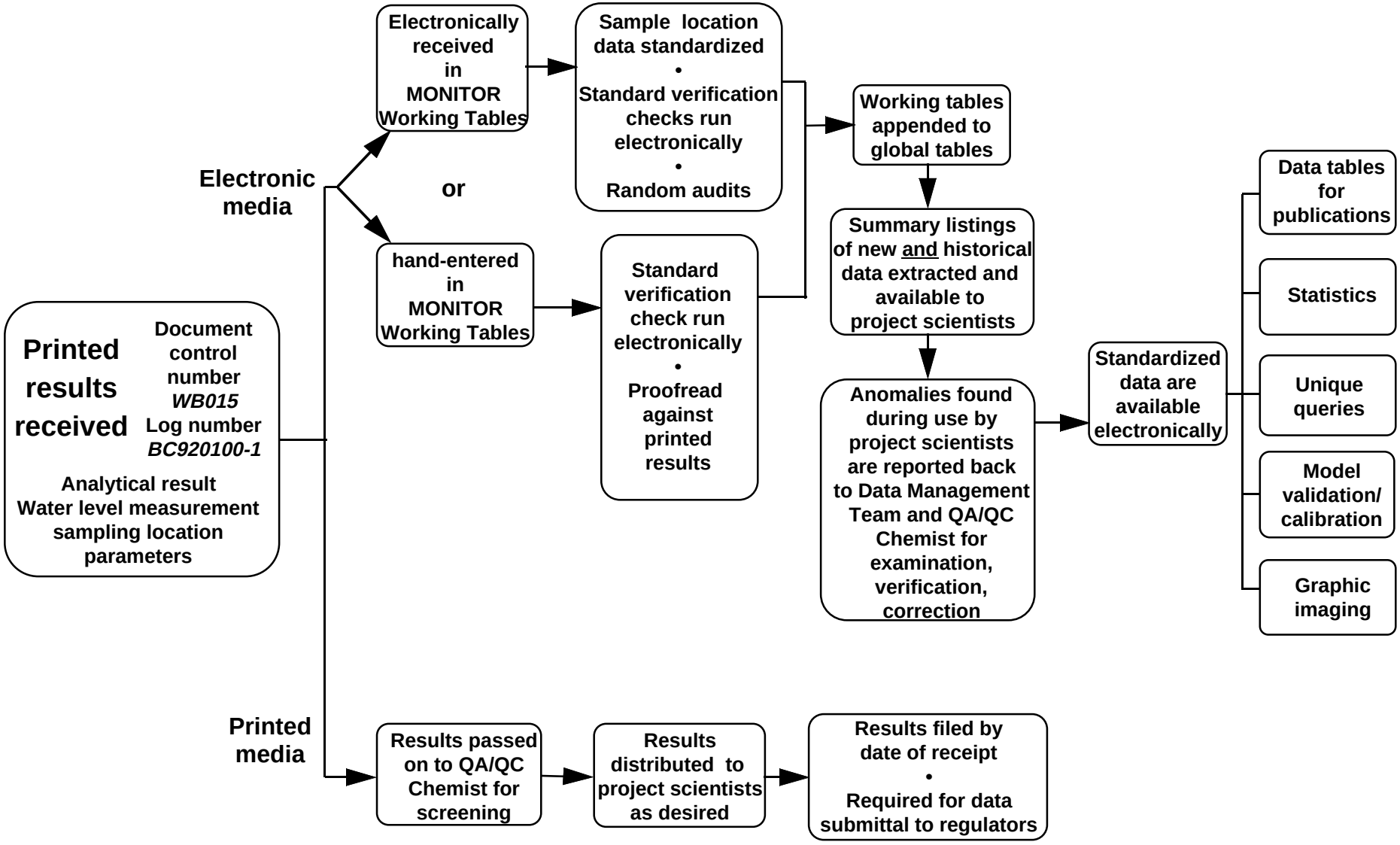

Figure 9. Environmental data flow - Monitor tables.

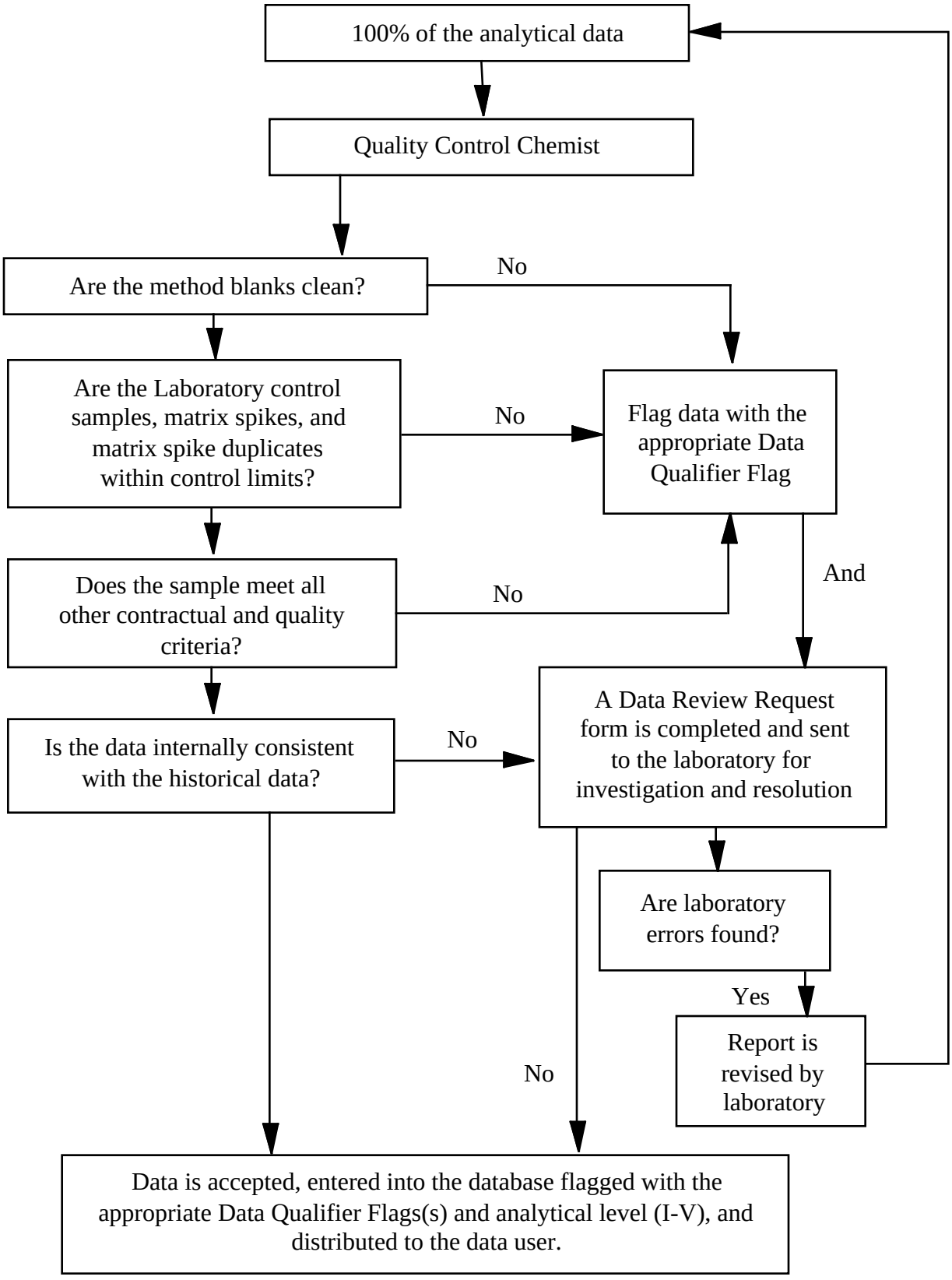

Figure 10. Flow of analytical data during validation/verification.

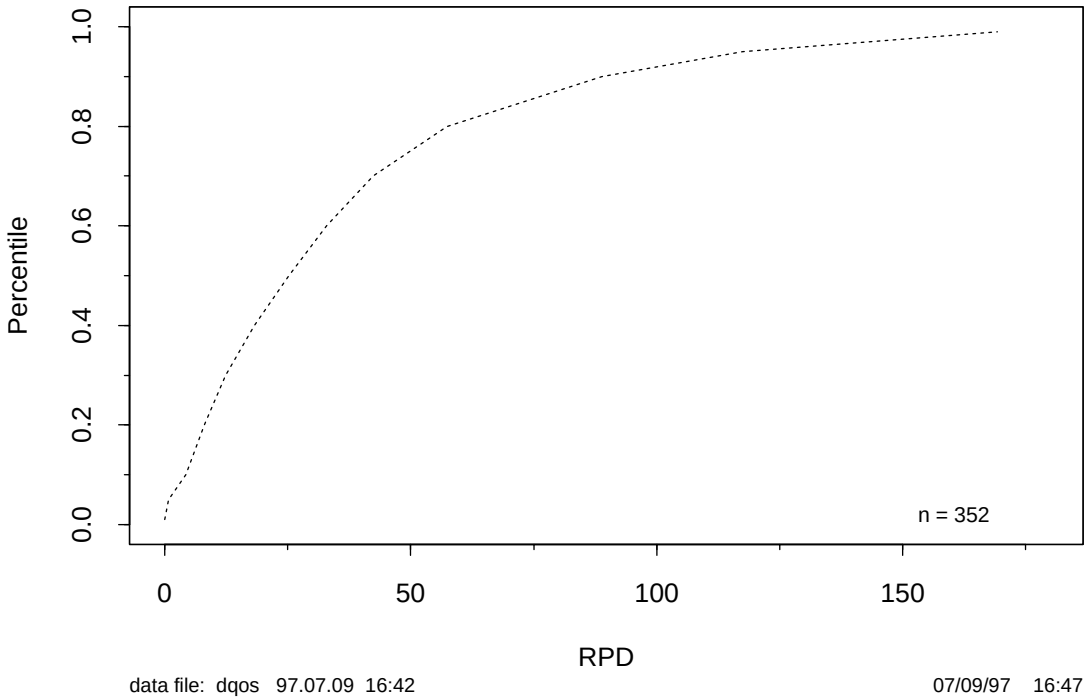

Figure 11. Data quality objective for VOCs in interlaboratory collocated ground water samples.

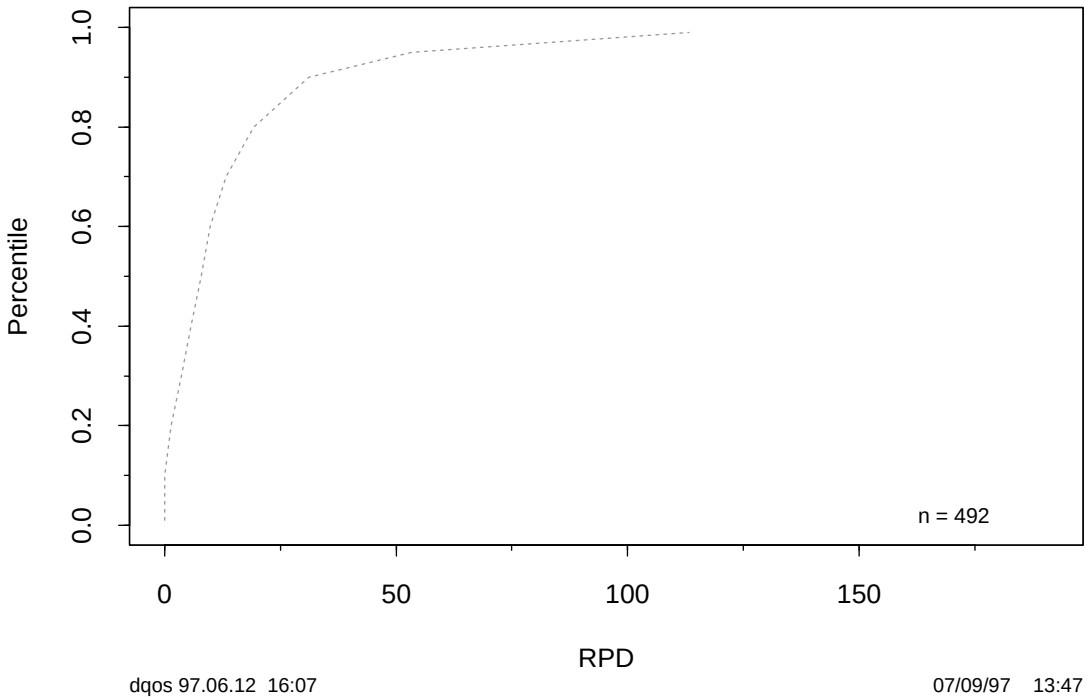

Figure 12. Data quality objective for VOCs in intralaboratory collocated ground water samples.

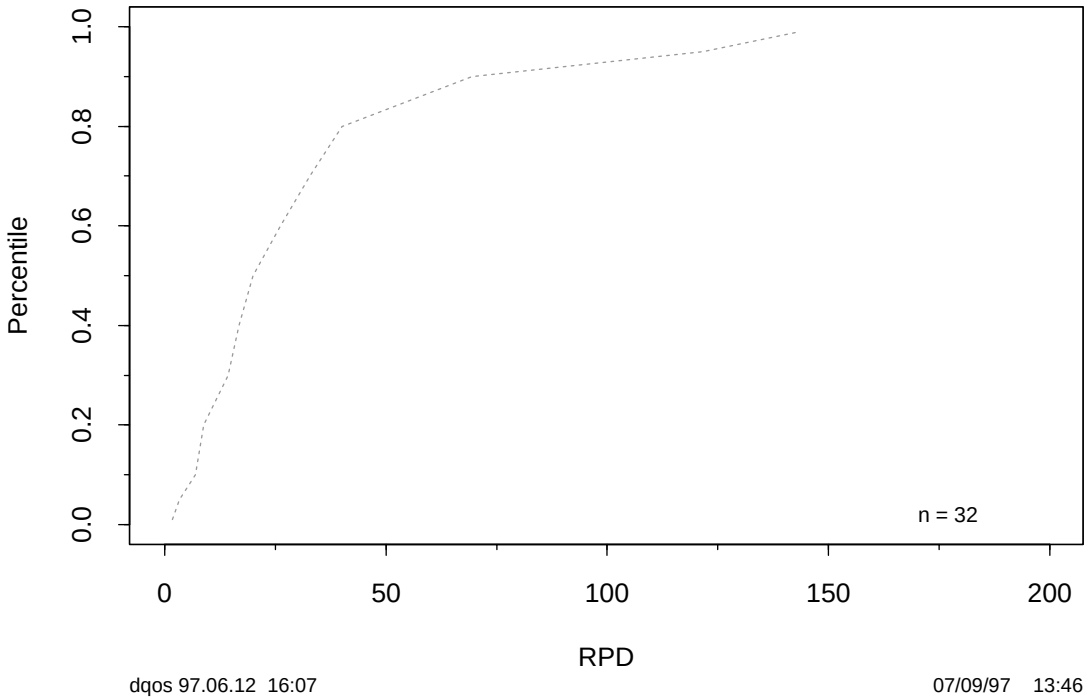

Figure 13. Data quality objective for metals in interlaboratory collocated ground water samples.

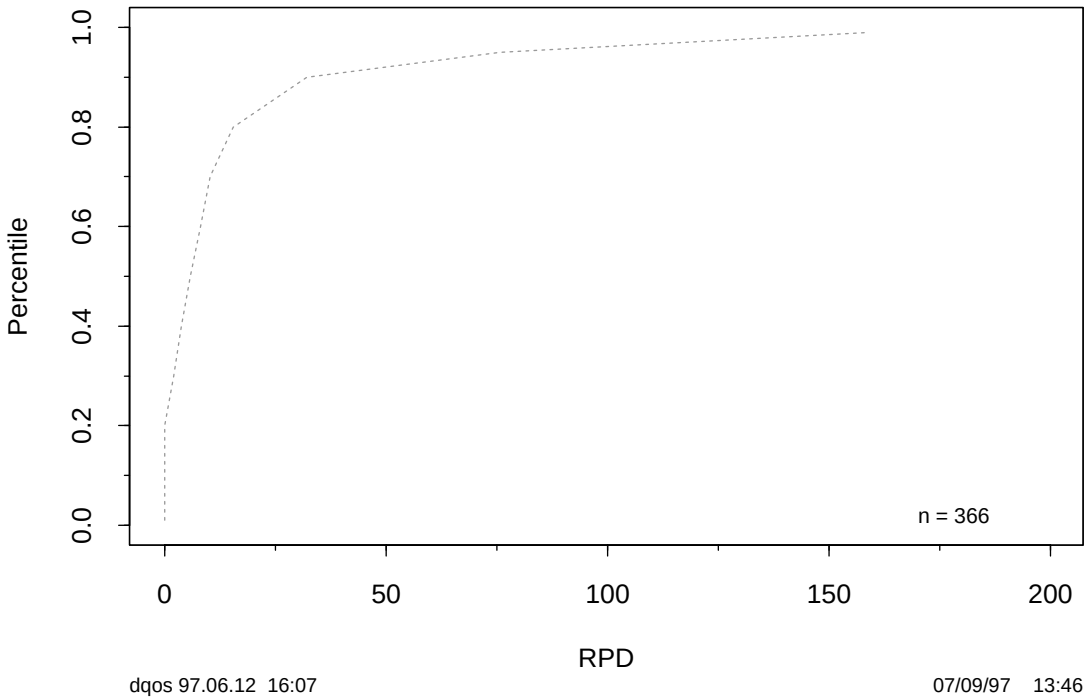

Figure 14. Data quality objective for metals in intralaboratory collocated ground water samples.

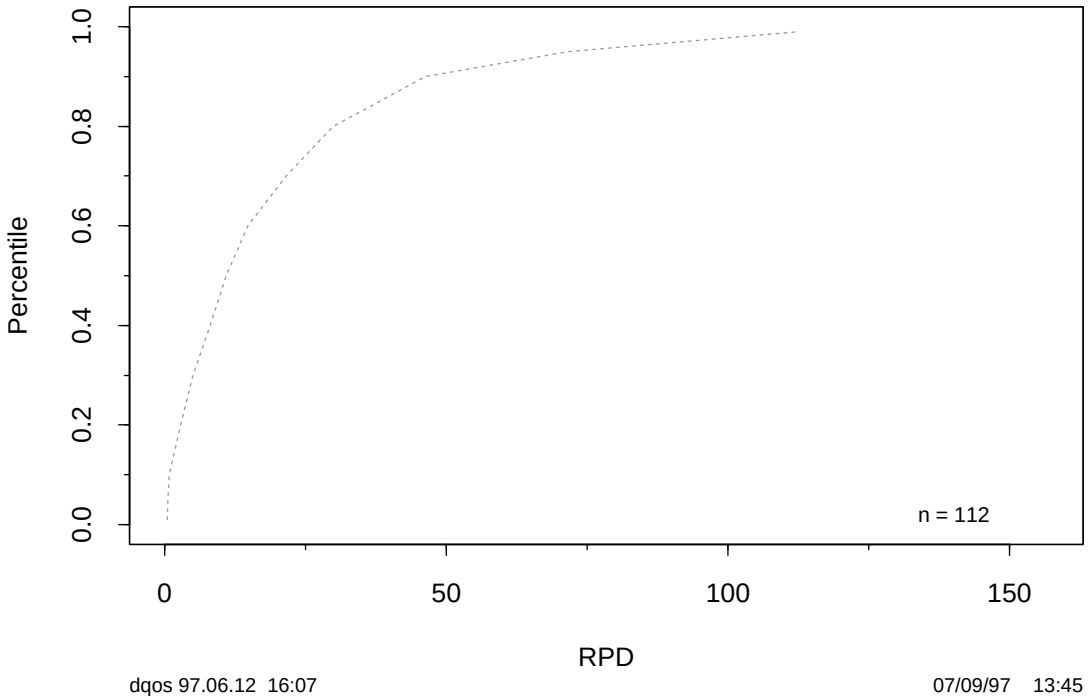

Figure 15. Data quality objective for tritium in interlaboratory collocated ground water samples.

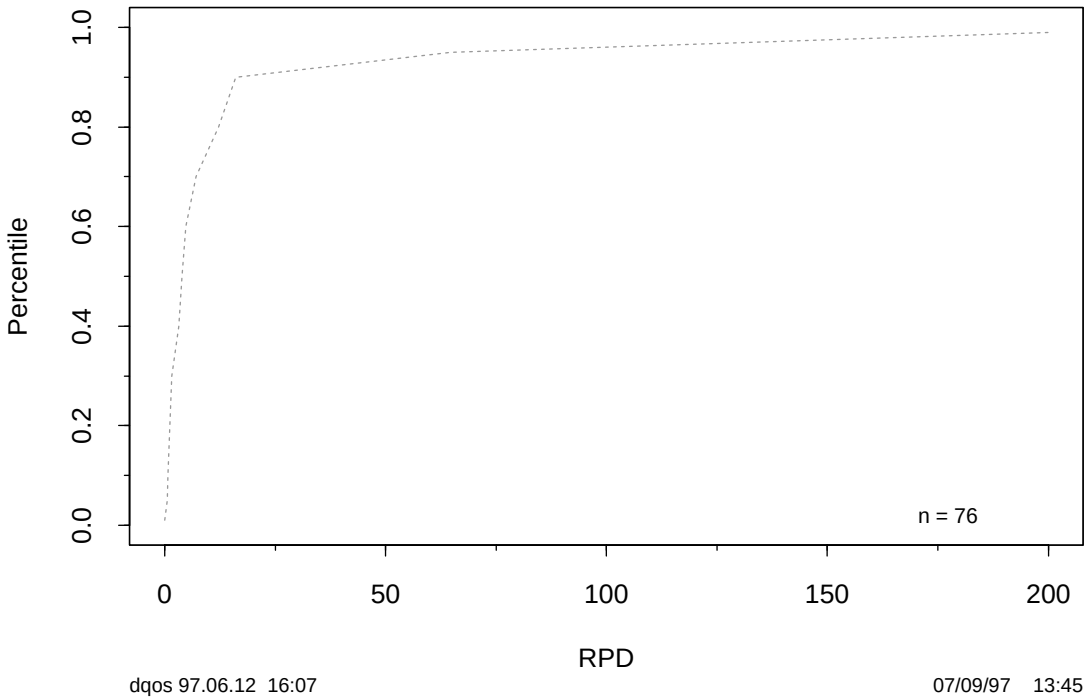

Figure 16. Data quality objective for tritium in intralaboratory collocated ground water samples.

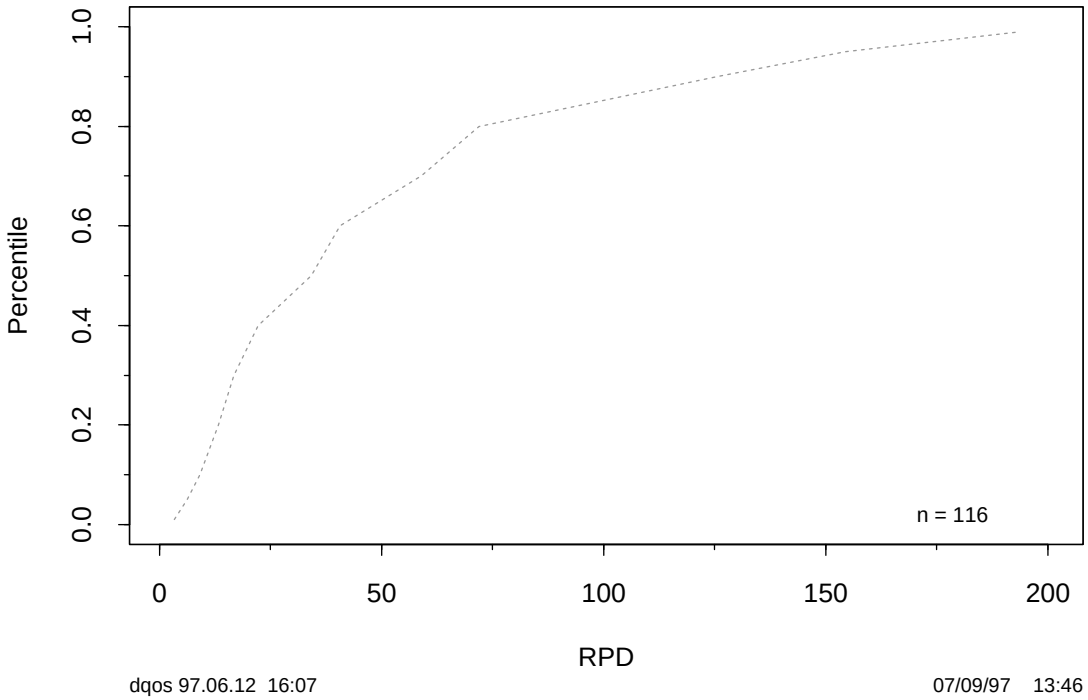

Figure 17. Data quality objective for radiologicals in interlaboratory collocated ground water samples.

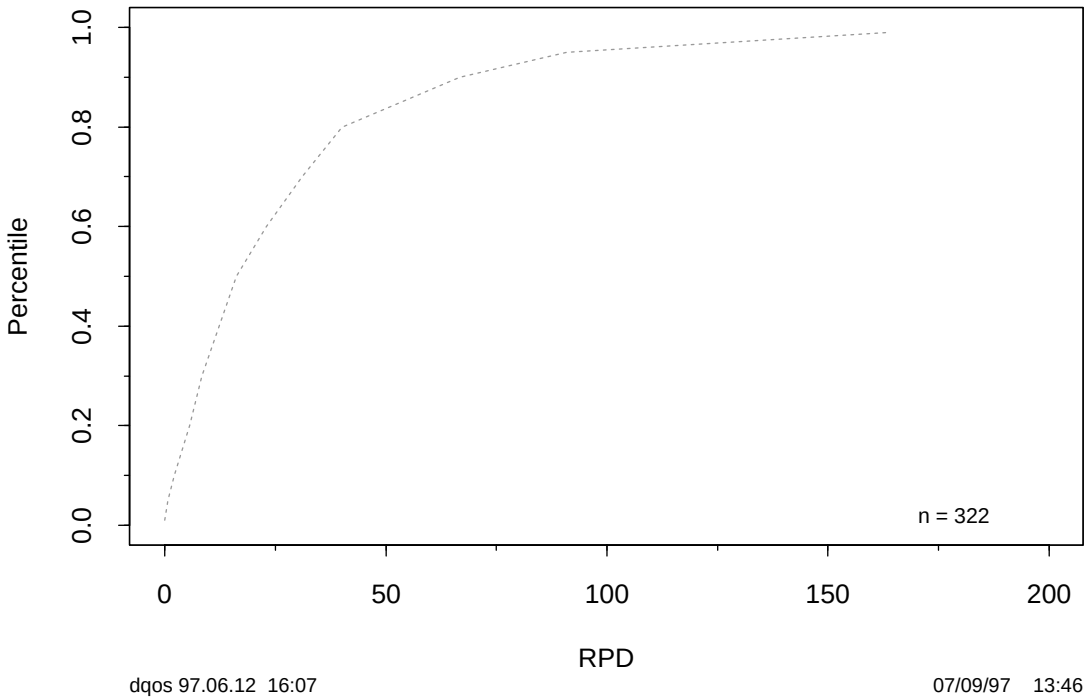

Figure 18. Data quality objective for radiologicals in intralaboratory collocated ground water samples.

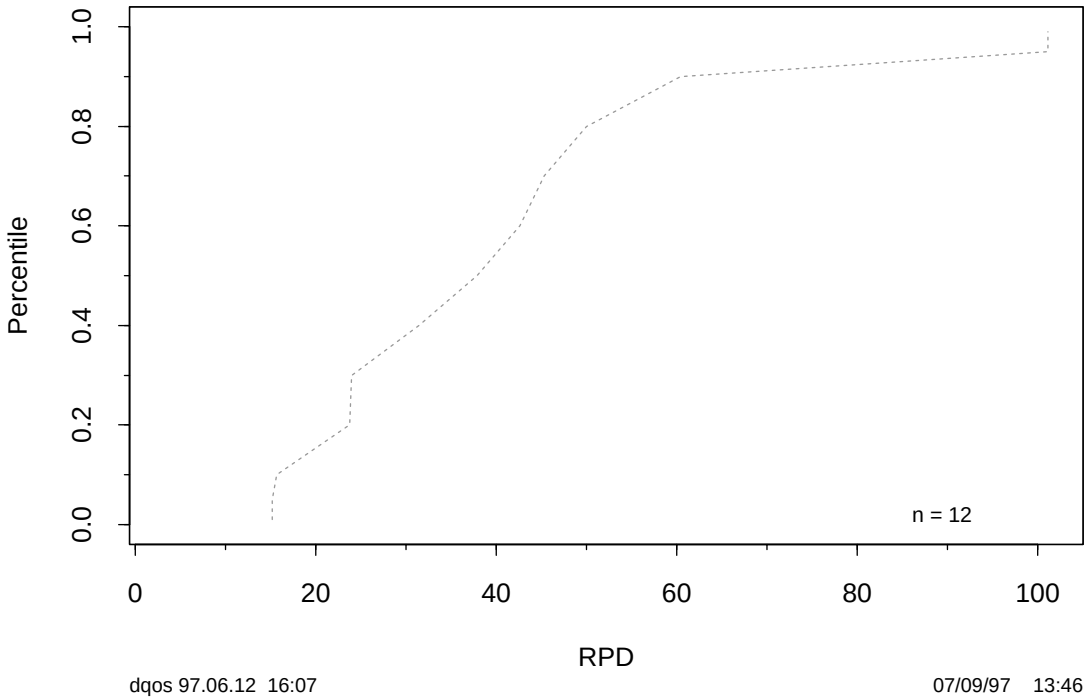

Figure 19. Data quality objective for explosives in interlaboratory collocated ground water samples.

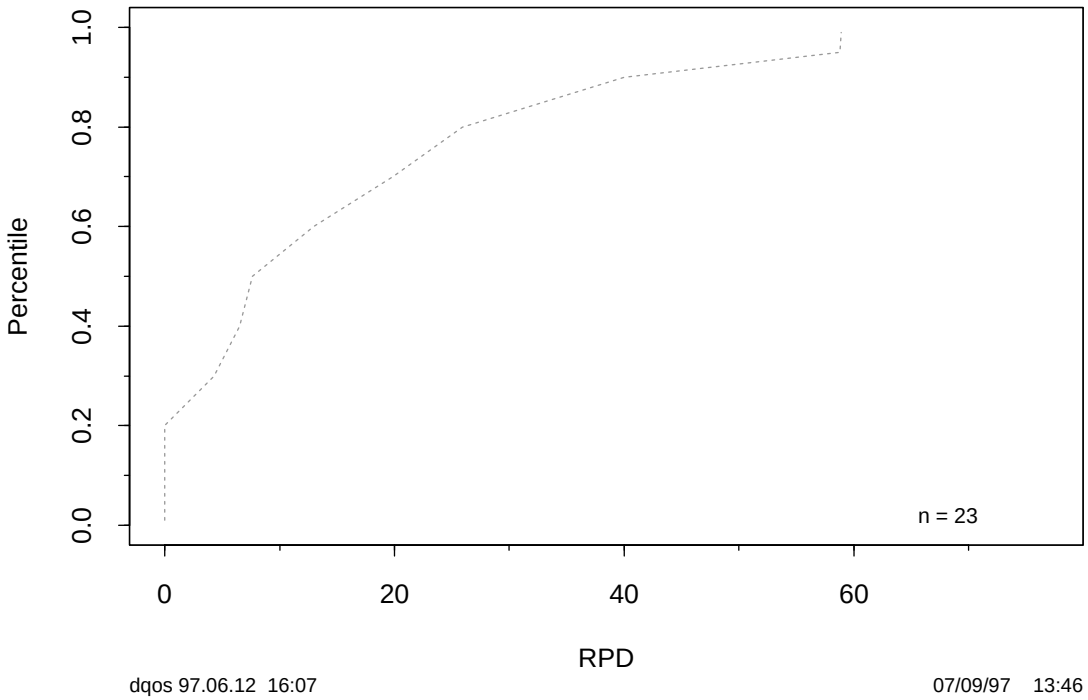

Figure 20. Data quality objective for explosives in intralaboratory collocated ground water samples.

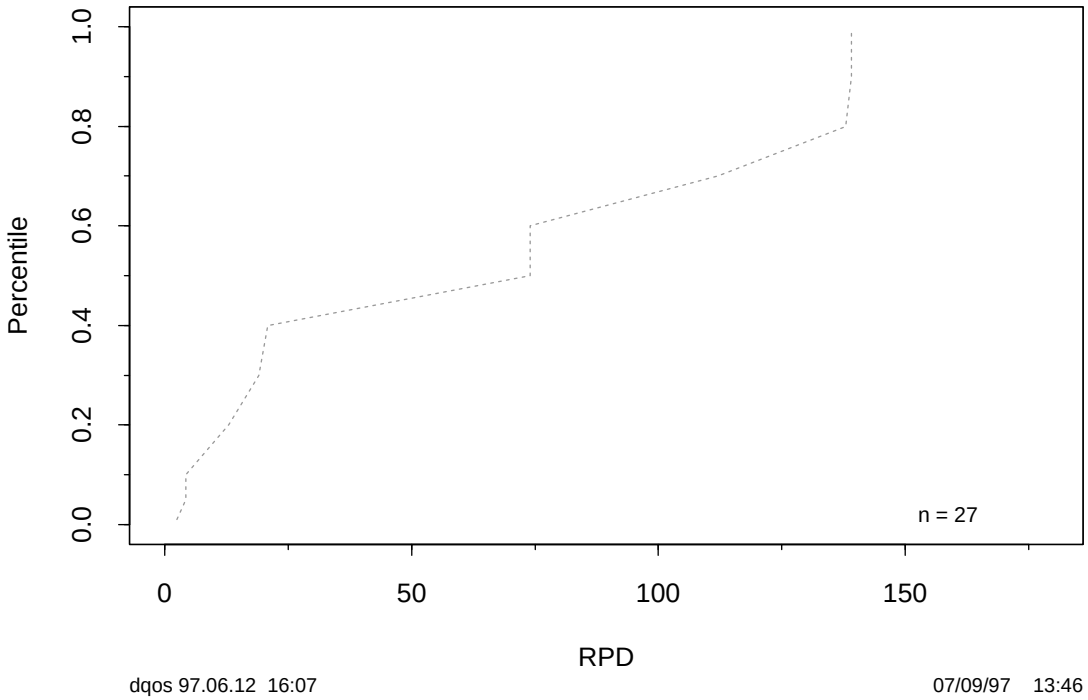

Figure 21. Data quality objective for nutrients in interlaboratory collocated ground water samples.

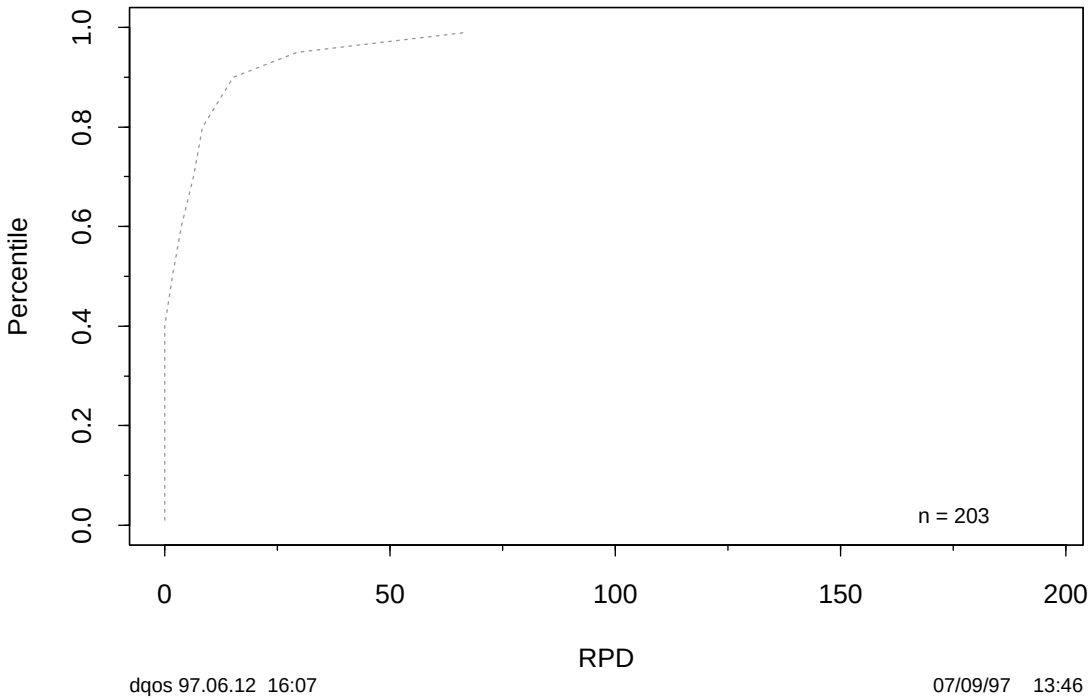

Figure 22. Data quality objective for nutrients in intralaboratory collocated ground water samples.

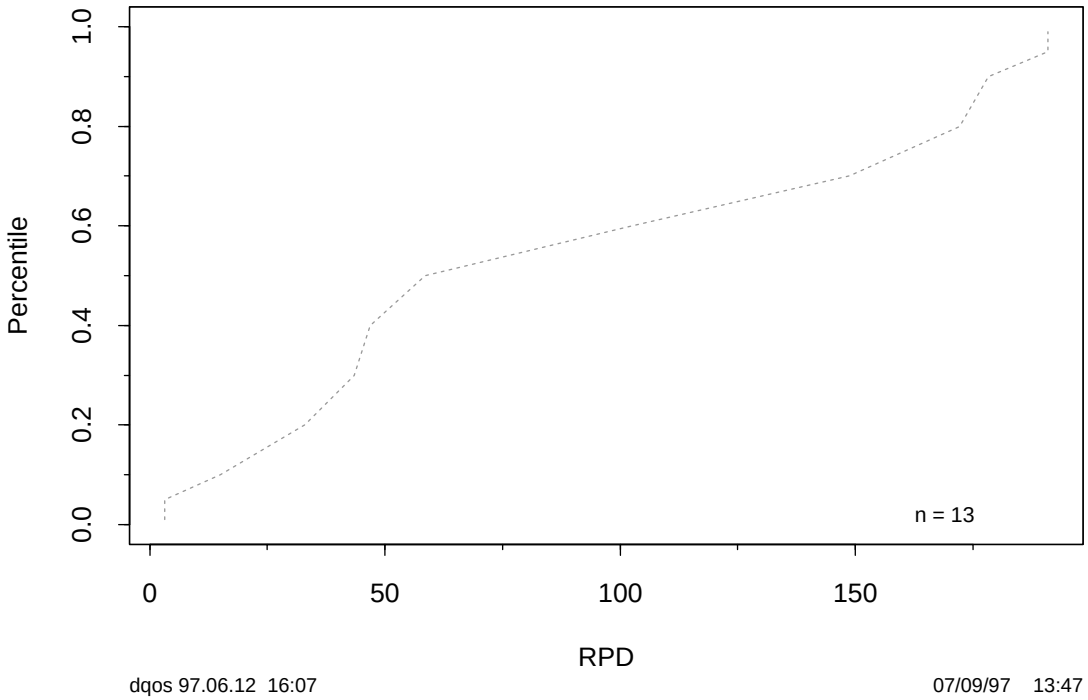

Figure 23. Data quality objective for VOCs in intralaboratory collocated soil samples.

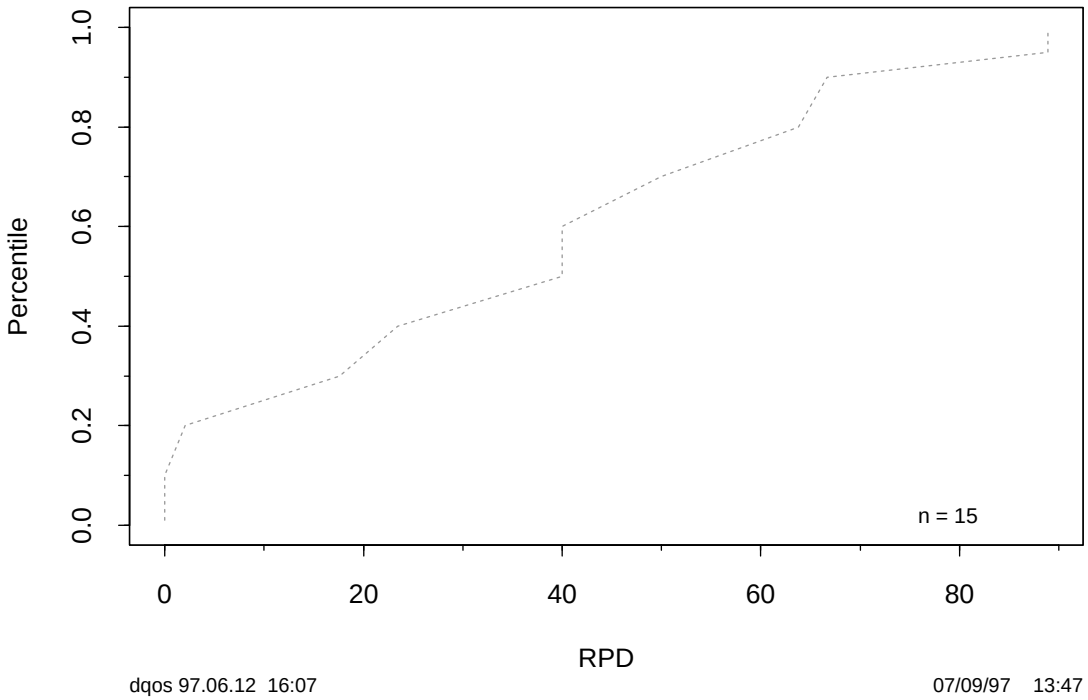

Figure 24. Data quality objective for soluble metals in intralaboratory collocated soil samples.

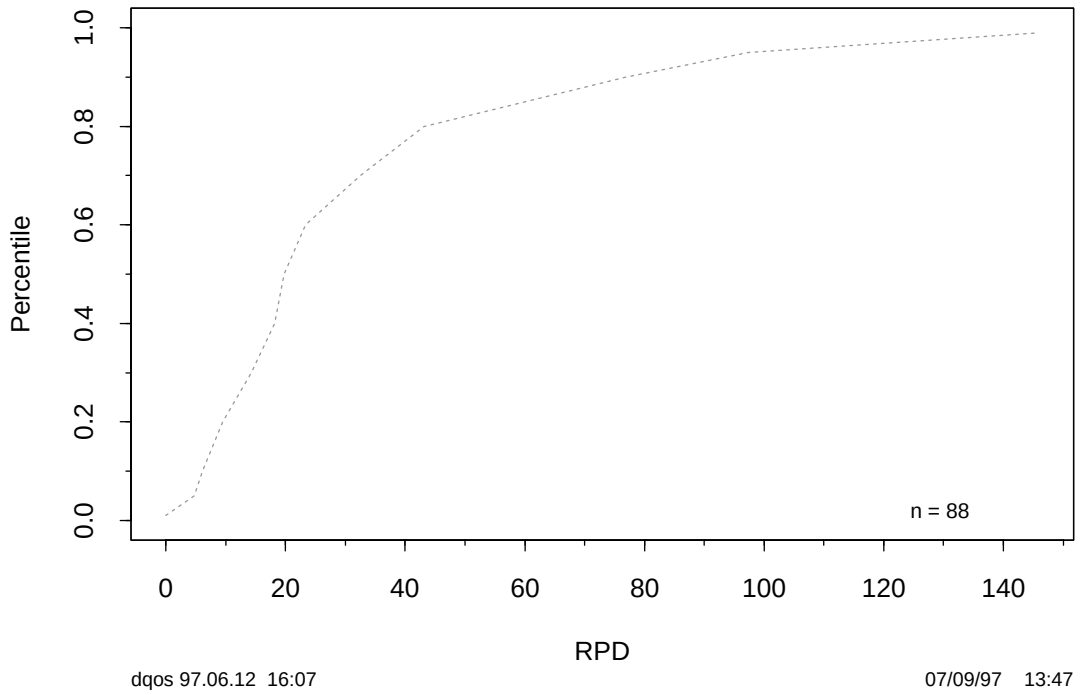

Figure 25. Data quality objective for soluble metals in interlaboratory collocated soil samples.

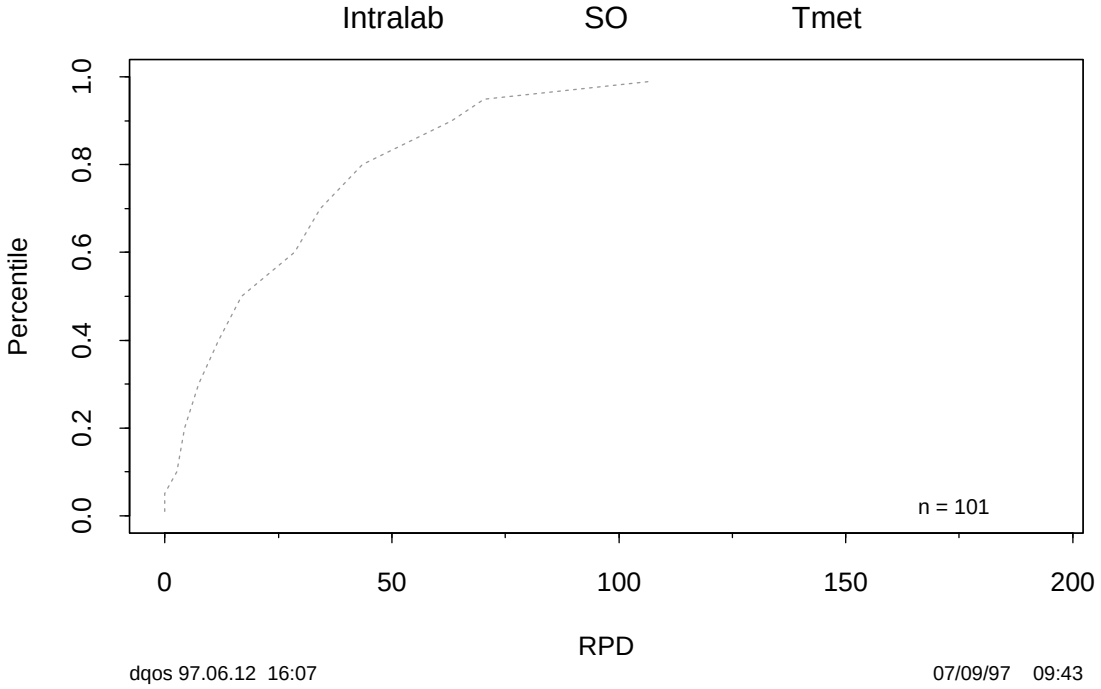

Figure 26. Data quality objective for total metals in intralaboratory collocated soil samples.

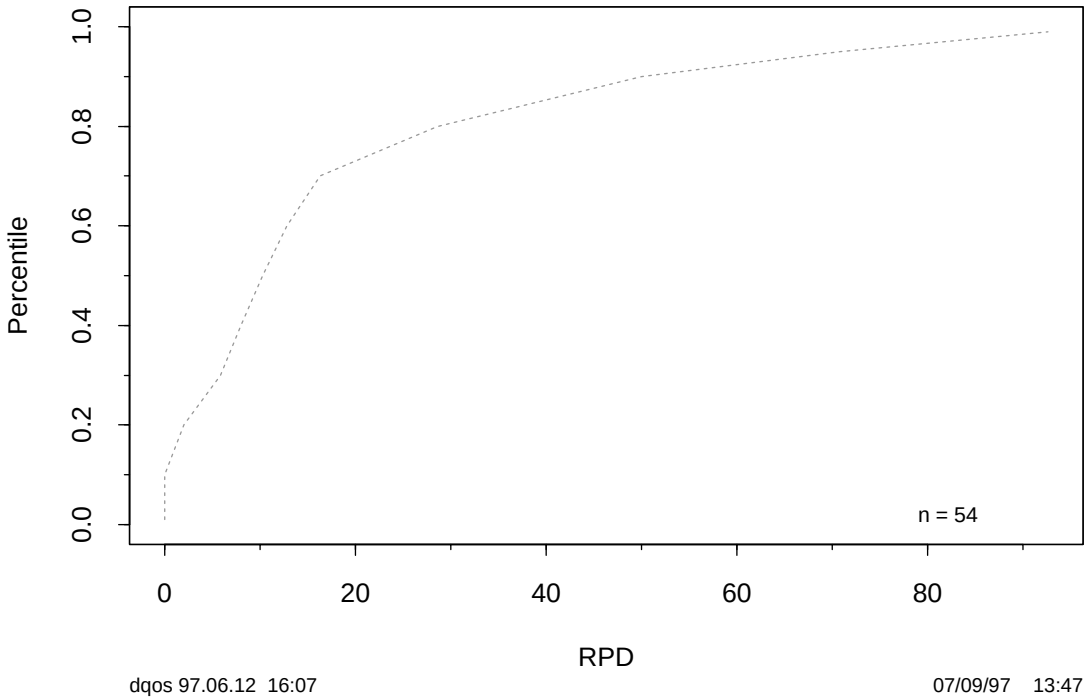

Figure 27. Data quality objective for radiologicals in intralaboratory collocated soil samples.

Tables

Table 1. Site 300 Environmental Restoration Project's Contaminants of Concern (COC) and action limits in ground water.

COC	Federal MCL (ppb)	California MCL (ppb)
Acetone	–	–
Benzene	5	1
Benzoic acid	–	–
Bis(2-ethylhexyl) phthalate	6	4
Chloroform	100[a]	–
cis-1,2-DCE	70	6
1,1-DCE	7	6
1,2-DCA	5	0.5
Ethylbenzene	700	700
Freon 113	–	1,200
HMX	–	–
Nitrate	10,000	45,000
PCE	5	5
Perchlorate	–	18
RDX	–	–
TBOS/TKEB	–	–
1,1,1-TCA	200	200
TCE	5	5
Toluene	1,000	150
trans-1,2-DCE	100	10
Tritium	20,000 pCi/L	20,000 pCi/L
Uranium 238	20	20 pCi/L
Xylenes (total)	10,000[b]	1,750[b]

Notes:

MCL = Maximum Contaminant Level.

ppb = Parts per billion.

DCE = Dichloroethylene.

DCA = Dichloroethane.

HMX = High explosive known also as octogen or homocyclonite.

PCE = Tetrachloroethylene.

RDX = A high explosive, also known as cyclonite or hexogen.

TBOS = Tetra 2-ethylbutylorthosilicate.

TKEB = Tetra-Kis-2-ethylbutyl orthosilicate.

TCE = Trichloroethylene.

pCi/L = Picocuries per liter in aqueous solution.

[a] **The trihalomethanes (THM) MCL was used for choloroform.**

[b] **MCL is for either a single isomer or the sum of the ortho, meta, and para isomers.**

Table 2. Livermore Site Environmental Restoration Project's Contaminants of Concern (COC) and action limits in ground water.

COC	Federal MCL (ppb)	California MCL (ppb)
PCE	5	5
TCE	5	5
1,1-DCE	7	6
cis-,2-DCA	70	6
trans-1,2-DCE	100	10
1,1-DCA	–	5
1,2-DCA	5	0.5
Carbon tetrachloride	5	0.5
Total THM[a]	100[a]	100[a]
Benzene	5	1.0
Ethyl benzene	700	680
Toluene	1,000	–
Xylenes (total)	10,000[b]	1,750[b]
Ethyl dibromide	0.05	0.02
Chromium^{+3}	100 (Total Cr)	50 (total Cr)
Chromium^{+6}	100 (Total Cr)	50 (total Cr)
Lead	15	50
Tritium	20,000 pCi/L	20,000 pCi/L

Notes:
ppb =Parts per billion.
PCE =Tetrachloroethylene.
TCE =Trichloroethylene.
DCE =Dichloroethylene.
DCA =Dichloroethane.

[a] Total trihalomethanes (THMs); includes chloroform, bromoform, chlorodibromoethane, and bromodichloromethane (California Drinking Water Requirement).

[b] MCL is for either a single isomer or the sum of the ortho, meta, and para isomers.

Table 3. Summary of the Environmental Restoration Project's data types and uses.

Data types	Data uses				
	Site characterization	Risk assessment	Evaluation of alternatives	Engineering design of alternatives	Monitoring during remedial action
Chemical and radiological analysis					
Ground water samples	D	D	D	D	D
Surface water samples	D/S[a]	D	D	D	D
Soil samples	D	D	D	D	D
Air samples	D	D	D	D	D
Soil vapor	D/S[b]	D	D	D	D
Well installation					
Well location	D	D	D	D	D
Screened depth	D	–	D	D	D
Screened interval	D	–	–	D	D
Meterological					
Windspeed and direction	–	S	S	S	S
Barometric pressure	–	S	S	S	S
Precipitation	–	S	S	S	S
Air temperature	–	S	S	S	S
Geologic					
Lithological logs	D	–	–	D	–
Geophysical logs	D	–	–	D	–
Hydraulic/hydrogeologic					
Ground water elevation	D	D	D	D	D
Well discharge rate	D	D	D	D	D
Aquifer characteristics[c]	D	D	D	D	D
Process control/self monitoring					
Flowrates	D	–	D	D	D
Process samples	–	–	D	D	D
Temperature	–	–	S	S	S
Numeric modeling					
Model outputs	D	D	D	D	D
Physical properties analysis[d]					
Soil samples	D	D	D	D	D

Notes:
D = Definitive data.
S = Screening data.
[a] Screening data may be used when drilling operations require rapid decisions.
[b] Soil vapor data may be definitive or screening based on the method used. Both are acceptable.
[c] Transmissivity, storage coefficient, hydraulic conductivity, porosity.
[d] Sorption constant (K_d), cation exchange capacity, bulk density, soil moisture content, grainsize, porosity.

Table 4. Quality control criteria.

Method	QC element	Frequency[a]	Acceptance criteria
EPA218.2	Method blank	1 per batch	<PQL
	Matrix spike %R	1 per batch	75-125%
	Matrix spike duplicate %RPD	1 per batch	25%
	Laboratory control sample %R	1 per batch	80-120%
EPA218.4	Method blank	1 per batch	<PQL
	Matrix spike %R	1 per batch	75-125%
	Matrix spike duplicate %RPD	1 per batch	25%
	Laboratory control sample %R	1 per batch	80-120%
EPA239.2	Method blank	1 per batch	<PQL
	Matrix spike %R	1 per batch	75-125%
	Matrix spike duplicate %RPD	1 per batch	25%
	Laboratory control sample %R	1 per batch	80-120%
EPA906	Method blank	1 per batch	<PQL
	Matrix spike %R	1 per batch	70-130
	Sample duplicate %RPD	1 per batch	30%
	Laboratory control sample %R	1 per batch	75-125%
EPA601	Method blank	1 per batch	<PQL
	Matrix spike %R	1 per batch	70-130%
	Matrix spike duplicate %RPD	1 per batch	30%
	Laboratory control sample %R	1 per batch	80-120%
EPA602	Method blank	1 per batch	<PQL
	Matrix spike %R	1 per batch	70-130%
	Matrix spike duplicate %RPD	1 per batch	30%
	Laboratory control sample %R	1 per batch	80-120%
EPA504 or EPA8011	Method blank	1 per batch	<PQL
	Matrix spike %R	1 per batch	60-140%
	Matrix spike duplicate %RPD	1 per batch	30%
	Laboratory control sample %R	1 per batch	60-140%
EPA625	Method blank	1 per batch	<PQL
	Matrix spike %R	1 per batch	60-140%
	Matrix spike duplicate %RPD	1 per batch	30%
	Laboratory control sample %R	1 per batch	60-140%
mod 8015	Method blank	1 per batch	<PQL
	Matrix spike %R	1 per batch	60-140%
	Matrix spike duplicate %RPD	1 per batch	30%
	Laboratory control sample %R	1 per batch	60-140%
Alpha spec.	Method blank	1 per batch	<PQL

Table 4. (Continued)

Method	QC element	Frequency[a]	Acceptance criteria
	Matrix spike %R	1 per batch	70-130%
	Matrix spike duplicate %RPD	1 per batch	25%
	Laboratory control sample %R	1 per batch	75-125%
EPA300	Method blank	1 per batch	<PQL
	Matrix spike %R	1 per batch	70-130%
	Matrix spike duplicate %RPD	1 per batch	25%
	Laboratory control sample %R	1 per batch	75-125%

Notes:

PQL =Practical Quantitation Limit (EPA); roughly equivalent to the limit of quantification (LOQ); 10 times the standard deviation.

R =Analyses received back from the laboratories.

RPD =Relative percent difference.

[a] **A batch is not to exceed 20 samples.**

Table 5. Quality control corrective action.

QC sample type	QC failure corrective action
Organic analysis	
Method blanks	Follow method specified actions if analytes are detected in the method blank.
Matrix spikes	If % recovery is outside of control limits, perform method specific corrective actions.
Matrix spike duplicate	If % relative percent difference is outside of control limits perform method specific corrective actions.
Laboratory control samples	If % recovery is outside control limits, reanalyze sample batch.
Surrogates	If % recovery is < lower acceptance limit, reanalyze sample.
Inorganic analysis	
Method blanks	If analytes are detected in the method blank; no analyte detections are acceptable, redigest/reanalyze samples.
Matrix spikes	If % recovery <30%, perform a post-digestion spike on samples to check for matrix interferences.
Matrix spike duplicate	If % relative percent difference is outside of control limits perform method specific corrective actions.
Laboratory control samples	If % recovery is outside control limits, reanalyze sample batch.
Radiological analysis	
Method blanks	Follow method specified corrective actions if analytes are detected in the method blank above sample MDA.
Matrix spikes	If % recovery is outside of control limits perform method specific corrective actions.
Sample duplicate	If relative percent difference is outside of control limits, perform method specific corrective actions.
Laboratory control samples	If % recovery is outside control limits, reanalyze sample batch.
Tracer yields	If % recovery is < lower acceptance limit, reanalyze sample.

Note:
MDA = Minimum detectable activity.

Table 6. Analytes in explosives group.

Parameter type	Analyte	Abbreviation	Parameter code
HE	HMX	hmx	4935
HE	RDX	rdx	7125

Note:
HE = Explosives.
HMX = High explosive known also as octogen or homocyclonite.
RDX = A high explosive, also known as cyclonite or hexogen.

Table 7. Analytes in metals group.

Parameter type	Analyte	Abbreviation	Parameter code
Met, Smet, Tmet	Aluminum	al	0313
Met, Smet, Tmet	Antimony	sb	0400
Met, Smet, Tmet	Arsenic	as	0450
Met, Smet, Tmet	Barium	ba	0475
Met, Smet, Tmet	Beryllium	be	0900
Met, Smet, Tmet	Boron	b	1400
Met, Smet, Tmet	Cadmium	cd	1650
Met, Smet, Tmet	Chromium	cr	2450
Met, Smet, Tmet	Hexavalent chromium	cr6	2550
Met, Smet, Tmet	Cobalt	co	2625
Met, Smet, Tmet	Copper	cu	2800
Met, Smet, Tmet	Iron	fe	5350
Met, Smet, Tmet	Lead	pb	5450
Met, Smet, Tmet	Manganese	mn	5550
Met, Smet, Tmet	Mercury	hg	5600
Met, Smet, Tmet	Molybdenum	mo	5775
Met, Smet, Tmet	Nickel	ni	5850
Met, Smet, Tmet	Selenium	se	7600
Met, Smet, Tmet	Silver	ag	7800
Met, Smet, Tmet	Thallium	tl	8300
Met, Smet, Tmet	Vanadium	v	8875
Met, Smet, Tmet	Zinc	zn	9050

Notes:
Met = Metals.
Smet = Soluble metals.
Tmet = Total metals.

Table 8. Analytes in nutrients group.

Parameter type	Analyte	Abbreviation	Parameter code
Nutr	Ammonia Nitrogen (as N)	ammon	0325
Nutr	Nitrate (as N)	nta	5895
Nutr	Nitrate (as NO_3)	no3	5945
Nutr	Nitrite (as N)	nti	5960
Nutr	Nitrite (as NO_2)	no2	5975
Nutr	Total kjeldahl nitrogen	tkn	5980
Nutr	Sodium	na	7850

Note:

Nutr = Nutrients.

Table 9. Analytes in radiologicals group.

Parameter type	Analyte	Abbreviation	Parameter code
3H	Tritium	h3	8800
Rad	Gross alpha	alf	4925
Rad	Gross beta	bet	4927
Rad	Radium 226	ra226	7251
Rad	Radium 228	ra228	7252
Rad	Uranium 234 and Uranium 233	u234	8860
Rad	Uranium 234 by mass measurement	u234m	8867
Rad	Uranium 235 and Uranium 236	u235	8861
Rad	Uranium 235 by mass measurement	u235m	8865
Rad	Uranium 236 by mass measurement	u236m	8868
Rad	Uranium 238	u238	8862

Notes:

3H = Tritium.

Rad = Other radiological constituents.

Table 10. Analytes in volatile organics group.

Parameter type	Analyte	Abbreviation	Parameter code
VOC	Benzene	benz	0500
VOC	Carbon tetrachloride	ccl4	1800
VOC	Chloroform	chlrf	2150
VOC	1,1-dichloroethane	11dca	3550
VOC	1,2-dichloroethane	12dca	3600
VOC	1,1-dichloroethene	11dce	3650
VOC	cis-1,2-dichloroethene	c12dce	3695
VOC	trans-1,2-dichloroethene	t12dce	3700
VOC	1,2-dichloroethene (total)	12dce	3705
VOC	Ethylbenzene	ethbz	4700
VOC	Freon 113	frn113	4850
VOC	Tetrachloroethene	pce	8250
VOC	Toluene	tol	8350
VOC	1,1,1-trichloroethane	111tca	8550
VOC	Trichloroethene	tce	8650
VOC	Trichlorofluoromethane	tcfm	8700
VOC	Total xylene isomers	totxi	8975

Note:
VOC = Volatile organic compound.

Table 11. Data quality objectives for VOC and metals in ground water.

Distribution percentile	VOC (Interlaboratory)	VOC (Intralaboratory)	MET (Interlaboratory)	MET (Intralaboratory)
1%	0.0	0.0	1.7	0.0
5%	0.8	0.0	3.3	0.0
10%	4.3	0.0	6.9	0.0
20%	8.0	1.4	8.8	0.0
30%	12.4	3.6	14.3	2.0
40%	18.2	5.7	16.7	3.7
50%	25.3	7.9	19.9	5.8
60%	32.9	9.8	26.1	8.0
70%	42.4	13.3	32.8	10.2
80%	57.3	19.2	40.0	15.4
90%	88.9	31.1	69.4	32.0
95%	117.5	53.3	121.6	75.7
99%	169.2	113.3	143.3	158.8
n	352	492	32	366

Note:
n = Number of collocated pairs used in the analysis.

Table 12. Data quality objectives for radiologicals in ground water.

Distribution percentile	3H (Interlaboratory)	3H (Intralaboratory)	Rad (Interlaboratory)	Rad (Intralaboratory)
1%	0.4	0.0	3.4	0.0
5%	0.5	0.5	6.2	0.7
10%	0.8	0.7	9.1	2.2
20%	2.8	1.1	13.3	5.6
30%	5.0	1.6	16.7	8.4
40%	8.1	3.1	22.2	12.3
50%	10.9	3.9	34.2	16.3
60%	14.8	4.8	40.6	23.0
70%	21.6	7.1	59.0	31.1
80%	29.9	12.1	71.9	40.1
90%	46.2	16.0	125.6	66.7
95%	71.6	64.8	154.5	90.9
99%	112.3	199.9	193.7	163.5
n	112	76	116	322

Notes:
3H = Tritium.
Rad = Other radiological constituents.
n = Number of collocated pairs used in the analysis.

Table 13. Data quality objectives for explosives and nutrients in ground water.

Distribution percentile	HE (Interlaboratory)	HE (Intralaboratory)	Nutrients (Interlaboratory)	Nutrients (Intralaboratory)
1%	15.2	0.0	2.5	0.0
5%	15.2	0.0	4.2	0.0
10%	15.7	0.0	4.3	0.0
20%	23.8	0.0	12.9	0.0
30%	24.0	4.3	19.0	0.0
40%	31.4	6.5	20.9	0.0
50%	37.9	7.6	74.0	1.7
60%	42.6	13.0	74.0	3.6
70%	45.3	19.9	112.1	6.3
80%	50.0	25.9	137.9	8.3
90%	60.4	40.0	139.1	15.2
95%	101.1	58.8	139.1	29.4
99%	101.1	58.9	139.1	66.7
n	12	23	27	203

Note:
n = Number of collocated pairs used in the analysis.

Table 14. Data quality objectives for VOCs, metals, and radiologicals in soil.

Distribution percentile	VOC (Intra-laboratory)	Smet (Intra-laboratory)	Tmet (Interla-boratory)	Tmet (Intra-laboratory)	Rad (Intra-laboratory)
1%	3.2	0.0	0.0	0.0	0.0
5%	3.2	0.0	4.7	0.0	0.0
10%	15.0	0.0	6.1	2.7	0.0
20%	33.0	2.1	9.5	4.4	2.0
30%	43.5	17.6	14.3	7.4	5.8
40%	46.9	23.5	18.2	11.8	8.0
50%	58.5	40.0	19.8	16.9	10.3
60%	102.6	40.0	23.4	28.6	12.8
70%	148.8	50.0	32.6	34.3	16.3
80%	172.1	63.8	43.1	43.5	28.6
90%	178.3	66.7	76.9	63.2	50.0
95%	190.9	88.9	97.4	70.3	70.8
99%	190.9	88.9	145.9	107.2	92.6
n	13	15	88	101	54

Note:

n = Number of collocated pairs used in the analysis.

Appendix A

Environmental Services Used by ERD

Appendix A

Enviromental Services Used by ERD

Air Toxics Ltd.
LLNL Isotope Sciences Division
Brown & Caldwell Emeryville
LLNL Noble Gas Mass Spec. Laboratory
Brown & Caldwell Pasadena
LLNL Nuclear Chemistry Laboratory
BC Laboratories, Inc.
LLNL Particle Characterization
Beta Analytical
Lockheed Analytical Services
California Analytical Laboratory
Maxwell Laboratories, Inc.
Coast-to-Coast Analytical Services
McKesson Environmental Services
Ceimic(replaced Maxwell Jul96)
Mobile Chem Labs, Inc.
Controls for Env. Pollution
Natl Air & Rad. Env. Lab (EPA)
ChromaLab, Inc.
Northeast Research Institute
Clayton Environmental Consultants
New World Technologies
California Laboratory Services
Pace Laboratories, Inc.
Colog, Inc., Petaluma, California
P. C. Exploration, Roseville, California
Curtis & Tompkins, Ltd
Superior Precision Analytical
Daniel B. Stephens & Associate
Thermo Analytical Inc.
Earth and Environmental Science
Weiss Associates
Enlab Mobile
W. L. Gore and Assoc. Inc.
Environmental Physics, Inc.
Woodward-Clyde Consultants
Environmental Science & Engineering Inc.
Environmental Testing and Certification
Eureka Laboratories
FruitGrowers Environmental Laboratory
Fruit Growers Laboratory, Inc.
GeoAnalytical Laboratories, Inc.
Groundwater Technology Envir. Laboratory
IT Analytical Services-Richland, WA
International Technology Corp.
LBL Isotope GeoChem Laboratory
LLNL Characterization Labs - Bacteria
LLNL Characterization Labs - Chemistry
LLNL Characterization Labs - Mineral
LLNL Characterization Labs - Photovac
LLNL Characterization Labs - Soil
LLNL C&MS Anal. Sci. Div. IPC
LLNL C&MS-Berm and Rain Waters
LLNL C&MS Environmental Service
LLNL C&MS-Gas Chromatography
LLNL C&MS-Gas Mass Spectrometry
LLNL Environmental Analytical Sciences
LLNL Environmental Chemistry Laboratory
LLNL Envir. Sci. Low Level Gamma Spec. Lab.
LLNL Envir. Science Scanning Facility
LLNL Envir. Science VOC Soil Laboratory
LLNL Forensic Laboratory
LLNL GET Clay Mineralogy Laboratory
LLNL Hazards Control Laboratory
LLNL Hazardous Waste Management Lab.
LLNL HydroThermo Research Laboratory
LLNL ICP MS Facility

Appendix B

Table of Contents for LLNL Livermore Site and Site 300 Environmental Restoration Project Standard Operating Procedures (SOPs)

Appendix B

Table of Contents for LLNL Livermore Site and Site 300 Environmental Restoration Project Standard Operating Procedures (SOPs)

B-1. Chapter 1

B-2. Chapter 2

SOPs listed in *italics* are currently in progress.

SOP-2.3 Sampling Monitor Wells with Bladder and Electric Submersible Pumps

SOP-2.4 Sampling Monitor Wells with a Bailer

SOP-2.5 Surface Water Sampling

SOP-2.6 Sampling for Volatile Organic Compounds

SOP-2.7 Presample Purging and Sampling of Low-Yielding Monitor Wells

SOP-2.8 Installation of Dedicated Sampling Pumps

SOP-2.9 Sampling for Tritium in Ground Water

SOP-2.10 Well Disinfection and Coliform Bacteria Sampling

SOP-2.11 Developing Ground Water Monitoring Sampling Schedules

SOP-2.12 Ground Water Monitor Well and Equipment Maintenance

SOP-2.13 Barcad Sampling

B-3. Chapter 3

SOP-3.1 Water Level Measurement

SOP-3.2 Pressure Transducer Calibration

SOP-3.3 Hydraulic Testing (Slug/Bail)

SOP-3.4 Hydraulic Testing (Pumping)

B-4. Chapter 4

SOP-4.1 General Instructions for Field Personnel

SOP-4.2 Sample Control and Documentation

SOP-4.3 Sample Containers and Preservation

SOP-4.4 Guide to the Handling, Packaging, and Shipping of Samples

SOP-4.5 General Equipment Decontamination

SOP-4.6 Validation and Verification of Non-Radiological Data Generated by Analytical Laboratories

SOP-4.7A Livermore Site Treatment and Disposal of Well Development and Well Purge Fluids

SOP-4.7B Site 300 Treatment and Disposal of Well Development and Well Purge Fluids

SOP-4.8 Calibration/Verification and Maintenance of Measuring and Test Equipment (M&TE)

SOP-4.9 Collection of Field QC Samples

SOP-4.10 Photovac Portable Gas Chromatograph Operating Instructions

SOPs listed in *italics* are currently in progress.

SOP-4.11 Validation and Verification of Radiological Data Generated by Analytical Laboratories

SOP-4.12 Quality Improvement Forms (QIFs)

SOP-4.13 Standard Operating Procedure Process

SOP 4.14 Mapping with the Trimble Pathfinder Pro XR GPS System

B-5. Chapter 5

SOP-5.1 Data Management Printed Analytical Result Receipt and Processing

SOP-5.2 Data Management Chain-of-Custody Receipt and Processing

SOP-5.3 Data Management Electronic Analytical Results Receipt and Processing for Sample and Analysis Date

SOP-5.4 Data Management Hand Entry of Analytical Results

SOP-5.5 Data Management Revision Receipt and Processing

SOP-5.6 Data Management Data Review Request Processing

SOP-5.7 Data Management Sample Location Entry

SOP-5.8 Field Logbook Control

SOP-5.10 Data Management Receipt and Processing of Lithology

SOP-5.11 Data Management Verification of Format and Quality of Electronic Data Deliverables (EDDs)

SOP-5.12 Data Management Update of Analysis Data Quality Flags

SOP-5.13 Data Management Receipt and Processing of Quality Improvement Forms (QIFs)

SOP-5.14 Data Management Validation of Analytical Data Quality Flags

SOP-5.15 Data Management Processing of Water Elevation Data Logger Data

SOP-5.16 Data Management Electronic Field Chain-of-Custody Receipt and Processing

SOP-5.17 Data Management Reference Report Preparation and Distribution

SOP-5.18 World Wide Web Custodianship

SOP-5.19 EPDData Copy Over Software Operating Procedure

SOP-5.20 Statistical Outliers

SOP-5.21 Cost Effective Sampling (CES) Algorithm Preparation

SOPs listed in *italics* are currently in progress.

Appendix C

Analytical Methods and Detection Limits for the ERP COCs

Appendix C

Analytical Methods and Detection Limits for the ERP COCs

COC	Description of analysis	Method	Sample matrix	Reporting limit
Ethylene Dibromide	Aqueous Ethylene Dibromide Only	EPA 504 or EPA 8011	Aqueous	0.01 μg/L
RDX & HMX	High explosives by HPLC	EPA 8330	Aqueous	5 μg/L
Chromium	AA, Furnace	EPA 218.2	Aqueous	0.001 mg/L
Chromium + VI	Chelation-extraction	EPA 218.4	Aqueous	0.002 mg/L
Lead	AA, Furnace	EPA 239.2	Aqueous	0.005 mg/L
Nitrate as NO_3	Ion-chromatography	EPA 300.0	Aqueous	0.5 mg/L
Bis (2-ethylhexyl) phthalate Benzoic acid	Semivolatiles by GC/MS	EPA 625 or EPA 8270	Aqueous	5 μg/L
TBOS/TKEB	Method development required	Modified EPA 8016	Aqueous	100 μg/L
Tritium	Tritium	EPA 906	Aqueous	100 pCi/L
Uranium 238	Alpha Spec.	NA	Aqueous	0.10 pCi/L
Benzene Ethylbenzene Toluene Xylene	Aromatic Volatile Organics by GC	EPA 602	Aqueous	0.3 μg/L
PCE TCE 1,1-DCE Trans-1,2-DCE 1,1-DCA 1,2-DCA Carbon tetracholoride Total THMs Chloroform 1,1,1-TCA Freon 113	Purgeable Halocarbons by GC	EPA 601	Aqueous	0.5 μg/L
Acetone	Volatile Organic Compounds by GC/MS	EPA 624	Aqueous	1.0 μg/L
Perchlorate	Ion-chromatography	EPA 300.0	Aqueous	4 μg/L

Appendix D

Qualifier Flags

Appendix D

Qualifier Flags

Flag	Definition	Indicates uncertain: Identity?	Conc.?
B	**Analyte found in method blank**	**no**	**yes**
D[a]	**Analysis performed at a secondary dilution or concentration (i.e. vapor samples).**	**no**	**no**
F	**Analyte found in field blank, trip blank, or equipment blank**	**no**	**yes**
G	**Quantitated using fuel calibration, but does not match typical fuel fingerprint (fuel maybe gasoline, diesel, motor oil etc.).**	**yes**	**yes**
H[a]	**Sample analyzed outside of holding time, sample results should be evaluated.**	**no**	**yes**
I	**Surrogate recoveries were outside of QC limits.**	**no**	**yes**
J	**The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample.**	**no**	**yes**
L	**Spike accuracy not within control limits.**	**No action is taken by data user on the MS/MSD data alone.**	
O	**Duplicate spike or sample precision not within control limits.**		
P	**Indicates that the absence of a data qualifier flag does not mean that the data does not need qualification, but that the implementation of electronic data qualifier flags was not yet established.**		
R	**Sample results are rejected due to serious deficiencies in the ability to analyze the sample and meet QC criteria. The presence or absence of the analyte cannot be verified.**		
S	**The analytical results from this sample are suspect. Supply reasoning on form.**	**yes**	**yes**
T	**Analyte is tentatively identified compound; result is approximate.**	**yes**	**yes**
U[a]	**Compound was analyzed for, but not detected above the detection limit.**	**yes**	**yes**

[a] Automatically flagged in the database by the data qualifier flag program.

D-1. Some General Rules for Appying QA Flags

Blanks

If analytes are found in the method, field, equipment, or trip blank, flag positive sample results only. Sample non-detects do not need flagging.

Surrogates

When surrogate recoveries are below the lower control limit (LCL), associated nondetect (ND) sample results should be flagged "IR" and positive results should be flagged "IJ". The "R" flag is for rejection of the sample results and the "J" flag indicates an estimated concentration. When surrogate recoveries are above the upper control limit (UCL), the positive sample results should be flagged "IJ" (NDs do not require flagging). When QC sample surrogates are out of control, all supporting infomation (i.e. MS/MSD accuracy and precision, LCS accuracy, and sample location historical data) should be considered to determine if the associated samples were affected.

Laboratory Control Samples

If the LCS %R is greater than %R upper control limit (UCL) for an analyte, check to see if the analyte is detected in the sample from the same batch number, if it is positive, qualify the data as being positively identified, but value is approximate ("J"). If the analyte is ND, no flag is necessary. If the LCS %R is less than %R lower control limit (LCL) for an analyte, check to see if the analyte is detected in the sample from the same batch number, if it is positive, qualify the data as being positively identified, but value is approximate ("J") and the associated non-detected compound(s) should be qualified as "R" meaning sample results are rejected due to serious deficiences in the ability to analyze the sample and meet QC criteria. The presence or absence of the analyte cannot be verified. Also, if more than half of the compounds in the LCS are not within the required recovery criteria, then all associated data should be qualified "R".

Matrix Spikes

If the MS %R is out of control (either above the UCL or below the LCL) for an analyte, but the MSD %R is within limits, no flag is necessary. If the MSD %R is out of control for an analyte, but the MS %R is within limits, no flag is necessary. If both the MS and MSD %R are out of control, qualify the associated sample results (both positve and negative detections) in the database ("L"). If the %RPD is out of control (either above the UCL or below the LCL) for an analyte, qualify the associated sample results (both positve and negative detections) in the database ("O"). Both positive and non-detect sample results should be flagged when the MS/MSD recoveries or precision are out of control.

Continuing Calibration Verification

Use professional judgement when qualifying data based on CCVs. The following IF, THEN statements are provided as a guide only:

IF recovery is <LCL and sample result is ND, THEN flag with a "J".

IF recovery is >UCL and sample result is ND, THEN no flag is needed.

IF recovery is <LCL and sample result is positive, THEN flag with a "J".

IF recovery is >UCL and sample result is positive, THEN flag with a "J".

IF recovery is <LCL and sample result is ND and other QC failed, THEN flag with a "R".

Acronyms and Abbreviations

Acronyms and Abbreviations

ARAR	Applicable or Relevant and Appropriate Requirement
BAAQMD	Bay Area Air Quality Management District
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CoC	chain-of-custody
CO_2	carbon dioxide
CLP	Contract Laboratory Program
cm	centimeter(s)
CP	Contingency Plan
DMT	Data Management Team
DOE	Department of Energy
DQO	data quality objective
DRR	data review request
DTSC	Department of Toxic Substances Control
ECBG	Environmental Chemistry and Biology Group
EDD	electronic data deliverables
EE/CA	Engineering and Evaluation/ Cost Analysis
ELAP	Environmental Laboratory Accreditation Program
EPA	Environmental Protection Agency
EPD	Environmental Protection Department
ERD	Environmental Restoration Division
ERP	Environmental Restoration Project
ES&H	Environmental Safety & Health
EWFA	East and West Firing area
FFA	Federal Facility Agreement
FLUTe	Flexible Liner Underground Technology
FS	Feasibility Study
GC	gas chromatograph
GSA	General Services Area
HE	High explosive
H_2O_2	hydrogen peroxide
ID	identification
K_d	sorption constant
km	kilometer(s)
LLNL	Lawrence Livermore National Laboratory
µg/L	micrograms per liter
LCS	laboratory control sample
LIMS	Laboratory Information Management Systems
M&TE	Measuring and Testing Equipment
MCL	Maximum Contaminant Level
MS	matrix spike
MSD	matrix spike duplicates
O&M	operations and maintenance
OSHA	Occupational Safety and Health Administration
PCE	tetrachloroethylene
pCi/L	picocuries per liter
PE	performance evaluation
PP	Proposed Plan
ppb	parts per billion
ppm	parts per million
PTS	project tracking systems
QA	quality assurance
QAE	Quality Assurance Engineer
QAIC	Quality Assurance Implementation Coordinator
QAMP	Quality Assurance Management Plan
QAPP	Quality Assurance Project Plan
QC	quality control
QIF	Quality Improvement Form
RAIP	Remedial Action Implementation Plan

RCRA	Resource Conservation and Recovery Act
%RCV	percent recovery
RD	Remedial Design
RI	Remedial Investigation
ROD	Record of Decision
%RPD	relative percent differences
%RSD	percent relative standard deviation
RWQCB	Regional Water Quality Control Board
SARA/OSHA	Superfund Amendments and Authorization Act/Occupational Safety and Health Administration
SC	Sampling Coordinator
SJVUAPCD	San Joaquin Valley Unified Air Pollution Control District
SOP	Standard Operating Procedure
SPACT	sampling planning and CoC tracking
SQA	software quality assurance
SSP	Site Safety Plan
TAT	turnaround time
TFA	Treatment Facility A
TFB	Treatment Facility B
TFC	Treatment Facility C
TFC-SE	TFC-Southeast
TFD	Treatment Facility D
TFD-East	portable treatment unit
TFD-West	portable treatment unit
TFE-E	Treatment Facility E-East
TFF	Treatment Facility F
TF406	Treatment Facility 406
TFG-1	Treatment Facility G-1
VTF518	Vapor Treatment Facility 518
TNT	trinitrotoluene, a well known high explosive
TRRs	Technical Release Representatives
UC	University of California
VOC	volatile organic compound