Rocky Flats Environmental Technology Site

Integrated Monitoring Plan
Background Document

Groundwater Monitoring

September 1999

Table of Contents

Page

3.0 GROUNDWATER MONITORING 3-1

3.1 Introduction 3-1
3.1.1 Purpose of the Integrated Monitoring Plan for Groundwater 3-1
3.1.2 Brief History of Groundwater Monitoring Activities 3-1
3.1.3 Current Status of the Groundwater Program 3-3
3.1.4 Groundwater Interactions with Surface Water 3-3
3.1.5 General Strategy for Groundwater Plume Management and Remediation 3-5
3.2 Groundwater Program Objectives 3-7
3.3 Monitoring Objectives 3-8
3.3.1 Identification of Potential Contaminants 3-8
3.3.2 Identification and Control of Contaminant Sources 3-8
3.3.2.1 Current Contaminated Areas 3-10
3.3.2.2 Hazardous Waste Management Areas 3-10
3.3.2.3 Storage Tanks 3-11
3.3.2.4 Process Waste System 3-11
3.3.2.5 Building Drains 3-11
3.3.2.6 Other Potential Contamination Sources 3-11
3.3.3 Identification of Potential Contaminant Pathways 3-12
3.3.4 Identification of Contaminant Concentrations 3-12
3.3.5 Monitoring of Remedial Actions 3-12
3.3.6 Protection from New Contaminant Sources 3-13
3.3.7 Evaluation of Groundwater Contaminant Impacts on Surface Water 3-13
3.4 Groundwater Data Quality Objectives 3-13
3.4.1 Programmatic Data Quality Objectives 3-13
3.4.2 Data Quality Objectives for Program Elements 3-14
3.4.2.1 Plume Definition Wells 3-15
3.4.2.2 Plume Extent Monitoring Wells 3-18
3.4.2.3 Drainage Monitoring Wells 3-21
3.4.2.4 Boundary Monitoring Wells 3-24
3.4.2.5 Building-Specific D&D Monitoring Wells 3-27
3.4.2.6 Performance Monitoring Wells 3-28
3.4.2.7 RCRA Monitoring Wells 3-30
3.4.2.8 Plume Degradation Monitoring Wells 3-32
3.4.3 Data Quality Objectives for Monitoring Groundwater Flow 3-36
3.4.3.1 Site-Wide Flow Monitoring 3-37
3.4.3.2 Water Quality Flow Monitoring 3-39
3.4.3.3 Industrial Area Flow Monitoring 3-40
3.4.3.4 Background Groundwater Flow Monitoring 3-42
3.4.4 Monitoring Frequencies to Meet DQOs 3-43

Tables of Contents (Continued)

Page

3.5 Quality Control Objectives for Collection/Evaluation of Groundwater Data 3-44
3.5.1 Field Data Collection 3-46
3.5.1.1 Representative Samples 3-46
3.5.1.2 Minimization of Contamination During Sampling 3-46
3.5.1.3 Standardization of Sampling Techniques 3-47
3.5.2 Accuracy of Water Level Measurement 3-47
3.5.3 Laboratory Analysis 3-49
3.5.4 Data Management 3-50
3.5.5 Groundwater Assessment and Reporting 3-50
3.6 Description of the Groundwater Monitoring Program Resulting from the DQO Process 3-51
3.6.1 Groundwater Monitoring Network 3-52
3.6.2 Sampling and Analysis 3-53
3.6.3 Measurement of Groundwater Elevations 3-54
3.6.4 Groundwater Reporting 3-54
3.6.4.1 Annual Report 3-55
3.6.4.2 RFCA Quarterly Reporting 3-57
3.6.5 Evaluation of Groundwater Impacts to Surface Water 3-58
3.6.6 Groundwater Flow Modeling 3-58
3.6.7 Well Control Program 3-58
3.6.8 Well Abandonment and Replacement 3-59
3.7 References 3-60

APPENDICES:
Appendix A: Site Description and Environmental History
Appendix B: Action Level Framework for Groundwater
Appendix C: Physical and Hydrologic Setting
Appendix D: Site Impacts to Groundwater
Appendix E: Water Quality and Water Level Monitoring Wells

List of Tables

Page

Table 3-1 Operating Procedures for Planning, Installing, and Sampling a Groundwater Monitoring Well. 3-48

List of Figures

Figure 3-1 Detention Ponds, Ditches, Effluent Water Courses, and Creeks at the Site..... 3-4

Figure 3-2 Organizational Responsibilities for Groundwater. 3-9

List of Plates

Plate 1 Location Map of Groundwater Monitoring Wells

Plate 2 Potentiometric Surface Map for Groundwater

Plate 3 Composite Plume Map for Groundwater

3.0 GROUNDWATER MONITORING

3.1 Introduction

This section of the *Integrated Monitoring Plan* (IMP) describes the groundwater monitoring requirements for Rocky Flats Environmental Technology Site (RFETS or the Site) as outlined in the *Rocky Flats Cleanup Agreement* (RFCA) [Department of Energy (DOE et al.), 1996], and how they will be implemented at the Site. All RFETS groundwater monitoring is performed by Site organizations because groundwater contaminant plumes occur within the Site boundaries. Therefore, this IMP covers all groundwater monitoring activities. After a brief history of the monitoring program, this section outlines the goals for groundwater monitoring and describes quality assurance/quality control (QA/QC) components and monitoring components. To evaluate groundwater monitoring needs, one must know the RFCA action levels for groundwater, Site history and areas of contamination, the physical and hydrologic setting of the Site, the effect of contaminated areas on groundwater, and the nature of the groundwater contaminant plumes. This information is presented in Appendices A, B, C, and D to this Groundwater Monitoring section, respectively. Appendix E lists the wells that will be monitored for water quality or for groundwater flow.

3.1.1 Purpose of the Integrated Monitoring Plan for Groundwater

In the past, two plans have been required at the Site to comply with DOE Order 5400.1 (DOE, 1988), a "Groundwater Protection Management Program Plan," and a "Groundwater Monitoring Plan." These two plans have historically been combined into one document, the *Groundwater Protection and Monitoring Program Plan* (GPMPP) (EG&G, 1993a), which defines and describes the groundwater protection and monitoring programs at the Site. In addition, an assessment groundwater monitoring plan was required under the Resource Conservation and Recovery Act (RCRA) for the interim status units on Site. This plan is called the *Final Groundwater Assessment Plan* (GWAP) (DOE, 1993). Other monitoring plans have been developed to address groundwater monitoring requirements as outgrowths of various Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Interim Measure/Interim Remedial Action (IM/IRA) decision documents. This portion of the IMP will serve as the Groundwater Monitoring Plan for the Site, and it will replace the requirements found in the group of plans named above. It will also revise the requirements of the routine groundwater monitoring portion of the Industrial Area IM/IRA decision document (DOE, 1994a) and the French Drain IM/IRA plan (DOE, 1992a).

3.1.2 Brief History of Groundwater Monitoring Activities

The historic growth of the groundwater monitoring network at the Site reflects the increasing DOE, regulatory, and public emphasis on identifying areas of groundwater contamination and preventing contaminant releases to the environment. The first three monitoring wells were installed in 1954 in the Solar Ponds area. A total of 1,055 wells and piezometers were installed

at the Site from 1971 to present. Plate 1 shows all the wells that have been installed at the Site since 1974.

Wells in the groundwater monitoring network were sampled annually until 1974, twice a year until 1980, and three times a year during 1981. From 1982 to 1995, designated monitoring wells were sampled quarterly. Beginning in 1995, designated wells were sampled either quarterly or semiannually, depending on regulatory requirements. The wells to be sampled are determined by the types of wells (e.g., RCRA), and the areas being monitored. Currently, wells are sampled on a semiannual basis. The groundwater monitoring program has supported the following compliance programs at the Site:

- RCRA programs;
- CERCLA programs;
- The Background Groundwater Characterization Program (completed in 1993);
- The Boundary Well Monitoring Program;
- Groundwater Protection (DOE Order 5400.1);
- French Drain IM/IRA Performance Monitoring Program;
- Industrial Area IM/IRA Monitoring Program;
- New Sanitary Landfill Permit Monitoring Program; and
- Special activities that support hydrogeologic projects, including aquifer testing and hydrogeological characterization.

Groundwater has been monitored for radionuclides since the first wells were installed in 1954; other chemical analytes were added in 1974, 1979, 1981, 1985, and 1994. Beginning in 1985, the wells were sampled and analyzed for volatile organic compounds (VOCs), metals, and major anions. Limited analyses for pesticides have also been performed. Results of groundwater analyses from 1986 to present are compiled in the Site Soil and Water Database (SWD).

In 1993, the large number of wells that were being monitored as an outgrowth of the various remedial investigations at the Site prompted the Well Evaluation Project. The *Well Evaluation Report* (WER) (EG&G, 1994c) reduced the monitoring network from 460 wells to 350 wells, but retained those wells in or near contaminant plumes.

In 1995, the Well Evaluation Project updated plume maps and again evaluated the monitoring network. On the basis of new plume configurations, the number of wells monitored was reduced from 350 wells to 150 wells, and the sample frequency and analyte list were amended.

3.1.3 Current Status of the Groundwater Program

In July 1996, the RFCA was approved (DOE, 1996). RFCA replaces the Interagency Agreement (IAG) as the environmental cleanup agreement for the Site. RFCA outlines the goals, objectives, and strategies that will lead to the Site cleanup and closure mission objectives. Supporting activities will reduce, eliminate, or mitigate existing environmental liabilities while maintaining the Site in a safe condition. The Action Levels and Standards Framework (ALF) portion of RFCA contains specific requirements for monitoring and reporting, and it sets action levels for contaminant concentrations in groundwater and in other media (see Appendix B to this section). The IMP is required under RFCA to further define the monitoring programs for the Site.

Defining the groundwater monitoring involved reevaluating the monitoring system to ensure that it was protective of the environment, compliant with all applicable regulations and agreements, and aligned with the new Site mission. A data quality objective (DQO) process was used to determine the function of each well in the network and the decisions supported by information from each well. The DOE, Rocky Flats Field Office (DOE, RFFO), the Colorado Department of Public Health and Environment (CDPHE), and the U.S. Environmental Protection Agency (EPA) stakeholders were directly involved in all decisions about the monitoring network. Results of this evaluation are presented starting in Section 3.2.

3.1.4 Groundwater Interactions with Surface Water

There is considerable interchange between surface water and groundwater at Rocky Flats. Interchange occurs along stream channels, ponds, ditches, and lakes by way of natural hillside and channel seepage and artificial flow control structures, such as foundation drains and dams, that interrupt the natural flow of water. Streams nearest to the Industrial Area are more likely to be contaminated by groundwater discharges and, thus, have traditionally been the focus of most groundwater monitoring.

As shown in Figure 3-1, three ephemeral streams drain the Site. The streams are Rock Creek, Walnut Creek (consisting of three tributaries, “No Name Gulch,” Walnut Creek, and South Walnut Creek), and Woman Creek. Groundwater is discharged from the Rocky Flats Alluvium and other surficial deposits through surface seeps and subsurface flow that, in turn, recharge stream flow and the stream valley groundwater system. Segments of streams have been shown to either gain or lose water as groundwater is discharged to or stream water is discharged from the stream channel. Gaining reaches of streams are more likely to be contaminated by groundwater discharges.

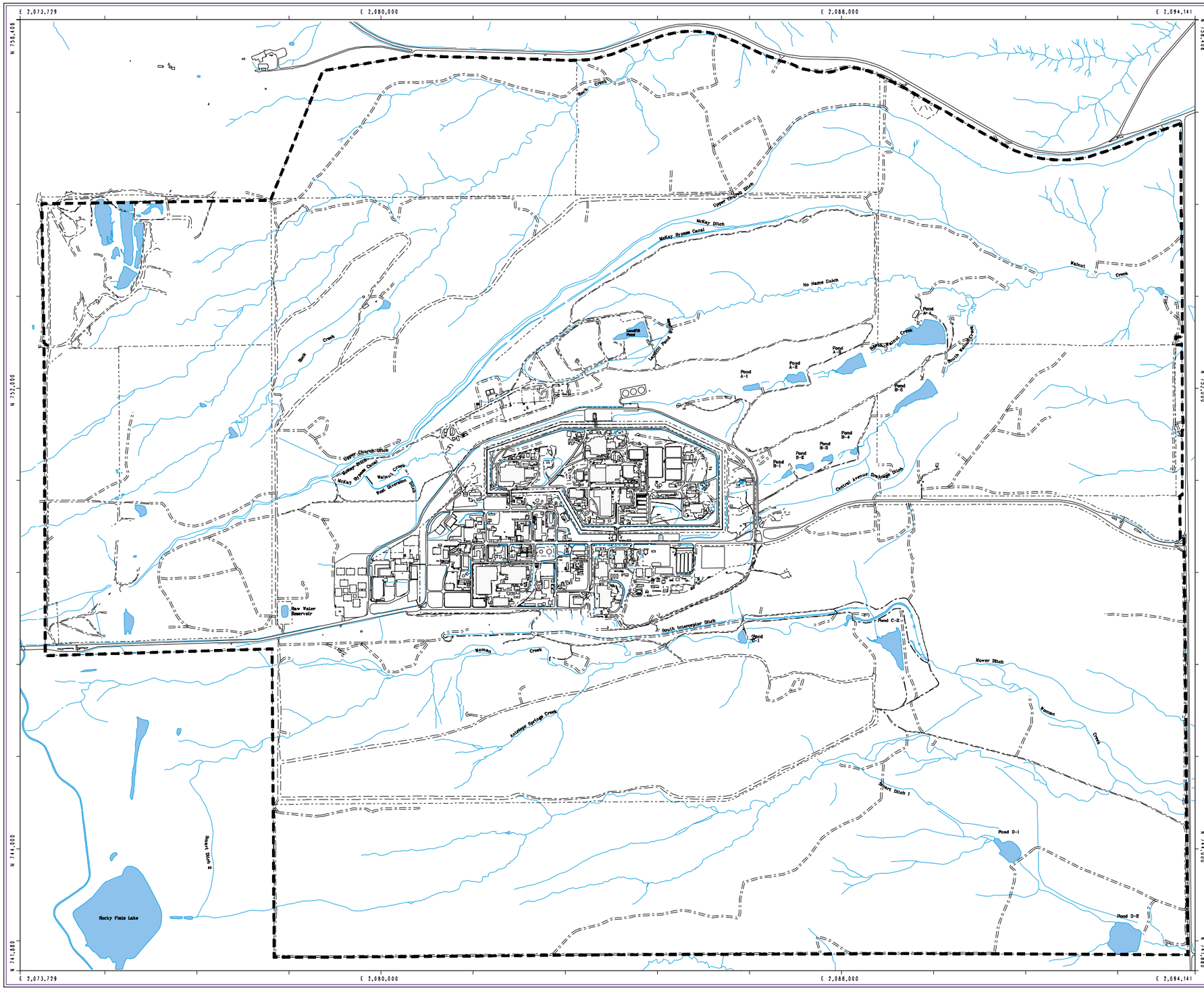


Figure 3-1

Detention Ponds, Ditches, Effluent Watercourses, and Creeks at RFETS

EXPLANATION

Standard Map Features

- Buildings
- Lakes and ponds
- Streams, ditches, or other drainage features
- Fences and other barriers
- Rocky Flats boundary
- Paved roads
- Dirt roads

DATA SOURCE:
Buildings, fences, hydrography, roads and other structures from 1994 aerially-over data captured by EG&G RSL, Las Vegas. Digitized from the orthophotographs. 1/95

Scale = 1 : 21330
1 inch represents approximately 1778 feet

500 0 1000 2000ft

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

Prepared by:

RMRS
Rocky Mountain Remediation Services, L.L.C.
Geographic Information Systems Group
Rocky Flats Environmental Technology Site
P.O. Box 464
Golden, CO 80402-0464

MAP ID: 97-0063

August 10, 1999

NT_Svr w:/projects/fy97/97-0063/surf-features99.aml

3.1.5 General Strategy for Groundwater Plume Management and Remediation

The existence of groundwater contaminant plumes (e.g., volatile organic, radionuclide, nitrate) at RFETS has been well documented. The *Groundwater Conceptual Plan for the Rocky Flats Environmental Technology Site* (RMRS, 1996) presented a summary of the known information on individual groundwater plumes and possible remedial actions. The plume management template below outlines the process for decision making for the management and remediation of plumes at the Site. This template serves as a unifying policy for plume management and decision making for groundwater plumes under the IMP and aids in the integration of groundwater functions at the Site.

The plume management strategy for RFETS will consist of the following components:

- Phase 1: Detection Monitoring:

  The IMP gives DQOs that establish the methods of detection monitoring in groundwater and the actions that will follow. The detection of groundwater contamination that could impact surface water at RFETS will be supported through the current water monitoring programs at RFETS as well as through historic data from past investigations and information on past contaminant spills. The surface and groundwater monitoring programs have been established to detect the migration of contaminants in water on Site that could have the potential to move off Site. The monitoring programs are dynamic and may be changed to accommodate new insights into contaminant migration. The Soil Water Database and the *Final Historic Release Report for the Rocky Flats Plant* (HRR) (DOE, 1992b) are the main repositories for information on groundwater contamination, and both are updated on a regular basis with new data. The Quarterly RFCA Groundwater Reports present data generated from the groundwater monitoring under the IMP. Exceedances of action levels are also identified and discussed in these reports.

- Phase 2: Plume Evaluation

  Plume evaluations to determine the potential for groundwater contamination to impact surface water are triggered by reportable exceedances of action levels as defined in the IMP and as reported in the Quarterly RFCA Groundwater Report. As stipulated in the ALF, the evaluation is predicated on the confirmatory sampling that follows an exceedance of groundwater action levels. The evaluation phase initiates a DQO assessment to determine the data needed to evaluate the nature of groundwater contamination to surface water. The following are possible components of an evaluation of surface water impact as determined by plume specific DQOs:

- Source identification and contaminants of concern,
- Plume extent through determination of pathway linear and areal extents by subsurface correlation of saturated thickness and permeable lithologies,
- Recharge and discharge through quantification of water balance, flow velocity, gradient and direction for groundwater,
- Concentration loadings and mass flux of contaminants to surface water, and
- Effects due to seasonal variations, natural attenuation of contaminants or changes in discharge due to construction/removal of containment structures, treatment systems or removal of sources.

Decisions with respect to plume evaluations will involve the groundwater working group. Results of the plume evaluations will be used to update the environmental restoration (ER) ranking process under RFCA to ensure that the available budget will be allocated to areas with the highest potential for contamination.

- Phase 3: Alternatives Analysis:

If a significant impact to surface water has been established, evaluation findings will be used to establish various options for present and long term management of the contamination. These options may include remedial actions or a long-term monitoring strategy to evaluate whether the nature and extent of contamination will change with time. The decision analysis step may include:

- Evaluation of remedial/management alternatives (per the nine CERCLA evaluation criteria) including the no action alternative,
- Determination of DQOs to support the alternative selected, and
- Consideration of practical implications of each alternative including compatibility with other Site closure activities and potential impact to the ecology and environment.

Alternatives will involve discussion with the groundwater workgroup during key phases of the process. Once an alternative has been selected, a remediation/ management project will be developed with its own scope, schedule and budget. The project will result in a decision document which will include the choice of alternatives, public review and an outline of the remedial design/construction and/or monitoring actions that are necessary.

- Phase 4: Remedial Design/Construction:

  If a remedial action decision has been reached, additional information may be needed to aid in the design and construction of a remedial system. A data quality objective process will be employed to establish the decision and data needs to aid in the construction of the remedial system. The remedial system may consist of a groundwater containment or treatment system, or a source removal action. Components of this step may include:

  — Preparation and presentation of design documents and construction workplans,

  — Preparation and presentation of additional sampling and analysis plans,

  — Determination of performance monitoring requirements, and

  — Alternatives will involve discussion with the groundwater workgroup during key phases of the project.

- Phase 5: Remedial Decision Validation:

  Additional groundwater monitoring may be required to validate the efficacy of a remedial action or the no-action alternative. Performance monitoring will consider both the short term and the long term protection of surface water. A DQO process will be employed to establish a performance monitoring system. Decisions will require involvement of the groundwater workgroup during key phases of the evaluation, and the actions will be implemented through the IMP process. The Quarterly and Annual RFCA Groundwater Reports will track the long term results of the monitoring activities and recommend changes if necessary.

3.2 Groundwater Program Objectives

The objectives of the Site groundwater program are to 1) protect surface water quality, 2) ensure compliance with regulations, 3) minimize the chances of further degradation of the Upper Hydrostratigraphic Unit (UHSU), and 4) support the design and selection of remedial measures and assess the effect of any future remedial actions. Development of the IMP and subsequent updates are the responsibility of the Environmental Restoration Department of Rocky Mountain Remediation Services, L.L.C. (RMRS/ER) under the direction the Kaiser-Hill Company, L.L.C. (Kaiser-Hill) and the DOE, RFFO. RMRS/ER directs and implements the Groundwater Monitoring Program. The Site management structure is shown in Figure 3-2.

3.3 Monitoring Objectives

The Site Groundwater Monitoring Program will be integrated with ongoing activities designed to protect surface water from contamination by groundwater. The Groundwater Monitoring Program will do the following:

- Identify groundwater containing contaminants;
- Identify and control contaminant sources;
- Identify contaminant pathways;
- Monitor contaminant concentrations;
- Monitor remediation and decontamination and decommissioning (D&D) actions;
- Protect groundwater from new sources of contamination; and
- Evaluate the effects of groundwater contaminants on surface water.

3.3.1 Identification of Potential Contaminants

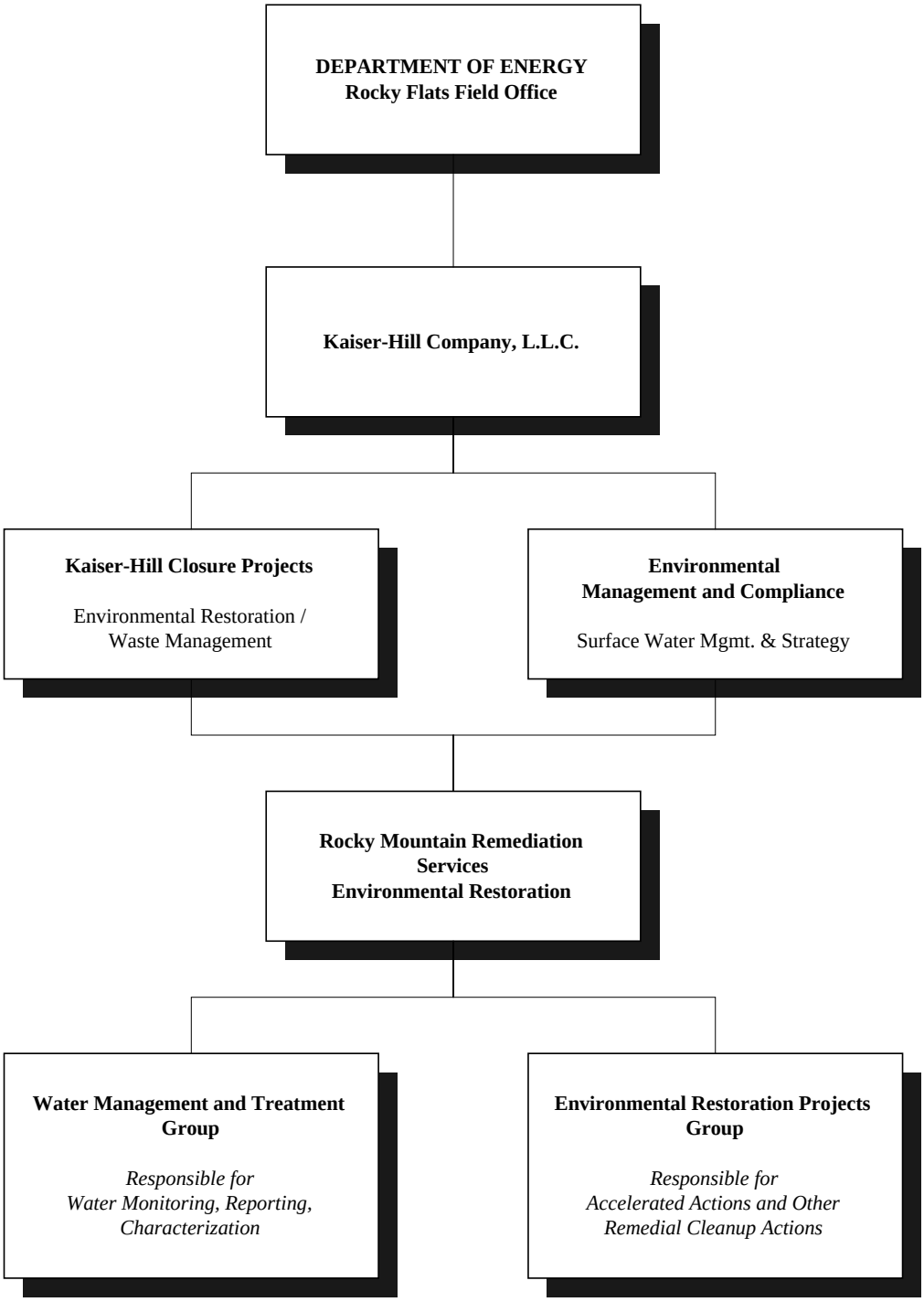
A chemical inventory system has operated since 1986. The current real-time chemical tracking system, which identifies chemicals used on Site that are potential contaminants, has been in operation since 1990. It fulfills RCRA requirements to track the disposition of hazardous chemicals. The Waste Programs Organization at the Site manages this tracking system.

In addition, the HRR (DOE, 1992b) was compiled to originally document spills and other releases of potentially hazardous chemicals at the Site. This report is updated annually and is maintained by the RMRS/ER Department.

3.3.2 Identification and Control of Contaminant Sources

Site area sources contaminated with hazardous substances are identified as Individual Hazardous Substance Sites (IHSSs) and have been characterized under the Remedial Investigation/Feasibility Study (RI/FS) process. The IHSS ER Ranking Project is required under RFCA to determine the relative risk associated with contaminant sources and assign a priority for remediation. Those IHSSs that have contributed to groundwater contamination have been identified and put into the priority list for remediation. The HRR will document any new sources of contamination and will assign an IHSS number to a significant release.

Figure 3-2
Organizational Responsibilities for Groundwater



3.3.2.1 Current Contaminated Areas

The remedial investigations at Operable Units (OUs) (a grouping of IHSSs) have provided adequate data for determining potential contamination sources for much of the Site. The Industrial Area OU has not been characterized as thoroughly as other OUs, but initial soil screening results helped to characterize sources in this area.

Table A-1 lists the IHSSs at the Site. Information about the effect of contaminated areas on groundwater is described in Appendix D to this section. Table D-1 lists the potential contaminants of concern (PCOC) in groundwater and in other media, based on risk assessment criteria in the OUs that have been characterized. The remedial investigations at OUs, combined with Site-wide groundwater characterization activities, have identified a number of groundwater contaminant plumes that emanate from contaminant sources. These plumes are described in Appendix D to this section. The dominant category of hazardous contaminants in groundwater are VOCs. Where feasible, general plume maps have been developed to show the extent of contamination in UHSU groundwater. Plate 3 shows the composite plumes of VOCs and the Solar Ponds nitrate plume. Analyte suites have been developed for wells that reflect the major contaminants of concern.

In areas where groundwater will be monitored during D&D activities, building-specific potential PCOCs will be developed. The RFCA ALF requires performance monitoring of remedial actions. Analyte suites will be developed for these wells based on knowledge of the contaminants of concern at the remediation site (DOE, 1996). However, a full sample suite will initially be collected for these wells as a check on known PCOCs.

Remediation activities protect groundwater by minimizing further migration of potential contaminants and by cleaning contaminated areas. Data are gathered to identify the extent of contamination and the rate of contaminant migration, and to develop a plan for appropriate remedial actions. Data generated by the Groundwater Monitoring Program support the goals of identifying and remediating existing contaminated areas, detecting new contamination caused by D&D or other activities, and preventing contamination of surface water.

3.3.2.2 Hazardous Waste Management Areas

Hazardous or mixed waste management areas at the Site are generally operated in compliance with the RCRA requirements applicable to each area. These are further described in the *Spill Prevention, Control, and Countermeasures/Best Management Practices (SPCC/BMP) Plan* (EG&G, 1992) and the RCRA Part B Permit. The RCRA waste management functions at the Site are the responsibility of Waste Programs.

3.3.2.3 Storage Tanks

The more than 2,000 storage tanks at the Site include underground storage tanks, production or process waste tanks, chemical feed tanks, and fuel oil tanks. Most production and process waste tanks are considered to have secondary containment because they are located inside buildings or have systems that contain spills. Some of the chemical feed and fuel oil tanks also have spill containment systems; these tanks are considered low risk for spills to the ground and thus unlikely to contaminate groundwater.

Further characterization and spill controls for non-waste storage tanks will be achieved with the implementation of the Tank Management Plan, which was developed as a result of the 1989 chromic acid incident (EG&G, 1990). The tank management project employs formal design, testing, and inspection standards to evaluate tanks and prevent environmental contamination. This Tank Management Plan complies with Title 40 of the *Code of Federal Regulations* (CFR) Parts 280, 281, and 282, where applicable. The Waste Programs Organization at the Site maintains and controls the tanks.

3.3.2.4 Process Waste System

The process waste system comprises process waste lines and valve vaults. Groundwater is protected from these systems by 1) inspection of single-contained lines, which are only in accessible locations, 2) development of secondary-containment systems for lines that are not as accessible, and 3) continuous monitoring of leak detectors.

3.3.2.5 Building Drains

The Drain Identification Study (DIS) at OU8 (DOE, 1994b) identifies all those buildings with floor and footing drains located in areas containing potentially hazardous substances, and characterizes whether they lead to sanitary or process waste treatment facilities. Floor and footing drains are considered potential contaminant pathways since a large spill could enter the drains and be transported to the surface-water control system. Should this happen, the spill would be retained, sampled, treated, and released in compliance with permit conditions. Final completion of all DIS tasks, including corrective actions, was completed in August 1996. The *Technical Memorandum No. 1 Data Compilation, Rocky Flats Plant, 700 area (OU8)* (DOE, 1994b) compiles locations and specifications on foundation drains, storm sewers, and sanitary sewers. This information may help define how the drain systems could affect groundwater and surface water flow and migration.

3.3.2.6 Other Potential Contamination Sources

Underground buildings, building operations, and building sumps are also potential sources of contamination. The effect of these sources on groundwater will be further investigated as part of the RMRS/ER program and integrated with D&D activities.

3.3.3 Identification of Potential Contaminant Pathways

To assess the direction and magnitude of contaminant movement, both natural and manmade groundwater migration pathways must be known. The Site groundwater flow regime is determined from water level measurements at monitoring wells. This information can be used to help estimate recharge and discharge rates, and it can be incorporated into water table maps and groundwater flow models that help predict the path along which contaminants migrate.

3.3.4 Identification of Contaminant Concentrations

Routine chemical analysis of groundwater identifies both the contaminants present and the concentration of contaminants with respect to Site action levels or standards. Background concentrations have been established for most inorganic compounds present in groundwater at the Site. These Site-specific background levels are used to help determine concentrations that are anomalous with respect to natural levels. Increases in contaminant concentrations with time may indicate that contaminants are migrating from sources that could affect surface water.

3.3.5 Monitoring of Remedial Actions

The majority of the Site remedial investigation and characterization activities have been completed. Based on these remedial investigations, some interim remedial actions have already been completed, such as the groundwater treatment systems that have been built at the former OU4 and the former OU1. Performance monitoring of groundwater is required for those remedial activities where groundwater has been impacted.

The Interceptor Trench System (ITS) was installed on the hillside north of the Solar Ponds to decrease groundwater migration towards Walnut Creek and to collect groundwater contaminated with high concentrations of radionuclides and nitrate. The water collected in the ITS is pumped to the Building 374 Treatment Plant for processing. Groundwater is not currently monitored immediately downgradient of the ITS, but the Walnut Creek drainage below the ITS is monitored to detect contaminants that are not collected by the system.

The OU1 French Drain System was installed on the 881 Hillside to collect groundwater migrating towards Woman Creek. In addition, groundwater is intercepted in a collection well located near the French Drain and transferred to the Building 891 Treatment Plant nearby. Water that enters the drain is also pumped to the Building 891 Treatment Plant for processing. Groundwater is monitored downgradient of the French Drain system to detect any leakage of potentially contaminated groundwater toward Woman Creek.

Additional remedial activities are planned, as accelerated actions, to excavate and remove hazardous waste sources and to set up additional treatment systems for groundwater. The ALF addendum to RFCA requires performance monitoring of groundwater affected by remedial cleanup activities. It is anticipated that performance monitoring decisions will be made on a case-by-case basis but will follow a general decision rule that is described in a later section.

3.3.6 Protection from New Contaminant Sources

Future plans for the Site involve decommissioning of Site production systems, building demolition, and excavation and removal or capping of source areas. The IM/IRA for the Industrial Area (DOE, 1994a) proposed a framework for monitoring the effects of building D&D on air, surface water, and groundwater quality. Groundwater will be monitored before, during, and immediately after any operation that could potentially degrade groundwater quality. This monitoring will determine the Site-specific ambient groundwater conditions and detect any release of contaminants to groundwater. Construction activities are also assessed to ensure that groundwater quality is not compromised. Groundwater protection will be considered in future D&D work plans to supplement existing programs for water collected and contained in the building footing drains, basements, valve vaults, and sumps in the Industrial Area . The goal is to monitor the Industrial Area perimeter and promptly detect any contaminant releases, primarily during D&D activities.

Additional sources of Site groundwater contamination may be identified by evaluating data from the groundwater monitoring network at the Site. Evaluation of these data may identify new areas with elevated contaminant concentrations.

3.3.7 Evaluation of Groundwater Contaminant Impacts on Surface Water

In the event that monitoring shows that a groundwater contaminant plume may reach and impact surface water, evaluations will be made to assess this impact. An activity plan will be prepared to identify the specific DQOs necessary for the proper collection and interpretation of information, such that an impact assessment can be made. Once a determination of impact to surface water has been made, a remedial action priority will be assigned.

3.4 Groundwater Data Quality Objectives

DQOs are qualitative and quantitative statements that specify the type, quality, and quantity of the data required to support decision making. At the programmatic level, DQOs are established to ensure that a project has been logically defined and planned, and that project scope will support the eventual decisions required. At the operational level, quality control objectives (QCOs) are established to ensure that data generated by the project will withstand scientific and legal scrutiny, and that the data will be gathered or developed using procedures appropriate for the intended use of the data.

3.4.1 Programmatic Data Quality Objectives

The DQO process was applied to the Site groundwater program at both a programmatic and decision-specific level. At the programmatic level, the DQO process was used to qualitatively evaluate the overall need for, and purpose of, groundwater monitoring. This effort established that groundwater data are needed to comply with applicable regulations, agreements, permits, and

to prevent unacceptable risks to public health and the environment through impacts to surface waters of the state. The information required to satisfy these requirements results from regular sampling of wells and surface locations selected to meet the above criteria. These data will be used to detect and document concentrations above limits established by regulations, agreements, permits, or risk-based analysis; to support planning, implementation, and assessment of removals, remedial actions, and D&D projects; to support modeling and evaluations; and to meet commitments to issue periodic monitoring reports to regulators. Sampling locations and frequency have been negotiated with regulators; locations were chosen to detect migration of known contaminant plumes along pathways and across boundaries. Analytical results need to be of high quality, owing to the many uses of the data — modeling, risk assessment, performance assessment, and compliance. These programmatic statements establish the general need for a groundwater monitoring program and outline program elements that need to be included.

3.4.2 Data Quality Objectives for Program Elements

The second DQO effort developed individual monitoring program decision elements. DQOs were approached on a medium-specific basis, although the goal was to integrate monitoring requirements for all media (e.g., surface water, ecology, air). Groundwater monitoring DQOs were developed for each component of the program and problem statements were established. These problem statements were then refined into a decision statement that specified corrective actions for that problem. Then data were identified and methods of analysis outlined to support the decision. Boundaries and scope are defined to clarify the spatial and temporal focus of the required monitoring information and exclude nonessential aspects of the problem. A decision rule was specified to document how data will be summarized to draw a conclusion upon which a decision will be based.

The groundwater monitoring network was defined with the Site-wide components described below.

- Plume Definition Wells: Wells that are within known contaminant plumes and are above Tier II Action Levels, but are below the Tier I Action Levels established in the ALF. These wells will be monitored to determine whether concentrations of contaminants are increasing, and, if a Tier I Action Level is exceeded, will be reported as a Tier I exceedance and be prioritized for remedial action.

- Plume Extent Wells: Wells at the edges of known groundwater contaminant plumes along pathways to surface water. A subset of these wells is listed in the ALF as Tier II Wells. The wells are monitored for increases in concentrations that would exceed Tier II Action Levels stated in the ALF, and they indicate movement that may result in contamination of surface water.

- Drainage Wells: Monitoring wells located in stream drainages downgradient of contaminant plumes. If contamination reaches these wells, and action levels are exceeded, they fall under the same requirements as plume extent wells.

- Boundary Monitoring Wells: Wells used to monitor the quality of groundwater leaving the eastern Site boundary.

In addition to this general groundwater monitoring scheme, specific requirements support regulatory directives. The following special categories are included as groundwater program elements:

- D&D Monitoring Wells: Wells used to monitor releases to groundwater from D&D activities on specific buildings. This requirement is specified in the IM/IRA for the Industrial Area (DOE, 1994a).

- Performance Monitoring Wells: Wells used to monitor the effect of a remedial treatment or source removal action. Performance monitoring of source remediation is specifically required in the RFCA ALF for groundwater. The French drain performance monitoring wells are included in this category and are specified in the French Drain IM/IRA plan (DOE, 1992a).

- RCRA Compliance Wells: Wells used in upgradient and downgradient monitoring of RCRA interim status units. This requirement is specified under 6 *Code of Colorado Regulations* (CCR) 1007-3. Wells monitored at the new landfill would be specified under 6 CCR 1007-2. Future retrievable storage facilities would also fall under the RCRA monitoring category.

On-Site groundwater has a surface water protection use classification and must be managed to be protective of surface water quality. The ALF lists specific analytes and the associated groundwater action levels. All DQO decisions will reflect the RFCA requirement to support the surface water protection classification. Each component of the groundwater program can be considered a decision element, and decision statements have been created for each component.

3.4.2.1 Plume Definition Wells

Problem Statement:

Are contaminants within groundwater plumes increasing in concentration with time or reaching Tier I Action Levels with the potential to impact surface water?

Problem Scope:

Plume definition wells lie within the currently known groundwater contaminant plumes and are located appropriately to monitor groundwater pathways that could affect surface water. Plume definition wells are designated based on knowledge of existing groundwater contaminant plumes and particle flow models that simulate groundwater pathways. It is possible that some plume definition wells have historically exceeded Tier I Action Levels. For these wells, only new exceedances of Tier I Action Levels

involving compounds that have concentrations greater than historic levels will cause the well to be reprioritized for remedial action.

Inputs:

- RFCA Tier I Action Levels;
- Background mean + 2 standard deviations;
- Historic baseline for contaminants;
- Selected analyte suites based on historic data (see Appendix E to this section);
- Historic data trends for contaminants;
- Field parameters; and
- Water levels.

Boundaries:

Spatial: Wells are located in areas known to be contaminated above the Tier II Action Level. Decisions will be made on an individual well basis.

Temporal: Data will be reviewed quarterly and decisions will be made annually.

Decision Statement:

IF Measured concentrations in well exceed Tier I Action Levels and background mean +2 standard deviations—

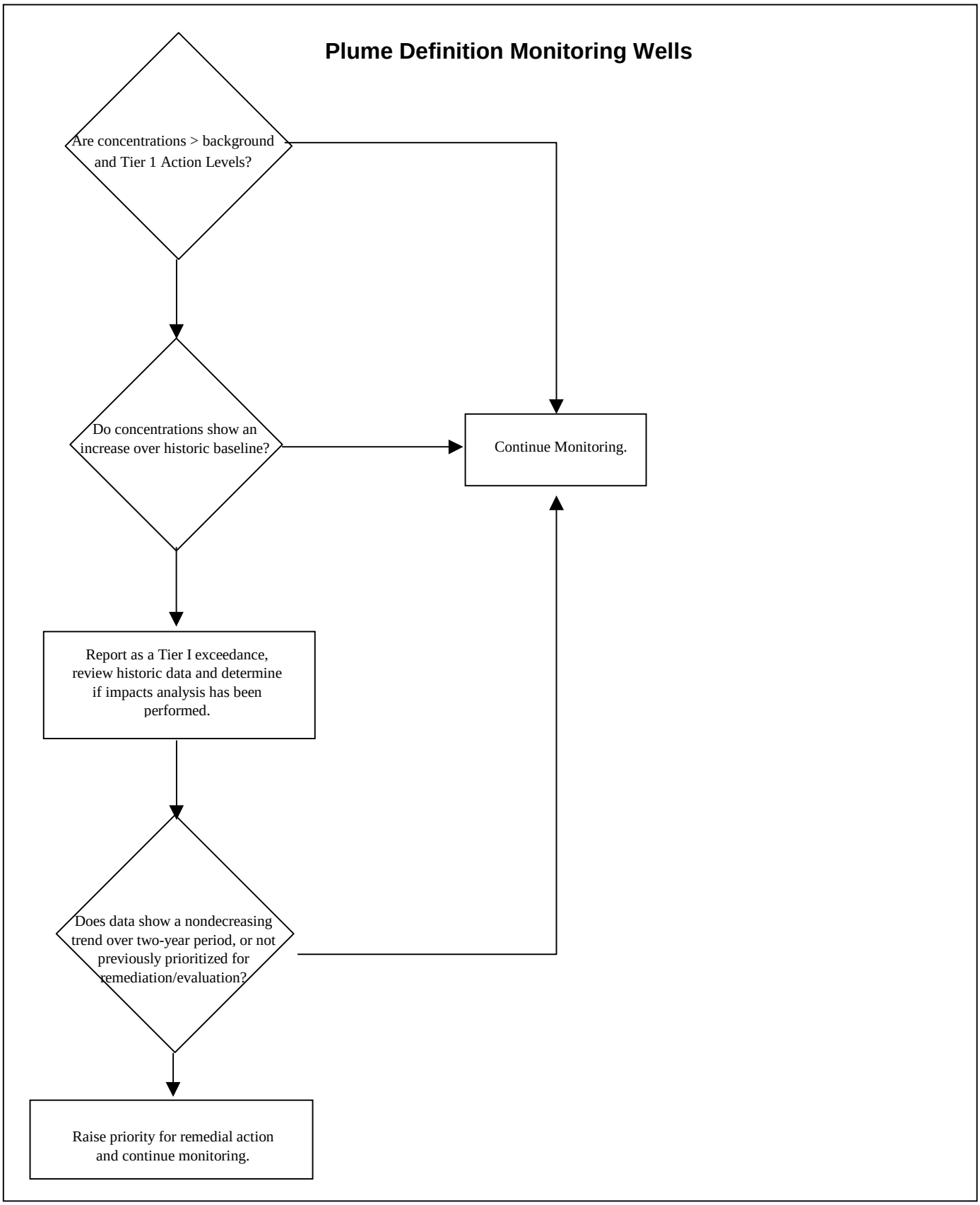
THEN Report as a Tier I exceedance and review historic data for well to determine if it has been prioritized for remediation/evaluation based on potential impact to surface water.

IF Data show a nondecreasing or increasing trend over a two-year period, or well has not been previously prioritized for remediation—

THEN Update priority for remediation/evaluation,

ELSE Continue monitoring.

Logic:


Plume Definition Monitoring Wells
Are concentrations > background and Tier 1 Action Levels?
Do concentrations show an increase over historic baseline?
Continue Monitoring.
Report as a Tier I exceedance, review historic data and determine if impacts analysis has been performed.
Does data show a nondecreasing trend over two-year period, or not previously prioritized for remediation/evaluation?
Raise priority for remedial action and continue monitoring.

3.4.2.2 Plume Extent Monitoring Wells

Problem Statement:

Have concentrations in wells exceeded Tier II Action Levels?

Problem Scope:

Plume extent monitoring is conducted to detect potential impact to surface water from known or suspected groundwater contamination plumes. Some of these wells are specifically listed as Tier II wells in the RFCA ALF for groundwater. If groundwater exceeds Tier II Action Levels, an evaluation is required to determine if remedial or management action is necessary to prevent surface water from exceeding standards. It is possible that some plume extent wells have historically exceeded Tier II Action Levels. For these wells, only new compounds with exceedances of Tier II Action Levels or involving compounds that have concentrations greater than historic levels will be sampled on a monthly basis as required by RFCA.

Inputs:

- RFCA Tier II Action Levels;
- Background mean + 2 standard deviations;
- Historic baseline for contaminants;
- Selected analyte suites based on historic data (see Appendix E to this section);
- Historic data trends for contaminants;
- Field parameters; and
- Water levels.

Boundaries:

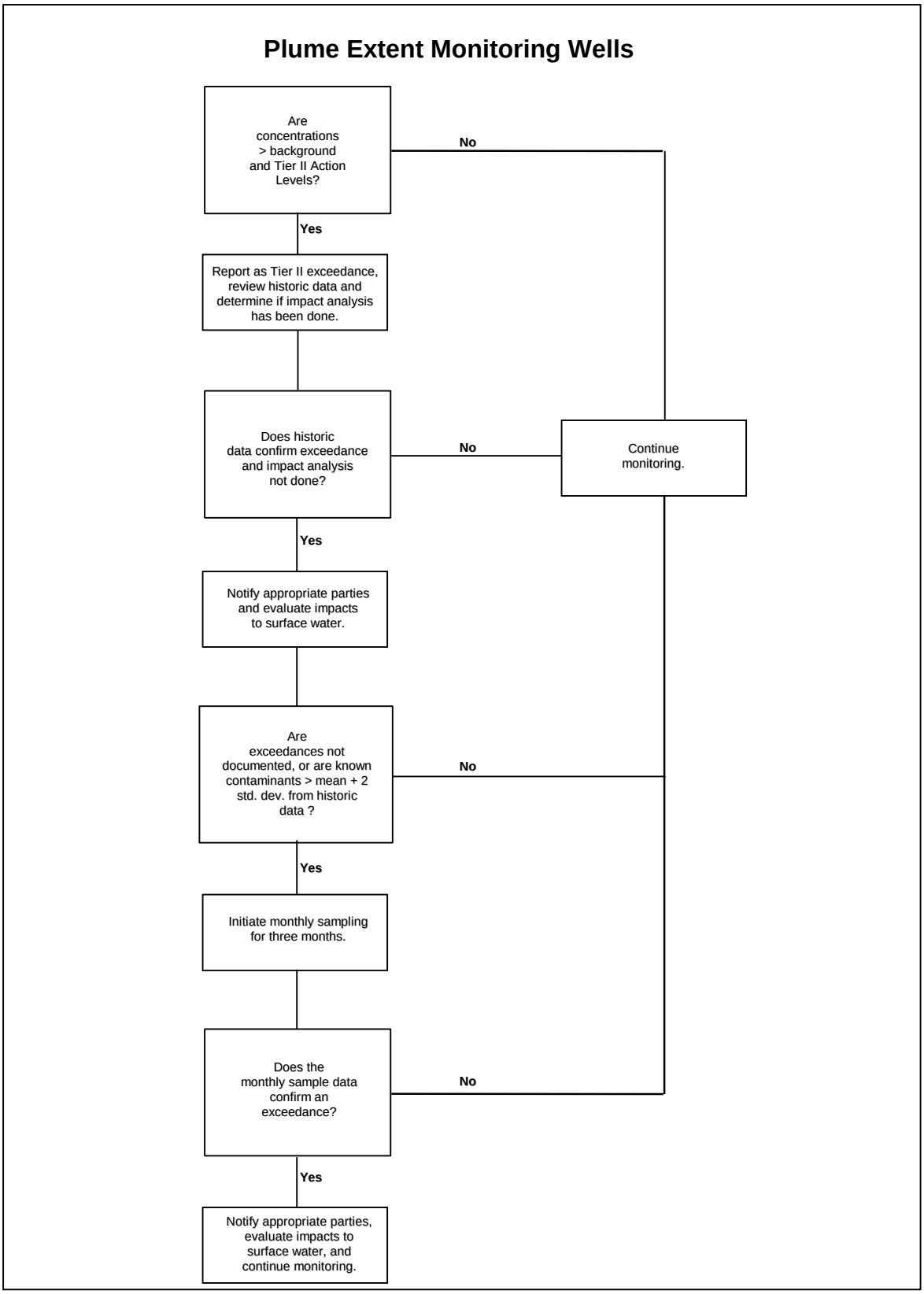
Spatial: Decisions will be made on an individual well basis.

Temporal: Data will be reviewed quarterly and decisions will be made on an annual basis.

Decision Statement:

IF	Sample results show detections in a well that exceed Tier II action levels and background mean + 2 standard deviations—
THEN	Report as a Tier II exceedance, review historic data for well, and determine if evaluation of impact to surface water has been done.
IF	Historic data confirm the exceedance and impact evaluation has not been done—
THEN	Notify appropriate parties and evaluate impacts to surface water.
IF	Historic exceedances have not been documented or concentrations for a known contaminant are greater than the mean + 2 standard deviations with respect to the historic data set for that well—
THEN	Initiate monthly sampling for three months.
IF	Monthly sampling confirms the exceedance—
THEN	Notify appropriate parties and determine whether a remedial or management action is necessary,
ELSE	Continue monitoring.

Logic:


Plume Extent Monitoring Wells
Are concentrations > background and Tier II Action Levels?
No
Yes
Report as Tier II exceedance, review historic data and determine if impact analysis has been done.
Does historic data confirm exceedance and impact analysis not done?
No
Continue monitoring.
Yes
Notify appropriate parties and evaluate impacts to surface water.
Are exceedances not documented, or are known contaminants > mean + 2 std. dev. from historic data ?
No
Yes
Initiate monthly sampling for three months.
Does the monthly sample data confirm an exceedance?
No
Yes
Notify appropriate parties, evaluate impacts to surface water, and continue monitoring.

3.4.2.3 Drainage Monitoring Wells

Problem Statement:

Do contaminants that have reached surface water in groundwater exceed action levels, and are they migrating downgradient in valley fill alluvium?

Problem Scope:

In some areas, groundwater contamination from multiple sources has migrated to surface water drainages. Drainage wells monitor groundwater in valley fill alluvium downstream of areas where contaminant plumes may have reached surface water stream drainages. Any contaminants detected in stream drainages are assumed to have affected surface water and to have the potential to migrate off Site. It is possible that some drainage wells have historically exceeded Tier II Action Levels. For these wells, only new compounds with exceedances of Tier II Action Levels or involving compounds that have concentrations greater than historic levels will be sampled on a monthly basis as required by RFCA.

Inputs:

- RFCA Tier II Action Levels;
- Background mean + 2 standard deviations;
- Historic baseline for contaminants;
- Selected analyte suites based on historic data (see Appendix E to this section);
- Historic data trends for contaminants;
- Field parameters; and
- Water levels.

Boundaries:

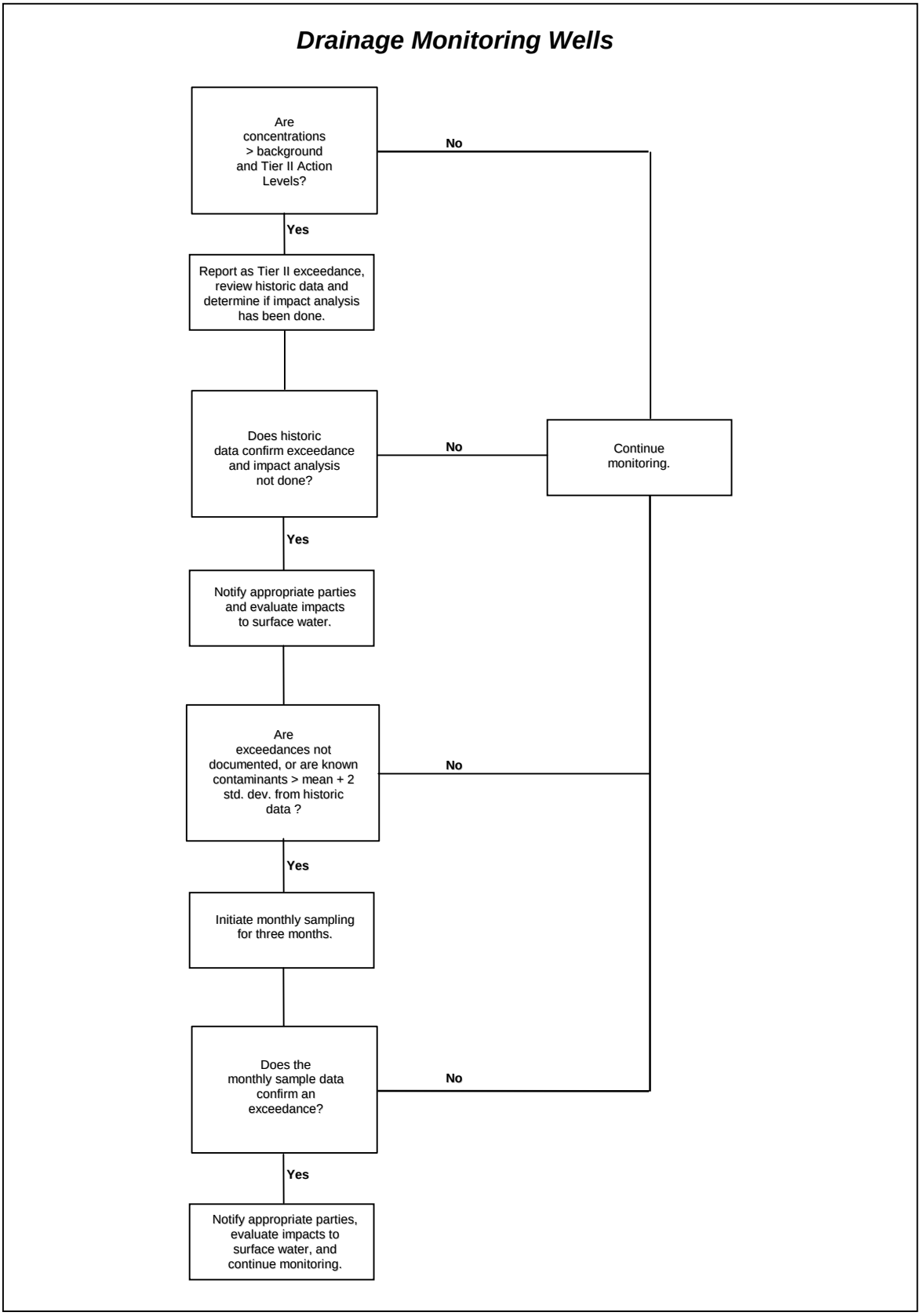
Spatial: Decisions will be made on an individual well basis.

Temporal: Data will be reviewed quarterly and decisions will be made annually.

Decision Statement:

IF	Sample results show detections in a well that exceed Tier II Action Levels and background mean + 2 standard deviations—
THEN	Report as a Tier II exceedance, review historic data for well, and determine if evaluation of impact to surface water has been done.
IF	Historic data confirm the exceedance and impact evaluation has not been done—
THEN	Notify appropriate parties and evaluate impacts to surface water.
IF	Historic exceedances have not been documented or concentrations for a known contaminant are greater than the mean + 2 standard deviations with respect to the historic data set for that well—
THEN	Initiate monthly sampling for three months.
IF	Monthly sampling confirms the exceedance—
THEN	Notify appropriate parties and evaluate impacts to surface water,
ELSE	Continue monitoring.

Logic:


Drainage Monitoring Wells
Are concentrations > background and Tier II Action Levels?
No
Yes
Report as Tier II exceedance, review historic data and determine if impact analysis has been done.
Does historic data confirm exceedance and impact analysis not done?
No
Continue monitoring.
Yes
Notify appropriate parties and evaluate impacts to surface water.
Are exceedances not documented, or are known contaminants > mean + 2 std. dev. from historic data ?
No
Yes
Initiate monthly sampling for three months.
Does the monthly sample data confirm an exceedance?
No
Yes
Notify appropriate parties, evaluate impacts to surface water, and continue monitoring.

3.4.2.4 Boundary Monitoring Wells

Problem Statement:

Do contaminants in groundwater exceed groundwater action levels, and do they migrate off Site?

Problem Scope:

Boundary wells monitor groundwater at the downstream boundary of the Site. Any contaminants detected in boundary wells that are above background and also above action levels are assumed to have impacted surface water and to have migrated off Site. Historically, the Site has monitored wells at the Indiana Street boundary to provide the surrounding cities with added certainty that there are no contaminants in alluvial groundwater leaving the Site. It is possible that some boundary wells historically exceeded Tier II Action Levels. For these wells, only new compounds that exceed Tier II Action Levels or that have concentrations greater than historic levels will be sampled on a monthly basis as required by RFCA.

Inputs:

- RFCA Tier II Action Levels;
- Background mean + 2 standard deviations;
- Historic baseline for contaminants;
- Selected analyte suites based on historic data (see Appendix E to this section);
- Historic data trends for contaminants;
- Field parameters; and
- Water levels.

Boundaries:

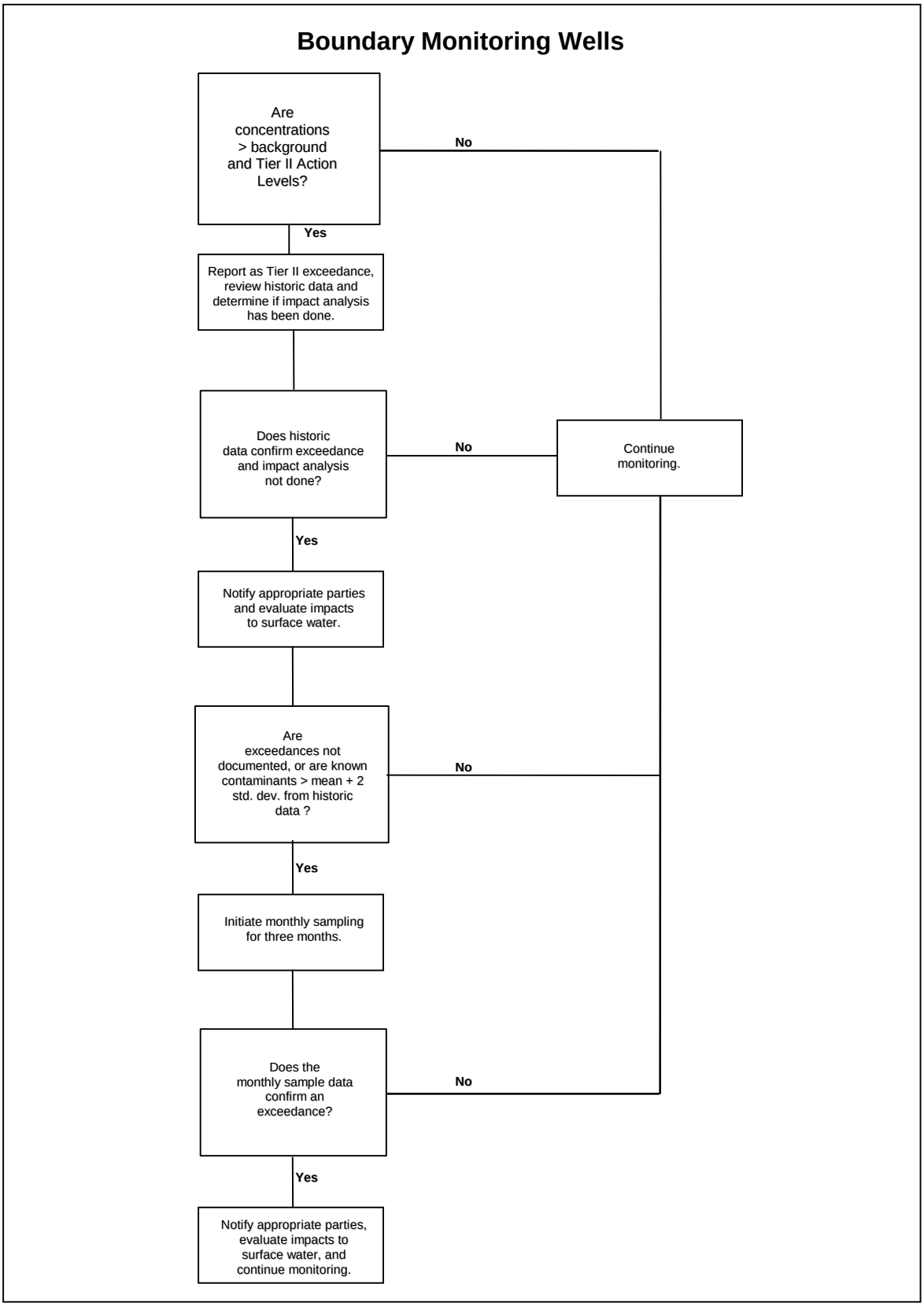
Spatial: Alluvial groundwater in the drainages at the Indiana Street boundary. Decisions will be made on an individual well basis.

Temporal: Data will be reviewed quarterly and decisions will be made annually.

Decision Statement:

IF	Sample results show detections in a well that exceed Tier II Action Levels and background mean + 2 standard deviations—
THEN	Report as a Tier II exceedance, review historic data for well, and determine if evaluation of impact to surface water has been done.
IF	Historic data confirms the exceedance and impact evaluation has not been done—
THEN	Notify appropriate parties and evaluate impacts to surface water.
IF	Historic exceedances have not been documented or concentrations for a known contaminant are greater than the background mean + 2 standard deviations with respect to the historic data set for that well—
THEN	Initiate monthly sampling for three months.
IF	Monthly sampling confirms the exceedance—
THEN	Notify appropriate parties and evaluate impacts to surface water,
ELSE	Continue monitoring.

Logic:


Boundary Monitoring Wells
Are concentrations > background and Tier II Action Levels?
No
Yes
Report as Tier II exceedance, review historic data and determine if impact analysis has been done.
Does historic data confirm exceedance and impact analysis not done?
No
Continue monitoring.
Yes
Notify appropriate parties and evaluate impacts to surface water.
Are exceedances not documented, or are known contaminants > mean + 2 std. dev. from historic data ?
No
Yes
Initiate monthly sampling for three months.
Does the monthly sample data confirm an exceedance?
No
Yes
Notify appropriate parties, evaluate impacts to surface water, and continue monitoring.

3.4.2.5 Building–Specific D&D Monitoring Wells

Problem Statement:

Have building-specific D&D activities degraded groundwater in a way that can impact surface water?

Problem Scope:

Building-specific D&D activities involve three major steps: deactivation of building processes, demolition of building structures, and remediation of building foundations and surroundings. The IM/IRA for the Industrial Area (U.S. DOE, 1994) outlines monitoring activities to ensure that building-specific D&D actions do not inadvertently degrade surface water through a groundwater transport pathway. The proposed monitoring will provide the data needed to determine if precautions or actions taken during D&D adequately prevent migration of contaminants to groundwater. D&D monitoring will begin at least one year before building demolition and continue for five years after demolition, sampled on a semiannual frequency.

Inputs:

- Building-specific PCOCs (to be determined);
- Baseline mean + 2 standard deviations;
- Field parameters (to be determined); and
- Water levels.

Boundaries:

Spatial: Decisions will be made on an individual well basis.

Temporal: Data will be reviewed quarterly and decisions will be made annually.

Decision Statement:

IF Existing information from a proposed D&D activity indicates a potential threat to surface water through a groundwater pathway—

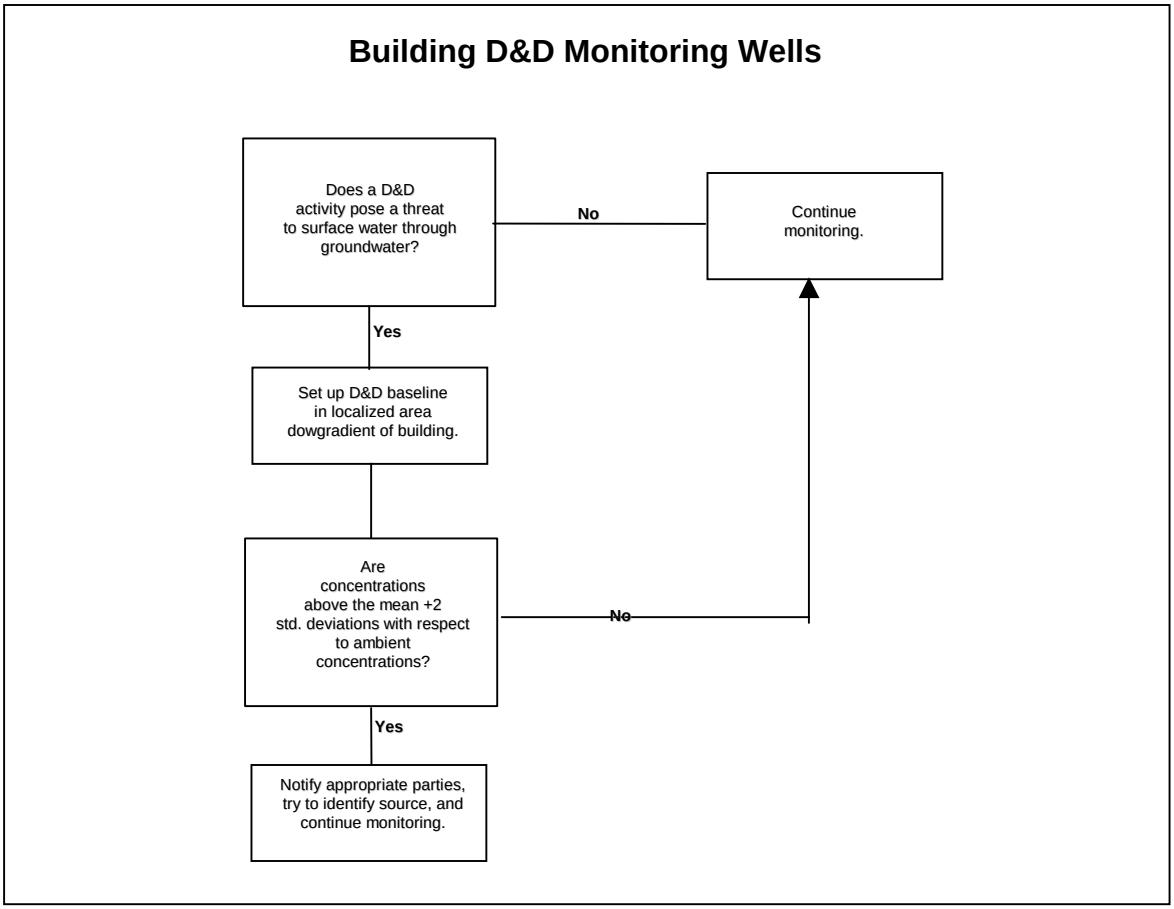
THEN Establish a pre-D&D baseline using wells located upgradient and downgradient of buildings.

IF Exceedances are detected greater than the mean + 2 standard deviations above baseline—

THEN Inform appropriate parties and evaluate the problem,

ELSE Continue monitoring.

Logic:



3.4.2.6 Performance Monitoring Wells

Problem Statement

Have remedial actions improved or further impacted groundwater?

Problem Scope:

Performance monitoring assesses the effectiveness of remedial activities such as contaminant source removals or treatment systems that are installed to clean groundwater plumes. In general, source removals are monitored by comparing current values to values

that existed before the remedial action. RFCA requires performance monitoring of all groundwater and appropriate soil remediation actions. Specific activities will be determined on a case-by-case basis and will be established in decision documents for those projects where it is required. Details will be determined by the groundwater work group in conjunction with project managers and incorporated into the IMP.

Inputs:

- Source-specific PCOCs (to be determined);
- Field parameters (to be determined); and
- Water levels.

Boundaries:

Spatial: Decisions will be made on a well-by-well basis. Wells will be placed downgradient from sources undergoing remediation.

Temporal: Data will be reviewed quarterly and decisions will be made annually.

Decision Statement:

IF Existing data or information from a remedial activity suggest potential impact through groundwater pathways to surface water—

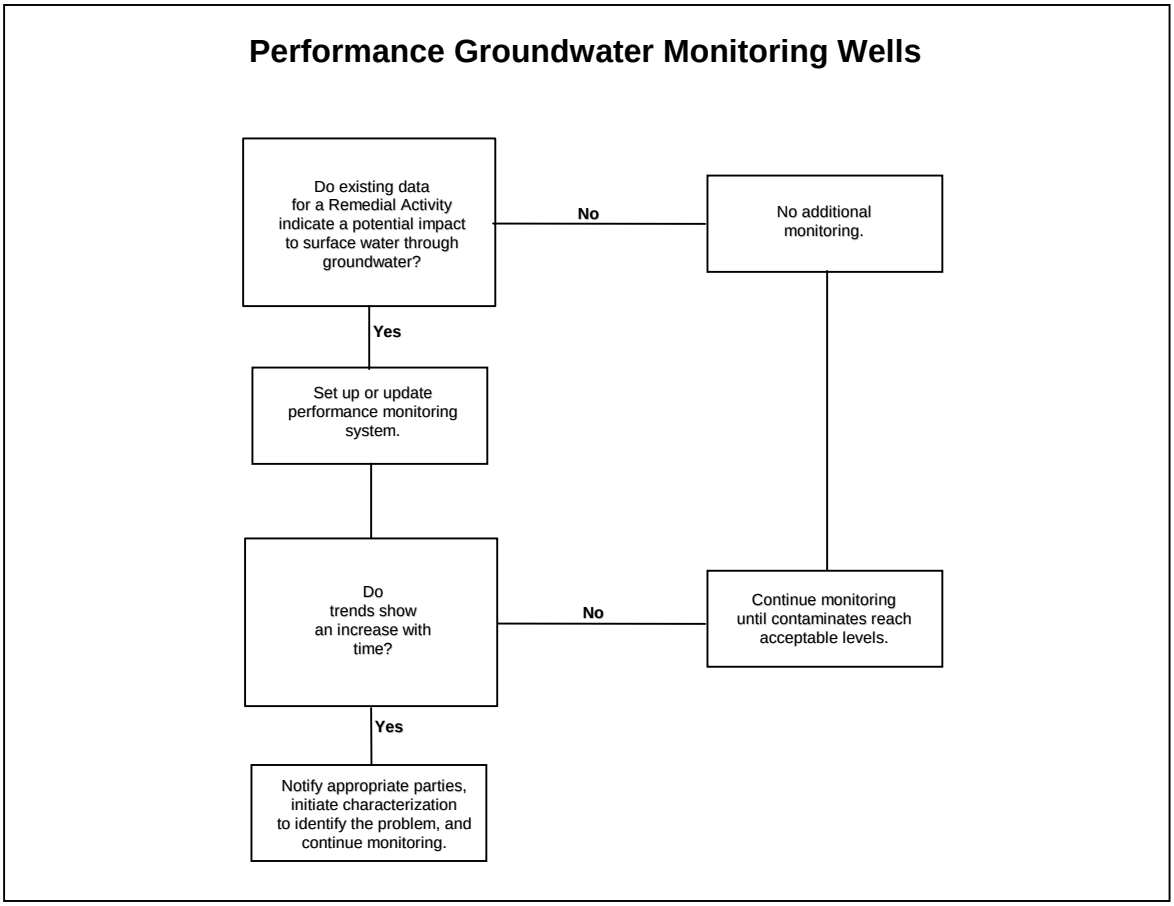
THEN Establish monitoring points and initiate sample collection.

IF Monitoring detects that the concentration of contaminants increases with time—

THEN Inform appropriate parties and initiate evaluation to assess the extent of the problem,

ELSE Continue monitoring until contaminant levels are reduced to acceptable levels.

Logic:



3.4.2.7 RCRA Monitoring Wells

Problem Statement:

Have concentrations of contaminants in downgradient monitoring wells exceeded the mean concentrations in upgradient monitoring wells at RCRA units?

Problem Scope:

RCRA monitoring is conducted to detect potential excursions of contamination that are below the point of compliance established for RCRA units on Site. RCRA units are considered to be any units that are regulated under 6 CCR 1007-2 solid waste requirements, such as the Existing Landfill and the New Sanitary Landfill, and any future waste repositories. Attachment 10 of the RFCA will be followed in determining points of compliance and alternate concentration limits affecting these units.

Inputs:

- Unit-specific PCOCs;
- Field parameters; and
- Water levels.

Boundaries:

Spatial: Decisions will be made based on pooled results of upgradient wells and on a well head basis in downgradient wells.

Temporal: Data will be reviewed quarterly and decisions will be made annually.

Decision Statement:

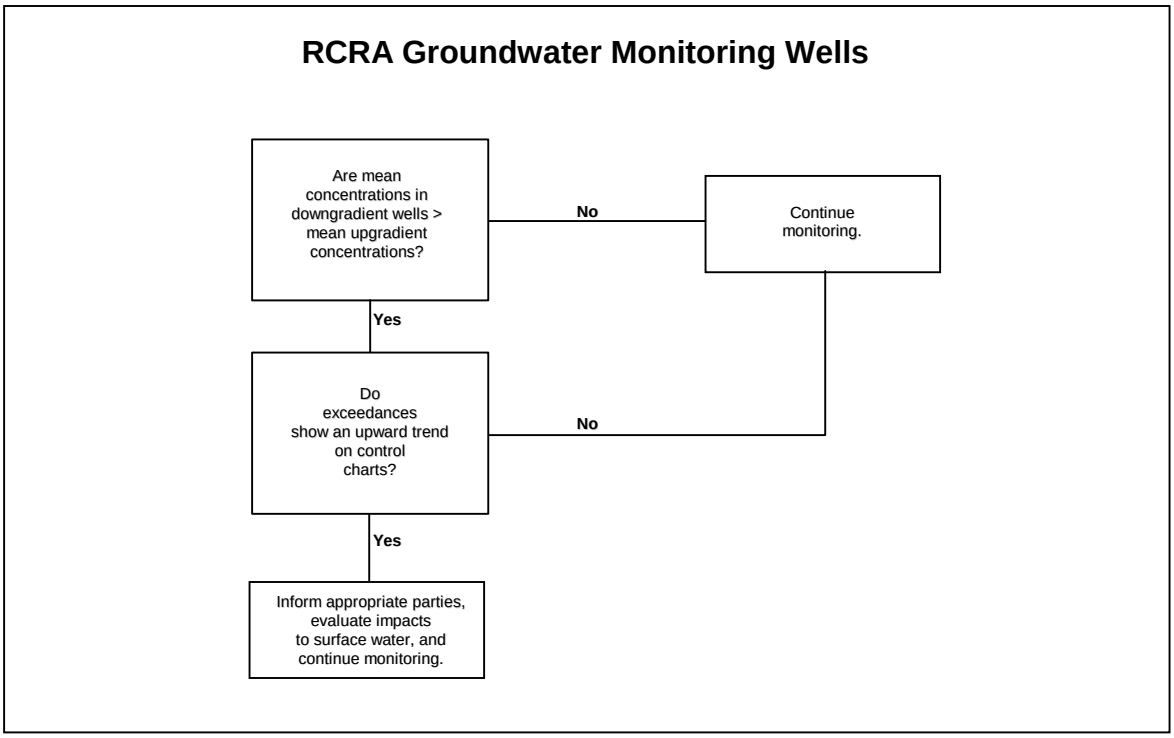
IF Mean concentrations in any downgradient well exceeds the mean concentration in upgradient wells

AND Concentrations at any downgradient well increase with time—

THEN Report to appropriate agencies and investigate possible causes,

ELSE Continue monitoring.

Logic:



3.4.2.8 Plume Degradation Monitoring Wells

Problem Statement:

Do natural processes acting on contaminants in groundwater affect the impact to surface water and therefore influence the priority and method of remediation?

Problem Scope:

The natural attenuation of contaminants in groundwater may be a significant factor influencing the nature and extent of contaminant migration. Plumes (and their potential sources) that have been evaluated under the IMP evaluation criteria and show evidence of natural attenuation may need additional characterization or monitoring to establish attenuation characteristics. Degradation monitoring would involve the placement and sampling of wells for use in decision making with respect to the methodology of source and plume remediation and will aid in assessing the priority for remediation.

Inputs:

- Concentration and speciation of project specific contaminants in the source groundwater with respect to time;
- Concentration and speciation of project specific contaminants in downgradient groundwater with respect to time;
- Concentration and speciation of background water quality in upgradient groundwater with respect to time;
- Water levels to establish gradient and saturated thickness;
- Project-specific field parameters;
- Trend analysis; and
- Mass flow rate analysis.

Boundaries:

Spatial: Wells are located in areas thought to be contaminated from a specific source or upgradient to distinguish contamination from other sources.

Temporal: Data will be reviewed annually to determine if sufficient data have been collected to support remedial decision making. Upon collection of sufficient data an evaluation will be performed to establish inputs to the remedial conceptual model.

Decision Statement:

IF Data evaluation concludes that sufficient data have been collected to characterize the nature and extent of the contaminant plume

AND Evaluation concludes that natural processes have decreased potential contaminant impact to surface water—

THEN Determine course of action using decision analysis phase in IMP plume management template to reevaluate the priority and methodology for remediation and discontinue monitoring,

ELSE Reestablish sufficient data needs and re-scope monitoring activities

- General Strategy for Groundwater Plume Management and Remediation:

  — The existence of groundwater contaminant plumes at RFETS has been well documented. *The Groundwater Conceptual Plan* for the Rocky Flats Technology Site (Kaiser-Hill, 1996) presented a summary of the known information on individual groundwater plumes and possible remedial actions. This section will outline the general strategy and approach to plume management and decision making for groundwater plumes and show the integration of groundwater functions at the Site.

- The plume management strategy for RFETS will consist of the following components.

Detection:

The detection of groundwater contamination that could impact surface water at RFETS will be supported through the current water monitoring programs at RFETS as well as through historic data from past investigations and information on past contaminant spills. The surface and groundwater monitoring programs have been established to detect the migration of contaminants in water that could move off Site. The monitoring programs are dynamic and may be changed to accommodate new insights into contaminant migration. The maintenance of historic data in the Soil Water Database and the HRR (DOE, 1992b) help provide information on potential groundwater contamination problems.

The IMP gives DQOs that establish the methods of detection and the actions that will follow.

Evaluation:

Many of the DQO decisions for groundwater monitoring require that an evaluation be performed to assess impacts to surface water caused by potential groundwater contamination. In many cases, the evaluation is predicated on the confirmatory sampling that follows an exceedance of groundwater action levels. If follow up sampling confirms an exceedance, or if historic data have indicated an impact to surface water that has not been evaluated, an evaluation will be performed. In general, the evaluation phase will spawn a focused data quality objective which will determine the type of data that will need to be collected and the methodology for determining the nature and extent of contamination and its impact on surface water. The following are possible components of an evaluation of surface water impact:

- Definition of extent of contaminants through additional sampling of soil, groundwater, surface water or seeps;

- Definition of areal extent of the contaminant pathway through additional well/borehole installations;

- Establishment of discharge, flow velocity and direction for groundwater and/or surface water;

- Determination of concentration loadings and mass flux of contaminants to the stream; and

- Estimation of impacts due to seasonal variations, discharges, or removal of groundwater collection systems.

It is understood that each evaluation will have a unique DQO that will consider such factors as relative impact, priority, and risk to the public. This approach will ensure that the available budget will be allocated to areas with the highest potential for contamination. Once a significant impact to surface water has been established, the findings will be used to establish or update priorities for remediation. At that point, the scope will be promulgated as an accelerated action, Proposed Action Memorandum (PAM), or an IM/IRA. The ALF section in RFCA that deals with Tier II wells requires modeling of impacts to surface water through mass balancing and flux calculations, where action levels have been exceeded. It is assumed that these predictive components of the evaluation will be weighed against actual field data in setting the priority for remediation.

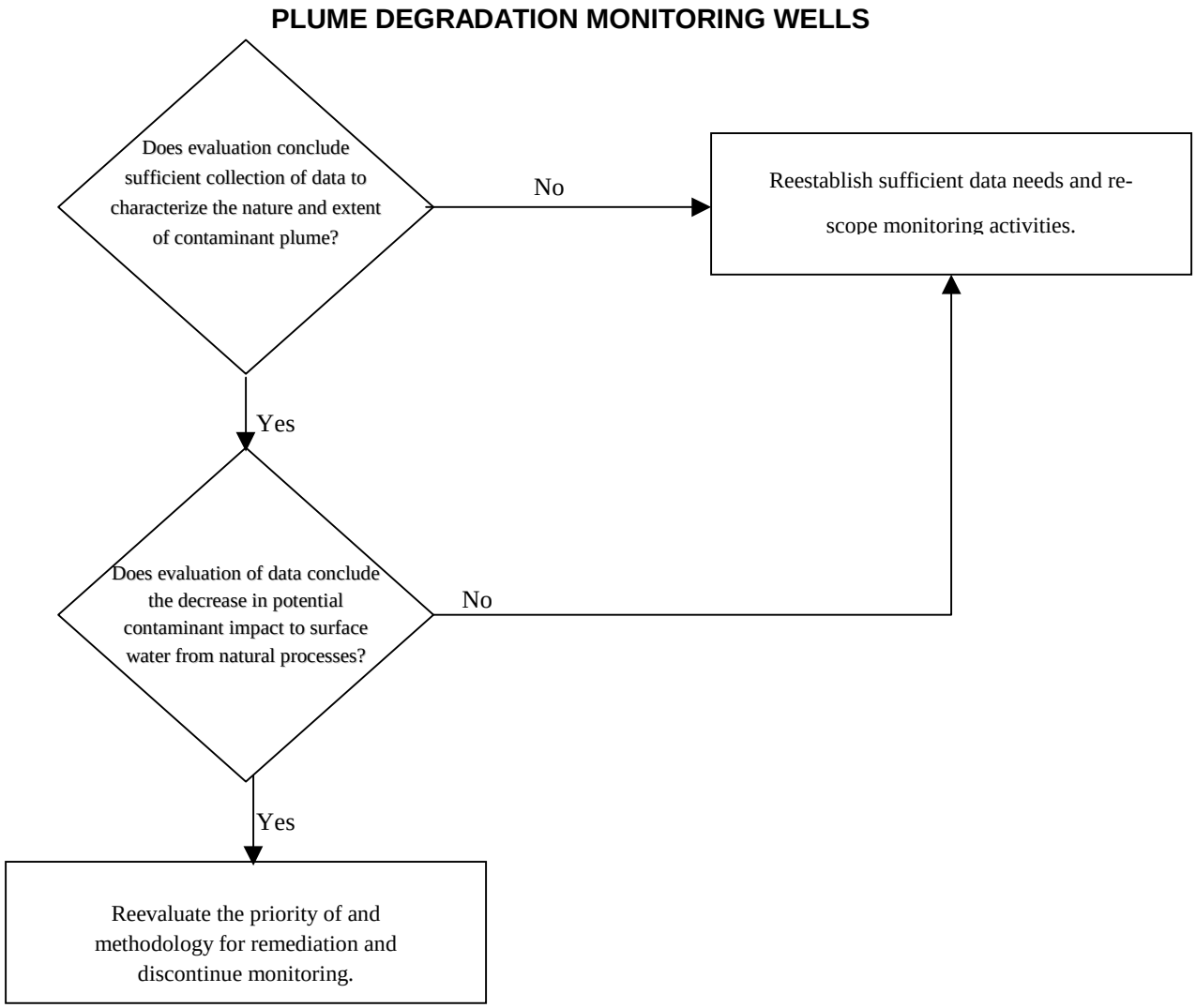
Remedial Decisions:

Once impact to surface water has been quantified, and the need for a remedial decision has been determined, the project scope will be promulgated as an accelerated action, PAM, or an IM/IRA. An alternatives analysis will be used to assess the remediation options. This analysis will consider such factors as risk reduction, remediation method, impact on the ecology, cost and performance. Once the remedial decisions have been reached, additional information may be needed to aid the design and construction of a remedial system. A DQO process will be employed to establish the data that need to be collected to aid in the construction of the remedial system. The remedial system may consist of a groundwater treatment system or source removal action. The decision alternatives analysis may propose that no remedial action be performed due to physical or technological impracticality, or adverse impact to the environment.

Remedial Decision Validation:

Additional groundwater monitoring may be required to validate the efficacy of a remedial action in reducing the risk of surface water impact. A DQO process will be employed to establish a performance monitoring system that will be maintained during and/or after remedial actions.

Logic:



3.4.3 Data Quality Objectives for Monitoring Groundwater Flow

Groundwater quantity and the magnitude and direction of groundwater flow are necessary to assess the effects of Site operations on surface water quality and to design effective remedial actions (if such are needed). Compiling water level information from wells supports the following analyses:

- Assessment of the impact of contaminant plumes on surface water quality through the creation of potentiometric surfaces from which horizontal hydraulic gradient and flow path can be derived;

- Development of groundwater flow and transport models to assess the effect of groundwater contamination on surface water in the event that an action level is exceeded;
- Evaluation of impacts to downgradient habitat and endangered species caused by changes to groundwater quantity and associated fluvial systems as a result of Site remediation activities; and

- Estimation of direction and rate of plume migration and the volumes of contaminated groundwater for use in treatment feasibility scenarios.

3.4.3.1 Site-Wide Flow Monitoring

Problem Statement:

Do Site remediation activities that adversely affect the quantity, velocity, and direction of Site-wide groundwater flow also adversely affect downgradient habitats or surface water quality and quantity?

Problem Scope:

The three flow-monitoring components described below will provide groundwater flow information on a well-by-well basis. To fully evaluate the Site regional groundwater flow regime, monitoring must be spatially distributed to define a potentiometric surface so that maps of this surface can be produced. These potentiometric surface maps can then be used to determine groundwater volume and the velocity and direction of groundwater flow. Water level will be measured more frequently on the perimeter of the Industrial Area where flow information is critical. Wells in areas where groundwater flow is believed to be relatively slow will be monitored at least semiannually. This semiannual flow data will be collected during high recharge and low recharge periods of the year (generally spring and fall).

Inputs:

- Water level measurements;

- Frequency of action level sampling;

- Historic water level data; and

- Meteorological data.

Boundaries:

Spatial: Decisions will be made on a regional basis.

Temporal: Data will be reviewed annually and decisions will be made on an annual basis.

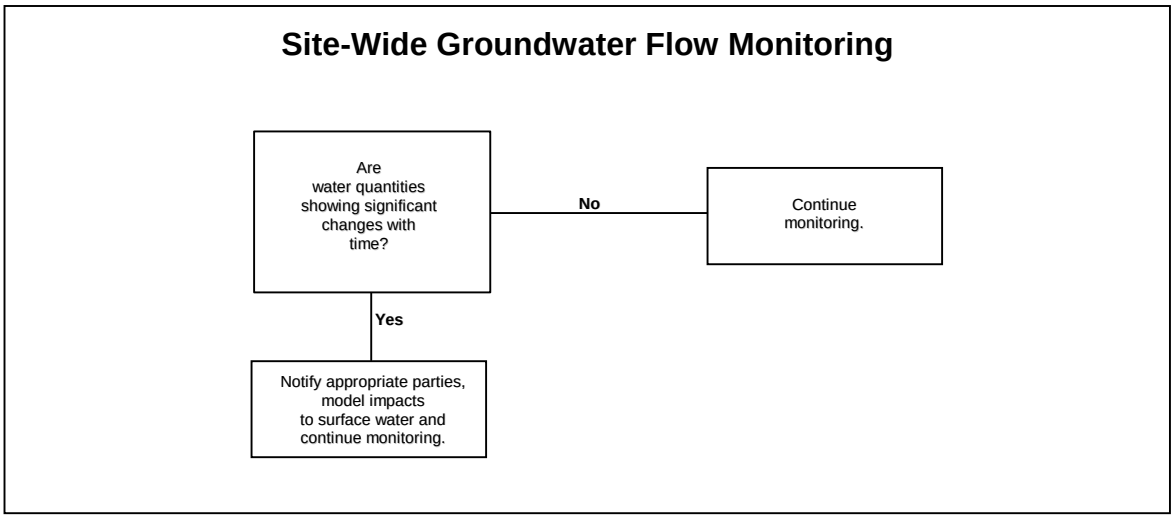
Decision Statement:

IF Groundwater elevations show significant changes in an area with time—

THEN Notify appropriate parties and evaluate impacts to surface water quality and quantity,

ELSE Continue taking measurements.

Logic:



The Site-wide groundwater flow monitoring program has three components. Each component provides information that supports the programmatic goals. The three components are as follows:

- Water Quality Flow Monitoring, which supports interpretation of water quality data in determining impacts to surface water.
- Industrial Area Flow Monitoring, which supports interpretation of changes to the groundwater flow regime leaving the Industrial Area to surface water resulting from remediation activities.

- Background Flow Monitoring, which supports interpretation of changes in the contribution of groundwater to surface water resulting from Site remediation activities by monitoring natural and off-Site impacts.

3.4.3.2 Water Quality Flow Monitoring

Problem Statement:

Do changes in the water level and gradient of groundwater affect surface water quality and flow regime?

Problem Scope:

The alluvial water table responds to seasonal and event-related changes in recharge. Interpretations of the fate and transport of contaminants depend on knowledge of the hydraulic gradient and saturated thickness of the aquifer. The frequency of water level measurements should be sufficient to establish useable hydrographs so that the effects of water table fluctuations can be correlated with water quality data. Because water quality sampling frequency is increased when action levels are exceeded, water level frequency should be increased to match the sampling frequency.

Inputs:

Water level measurements.

Boundaries:

Spatial: Decisions will be made on a well head basis.

Temporal: Data will be reviewed quarterly and decisions will be made annually.

Decision Statement:

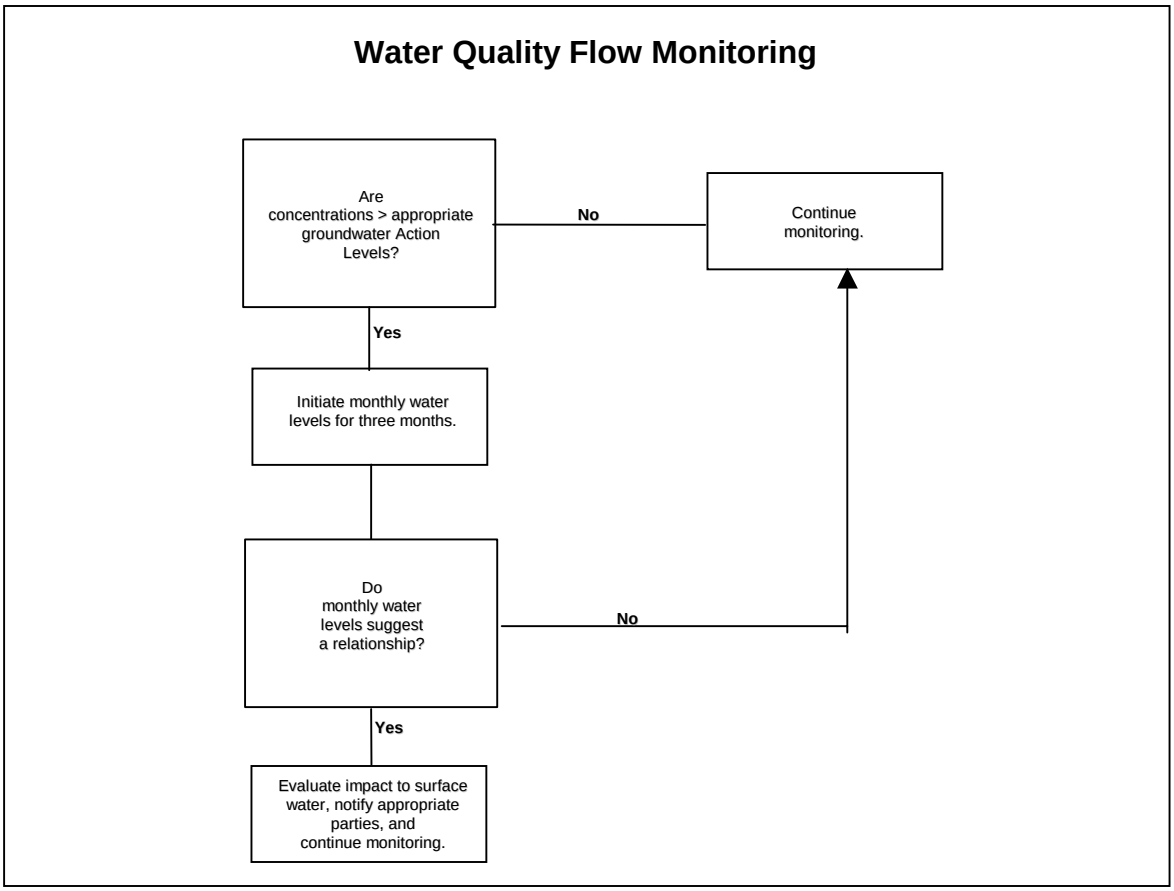
IF Action levels have been exceeded in the well—

THEN Adjust water level frequency to mirror water quality sampling frequency

AND Evaluate impacts to determine whether a remedial or management action is necessary,

ELSE Continue water level measurement at regular frequency.

Logic:



3.4.3.3 Industrial Area Flow Monitoring

Problem Statement:

Do remedial activities affect the groundwater flow regime surrounding the Industrial Area, and what impact to these changes have on surface water quality and quantity?

Problem Scope:

The alluvial water table responds to both seasonal and event-related changes in recharge. To understand how remediation activities affect contaminant migration, surface water quality and quantity, and wetlands, the hydraulic gradient and saturated thickness of the aquifer must be known. Because source wells in the Industrial Area are now monitored less frequently, the level of resolution of groundwater flow is too low to predict the effect of Site activities on groundwater migration. The frequency of measurements should be increased to a level sufficient to track the effects of remedial actions in the Industrial Area.

Inputs:

- Water level measurements; and
- Historic water level data.

Boundaries:

Spatial: Decisions will be made on a well head basis, but high resolution maps are also needed involving all Industrial Area wells that are monitored.

Temporal: Data will be reviewed quarterly and decisions will be made annually.

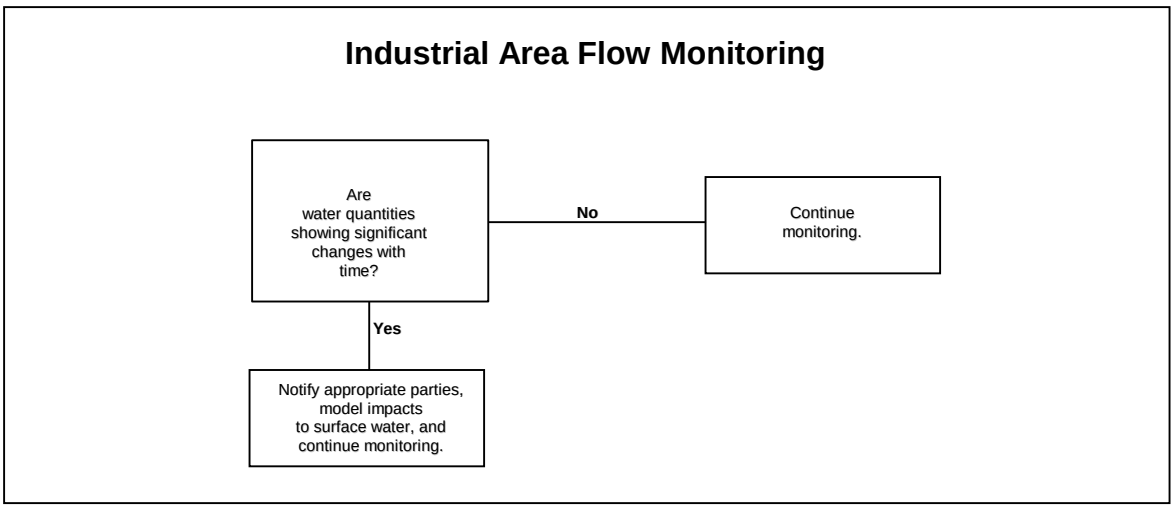
Decision Statement:

IF Groundwater levels show significant change with time—

THEN Notify appropriate parties and model effects on surface water quality and quantity using background water level data as appropriate,

ELSE Continue taking measurements.

Logic:



3.4.3.4 Background Groundwater Flow Monitoring

Problem Statement:

Are effects on surface water due to Site activities or natural climatic processes?

Problem Scope:

Background quantity, velocity, and direction of groundwater flow must be measured so that the effects of natural climatic or off-Site variations can be filtered out of the evaluations of the effects of Site actions on groundwater.

Inputs:

- Water level measurements;
- Event monitoring water level measurements; and
- Meteorological data.

Boundaries:

Spatial: Decisions will be made on an individual well basis.

Temporal: Data will be reviewed quarterly and decisions will be made annually.

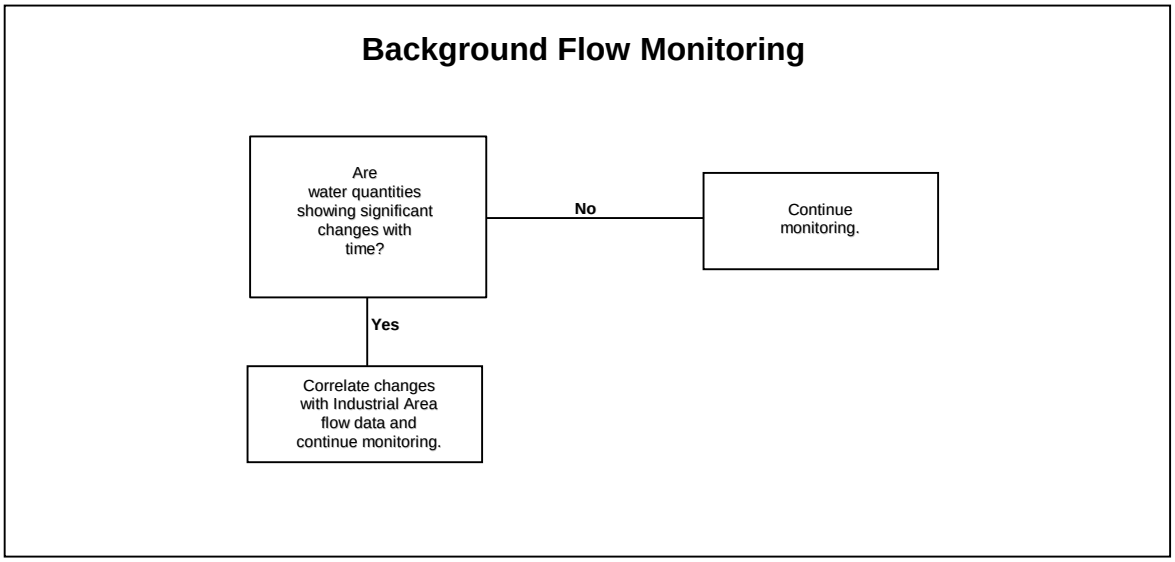
Decision Statement:

IF Site-wide groundwater elevations show significant changes with time that might cause significant impact surface water quantity—

THEN Evaluate changes in groundwater flow measurements with respect to background flow,

ELSE Continue monitoring.

Logic:



3.4.4 Monitoring Frequencies to Meet DQOs

Hydrogeologic interpretation of the sampling media and statistical treatment of existing data sets determine the sample frequency required to meet the DQOs. Sampling frequency should reflect both the velocity that groundwater is moving through the aquifer and professional judgement. Aquifer tests conducted on wells at the Site have provided general estimates of flow velocity in geologic formations. Appendix C to this section gives relative hydraulic conductivities for groundwater in the various geologic units on Site. Groundwater flow in the Rocky Flats Alluvium and colluvium, which are the dominant components of the UHSU, averages 100 to 200 feet per year. Given these rates, a sampling frequency of twice a year would be able to detect a 50- to 100-foot excursion of contaminants. Because most monitoring wells are located 500 to 1,000 feet from major drainages, detection at this frequency would provide adequate time to evaluate and remediate a moving contaminant plume.

The historic variability of groundwater monitoring data can be used to help determine whether a particular sample represents actual changes in the concentration of contaminants. The EPA's Decision Error Feasibility Trials (DEFT) Program can be used to evaluate the expected performance of various sample frequencies based on DQO constraints, assuming that the decision will be based on a comparison of a mean value to an action level. Using two kinds of data (historical data for several wells to obtain estimates of variability, and preliminary limits on decision errors developed during the DQO process) suggest that two to four samples per year adequately determine exceedances of the RFCA action levels. These preliminary investigations, therefore, support the biannual sampling scheme that is proposed.

3.5 Quality Control Objectives for Collection/Evaluation of Groundwater Data

DOE Order 5400.1 *General Environmental Protection Program* (DOE, 1988) requires that a quality assurance (QA) program be developed consistent with DOE Order 5700.6C, *Quality Assurance*. The program must cover all environmental activities and describe the requirements, methods, and responsibilities of environmental management, staff, contractors, and vendors for achieving and ensuring quality. General requirements for the Groundwater Monitoring Program activities are covered under the RMRS Quality Assurance Program Description (QAPD) and associated operating procedures (OPs).

The Site management structure showing organizational responsibilities is illustrated in Figure 3-2. The organization has been structured to maintain quality for the duration of the program. Conformance to the applicable plan, operating procedures, and established requirements will be verified by personnel not directly responsible for performing the work. Issues identified during implementation of the plan will be tracked and closed out through the Site-wide Commitments Management Program (SCMP). Data (operating procedure forms, logbooks, analytical results, and other quality related information as deemed) will be managed in accordance to the Environmental Restoration Management Administrative Procedure RM-06.02, which governs records capture and transmittal, as described in the SWD data management plan. Work-controlling documents are controlled per Operating Procedure ERM Administrative Procedure 2-G01-ER-ADM-06.01 which governs document control.

The RMRS QAPD requires quality control (QC) for the collection and analysis of environmental samples. The major requirements include the following:

- Developing DQOs;
- Collecting and analyzing samples according to approved procedures; and
- Reducing and reporting data in a controlled manner.

DQOs, sampling design and analysis, and ultimate conclusions about groundwater at the Site are based on judgmental sampling (Gilbert, 1987) and consensus decision making (among, for example, RMRS, Kaiser-Hill, DOE, RFFO, CDPHE, and EPA Region VIII). DQOs, conclusions, and decisions are documented through reports, memos, and meeting minutes.

The following documents provide guidance to QA at the Site:

- *The Data Quality Objectives Process* (EPA, 1994).
- *Data Quality Objectives for Remedial Response Activities Development Process* (EPA, 1987).
- *Guidance for Data Usability in Risk Assessment* (EPA, 1990).

- *Rocky Flats Plant Data Management Plan for Environmental Restoration Management Program* (EG&G, 1994d).

- *Evaluation of Environmental Restoration Management Data for Usability in Final Reports* (EG&G, 1994e).

For nonroutine groundwater investigation activities, the types of data, level of detail, and the data quality needed are determined by the DQOs specified for each data collection activity. OU- or IHSS-specific remedial investigations require DQOs with the primary goal of risk assessment and remediation. OU- and IHSS-specific DQOs are established in the work plan or in the QA addenda for that project.

For those data collection activities where project-specific DQOs are not developed, general groundwater DQO guidance is as follows:

- For precision, field duplicates will be collected at a rate of 5% (one in 20 samples), with a relative percent difference not to exceed 30 percent.

- For accuracy, the analytical method and detection or quantitation limits used for each groundwater analyte will be those specified in Analytical Services' *Statement of Work for Analytical Measurement, General Laboratory Requirements* (Kaiser-Hill, 1996), or provided with the instruments in the case of field measurements. Justification for deviation from the project-specific plan must be provided, along with a determination of whether the actual number of samples collected will be adequate for the end use. Laboratory analyses will be independently validated at 25% of the sample population, unless otherwise specified.

- For representativeness, the actual sample types and quantities collected are compared with those planned for the project. Justification for deviation from the project plan must be provided, as must a determination that the actual number of samples collected will be adequate for the end use.

- For completeness, 90% of the groundwater samples and associated QC samples planned for the groundwater monitoring program must be collected.

- Field QC samples will be collected at the rate of 5% (1 in 20 samples) for equipment rinsates and preservation blanks, and will be compared to the real sample using EPA's 5%/10% criterion. Ambient condition blanks are important when groundwater is sampled in areas close to possible sources of volatile organic contamination, such as areas with gasoline engines operating.

3.5.1 Field Data Collection

QC objectives for the collection of field parameters and representative samples of groundwater are established to ensure that data are of sufficient quality to support the decisions identified in the previous section.

The QC objectives for field data collection are the following:

- Sampled water represents formation water;
- Sampling techniques do not introduce contaminants to samples or wells;
- All sampling techniques are standardized to ensure reproducibility and comparability of results; and
- Water elevations are measured precisely enough to detect minor fluctuations in the water table.

3.5.1.1 Representative Samples

All sampling devices are designed to collect representative samples that reflect actual formation conditions. Well productivity is also a factor since some alluvial and bedrock formations at the Site produce so little water that they dewater while purging. Recharge water becomes aerated while cascading along the inner wall of the well casing, which may alter the chemistry of the collected water. Therefore, specific recharge volumes and sampling times have been established that produce samples most closely representing formation conditions.

In addition, micropurging will be used in wells where there is sufficient sample volume to use a dedicated bladder pump. Micropurging collects the sample at a slow enough rate so that turbulence is reduced and limited drawdown is maintained in the well. Use of the dedicated pump also limits the aeration of the sample before it is placed in the sample bottle.

3.5.1.2 Minimization of Contamination During Sampling

Operating procedures are written to ensure that proper techniques are used to collect samples. The groundwater series of OPs describes sampling techniques that minimize operator-induced contamination. All downwell sampling equipment is made of inert materials. Techniques for the use and decontamination of this equipment ensure a high level of sample integrity and minimize the potential for cross-contamination of samples or contamination of any well with foreign materials. One rinsate sample is collected for every 20 wells sampled. These analyses are routinely checked to ensure that sample equipment does not cross-contaminate wells.

3.5.1.3 Standardization of Sampling Techniques

Standardization of sampling methodology is ensured by Site standard OPs. These OPs ensure consistency and standardization of sample collection, data entry, field parameter measurements, sample packaging and shipping, and equipment decontamination. Procedures are updated regularly to reflect any changes to the methodology of sample collection, and distribution of procedures is controlled to ensure that work is performed to the most current version of the procedure.

The RMRS/ER OPs (EG&G, 1991a, b, c) that are required to perform the groundwater monitoring tasks have been approved by CDPHE and EPA. Adherence to the directions set forth in these OPs for field operations (FO), groundwater (GW), and geotechnical (GT) activities should produce data that are representative of groundwater quality, comparable from well to well, and reproducible for any given well at the Site.

The collection of groundwater from a new location involves the planning, permitting, and installation of an engineered well. OPs are used at the Site for siting, installing, and sampling wells containing groundwater (EG&G, 1991a, b, c). The applicable OPs are partitioned into three groups (A, B, and C) (Table 3-1) and generally arranged in order of performance. Several of the OPs will be followed more than once (e.g., transmittal of field QA records following completion of a documentable field technical procedure).

All field sampling crews are trained in the techniques described in the OPs, and standardized equipment is used during the sampling events. This uniformity of sampling crews eliminates sampling variability, and samples collected during any quarter can be compared without concern about field inconsistencies.

Adherence to procedures is ensured by both self-assessment audits by project management and formalized audits by the Site health, safety, and quality organizations.

One field duplicate sample is collected for every 20 wells sampled. Field duplicates are used to assess the consistency of sample collection techniques.

3.5.2 Accuracy of Water Level Measurement

Water elevations are taken in accordance with OP GW.1, Water Level Measurements (EG&G, 1991b). Water level measurements are taken by each member of the sampling crew and compared. In addition, total depth of the well is measured to determine whether sediment has collected in the bottom of the well. Wells that contain large amounts of sediment are targeted for redevelopment. Event-related water level measurements may be collected with a continuous data electronic logging device.

Table 3-1
Operating Procedures for Planning, Installing and Sampling a Groundwater Monitoring Well

A. Planning

OP No.	Procedure
GT.6	Monitoring Well and Piezometer Installation
GT.18	Surface Geophysical Surveys
GT.10	Borehole Clearing
FO.16	Field Radiological Measurements
GT.24	Approval Process for Construction Activities on or Near Individual Hazardous Substance Sites

B. Installation

OP No.	Procedure
FO.4	Heavy Equipment Decontamination
FO.12	Decontamination Facility Operations
FO.11	Field Communications
GW.5	Field Measurement of Groundwater
GT.2	Drilling and Sampling Using Hollow-Stem Auger Techniques
GT.4	Rotary Drilling and Rock Coring
FO.14	Field Data Management
FO.7	Handling of Decontamination Water and Wash Water
FO.6	Handling of Personal Protective Equipment
GT.3	Isolating Bedrock from Alluvium with Grouted Surface Casing
GT.6	Monitoring Well and Piezometer Installation
GW.2	Well Development
FO.8	Handling of Drilling Fluids and Cuttings
FO.10	Receiving, Labeling, and Handling Environmental Materials Containers
FO.23	Management of Soil and Sediment Investigative Derived Material (IDM)
FO.2	Transmittal of Field Quality Assurance Records
GT.1	Logging Alluvial and Bedrock Material
GT.11	Plugging and Abandonment of Wells
GT.15	Geophysical Borehole Logging
GT.39	Push Subsurface Soil Sampling

Table 3-1 (Continued)

C. Sampling

OP No.	Procedure
FO.15	Photoionization Detectors (PIDs) and Flame Ionization Detectors (FIDs)
GW.1	Water Level Measurements in Wells and Piezometers
GW.6	Groundwater Sampling
FO.5	Handling of Purge and Development Water
FO.3	General Equipment Decontamination
FO.13	Containerizing, Preserving, Handling, and Shipping of Soil and Water Samples
FO.25	Shipping Limited Quantities of Radioactive Materials in Samples

3.5.3 Laboratory Analysis

Standardization of laboratory analysis is established through Analytical Services' *Statement of Work for Analytical Measurement, General Laboratory Requirements* which presents the approved analytical methods, holding times, detection limits, and reporting procedures for laboratories performing analytical work (Kaiser-Hill 1996b). Standardization of analytical results allows information generated from different laboratories to be used interchangeably for decision making.

General chemistry samples are typically sent to laboratories approved by the EPA Contract Laboratory Program (CLP). Radiochemistry samples are sent to labs that are licensed to analyze for radionuclides. Groundwater samples are analyzed at prequalified analytical laboratories both on and off the Site. The QA/QC for any non-CLP and non-radiochemistry samples parallels CLP protocol to include continuous equipment calibrations and method blanks for every one in ten samples. The CLP-type analysis is outlined in Section 2.4 of Analytical Services' *Statement of Work for Analytical Measurement, General Laboratory Requirements* (Kaiser-Hill, 1996b). Analytical Services audits laboratories that analyze the Site groundwater samples. The SWD ensures that data are complete and accurate as they are archived into the database by performing automated error checks of the electronic laboratory deliverables. One hundred percent of all analytical data currently undergo a verification review by Analytical Services. At a minimum, 25% of the analytical data produced receives an independent laboratory validation by a subcontractor. This percentage may be reduced in the future to a statistically significant percentage, upon approval of the regulatory agencies.

3.5.4 Data Management

All field data and laboratory analyses performed for groundwater monitoring are maintained in the SWD. This is a relational database that holds all groundwater, surface water, soil, and borehole data collected on Site. All data analysis and reporting are done with data extracted from SWD.

SWD uses Oracle® (registered trademark of Oracle Company) software for data management and retrieval. It compiles water quality data, field parameter data, sample tracking data, and water level data for groundwater, surface water, boreholes, soils, and sediment samples. Field parameter data (sample location, sample date, pH, turbidity, conductivity, and temperature) are included as are groundwater level measurements and chemical information [Chemical Abstracts Service (CAS) registry numbers, analytical results, and detection limits]. Specific procedures for verification of database information received from subcontractors, or input directly into SWD, have been developed and are being implemented. These procedures provide QA documentation, which ensures that all available data have been incorporated and entered or uploaded properly into SWD. Data integrity is maintained with standard OPs and standardized error checking routines used when loading data into SWD. Other procedures are being developed for database system security and software change control.

The field data gathered on Site is entered through the DATACAP field data entry system. This system is a data entry module that is compatible with the SWD database, and can be used in remote field locations by field personnel. Data entered into DATACAP is verified and signed off by the subcontractor before it is delivered to the main SWD database.

Spatial information for groundwater is located in the RMRS/ER geographic information system (GIS) system. This system uses ARC/INFO® (registered trademark of ESRI) software to store and present locational data for well locations, potentiometric surfaces, plume configurations, topographic contours, and Site facilities.

All well and borehole log information is maintained in the Geoscience Group's Logger Database. The Logger Database has graphic logs of all boreholes and wells on Site, and displays well construction details and geologic information. Subsurface geologic correlations are displayed using Earth Vision® (registered trademark of Dynamic Graphics Incorporated) Software.

3.5.5 Groundwater Assessment and Reporting

Part of the data assessment process is to establish that the data are of the requisite precision, accuracy, representativeness, comparability, and completeness (PARCC parameters) to give accurate evaluations for decision making (data usability). Definitions of the PARCC parameters and further information on the establishment of project-specific DQOs are found in the preceding sections.

3.6 Description of the Groundwater Monitoring Program Resulting from the DQO Process

Groundwater monitoring is an essential function of surface water protection at the Site, since the majority of groundwater becomes surface water within the Site boundaries. The overall objective is to identify contaminated groundwater and associated pathways to surface water, and protect those resources from further or potential damage. The goal is to assess the quality and quantity of groundwater resources in the vicinity of the Site to enable proper management of those resources.

Elements of the program include measurement of hazardous constituent concentrations in groundwater, determination of the gradient and direction of groundwater flow, and assessment of the nature and extent of any contaminant plumes in the UHSU within the Site boundaries. The monitoring network is designed to monitor areas of known or suspected groundwater contamination based on composite groundwater plume information and OU-specific source characterization activities. Composite plume maps are presented in Plate 3.

The monitoring well network should undergo constant evaluation to determine the most effective approach to monitoring groundwater at the Site. This evaluation should take into account current regulations and agreements, but, more important, it should integrate new data and technical information on the nature and extent of Site contamination.

The proposed monitoring program comprises the following monitoring components:

- A network of 100 wells sampled on a semiannual basis;
- A network of 14 well and seeps sampled quarterly;
- Monthly measurement of water elevations at 67 wells;
- Quarterly measurement of water elevations at 89 wells;
- Semiannual measurement of water elevations at 93 wells;
- Real-time measurement of water elevations in 32 wells;
- A program plan for updating and proposing changes to the groundwater monitoring program;
- Annual evaluation and reporting to the appropriate regulatory and community agencies;
- Quarterly reporting of groundwater data that exceed action levels;

- A groundwater modeling capability;
- A well control program;
- A well abandonment, replacement, and maintenance program; and
- Other special projects pertinent to groundwater assessment.

The groundwater monitoring network at the Site comprises the following seven categories of monitoring wells:

- Plume definition;
- Plume extent;
- Drainage;
- Boundary;
- Performance;
- D&D;
- RCRA; and
- Plume degradation.

Well categories and wells of the groundwater monitoring network are described in Appendix E of this section (Well List).

3.6.1 Groundwater Monitoring Network

The current DQO evaluation process has prompted a review of the groundwater monitoring program and the determination of specific decisions for each well that is monitored. The general premise is that each well should provide data for a decision or action that is prompted when set criteria are met. At present, groundwater monitoring data are acted on only when they exceed specified action levels for analytes listed in the RFCA ALF document. The list of regulated analytes in RFCA is extensive. Historic data and Site knowledge have been used to determine which contaminants are of major concern in Site groundwater. Table D-1 summarizes the chemicals of concern associated with the various groundwater plumes described in Appendix D of this section. The analyte suites tested for in water from current monitoring wells include the identified chemicals of concern.

The RFCA analyte lists for groundwater use concentration levels that may differ from the Site-specific levels used in the past. Major contaminants of concern were determined after reviews of historic groundwater data. The inorganic and radionuclide data for each well were initially screened against background concentrations using the 99/99 Upper Tolerance Limits reported in the Background Characterization Report (EG&G, 1993b). The data were then screened against the action levels in the ALF and exceedances were noted for each well. Table D-1 shows the results of this data screening and was used to determine the analyte suite for the wells in the program. The wells were then associated with the IHSS or plume source area where the groundwater contamination originated. Areas were delineated based on the known plumes and potential area of influence for those plumes. Area-specific monitoring suites were then derived. Appendix E to this section contains the analyte suites that will be collected for each well.

3.6.2 Sampling and Analysis

The operational groundwater sampling network will contain 100 wells, the majority of which will monitor the extent of various contaminant plumes. Appendix E lists the wells in the monitoring program along with their well classification. Appendix E also lists the sampling frequency for wells in the program. A semiannual schedule of sampling and analysis of water quality in Site wells has been chosen to generate data representative of the various groundwater conditions and to ensure compliance with applicable groundwater regulations. The frequency of sampling wells used for other purposes (such as performance monitoring and D&D monitoring) will be derived from compliance documents, agreements, or controlled work plans.

A data collection schedule will be adopted for the sampling network. This will ensure that samples for any particular well are collected as closely as possible to semiannual intervals. The schedule is used as a guide (except as required by specific regulations) and may be modified as needed to account for unplanned changes that occur during the sampling quarter.

The following are guidelines for the collection of groundwater samples:

- For bailed wells, filtered samples will be collected for metals analyses and uranium isotopes; unfiltered samples will be collected for organics analyses, water quality, and all other radionuclides. For micropurged wells, samples will not be filtered.

- Well-site field parameters measured are temperature, pH, specific conductance, turbidity, and alkalinity. Total dissolved solids will be measured as either a laboratory parameter or a field parameter.

- If limited groundwater sample volumes prevent analysis of the entire analyte list, the analyses will be performed in the following order in accordance with RMRS/ER OP GW.6 Groundwater Sampling (EG&G, 1991a):

1. CLP Method 524.2 VOCs;
2. Semivolatile organic compounds (SVOCs);
3. Pesticides/polychlorinated biphenyls (PCBs);
4. Nitrate/nitrite, as nitrogen;
5. Radiation screen;
6. Metals—Target Analyte List (TAL), with cesium, lithium, strontium, tin, molybdenum, and silica;
7. Specific metals—list of metals specific to a given well;
8. Uranium-233/234, -235, -238;
9. Strontium-89/90;
10. Plutonium-239/240, americium-241;
11. Major anions (chloride, fluoride, sulfate, carbonate/bicarbonate); and
12. Tritium.

This order in which analyses are to be performed may be altered to fit specific characterization or statistical needs or work plan specifications.

3.6.3 Measurement of Groundwater Elevations

Preparation of water elevation maps and hydrographs addresses both a regulatory requirement and a technical need to know groundwater flow directions and gradients accurately. The measurement of groundwater elevations has been designed to produce data that are as representative of current conditions as possible. These water level measurements are collected within 10 working days of the period designated for measurement, so that the data are as temporally related as possible.

Based on the DQO for each activity, Appendix E lists the frequency of water level measurement proposed for the components of the Site-wide Groundwater Flow Monitoring Program.

3.6.4 Groundwater Reporting

Groundwater activities will be reported throughout the life of the Site monitoring program. Reports will be transmitted to EPA and CDPHE as the responsible parties listed in the DQO decision statements in Section 3.4.2, after review and approval by DOE.

The following basic reporting vehicles are required for the groundwater program based on the integration of past regulatory requirements with the RFCA ALF.

3.6.4.1 Annual Report

An annual assessment of groundwater conditions is required in the DQO decisions in this document, the Industrial Area IM/IRA, and in the regulations governing RCRA interim status units and municipal landfills (6 CCR 1007). Therefore, this report will incorporate the data elements that were historically reported in the RCRA Annual Groundwater Report, Well Evaluation Reports, and IM/IRA reports. This annual report will replace these latter reports and will be the primary compliance report for groundwater monitoring. This integrated report will contain the following elements:

- A general description of the various monitoring program elements, including any new monitoring or sampling activities.

- Interpretation of the geochemical data generated from the year's sampling with respect to action levels and trends that may show contaminant movement. Where documented exceedances exist, the report will evaluate the need for further actions and propose those activities.

- Interpretation of the Site groundwater flow-through analysis of water level data collected by use of hydrographs, potentiometric surface maps, and modeling, where appropriate.

- Recommendations for improvements to the monitoring program that may include changes in the well network, analytes collected, and sampling frequency.

In general, reports on potential exceedances for wells will use the following methodology:

Plume Definition Wells:

- Data will first be compared with Tier I Action Levels for groundwater. If an action level has been exceeded for any analyte that has an action level, data will then be compared with background values using the mean + 2 standard deviations established in the 1993 Background Characterization Report (EG&G, 1993a).

- If both the action level and background levels have been exceeded for an analyte that has not had consistent historic exceedances, an evaluation will be proposed. Remediation and/or management decisions will be made based on the results of the evaluation.

- If a particular contaminant has been detected consistently above the Tier I Action Level in historic data, then the result will be plotted against historic data set for

that analyte and that well. If the analytical results show an increasing trend in concentration over a two-year period with respect to the historic data set, then an evaluation will be proposed and remedial priority established.

For purposes of data analysis the historic data set is defined as the data generated for a particular well from the years 1991-1995. If a well does not have this data set, or is a newer well, the historic data set will be all data generated for the well until a five-year data set is reached.

Plume Extent, Tier II, Drainage, and Boundary Wells:

- Data will be compared with Tier II Action Levels for groundwater. If an action level has been exceeded for an analyte, data will then be compared with background values using the mean + 2 standard deviations, established in the 1993 Background Characterization Report (EG&G, 1993a).

- If both the action level and background level have been exceeded by an analyte that has not had consistent historic exceedances, monthly sampling will be performed per RFCA. An evaluation will be proposed to determine the impact to surface water. Remediation and/or management decisions will be made based on the results of the evaluation.

- If a particular analyte has been detected consistently above the Tier II Action Level and background in historic data, a check will be made to see if an evaluation of impact to surface water has been performed. If no evaluation has been performed, an evaluation will be proposed. If an evaluation has been performed, then future monitoring results will be tested against an historic data set of values for that analyte and that well. If the result is higher than the background mean + 2 standard deviations with respect to the historic data set, then another evaluation will be proposed to assess impacts to surface water.

Building D&D Monitoring Wells:

- Performance wells may be existing monitoring wells or special wells installed to detect any unplanned excursion of contaminants during a building D&D activity. Where there is a groundwater concern, a baseline should be established for water quality before D&D activities begin. The baseline should be established one year prior to the D&D action and should be composed of a minimum of four sample events. After the baseline is established, any exceedances above the baseline mean + 2 standard deviations will be reported. Trend plots may be used to track concentrations where exceedances are determined. The results of building specific decisions may also be addressed in the Industrial Area IM/IRA annual report.

Performance Monitoring Wells:

- Performance wells may be existing monitoring wells or special wells installed to measure the effectiveness of a source removal or plume treatment system. In each case, it is assumed that the wells that will be used already exceed Tier I or Tier II Action Levels. Therefore, the trend in concentration with time is the best measure of performance. Trend plots will be constructed to track whether contaminant concentrations change with time. A performance monitoring activity may also be described in separate closure documents for that source area.

RCRA Monitoring Wells:

- The reporting of monitoring wells used for a permitted RCRA facility are prescribed in the state and federal regulations. Reporting will follow the requirements of these regulations and associated guidance documents. The results of unit-specific monitoring requirements may also be addressed in specific annual reports. An example of this is the annual report for the Existing Landfill.

The annual report will provide the results of monitoring on a calendar year basis. The annual report will be submitted to the DOE at the end of the fiscal year in which the calendar year ended. This date is typically September 30. DOE will review and transmit the report to the regulatory agencies by November 15.

3.6.4.2 RFCA Quarterly Reporting

Quarterly reporting of groundwater analyses is currently required for 1) RCRA interim status units, 2) the boundary wells under the Agreement in Principal, and 3) the French drain monitoring wells under the IM/IRA for the French Drain, and a RFCA ALF document.

The RFCA quarterly report for groundwater will replace all previous quarterly reports and integrate all the various reporting elements into a standardized evaluation, using the action levels as a means of assessing results. The report will summarize the data collected and any exceedances of standards that have occurred using the methods outlined in the previous section. Because semiannual sampling is proposed, the quarterly reports will present only those data that have been analyzed and uploaded into SWD in time for the report. The report for any calendar quarter will be compiled 60 working days after the end of the quarter to allow time for laboratory analysis, data upload, and evaluation. The reports will be issued and presented at the next Quarterly Information Exchange Meeting following the 60-day compilation period. Summary results from the data evaluation will be submitted to DOE, EPA, and CDPHE one week prior to the Quarterly Information Exchange Meeting.

3.6.5 Evaluation of Groundwater Impacts To Surface Water

Many of the DQO decisions for groundwater monitoring require that the effect of potential groundwater contamination on surface water be evaluated. In many cases, when groundwater action levels are exceeded, confirmatory samples will be taken. If analyses of follow-up samples confirm an exceedance, or if historic data indicate an impact to surface water that has not been evaluated, an evaluation will be performed. In general, the evaluation phase will result in a focused data quality objective that will determine two things: the type of data that need to be collected, and the methodology for determining the nature and extent of contamination and its effect on surface water. The Plume Management Template in Section 3.1.5 outlines the role of plume evaluations in the overall Plume Management Strategy.

3.6.6 Groundwater Flow Modeling

Computer modeling of the groundwater system at the Site is a valuable tool for characterizing the groundwater flow regime and determining the fate of potential contaminants introduced into the groundwater system. The primary purpose of groundwater modeling is to integrate geologic, hydrogeologic, and geochemical characterization data into numerical representations of the groundwater system. These models provide predictive capabilities that can be used to analyze and design a groundwater monitoring network, and to evaluate how groundwater affects surface water.

This plan proposes that the current groundwater flow model and supporting software and graphic coverages should be maintained and updated; they are used in problem-solving and tracking how Site closure activities affect the environment. The activity would update and maintain the input grids and coverages for modeling so that real-time simulations can be run when potential impacts to the environment are discovered. Numeric modeling will be used if it is established that the project merits a numeric solution. This will be decided during the DQO development phase of the evaluation.

An annual status report for the maintenance and update of the groundwater flow model, including the results of any modeling performed, will be incorporated into the RFCA Annual Report.

3.6.7 Well Control Program

The Well Control Program is currently a Site Level 1 administrative procedure for new well and piezometer installations (EG&G, 1994a). The procedure is implemented through the RMRS/ER Groundwater Group. The Well Control Program ensures that proper recording and tracking of all well installation activities on Site are done, and serves as a necessary approval process for the installation of wells. The program will support the following activities:

- Assigning well location codes to eliminate misidentification of wells or use of redundant well names.

- Maintaining a database with summary well information to be used for evaluation of the functions of new wells, and preparing and obtaining well permits as required by 2 CCR 402-2 regulations. The instructions and form are available in the Environmental Management Department OP GT.6 1994 revision (EG&G, 1991a).

- Maintaining a database of well construction information and geologic log information that must be submitted with the permit applications.

- Submitting to the State Engineer's Office permits for wells that are installed or abandoned.

- Maintaining the Site geologic core repository for use in correlation of geologic strata and interpretation of hydrogeologic properties.

- Through an approval process before well construction, ensuring that wells are installed following applicable procedures and with appropriate knowledge of geologic and Site conditions.

3.6.8 Well Abandonment and Replacement

In certain cases, the usefulness of a groundwater monitoring well is exceeded by its potential liability. Such wells should be considered for abandonment or, in certain cases, replacement. Abandoning a well eliminates it from the monitoring network in such a manner that the well will not remain a conduit for groundwater or contaminant migration. Installation and monitoring procedures have been established to minimize the need for abandonments. However, well abandonment is a necessary component of the Groundwater Monitoring Program. Damaged wells must also be abandoned.

This IMP proposes that proper abandonment of wells be required under the following circumstances:

- When the potential for cross-contamination from the well exists;

- When the well is poorly constructed or of unknown construction;

- When the well is in the way of proposed construction or demolition activities; and

- When the well has been damaged.

A report describing the results of the Well Abandonment and Replacement Program (WARP), including well installations, abandonments and replacements, will be included as a section in the RFCA Annual Report.

3.7 References

EG&G Rocky Flats, Inc., 1990. "Federal Facilities Compliance Agreement; Chromic Acid Incident Plan and Implementation Schedule."

EG&G Rocky Flats, Inc., 1991a. *EG&G Environmental Management Department, Volume I, Field Operations.* Manual No. 5-21000-OPS-FO (revised, 1994).

EG&G Rocky Flats, Inc., 1991b. *EG&G Environmental Management Department, Volume II, Groundwater*, Manual No. 5-21000-OPS-GW (revised, 1994).

EG&G Rocky Flats, Inc., 1991c. *EG&G Environmental Management Department, Volume III, Geotechnical*, Manual No. 5-21000-OPS-GT (revised, 1994).

EG&G Rocky Flats, Inc., 1992. *Spill Prevention Control Countermeasures/Best Management Practices Plan.*

EG&G Rocky Flats, Inc., 1993a. *Groundwater Protection and Monitoring Program Plan for Rocky Flats Plant, Golden, Colorado*, October.

EG&G Rocky Flats, Inc., 1993b. *Background Geochemical Characterization Report, Rocky Flats Plant, Golden, Colorado.* September.

EG&G Rocky Flats, Inc., 1994a. *Well Control Program, Draft.* Level 1 Procedure 1-K92-RFP-94-001.

EG&G Rocky Flats, Inc., 1994b. *General Radiochemistry and Routine Analytical Service Protocol*, February.

EG&G Rocky Flats, Inc., 1994c. *Well Evaluation Report Final*, Golden, Colorado, April.

EG&G Rocky Flats, Inc., 1994d. *Rocky Flats Plant Data Management Plan for Environmental Restoration Management Program.* RFP/ER-MP-93-006, July.

EG&G Rocky Flats, Inc., 1994e. *Evaluation of ERM Data for Usability in Final Reports.* 2-G32-ER-ADM-08.02, Rev. 0, September.

EG&G, 1994f, *Evaluation of ERM Data for Usability in Final Reports*. 2-G32-ER-ADM-08.02, Rev. 0. September.

Gilbert, R.O., 1987. *Statistical Methods for Environmental Pollution Monitoring*, Van Nostrand Reinhold, New York, New York.

Kaiser-Hill Company, L.L.C., 1996. *Statement of Work for Analytical Measurements, General Laboratory Requirements, Module GR01-A.* Golden, Colorado. December.

Rocky Mountain Remediation Services, L.L.C., 1996. *Groundwater Conceptual Plan for the Rocky Flats Environmental Technology Site*-Final Revised. March.

U.S. Department of Energy, Colorado Department of Health and Environment, and U.S. Environmental Protection Agency, 1996. *Final Rocky Flats Cleanup Agreement*. July.

U.S. Department of Energy, 1988. DOE Order 5400.1, *General Environmental Protection Program*.

U.S. Department of Energy, 1992a. *Interim Measure/Interim Remedial Action French Drain Performance Monitoring Plan*, June.

U.S. Department of Energy, 1992b. *Final Historical Release Report for the Rocky Flats Plant*, Rocky Flats Plant, Golden, Colorado, June.

U.S. Department of Energy, 1993. *Final Ground Water Assessment Plan*, Rocky Flats Plant, Golden, Colorado, February 24.

U.S. Department of Energy, 1994a. *Final Interim Measures/Interim Remedial Action Decision Document for the Rocky Flats Industrial Area*, Rocky Flats Plant, Golden, Colorado, March.

U.S. Department of Energy, 1994b. *Technical Memorandum 1, Data Compilation, Rocky Flats Plant, 700 Area (Operable Unit No. 8).*, Rocky Flats Plant, Golden, Colorado, April.

U.S. Environmental Protection Agency, 1987. *Data Quality Objectives for Remedial Response Activities - Development Process.* EPA 540/G-87/003.

U.S. Environmental Protection Agency, 1990. *Guidance for Data Usability in Risk Assessment*, EPA 540/G-90/008, October.

U.S. Environmental Protection Agency, 1994. *The Data Quality Objective Process.* EPA QA/G-4, March.

APPENDIX A

Site Description and Environmental History

APPENDIX A

Site Description and Environmental History

A.1 Site Description A-1
A.2 Environmental History A-4
A.2.1 Definition and Description of Contaminated Sites A-4
A.3 References A-13

List of Figures

Figure A-1 General Location Map A-2
Figure A-2 RFETS Location Map A-3
Figure A-3 Individual Hazardous Substance Sites by Operable Units A-6

List of Tables

Table A-1 Individual Hazardous Substance Sites A-7

A.1 Site Description

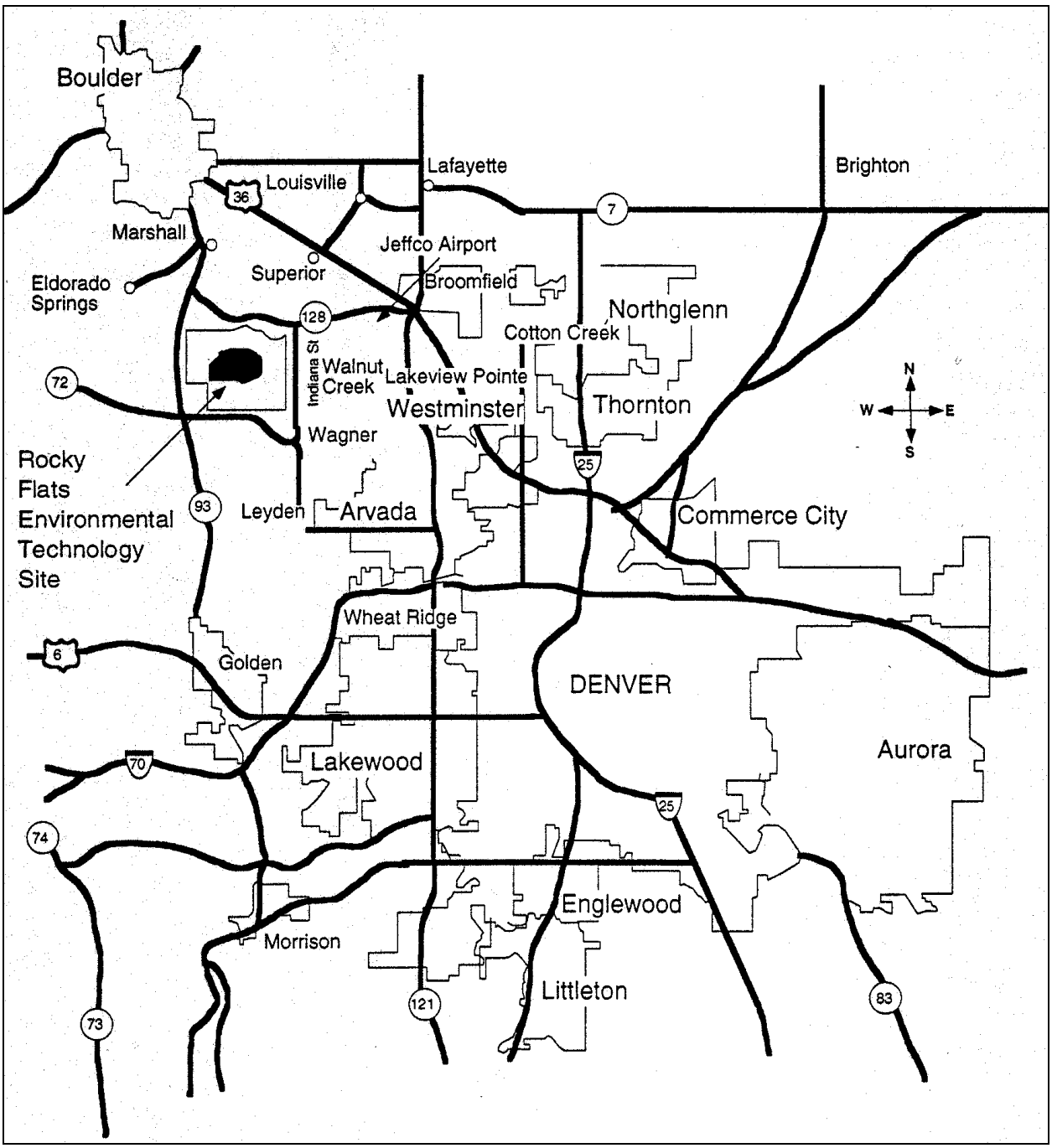
Rocky Flats Environmental Technology Site (RFETS or the Site) is located 16 miles northwest of Denver in Jefferson County, Colorado, and is situated within a 50-mile radius of 2.1 million people. The Site encompasses approximately 6,550 acres of federally-owned land (Figure A-1). Ownership, however, does not include surface and subsurface minerals or water rights. The Site is a U.S. government-owned and contractor-operated facility. Site construction was initiated in 1951 and operations began in 1952 (DOE, 1992).

RFETS was part of the nationwide nuclear weapons research, development, and production complex governed by its original mission. The plant produced metal components for nuclear weapons from plutonium (Pu), uranium (U), beryllium (Be), and stainless steel. Other production activities included chemical recovery and purification of recyclable transuranic radionuclides, metal fabrication and assembly, and related quality control functions. The plant conducted research and development programs in metallurgy, machining, nondestructive testing, coatings, remote engineering, chemistry, and physics. Parts manufactured at the Site were shipped off Site for final assembly.

Major plant structures, including all production buildings, are located within a 400-acre Industrial Area (Figure A-2), with a 6,150-acre Buffer Zone that surrounds the Industrial Area. Industrial activity immediately adjoining the Site includes present and/or prior coal and clay mining, petroleum recovery, natural classified-aggregate quarrying, and fabricated-aggregate mining. Other activities include cattle ranching and wind energy research. Several irrigation ditches intersect the Site, transmitting water for downstream agricultural, industrial, and municipal purposes. Three ephemeral streams drain the Site and flow eastward.

The Site operations have generated solid and liquid nonhazardous, hazardous, radioactive, and mixed (hazardous and radioactive) waste streams. These wastes have been handled and disposed of in a variety of ways. Solid nonhazardous and nonradioactive wastes are disposed of at the Site landfill. Hazardous and mixed radioactive wastes are present on Site and recycled, stored on Site, or shipped off Site for recycling, treatment, or disposal.

Figure A-1
General Location Map



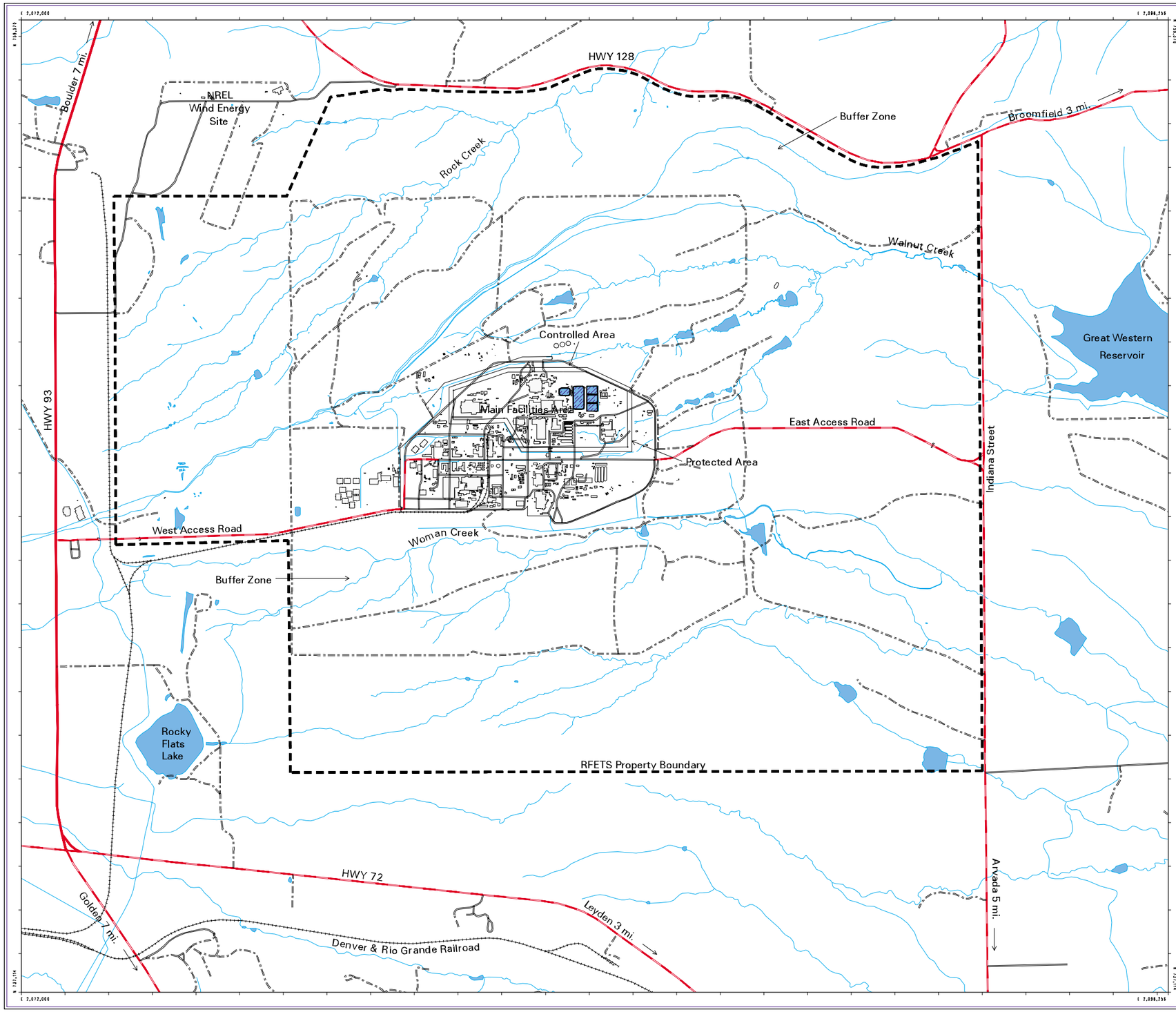


Figure A-2

Rocky Flats Environmental Technology Site Map

EXPLANATION

Standard Map Features

- Buildings
- Solar evaporation ponds
- Lakes and ponds
- Streams, ditches, or other drainage features
- Fences
- Rocky Flats boundary
- Heavy duty paved roads
- Medium duty paved roads
- Light duty paved roads
- Dirt roads
- Railroads

DATA SOURCE:
Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by EG&G RSL, Las Vegas. Digitized from the orthophotographs. 1/95

Scale = 1 : 28720
1 inch represents approximately 2393 feet

700 0 1400 2800 ft

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

Prepared by:

RMRS Rocky Mountain Remediation Services, L.L.C.
Geographic Information Systems Group
Rocky Flats Environmental Technology Site
P.O. Box 464
Golden, CO 80402-0464

MAP ID: 97-0063

September 07, 1999

NT_Svr w:/projects/fy99/99-0372/sitemapa99.aml

A.2 Environmental History

Processing and fabrication of weapons-related components began at the Site in 1952. At that time, environmental protection measures were established that seemed consistent with prudent environmental management. However, some activities resulted in the environmental contamination of portions of the Site. Efforts to document the extent of Site contamination are in progress, in accordance with the Resource Conservation and Recovery Act (RCRA), the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), and the *Rocky Flats Cleanup Agreement* (RFCA) (DOE et al, 1996), a cooperative agreement between the Department of Energy (DOE), the U.S. Environmental Protection Agency (EPA), and Colorado Department of Public Health and Environment (CDPHE). In addition, an Historical Release Report (HRR) (DOE, 1992) has been developed that documents knowledge gained to date about contamination arising from past practices. The HRR is updated annually to document any changes in status for known spills and contaminant sources.

A.2.1 Definition and Description of Contaminated Sites

Section 3004(u) of the RCRA requires that all Solid Waste Management Units (SWMUs) be identified. This became applicable to the Site with the signing of the Compliance Agreement between the State of Colorado and DOE, on July 31, 1986 (State of Colorado, 1986). The exact definition of SWMUs had not been formalized. Therefore, the Site used guidance from the State of Colorado and EPA Region VIII (EPA, 1985). The State of Colorado and EPA required the identification of all areas where releases to the environment may have occurred, including hazardous waste and nonhazardous waste. Also included were single-release areas and locations where long-term management of waste may have occurred.

The SWMUs were initially identified in the *Comprehensive Environmental Assessment and Response Program (CEARP) Phase I: Installation Assessment* (DOE, 1985). The SWMUs consisted of inactive waste disposal sites, accidentally contaminated sites, and sites found to pose potential environmental concern due to past or current waste management practices. Inspections were conducted on each site. The first identification of SWMUs [now titled Individual Hazardous Substance Sites (IHSSs)], consistent with the guidance provided by the State of Colorado, was presented as an appendix to the November 1986, RCRA, Part B Permit Application (Rockwell, 1986).

The SWMUs at the Site were renamed as IHSSs in the Interagency Agreement (IAG), which became the compliance document for Site cleanup under RCRA and CERCLA (State of Colorado, 1991). The term IHSS is specific to the Site and is defined in the IAG (Section 3.2.8) as ". . . locations associated with a release or threat of release of hazardous substances which may cause harm to human health and/or the environment …".

Once the IHSSs were identified, they were grouped into Operable Units (OUs). The IHSSs were grouped based on cleanup priorities, waste type, and geographic setting into 16 OUs, as defined in the IAG. Under RFCA, the OUs have since been consolidated to eliminate redundant paperwork and to streamline the CERCLA remediation process.

Table A-1 lists IHSSs for each OU. Figure A-3 shows the IHSSs and their locations relative to the original 15 OUs located within the Site. Investigations of off-Site contamination beyond the Site boundary were investigated under OU3, which encloses 38 square miles and is not shown on Figure A-3.

These IHSSs have been investigated according to schedules presented in the IAG (State of Colorado, 1991).

The IHSS list is updated as new IHSSs are identified in the HRR (DOE, 1992). Each IHSS is considered a potential source of environmental contamination and, therefore, a potential source of contamination to groundwater.

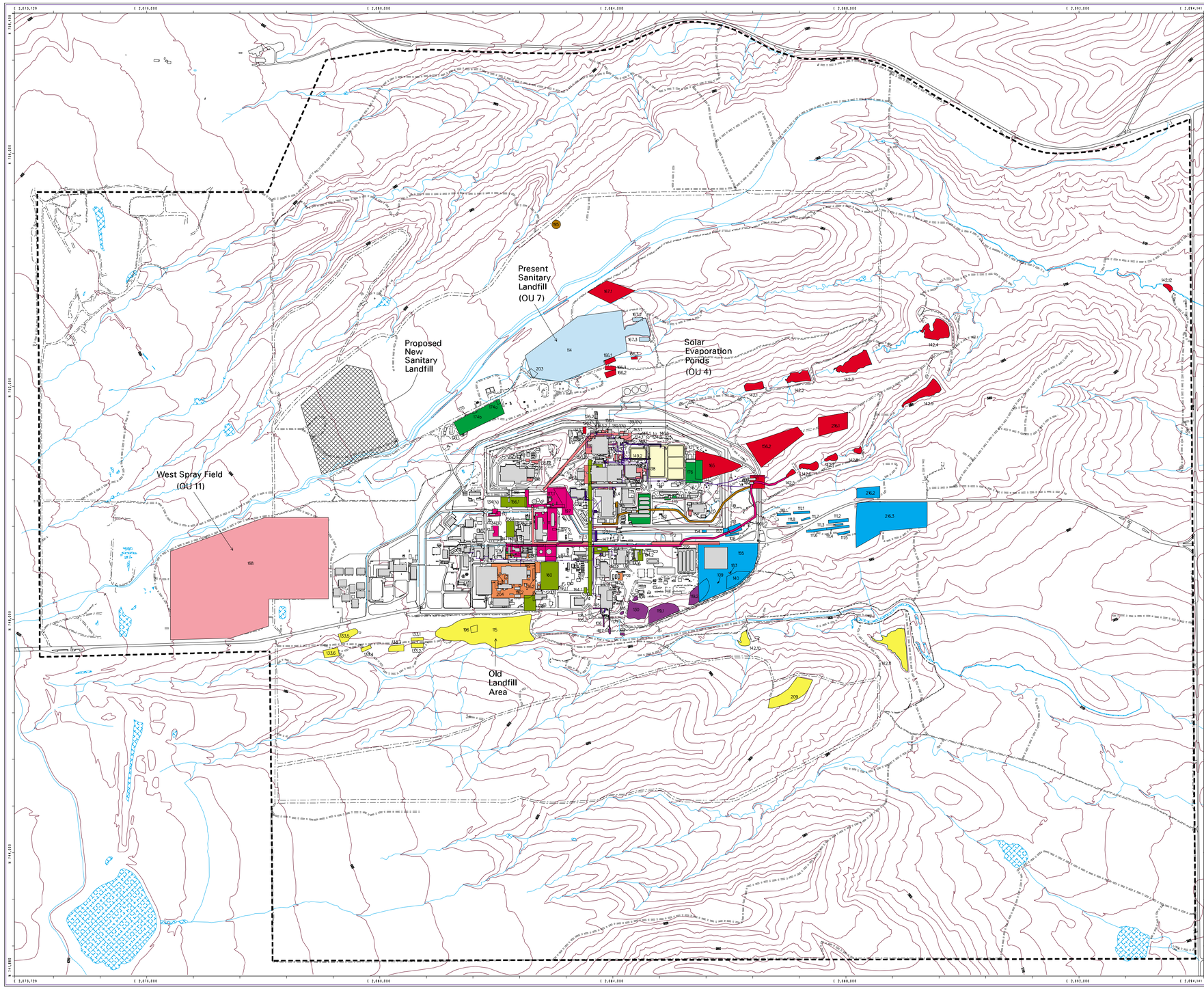


Figure A-3

Individual Hazardous Substance Sites by Operable Unit

EXPLANATION

- Operable Unit 1
- Operable Unit 2
- Operable Unit 4
- Operable Unit 5
- Operable Unit 6
- Operable Unit 7
- Operable Unit 8
- Operable Unit 9
- Operable Unit 10
- Operable Unit 11
- Operable Unit 12
- Operable Unit 13
- Operable Unit 14
- Operable Unit 15
- Operable Unit 16

Standard Map Features

- Lakes and ponds
- Streams, ditches, or other drainage features
- Fences
- Contours (20' Intervals)
- Rocky Flats boundary
- Paved roads
- Dirt roads

DATA SOURCE:
Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by EG&G RSL, Las Vegas.
Digitized from the orthophotographs. 1/95

Scale = 1 : 21330
1 inch represents approximately 1778 feet

350 0 500 1000 ft

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy

Rocky Flats Environmental Technology Site

Prepared by:

RMRS **Rocky Mountain Remediation Services, L.L.C.**
Geographic Information Systems Group
Rocky Flats Environmental Technology Site
P.O. Box 464
Golden, CO 80402-0464

MAP ID: 99-372

August 16, 1999

NT_Svr w:/projects/fy99/99-0372/oushd-nt.aml

Table A-1
Individual Hazardous Substance Sites

IHSS NO.	PAC NO.	PAC NAME
101*	000-101	Solar Ponds
102	800-102	Oil Sludge Pit
103	800-103	Chemical Burial
104	800-104	Liquid Dumping
105.1	800-105.1	Westernmost Out-of-service Fuel Tanks
105.2	800-105.2	Easternmost Out-of-service Fuel Tanks
106	800-106	Outfall
107	800-107	Hillside Oil Leak
108	900-108	Trench T-1
109	900-109	Trench T-2
110	NE-110	Trench T-3
111.1	NE-111.1	Trench T-4
111.2	NE-111.2	Trench T-5
111.3	NE-111.3	Trench T-6
111.4	NE-111.4	Trench T-7
111.5	NE-111.5	Trench T-8
111.6	NE-111.6	Trench T-9
111.7	NE-111.7	Trench T-10
111.8	NE-111.8	Trench T-11
112	900-112	903 Pad
113	900-113	Mound Area
114*	NW-114	Present Landfill
115	SW-115	Original Landfill
116.1	400-116.1	West Loading Dock, Building 447 (IAG Name: West Loading Dock Area)
116.2	400-116.2	South Loading Dock, Building 444 (IAG Name: South Loading Dock Area)
117.1	500-117.1	North Site Chemical Storage
117.2	500-117.2	Middle Site Chemical Storage
117.3	600-117.3	South Site Chemical Storage
118.1	700-118.1	West of Building 730 Solvent Spill
118.2	700-118.2	South End of Building 776 Solvent Spill
119.1	900-119.1	West Scrap Metal Storage Area (IAG-Name: West Area Solvent Spill)
119.2	900-119.2	East Scrap Metal Storage Area (IAG-Name: East Area Solvent Spill)
120.1	600-120.1	Fiberglassing Area North of Building 664
120.2	600-120.2	Fiberglassing Area West of Building 664

Table A-1
(continued)

IHSS NO.	PAC NO.	PAC NAME
121*	000-121	Original Process Waste Lines
122*	400-122	Underground Concrete Tanks
123.1*	700-123.1	Valve Vault 7
123.2	700-123.2	Valve Vault West of Building 707
124.1*	700-124.1	30,000 Gallon Tank (Tank #68)
124.2*	700-124.2	14,000 Gallon Tank (Tank #66)
124.3*	700-124.3	14,000 Gallon Tank (Tank #67)
125*	700-125	Holding Tank (Tank #66)
126.1	700-126.1	Westernmost Out-of-service Waste Tank
126.2	700-126.2	Easternmost Out-of-service Waste Tank
127	700-127	Low-level Radioactive Waste Leak
128	300-128	Oil Burn Pit No. 1
129*	400-129	Oil Leak
130	900-130	Radioactive Site - 800 Area Site No. 1
131	700-131	Radioactive Site - 700 Area Site No. 1
132*	700-132	Radioactive Site - 700 Area Site No. 4
133.1	SW-133.1	Ash Pit I-1
133.2	SW-133.2	Ash Pit I-2
133.3	SW-133.3	Ash Pit I-3
133.4	SW-133.4	Ash Pit I-4
133.5	SW-133.5	Incinerator
133.6	SW-133.6	Concrete Wash Pad
134	300-134 & 300-134.2	Metal Disposal Site North Area (IAG Name: Lithium Metal Destruction Site) & Reactive Metal Destruction Site South Area
135	300-135	Cooling Tower Blowdown
136.1	400-136.1	Cooling Tower Pond West of Building 444 (IAG Name: Cooling Tower Pond Northeast Corner of Building 460)
136.2	400-136.2	Cooling Tower Blowdown Building 444 (IAG Name: Cooling Tower Pond West of Building 460)
137	700-137	Cooling Tower Blowdown Buildings 712 and 713 (IAG Name: Cooling Tower Blowdown Building 774)
138	700-138	Cooling Tower Blowdown Building 779
139.1	700-139.1	Hydroxide Tank Area Spill
139.2	700-139.2	Hydrofluoric Acid Tanks Spill
140	900-140	Hazardous Disposal Area (IAG Name: Reactive Metal Destruction Site)

Table A-1
(continued)

IHSS NO.	PAC NO.	PAC NAME
141	900-141	Sludge Dispersal
142.1	NE-142.1	A-1 Pond
142.10	SE-142.10	C-1 Pond
142.11	SE-142.11	C-2 Pond
142.12	NE-142.12	Flume Pond (IAG Name: A-5 Pond)
142.2	NE-142.2	A-2 Pond
142.3	NE-142.3	A-3 Pond
142.4	NE-142.4	A-4 Pond
142.5	NE-142.5	B-1 Pond
142.6	NE-142.6	B-2 Pond
142.7	NE-142.7	B-3 Pond
142.8	NE-142.8	B-4 Pond
142.9	NE-142.9	B-5 Pond
143	700-143	Old Outfall - Building 771 (IAG Name: Old Outfall)
144	700-144	Sewer Line Overflow (IAG Name: Sewer Line Break)
145	800-145	Sanitary Waste Line Leak
146.1	700-146.1	7,500 Gallon Tank (31)
146.2	700-146.2	7,500 Gallon Tank (32)
146.3	700-146.3	7,500 Gallon Tank (34W)
146.4	700-146.4	7,500 Gallon Tank (34E)
146.5	700-146.5	7,500 Gallon Tank (30)
146.6	700-146.6	7,500 Gallon Tank (33)
147.1	700-147.1	Process Waste Line Leaks (IAG Name: Maas) Area
147.2	800-147.2	Building 881 Conversion Activity Contamination (IAG: Name: Owen Area)
148	100-148	Waste Spills
149	700-149	Effluent Pipe
150.1	700-150.1	Radioactive Site West of Building 771 (IAG: Name: Radioactive Leak North of Building 771)
150.2	700-150.2	Radioactive Site West of Building 771 (IAG Name: Radioactive Leak West of Building 771)
150.3	700-150.3	Radioactive Site Between Buildings 771 & 774 (IAG Name: Radioactive Leak Between Buildings 771 & 774)
150.4	700-150.4	Radioactive Site Northwest of Building 750 (IAG Name: Radioactive Leak East of Building 750)

Table A-1
(continued)

IHSS NO.	PAC NO.	PAC NAME
150.5	700-150.5	Radioactive Site West of Building 707 (IAG Name: Radioactive Leak West of Building 707)
150.6	700-150.6	Radioactive Site South of Building 779 (IAG Name: Radioactive Leak South of Building 779)
150.7	700-150.7	Radioactive Site South of Building 776 (IAG Name: Radioactive Leak South of Building 776)
150.8	700-150.8	Radioactive Site Northeast of Building 779 (IAG Name: Radioactive Leak Northeast of Building 779)
151	300-151	Fuel Oil Leak
152	600-152	Fuel Oil Tank
153	900-153	Oil Burn Pit No. 2
154	900-154	Pallet Burn Site
155	900-155	903 Lip Area
156.1	300-156.1	Building 334 Parking Lot
156.2	NE-156.2	Soil Dump Area
157.1	400-157.1	Radioactive Site North Area
157.2	400-157.2	Radioactive Site South Area
158	500-158	Radioactive Site - Building 551
159	500-159	Radioactive Site - Building 559
160	600-160	Radioactive Site Building 444 Parking Lot
161	600-161	Radioactive Site West of Building 664
162	000-162	Radioactive Site - 700 Area Site No. 2
163.1	700-163.1	Radioactive Site 700 Area Site No. 3 Wash Area
163.2	700-163.2	Radioactive Site 700 Area Site No. 3 Buried Slab
164.1	600-164.1	Radioactive Site 800 Area Site No. 2 Concrete Slab
164.2	800-164.2	Radioactive Site 800 Area Site No. 2 Building 886 Spills
164.3	800-164.3	Radioactive Site 800 Area Site No. 2 Building 889 Storage Pad
165	900-165	Triangle Area
166.1	NE-166.1	Trench A
166.2	NE-166.2	Trench B
166.3	NE-166.3	Trench C
167.1	NE-167.1	Spray Field: North Area
167.2	NE-167.2	Spray Field: Pond Area (Center Area)
167.3	NE-167.3	Spray Field: South Area
168*	SW-168	West Spray Field

Table A-1
(continued)

IHSS NO.	PAC NO.	PAC NAME
169	500-169	Waste Drum Peroxide Burial
170*	NW-170	PU&D Storage Yard - Waste Spills
171	300-171	Solvent Burning Ground
172	000-172	Central Avenue Waste Spill
173	900-173	South Dock - Building 991 (IAG Name: Radioactive Site - 900 Area)
174*	NW-174	PU&D Container Storage Facilities (2)
175*	900-175	S&W Building 980 Contractor Storage Facility
176*	900-176	S&W Contractor Storage Yard
177*	800-177	Building 885 Drum Storage Area
178*	800-178	Building 881 Drum Storage Area
179*	800-179	Building 865 Drum Storage Area
180*	800-180	Building 883 Drum Storage Area
181*	300-181	Building 334 Cargo Container Area
182*	400-182	Building 444/453 Drum Storage Area
183	900-183	Gas Detoxification Area
184	900-184	Building 991 Steam Cleaning Area
185	700-185	Solvent Spill
186*	300-186	Valve Vault 12
187	400-187	Sulfuric Acid Spill [IAG Name: Acid Leaks (2)]
188	300-188	Acid Leak
189	600-189	Multiple Acid Spills 218 Tanks (IAG Name: Multiple Acid Spills)
190	000-190	Caustic Leak
191	400-191	Hydrogen Peroxide Spill
192	000-192	Antifreeze Discharge
193	400-193	Steam Condensate Leak
194	700-194	Steam Condensate Leak
195	NW-195	Nickel Carbonyl Disposal
196	100-196	Water Treatment Plant Backwash Pond
197	500-197	Scrap Metal Sites
203*	NW-203	Inactive Hazardous Waste Storage Area
204*	400-204	Original Uranium Chip Rowster
205*	400-205	Building 460 Sump No. 3 Acid Side
206*	300-206	Inactive D-836 Hazardous Waste Tank
207*	400-207	Inactive 444 Acid Dumpster
208*	400-208	Inactive 444/447 Waste Storage Area
209	SE-209	Surface Disturbance Southeast of Building 881
210*	900-210	Unit 16, Building 980 Cargo Container

IHSS NO.	PAC NO.	PAC NAME
211*	800-211	Building 881 Drum Storage Unit 26
212*	300-212	Building 371 Drum Storage Unit 53
213*	900-213	Unit 15, 904 Pad Pondcrete Storage
214*	700-214	750 Pad Pondcrete and Saltcrete Storage, Unit 25
215*	700-215	Tank T-40, Unit 55.13
216.1	NE-216.1	Easy Spray Fields - North Area
216.2	NE-216.2	East Spray Fields - Center Area
216.3	NE-216.3	East Spray Fields - South Area
217*	800-217	Building 881, CN Bench Scale Treatment, Unit 32

Notes:

"*" indicates IHSSs that are RCRA units per the Interagency Agreement that was signed in 1991. IHSS 198 was deleted in 1990.

199	=	Contamination of the Land Surface
200	=	Great Western Reservoir
201	=	Standley Lake Reservoir
202	=	Mower Reservoir
IAG	=	Interagency Agreement
PAC	=	Personnel Access Control
PU&D	=	Property Utilization and Disposal

A.3 References

State of Colorado, 1986. Compliance Agreement signed by the U.S. EPA and the U.S. Department of Energy, 1986. *In the Matter of Department of Energy, RFP, Golden, Colorado.* July 31.

Rockwell International, 1986. *RCRA Part B Permit Application*.

State of Colorado, U.S. Environmental Protection Agency, and U.S. Department of Energy, 1991. *Rocky Flats Interagency Agreement: Federal Facility Agreement and Consent Order*, CERCLA-VIII-91-03, RCRA (3008(h))-VIII-91-07, State of Colorado Docket #91-01-22-01. January.

U.S. Department of Energy, 1985. *Comprehensive Environmental Assessment and Response Program (CEARP) Phase 1: Installation Assessment*.

U.S. Department of Energy, 1992. *Final Historical Release Report for the Rocky Flats Plant*, Rocky Flats Plant, Golden, Colorado. June.

U.S. Department of Energy, Colorado Department of Health and Environment, U.S. Environmental Protection Agency, 1996. *Final Rocky Flats Cleanup Agreement.* July.

U.S. Environmental Protection Agency, 1985. Letter to James R. Nicks, DOE, RFP from Robert L. Duprey, Director of EPA Waste Management Division and Kenneth Waesche, Director of Colorado Department of Health Waste Management Division. Environmental Protection Agency (EPA).

APPENDIX B

Action Level Framework for Groundwater

APPENDIX B

Action Level Framework for Groundwater

List of Tables

Table B-1 Action Level Framework for Groundwater B-1

APPENDIX B

Action Level Framework for Groundwater

Analyte	CAS No.	Tier 1- 100 x MCLs (mg/L)	Tier 2- MCLs (mg/L)
Acenaphthene (V)	83-32-9	2.19E+02	2.19E+00
Acetone (V)	67-64-1	3.65E+02	3.65E+00
Aldrin	309-00-2	5.00E-04	5.00E-06
Aluminum	7429-90-5	1.06E+04	1.06E+02
Anthracene (V)	120-12-7	1.10E+03	1.10E+01
Antimony	7440-36-0	6.00E-01	6.00E-03
Aroclor-1016	12674-11-2	5.00E-02	5.00E-04
Aroclor-1221	11104-28-2	5.00E-02	5.00E-04
Aroclor-1232	11141-16-5	5.00E-02	5.00E-04
Aroclor-1242	53469-21-9	5.00E-02	5.00E-04
Aroclor-1248	12672-29-6	5.00E-02	5.00E-04
Aroclor-1254	11097-69-1	5.00E-02	5.00E-04
Aroclor-1260	11096-82-5	5.00E-02	5.00E-04
Arsenic	7440-38-2	5.00E+00	5.00E-02
Barium	7440-39-3	2.00E+02	2.00E+00
Benzene (V)	71-43-2	5.00E-01	5.00E-03
alpha-BHC	319-84-6	1.35E-03	1.35E-05
beta-BHC	319-85-7	4.72E-03	4.72E-05
gamma-BHC (Lindane)	58-89-9	2.00E-02	2.00E-04
Benzo(a)anthracene	56-55-3	1.16E-02	1.16E-04
Benzo(a)pyrene	50-32-8	2.00E-02	2.00E-04
Benzo(b)fluoranthene	205-99-2	1.16E-02	1.16E-04
Benzo(k)fluoranthene	207-08-9	1.16E-01	1.16E-03
Benzoic Acid	65-85-0	1.46E+04	1.46E+02
Benzyl Alcohol	100-51-6	1.10E+03	1.10E+01
Beryllium	7440-41-7	4.00E-01	4.00E-03
bis(2-Chloroethyl)ether (V)	111-44-4	1.63E-03	1.63E-05
bis(2-Chloroisopropyl)ether (V)	108-60-1	4.22E-02	4.22E-04
bis(2-Ethylhexyl)phthalate	117-81-7	6.00E-01	6.00E-03
Bromodichloromethane (V)	75-27-4	1.00E+01	1.00E-01
Bromoform (V)	75-25-2	1.00E+01	1.00E-01
Bromomethane (V)	74-83-9	1.09E+00	1.09E-02
2-Butanone (V)	78-93-3	2.47E+02	2.47E+00
Butylbenzylphthalate	85-68-7	7.30E+02	7.30E+00
Cadmium	7440-43-9	5.00E-01	5.00E-03
Carbon disulfide (V)	75-15-0	2.76E+00	2.76E-02
Carbon tetrachloride (V)	56-23-5	5.00E-01	5.00E-03
alpha-Chlordane	5103-71-9	2.00E-01	2.00E-03
beta-Chlordane	5103-74-2	2.00E-01	2.00E-03
gamma-Chlordane	5103-74-2	2.00E-01	2.00E-03
4-Chloroaniline	106-47-8	1.46E+01	1.46E-01
Chlorobenzene (V)	108-90-7	1.00E+01	1.00E-01
Chloroethane (V)	75-00-3	2.78E+03	2.78E+01
Chloroform (V)	67-66-3	1.00E+01	1.00E-01
Chloromethane (V)	74-87-3	2.32E-01	2.32E-03
2-Chloronaphthalene (V)	91-58-7	2.92E+02	2.92E+00
2-Chlorophenol (V)	95-57-8	1.83E+01	1.83E-01

Analyte	CAS No.	Tier 1- 100 x MCLs (mg/L)	Tier 2- MCLs (mg/L)
Chromium	7440-47-3	1.00E+01	1.00E-01
Chrysene	218-01-9	1.16E+00	1.16E-02
Cobalt	7440-48-4	2.19E+02	2.19E+00
Copper	7440-50-8	1.30E+02	1.30E+00
Cyanide	57-12-5	2.00E+01	2.00E-01
4,4-DDD	72-54-8	3.54E-02	3.54E-04
4,4-DDE	72-55-9	2.50E-02	2.50E-04
4,4-DDT	50-29-3	2.50E-02	2.50E-04
Dalapon	75-99-0	2.00E+01	2.00E-01
Dibenz(a,h)anthracene	53-70-3	1.16E-03	1.16E-05
Dibromochloromethane	124-48-1	1.01E-01	1.01E-03
1,2-Dibromo-3-chloropropane	96-12-8	2.00E-02	2.00E-04
Di-n-butylphthalate	84-74-0	3.65E+02	3.65E+00
2,4-D	94-75-7	7.00E+00	7.00E-02
1,2-Dichlorobenzene (V)	95-50-1	6.00E+01	6.00E-01
1,3-Dichlorobenzene (V)	541-73-1	6.00E+01	6.00E-01
1,4-Dichlorobenzene (V)	106-46-7	7.50E+00	7.50E-02
3,3-Dichlorobenzidine	91-94-1	1.89E-02	1.89E-04
1,1-Dichloroethane (V)	107-06-2	1.01E+02	101E+00
1,2-Dichloroethane (V)	107-06-2	5.00E-01	5.00E-03
1,1-Dichloroethene (V)	540-59-0	7.00E-01	7.00E-03
1,2-Dichloroethene (total)(V)	540-59-0	7.00E+00	7.00E-02
2,4-Dichlorophenol	120-83-2	1.10E+01	1.10E-01
1,2-Dichloropropane (V)	78-87-5	5.00E-01	5.00E-03
cis-1,3-Dichloropropene (V)	1006-01-5	1.27E-02	1.27E-04
trans-1,3-Dichloropropene (V)	10061-02-6	1.27E-02	1.27E-04
Dieldrin	60-57-1	5.31E-04	5.31E-06
Diethylphthalate	84-66-2	2.92E+03	2.92E+01
2,4-Dimethylphenol (V)	105-67-9	7.30E+01	7.30E-01
Dimethylphthalate	131-11-3	3.65E+04	3.65E+02
2,4-Dinitrophenol	51-28-5	7.30E+00	7.30E-02
2,4-Dinitrotoluene	121-14-2	7.30E+00	7.30E-02
2,6-Dinitrotoluene	606-20-2	1.25E-02	1.25E-04
Di-n-octylphthalate	117-84-0	7.30E+01	7.30E-01
Endosulfan I	959-98-8	2.19E+01	2.19E-01
Endosulfan II	33213-65-9	2.19E+01	2.19E-01
Endosulfan sulfate	1031-07-8	2.19E+01	2.19E-01
Endosulfan (technical)	115-29-7	2.19E+01	2.19E-01
Endrin (technical)	72-26-8	2.00E-01	2.00E-03
Ethylbenzene (V)	100-41-4	7.00E+01	7.00E-01
Fluoranthene	206-44-0	1.46E+02	1.46E+00
Fluorene (V)	86-73-7	1.46E+02	1.46E+00
Fluoride	16984-48-8	4.00E+02	4.00E+00
Glyphosate	1071-83-6	7.00E+01	7.00E-01
Heptachlor	76-44-8	4.00E-02	4.00E-04
Heptachlor epoxide	1024-57-3	2.00E-02	2.00E-04
Hexachlorobenzene	118-74-1	1.00E-01	1.00E-03
Hexachlorobutadiene	87-68-3	1.09E-01	1.09E-03
Hexachlorocyclopentadiene	77-47-4	5.00E+00	5.00E-02
Hexachloroethane	67-72-1	6.07E-01	6.07E-03
Indeno(1,2,3-cd)pyrene	193-39-5	1.16E-02	1.16E-04

Analyte	CAS No.	Tier 1- 100 x MCLs (mg/L)	Tier 2- MCLs (mg/L)
Isophorone	78-59-1	8.95E+00	8.95E-02
Lithium	7439-93-2	7.30E+01	7.30E-01
Manganese	7439-96-5	1.83E+01	1.83E-01
Mercury	7439-97-6	2.00E-01	2.00E-03
Methoxychlor	72-43-5	4.00E+00	4.00E-02
Methylene chloride (V)	75-09-2	5.00E-01	5.00E-03
4-Methyl-2-pentanone (V)	108-10-1	2.03E+01	2.03E-01
2-Methylphenol	95-48-7	1.83E+02	1.83E+00
Molybdenum	7439-98-7	1.83E+01	1.83E-01
Naphthalene (V)	91-20-3	1.46E+02	1.46E+00
Nickel	7440-02-0	1.00E+01	1.00E-01
Nitrate (MCL as N)	1-005	1.00E+03	1.00E+01
Nitrite (MCL as N)	1-005	1.00E+02	1.00E+00
Nitrobenzene (V)	98-95-3	4.20E-01	4.20E-03
n-Nitrosodiphenylamine (V)	86-30-6	1.73E+00	1.73E-02
n-Nitrosodipropylamine	621-64-7	1.21E-03	1.21E-05
Pentachlorophenol	87-86-5	1.00E-01	1.00E-03
Phenol	108-95-2	2.19E+03	2.19E+01
Pyrene	129-00-0	1.10E+02	1.10E+00
Selenium	7782-49-2	5.00E+00	5.00E-02
Silver	7440-22-4	1.83E+01	1.83E-01
Strontium	7440-24-6	2.19E+03	2.19E+01
Styrene (V)	100-42-5	1.00E+01	1.00E-01
Sulfate	14808-79-8	5.00E+04*	5.00E+02*
1,1,2,2-Tetrachloroethane (V)	79-34-5	8.95E-03	8.95E-05
Tetrachloroethene (V)	127-18-4	5.00E-01	5.00E-03
Thallium	7440-28-0	2.00E-01	2.00E-03
Tin	7440-31-5	2.19E+03	2.19E+01
Toluene (V)	108-88-3	1.00E+02	1.00E+00
Toxaphene	8001-35-2	3.00E-01	3.00E-03
1,2,4-Trichlorobenzene (V)	120-82-1	7.00E+00	7.00E-02
1,1,1-Trichloroethane (V)	71-55-6	2.00E+01	2.00E-01
1,1,2-Trichloroethane (V)	79-00-5	5.00E-01	5.00E-03
Trichloroethene (V)	79-01-6	5.00E-01	5.00E-03
2,4,5-Trichlorophenol	95-95-4	5.00E+00	5.00E-02
2,4,6-Trichlorophenol	88-06-2	7.73E-01	7.73E-03
Vanadium	7440-62-2	2.56E+01	2.56E-01
Vinyl acetate	108-05-4	3.65E+03	3.65E+01
Vinyl chloride (V)	75-01-4	2.00E-01	2.00E-03
Xylene (total)(V)	1330-20-7	1.00E+03	1.00E+01
Zinc	7440-66-6	1.10E+01	1.10E+01

Analytes without an MCL value list the corresponding residential groundwater ingestion Preliminary Programmatic Remediation Goal (PPRG) which is shown in bold italics
Analytes without an MCL or a PPRG value are not listed
(V) = Volatile chemicals
*Based on proposed MCL

APPENDIX B

Action Level Framework for Groundwater

Analyte	CAS No.	Tier 1- 100 x MCLs (pCi/L)	Tier 2- MCLs (pCi/L)
RADIOLOGIC PARAMETERS			
Americium-241	14596-10-2	1.45E+01	1.45E-01
Cesium-137+D	10045-97-3	1.51E+02	1.51E+00
Plutonium-239	10-12-8	1.51E+01	1.51E-01
Plutonium-240	10-12-8	1.51E+01	1.51E-01
Radium-226+D	13982-63-3	2.00E+03*	2.00E+01*
Radium-228+D	15262-20-1	2.00E+03*	2.00E+01*
Strontium-89	11-10-9	4.62E+02	4.62E+00
Strontium-90+D	11-10-9	8.52E+01	8.52E-01
Tritium	10028-17-8	6.66E+04	6.66E+02
Uranium-233+D	11-08-5	2.98E+02	2.98E+00
Uranium-234	11-08-5	1.07E+02	1.07E+00
Uranium-235+D	15117-96-1	1.01E+02	1.01E+00
Uranium-238+D	7440-61-1	7.68E+01	7.68E-01

D = Daughters
*Based on proposed MCL

APPENDIX C

Physical and Hydrologic Setting

APPENDIX C

Physical And Hydrologic Setting

C.1 Geology C-1
C.1.1 Introduction C-1
C.1.2 Stratigraphy C-1
C.1.2.1 Pediment-Covering Alluviums C-2
C.1.2.2 Other Surficial Deposits C-2
C.1.2.3 Arapahoe Formation C-4
C.1.2.4 Laramie and Fox Hills Sandstone Formations C-4
C.1.2.5 Pierre Formation C-4
C.1.3 Geologic Structure C-4
C.2 Hydrogeology C-5
C.2.1 Introduction C-5
C.2.2 Definition of the Uppermost Aquifer for the Site C-5
C.2.3 Groundwater Occurrence and Distribution C-7
C.2.4 Groundwater Flow C-8
C.2.5 Hydraulic Conductivity C-8
C.3 References C-9

List of Figures

Figure C-1 Generalized Stratigraphic Column for the Rocky Flats Area C-3
Figure C-2 Generalized Geological Cross Section of the Front Range and the Rocky Flats Areas C-6

C.1 Geology

C.1.1 Introduction

Rocky Flats Environmental Technology Site (RFETS or the Site) is situated approximately 2 to 6 miles east of the Front Range of Colorado (Figure A-1) on the western margin of the Colorado Piedmont section of the Great Plains Physiographic Province (Spencer, 1961). The geologic history of the Rocky Mountain region of Colorado (which includes the Site area) has been summarized by Haun and Kent (1965). The elevation at the Site is approximately 6,000 feet above mean sea level (msl). The Industrial Area (main facility area) of the Site is located on alluvial-covered pediment. The upper surface of the alluvium slopes easterly one to two degrees. Most of the surrounding area in the Buffer Zone is more prominently dissected with intermittent streams. These small, eastward flowing streams include Rock Creek, Walnut Creek, Woman Creek, and several surface water diversion ditches (see Section 3.1.4 of this report, Figure 3-1).

The following major geologic and hydrologic parameters influence groundwater flow at the Site (EG&G, 1995a):

- Topography controls the surface waters of the upslope drainage basin that, in part, recharges groundwater and the three principal streams draining the Site. The majority of shallow groundwater is intercepted by these drainages.

- The lithology and permeability of the unconsolidated surficial deposits permit meteoric waters to recharge the water table. The water table is contained in alluvium and weathered bedrock.

- Paleotopography of the bedrock pediment, which is less permeable than the overlying unconsolidated surficial deposits, serves to focus groundwater movement along bedrock "lows."

- Paleoweathering of shallow bedrock materials has enhanced the permeability of the upper 10 to 60 feet relative to unweathered bedrock.

- The permeability of bedrock units, composed primarily of claystone with lesser amounts of siltstone and sandstone, is generally several orders of magnitude less than for unconsolidated surficial deposits. The 600+ feet of unweathered bedrock between the shallow groundwater flow system and deep regional Laramie-Fox Hills aquifer provides an effective barrier to vertical groundwater and contaminant movement.

C.1.2 Stratigraphy

The stratigraphic sequence that underlies the Site extends from the crystalline Precambrian gneiss, schist, and granitoids at 3,000 feet below msl to the unconsolidated Quaternary deposits at surface approximately 6,000 feet above msl. Based upon aerial photographic interpretation,

field geologic mapping, coal and aggregate mine development, petroleum exploration in the vicinity, and numerous borehole investigations, a substantial amount of lithologic information has been gained about the Site. The generalized lithologic section in the Rocky Flats area is shown in Figure C-1.

Bedrock formations from the uppermost Cretaceous Pierre, Fox Hills, Laramie, and Arapahoe Formations are present and exposed at the surface and beneath the Site. The Quaternary Rocky Flats Alluvium, and to a limited extent Verdos Alluvium, unconformably overlie the Cretaceous Arapahoe and Laramie Formations in the central portion of the Site. The unconsolidated surficial deposits, combined with the weathered portion of subcropping bedrock formations, form the sequence of rocks which have the greatest importance regarding groundwater flow and contaminant transport at the Site.

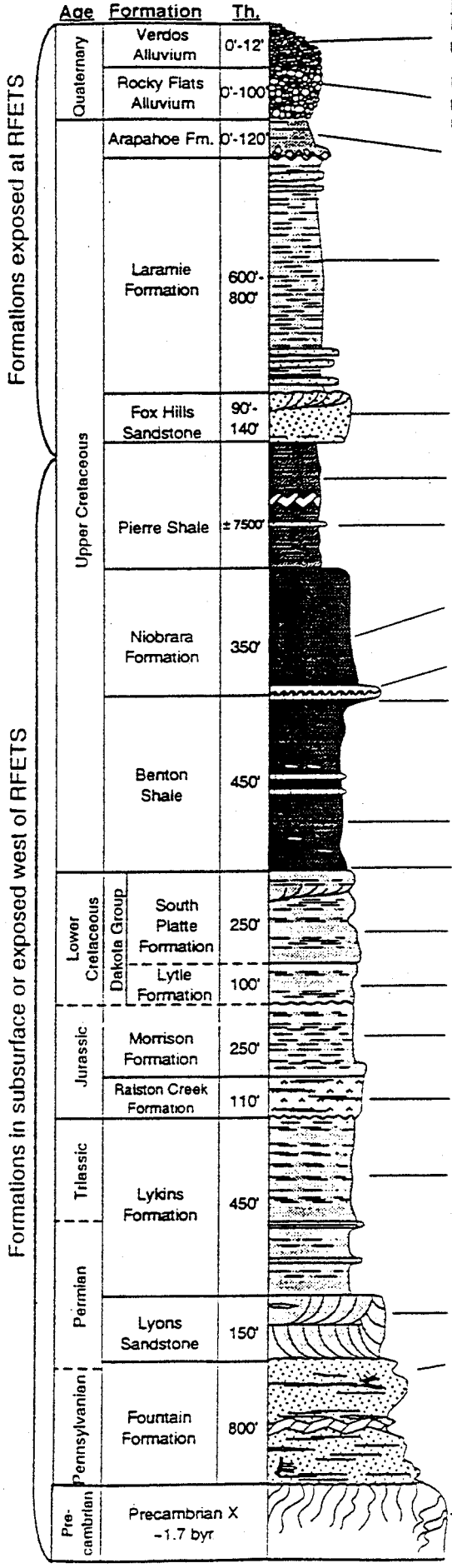
C.1.2.1 Pediment-Covering Alluviums

Several Quaternary alluvial formation pediment covers have been identified in the vicinity of the Site by Scott (1975). The Rocky Flats Alluvium is an unconsolidated deposit derived from quartzites and granites of the Coal Creek Canyon provenance west of the Site. The deposit diminishes from west to east with thicknesses ranging from approximately 100 feet to less than 1 foot. In the central portion of the Site, the deposit is approximately 15 to 25 feet thick. The Rocky Flats Alluvium is a heterogeneous deposit dominantly composed of angular to subrounded, poorly-sorted, coarse, bouldery-gravel with a clay and sand matrix. Clay, silt, and sand lenses as well as varying amounts of caliche are also present. Exposures of Rocky Flats Alluvium in the aggregate quarries north and west of the Site exhibit some large scale cross-stratification. Depositional processes include fluvial and debris-flow transport (Shroba, 1994) infilling paleotopographic lows but leaving a widespread surface of erosion with extremely low relief.

C.1.2.2 Other Surficial Deposits

In addition to the pediment-forming alluvial deposits, younger Quaternary units consisting of colluvium, landslide alluvium, and valley fill alluvium mantle the hillslopes and valley bottoms below the pediment surface. Colluvial deposits are derived from Arapahoe and Laramie Formations and older alluvial deposits. This unit consists of sheetwash, soil creep, and landslide materials in a total thickness of 3 to 16 feet (Shroba, 1994). These deposits locally flank the Rocky Flats Alluvium and generally extend to lower parts of the slopes along the principal drainages.

Landslide deposits more commonly flank the Rocky Flats Alluvium. They are often bounded by headwall scarps and lobate toes at the downslope margins. Seeps issuing from the base of the Rocky Flats Alluvium contribute to landslide colluvium generation. The landslide units include earth flows, slumps, and debris flows in a thickness estimated between 10 to 33 feet (Shroba, 1994).



Description

Reddish brown matrix, moderately sorted, sandy pebble gravel and pebbly, silty sand

Reddish brown to yellowish brown matrix, grayish-orange to dark gray, poorly sorted, angular to subrounded, cobbles, coarse gravels, coarse sands and gravelly clays; varying amounts of caliche; aggregate source

Gray to yellowish orange clay stone, sandy clay stone, and clayey sandstone, medium to coarse sandstone and chert pebble conglomerate locally at base; aquifer east of RFETS

Gray, fine- to medium-grained sandstone and clay stones; thin coal beds mined in lower part and locally uraniferous; ironstone nodule; aquifer east of RFETS

Light olive gray to yellowish brown fine- to medium-grained cross-bedded sandstone, and laminated silty sandstone and shale at base; aquifer east of RFETS

Dark gray, silty bentonitic shale and few thin, silty sandstones

Hygiene Sandstone Member in lower part

Olive gray to dusky yellow, very calcareous shale, thin bentonite, gypsum, and fossiliferous limestone beds

Light gray, dense, fossiliferous limestone

Yellowish gray, sandy fossiliferous limestone

Dark gray shale with bentonite streaks, thin limestones in middle part

Dark gray to black, brittle silty shale

Light gray, fine- to medium-grained cross-bedded sandstone, dark gray clay stone in middle part;mined for uranium ore; major oil reservoir

Light gray to tan, fine- to coarse-grained, locally conglomeratic sandstone, frequent red and green siltstone interbeds

Gray to greenish-gray to red shale and siltstone, thin limestones in middle part; lenticular sandstones in upper and lower part; locally uraniferous

Light gray siltstone and light red, silty shale; calcareous; chert nodules and beds

Red siltstone and clay stone with two laminated limestones in lower part

Pinkish-gray, fine- to medium-grained, cross-bedded sandstone; conglomeratic lenses frequent

Red, fine- to coarse-grained sandstone and conglomerate, arkosic, thin, lenticular red siltstones frequent throughout

Gneiss, schist, and small granitic intrusions; mined for uranium ore

Modified from LeRoy and Weimer (1971); USGS OFR-94-162 (1994); Nelson-Moore, et al.(1978); and Pearl (1980)

Rocky Flats Environmental Technology Site

Generalized Stratigraphic Column for the Rocky Flats Area

1996 IMP

August 1994 | Figure C-1

M\ES\Fig 4-02 Stratigraphy/ S.M. Stoller

C.1.2.3 Arapahoe Formation

The Arapahoe Formation is composed of claystones and silty claystones with some lenticular sandstones. In the Geologic Characterization Report for the U.S. DOE Rocky Flats Plant (EG&G, 1991), the Arapahoe Formation was interpreted to be 150 feet thick in the central area and to contain five sandstones named Sandstones 1 through 5. The thickest and most widespread, uppermost sandstone was defined as the No. 1 Sandstone which was interpreted to be deposited in a fluvial environment. The more recent Site-wide mapping program (EG&G, 1992) determined that the overall Arapahoe Formation is generally less than 25 feet thick in the Site area. The No. 1 Sandstone (EG&G, 1991) was correlated to the basal Arapahoe Sandstone. Lower bedrock sandstones (i.e., Sandstones 2 through 5) in the 1991 Geologic Characterization Report were redefined as lenticular Laramie sandstones as they are texturally distinct from the No. 1 Sandstone by virtue of their high silt and clay content. These lower sandstones have limited hydrologic significance and are currently identified as part of the upper Laramie Formation.

The No. 1 Sandstone, which is currently defined as the basal Arapahoe Sandstone, is of concern as a potential contamination pathway, especially where it subcrops beneath the alluvial/bedrock unconformity. The other sandstones pose a limited threat as potential contamination pathways since they are lenticular and discontinuous.

C.1.2.4 Laramie and Fox Hills Sandstone Formations

The Laramie Formation is approximately 600 to 800 feet thick and is composed of a lower sandstone/claystone/coal interval and an upper, thicker claystone interval. The permeable lower sandstones and coals of the Laramie, combined with the permeable sandstones of the Fox Hills, constitute a regional aquifer system known as the Laramie-Fox Hills aquifer. This aquifer system is an important water source in the South Platte River Basin (Pearl, 1980), and is the sole water supply for some residents in the Rocky Flats area. The Fox Hills Formation is primarily a fine-grained sandstone with an approximate thickness of between 75 to 125 feet with thin siltstone and claystone interbeds. The Fox Hills Formation outcrops and subcrops along a narrow, north-south trending pattern in the extreme western part of the Site upgradient from known sources of contamination.

C.1.2.5 Pierre Formation

The Pierre Formation is a 7,500-foot thick, dark gray, silty bentonitic shale that acts as a lower confining layer for the Laramie-Fox Hills aquifer in the Denver Basin. This thick marine shale unit subcrops only in the extreme western part of the Site.

C.1.3 Geologic Structure

The Site is located along the western margin of the Denver Basin, an asymmetric basin with a steeply east-dipping western flank and a gentle eastern flank. The interpretation of the

subsurface structure is generalized in the east-west geological cross section of the Site area presented in Figure C-2. A monoclinal fold limb exposed west of the Site is the most significant surficial structural feature in the Site area. Along the west limb of the fold, an angular unconformity exists between the Upper Cretaceous bedrock and the base of the Quaternary Rocky Flats Alluvium.

No active faults have been identified at the Site. Several high angle bedrock faults have been inferred to exist in the Industrial Area of the Site based on various stratigraphic and borehole correlation criteria. These faults appear to have only a limited hydrologic significance with regard to vertical groundwater movement and contaminant transport (DOE, 1996).

C.2 Hydrogeology

C.2.1 Introduction

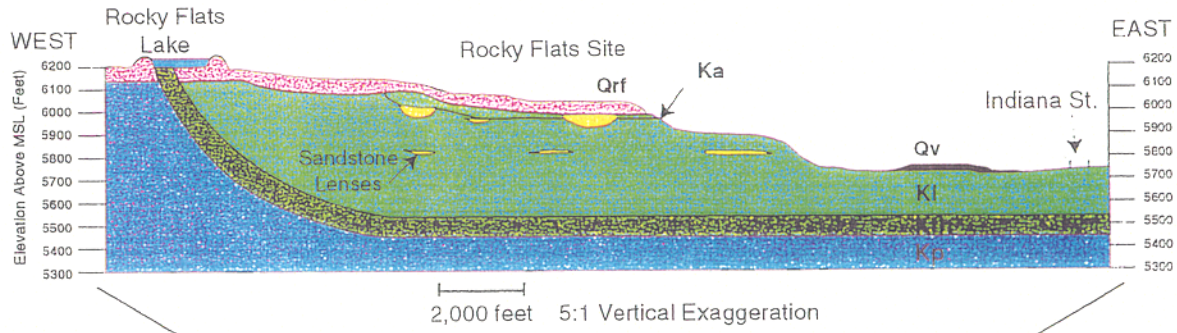
This section presents the basic concepts about the hydrogeologic conditions at the Site that affect groundwater monitoring and protection. Characterization of the hydrogeologic setting is based on the currently accepted conceptual geologic and hydrogeologic models described in the Sitewide Geoscience Characterization Study (EG&G, 1995b; Shroba, 1994; EG&G, 1995c). These conceptual geologic and hydrogeologic models are used to predict the direction and rate of groundwater flow, identify potential pathways for contaminant migration, and determine the extent of contaminant plumes given varying physical, chemical, and biological factors.

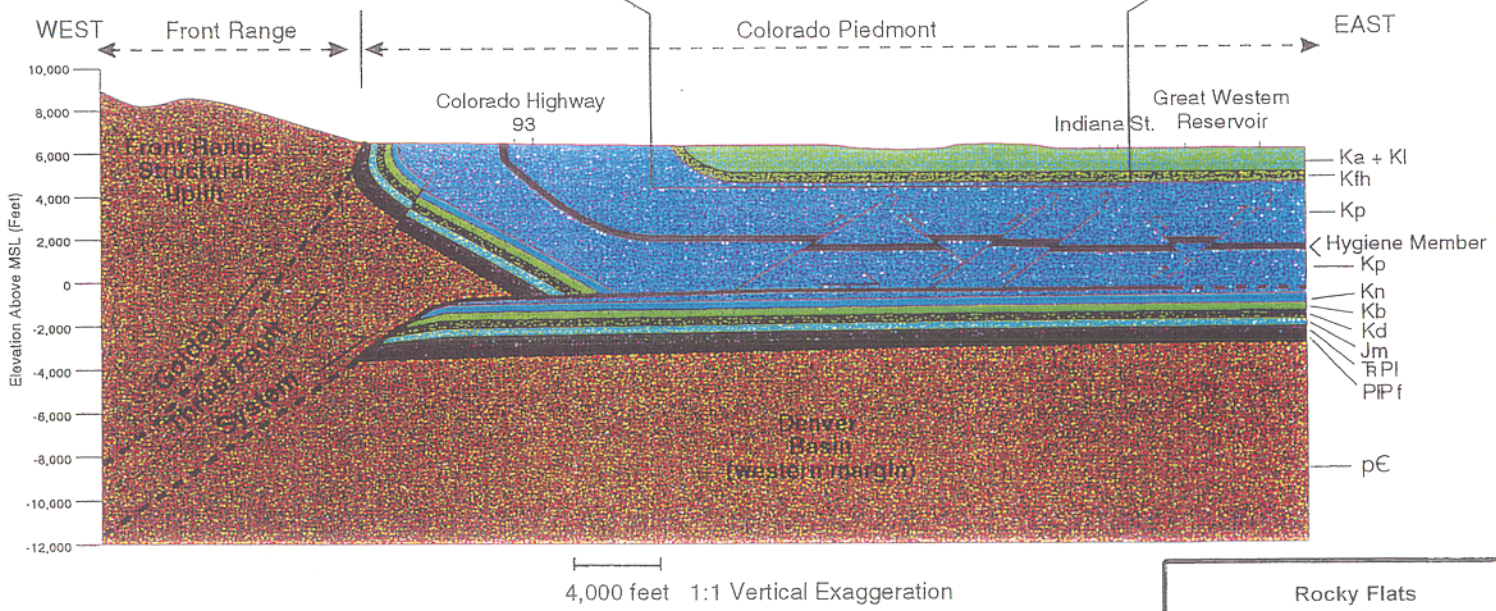
C.2.2 Definition of the Uppermost Aquifer for the Site

The term “aquifer” as defined by Title 40 of the *Code of Federal Regulations (*CFR) Section 260.10 is a "geologic formation, group of formations, or a part of a formation that is capable of yielding a significant amount of water to a well or spring." An “uppermost aquifer” is defined as "the geologic formation nearest the natural ground surface that is an aquifer, as well as lower aquifers that are hydraulically interconnected with this aquifer within the facility's boundary.” Geologic materials with similar hydrologic properties comprise a hydrostratigraphic unit (HSU) (Fetter, 1988). For purposes of this report, the uppermost aquifer or upper hydrostratigraphic unit (UHSU) consists of the unconfined saturated zone, in which unconsolidated and consolidated groundwater-bearing strata are in hydraulic communication. The UHSU consists of the following geologic units: Rocky Flats Alluvium, valley-fill alluvium, colluvium, landslide deposits, weathered Arapahoe and Laramie Formation bedrock, and all sandstones within the Arapahoe and upper Laramie Formations in hydraulic communication with the overlying unconsolidated surficial deposits. The UHSU is considered to be equivalent to the uppermost aquifer at the Site.

Geologic Units

- Qv — Verdos Alluvium
- Qrf — Rocky Flats Alluvium
- Ka — Arapahoe Formation
- Kl — Laramie Formation
- Kfh — Fox Hills Sandstone
- Kp — Pierre Shale/Hygiene Member
- Kn — Niobrara Formation
- Kb — Benton Shale
- Kd — Dakota Group
- Jm — Morrison Formation
- TRPl — Lykins Formation
- PIPf — Lyons & Fountain Formations
- p€ — Undivided Igneous & Metamorphic Units





Structural interpretation from EG&G, 1993a.

Rocky Flats
Environmental Technology Site

Generalized Geologic Cross Section of the Front Range and the Rocky Flats Area

Geologic Characterization Report

March 1995 | Figure C-2

Beneath the surficial materials and the consolidated sandstones of the UHSU are the geologic units of the lower hydrostratigraphic unit (LHSU). The LHSU consists of the consolidated, unweathered bedrock zone of the Arapahoe and upper Laramie Formations not in hydraulic communication with the overlying UHSU. The Arapahoe and upper Laramie Formations comprising the geologic units of the LHSU consist of lesser amounts of sandstone and greater amounts of adjacent claystones. Because of the low permeability of the claystones, they behave as aquitards restricting hydraulic communication with the UHSU. The lower Laramie and Fox Hills Formations comprise a stratigraphically lower and third hydrostratigraphic unit beneath the Site.

Groundwaters of the three hydrostratigraphic units are hydraulically separated beneath the Industrial Area of the Site. They do converge, however, and are in mutual contact immediately upgradient near the western margin of the Site due to monoclinal folding and erosional proximity. Initially, background geochemical characterization of the UHSU and LHSU revealed the units as having statistically different groundwater chemistry concurring with the delineation of separate hydrostratigraphic units (EG&G, 1993a). This concept is presently being qualified. In addition, possible communication of the hydrostratigraphic units along other geologic structures is currently being assessed. More detailed differentiation of the LHSU will be achieved as new hydrogeologic and geochemical data are generated from Site investigations currently proposed or in progress.

C.2.3 Groundwater Occurrence and Distribution

The Site is located in a regional groundwater recharge area (EG&G, 1991). Groundwater recharge occurs from the infiltration of incident precipitation and as base flow near the upgradient area of the Site drainage basin, which extends west to Coal Creek. Groundwater recharge occurs from the infiltration of precipitation and from stream, ditch, and pond seepage. Much of the groundwater that discharges from the UHSU to streams and seeps evaporates as it is being discharged. Limited investigation of the former Operable Unit (OU) 2 area during the period of July through October 1993 indicated that the precipitation component of recharge was lost to evapotranspiration demands (EG&G, 1993b).

In the western part of the Site, where the thickness of the Rocky Flats Alluvium reaches 100 feet, the depth to the water table is 50 to 70 feet below the surface. The depth to water generally becomes shallower from west to east as the alluvial material thins and the confining claystones approach the ground surface. At the head of stream drainages and valley sides, seeps are common at the base of the Rocky Flats Alluvium where it is in contact with claystones of the Arapahoe/Laramie Formations, and where Arapahoe Formation sandstone crops out. In general, the unconsolidated surficial materials are thicker in the western, higher elevations at the Site. Accordingly, the saturated thickness of these materials also thins eastward. The potentiometric surface of groundwater in unconsolidated surficial deposits has been mapped and is shown on Plate 2. The period illustrated represents the time of year when static water levels are highest. Extensive areas of unsaturated and seasonally unsaturated alluvium and colluvium are indicated east and northeast of the Industrial Area.

Groundwater in the Arapahoe Formation sandstone units, which subcrop beneath the alluvial material, is not confined when in contact with the surficial materials. In this setting, a hydraulic connection exists between the bedrock sandstone and the alluvial material allowing the bedrock groundwater to exist under unconfined conditions as part of the UHSU. The subcropping Arapahoe Formation No. 1 Sandstone located in the eastern portion of the Industrial Area and in the area between South Walnut Creek and Woman Creek is part of the UHSU (EG&G, 1991). The upper discontinuous sandstones of the Laramie Formation also subcrop beneath alluvium and colluvium, but in limited areas in the valleys and along valley slopes. Groundwater in the lenticular sandstone units of the Laramie Formation occurs under confined conditions over scattered areas of the Site.

Groundwater levels in UHSU wells fluctuate in response to seasonal recharge events. Approximately 15% of the groundwater monitoring wells commonly are dry during at least one of the quarterly sampling events. Of the remaining wells, approximately half cannot yield sufficient water volume (4.5 gallons) specified for laboratory samples. Sampling crews must return later after wells have recovered and obtain additional sample volumes.

C.2.4 Groundwater Flow

The shallow groundwater flow regime at the Site is illustrated by the configuration of potentiometric contours in Plate 2. This map indicates that groundwater flow is largely controlled by the topography of the bedrock surface. Groundwater in the ridge tops generally flows toward the east-northeast. In areas where the ridge tops are dissected by east-northeast trending stream drainages, groundwater flows to the north or south toward the bottom of the valleys. In the valley bottoms, groundwater flows to the east, generally following the course of the stream. Shallow groundwater flow is primarily lateral due to the low permeability of the underlying claystone bedrock.

A potential for vertical groundwater flow, although limited by the low permeability of bedrock claystones, is indicated by the presence of strong downward vertical hydraulic gradients between the UHSU and underlying bedrock units. This situation implies a condition of poor hydraulic communication. For example, vertical gradients on the order of 0.79 to 1.05 feet per foot (ft/ft) have been calculated between colluvial and bedrock sandstones at OU1. The vertical groundwater flux through claystones is assumed to be small, on the order of 10^{-10} to 10^{-7} centimeters per second (cm/sec), based on calculations provided (DOE, 1996). Fracturing, where evident, is most abundant in the weathered bedrock zone, but is observed to decrease with depth in unweathered bedrock. Preferential vertical groundwater flow and contaminant transport along fractures or fault zones do not appear to represent a viable pathway for contaminant migration based on an assessment of available data (DOE, 1996).

C.2.5 Hydraulic Conductivity

The UHSU at the Site has a relatively low to moderate hydraulic conductivity that typically yields small amounts of water to groundwater monitoring wells. The UHSU exhibits a wide range of hydraulic conductivities because of the diverse nature of the individual geologic units

that comprise this unit. Summary statistics for UHSU hydraulic conductivities [(EG&G, 1995c) Table G-2] indicate a range of 5.0 x 10^{-2}cm/sec [3.0 x 10^{4} feet per year (ft/yr)] to 3 x 10^{-8}cm/sec (9.3 x 10^{-1}ft/yr). Listed in order of decreasing geometric mean hydraulic conductivity, the relative ranking of individual units of the UHSU is presented as follows: valley-fill alluvium (2.5 x 10^{-3}cm/sec); Arapahoe No. 1 sandstone (7.9 x 10^{-4} cm/sec); Rocky Flats Alluvium (2.1 x 10^{-4} cm/sec); colluvium (9.3 x 10^{-5} cm/sec); weathered Laramie Formation sandstones (3.9 x 10^{-5} cm/sec); and weathered Laramie Formation claystones (8.8 x 10^{-7} cm/sec). Hydraulic conductivities for LHSU materials are generally the lowest measured at the Site with geometric mean values for individual lithologic groups ranging from 1.6 x 10^{-7} to 5.8 x 10^{-7} cm/sec [(11), Table G-2]. The low permeability and 600+ foot thickness of the upper Laramie Formation claystones act as an effective aquitard that restricts downward vertical groundwater flow and contaminant transport to the Laramie-Fox Hills aquifer (DOE, 1996).

C.3 References

EG&G, 1991. *Final Geologic Characterization Report for the U.S. Department of Energy Rocky Flats Plant*.

EG&G, 1992. *Surface Geologic Mapping of the Rocky Flats Plant and Vicinity, Jefferson and Boulder Counties, Colorado*.

EG&G, 1993a. *Background Geochemical Characterization Report, Rocky Flats Plant, Golden, Colorado*. September.

EG&G, 1993b. *Groundwater Recharge Study, Final Interim Report Rocky Flats Plant, Golden, Colorado*. October.

EG&G, 1995a. *Geologic Characterization Report For the Rocky Flats Technology Site, Site-wide Geoscience Characterization Study, Vol 1*. March.

EG&G, 1995b. *Groundwater Geochemistry Report For the Rocky Flats Environmental Technology Site, Site-wide Geoscience Characterization Study Vol III*. January.

EG&G, 1995c. *Hydrogeologic Characterization Report for the Rocky Flats Technology Site, Site-wide Geoscience Characterization Study Vol II*. April.

Fetter, G.W. Jr., 1988. *Applied Hydrogeology*, 2nd ed. Merrill Publishing Company, Columbus, OH.

Haun, J.D. and H.C. Kent, 1965. *Geologic History of the Rocky Mountain Region, Bulletin of the American Association of Petroleum Geologists*, v 49, no. 11, p. 1781-1800.

Pearl, R.H., 1980. *Ground-Water Resources of Colorado in: Colorado Geology*. H.C. Kent and K.W. Porter, editors.

Scott, G.R., 1975. “Cenozoic Surfaces and Deposits in the Southern Rocky Mountains”, *In: Cenozoic History of the Southern Rocky Mountains*. Curtis, B.F., editor, Geological Society of America Memoir 144.

Shroba, R.R. and P.E. Carrara, 1994. *Preliminary Surficial Geologic Map of the Rocky Flats Plant and Vicinity, Jefferson and Boulder Counties, Colorado*. U.S. Geological Survey Open-file Report, OFR-94-162.

Spencer, F.D., 1961. *Bedrock Geology of the Louisville Quadrangle, Colorado*. USGS Geological Quadrangle Map GQ-151, Lat 39 52'30" to 40 , Long. 105 07'30" to 105 15'. Scale 1:24,000, Contour Interval 10 Feet.

U.S. Department of Energy, 1996. *White Paper – Analysis of Vertical Contaminant Migration Potential, Final*. August.

APPENDIX D

Site Impacts to Groundwater

APPENDIX D

Site Impacts to Groundwater

D.1 Impact of Individual Hazardous Substance Sites on the Quality of Groundwater..... D-1
D.2 Groundwater Contaminant Plumes D-1
D.2.1 Groundwater Contamination at 881 Hillside (OU1) D-4
D.2.1.1 Individual Hazardous Substance Sites 119.1 Plume..... D-4
D.2.2 Groundwater Contamination Associated with the Former OU2 ..... D-6
D.2.2.1 Mound Plume..... D-6
D.2.2.2 903 Pad and Ryan's Pit Plume D-8
D.2.2.3 East Trenches Plume..... D-8
D.2.3 Solar Evaporation Ponds Groundwater Contamination (OU4)..... D-9
D.2.3.1 Solar Ponds Plume..... D-9
D.2.4 Industrial Area Groundwater Contamination..... D-11
D.2.4.1 Carbon Tetrachloride Plume..... D-11
D.2.4.2 Industrial Area Plume D-12
D.2.5 Groundwater Contamination at the Existing Landfill (OU7)..... D-13
D.2.5.1 PU&D Yard Plume D-13
D.2.6 Old Landfill (OU5)..... D-15
D.3 References D-15

List of Figures

Figure D-1 Individual Hazardous Substance Sites of OU1 ..... D-5

Figure D-2 Individual Hazardous Substance Sites of OU2, 903 Pad, Mound, and East Trenches..... D-7

Figure D-3 Individual Hazardous Substance Sites of OU4..... D-10

Figure D-4 Individual Hazardous Substance Sites Near OU7 ..... D-14

List of Tables

Table D-1 Summary of Potential Chemicals of Concern for Groundwater Plumes..... D-2

D.1 Impact of Individual Hazardous Substance Sites on the Quality of Groundwater

The characterization and assessment of Individual Hazardous Substance Sites (IHSSs) and their potential to impact groundwater and surface water has historically been conducted under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) remedial investigation/feasibility study (RI/FS) programs for individual Operable Units (OUs). In 1995, the decision was made to take a Site-wide approach to the evaluation and remediation of the Rocky Flats Environmental Technology Site (RFETS or the Site). Of the original 16 OUs, there are only 7 OUs remaining: the Buffer Zone OU; the Industrial Area OU; and OUs 1, 3, 5, 6, and 7. However, groundwater issues will be investigated on a Site-wide basis.

The general conclusions reached with respect to groundwater contamination are that the hydrogeologic setting of a specific area directly affects the movement and quality of groundwater. Chemicals at some of the Site IHSSs have impacted groundwater quality. To characterize this impact, groundwater quality data have been compiled to identify hazardous constituents, determine their concentrations and rate of migration, and delineate the horizontal and vertical extent of potential contaminant plumes. The migration of contaminants can be highly influenced by engineered structures such as buildings, dams, slurry walls, diversion drains, pipelines, and diversion flumes that affect natural, near-surface water movement at the Site.

Because so much of the information dealing with individual IHSSs and contaminant sources is referenced in documents pertaining to the OUs, a short description and references pertinent to the OU where plumes exist is provided in this section. Summaries of groundwater analytical data for determination of historic chemicals of concern is presented in Table D-1.

D.2 Groundwater Contaminant Plumes

Evaluation of geochemical data from groundwater wells sampled as part of the Site-wide monitoring program has delineated a number of areas of groundwater contamination. The most widespread contamination is that of volatile organic compounds (VOCs). Plate 3 shows the distribution of VOC contamination in the upper hydrostatigraphic unit (UHSU). Plume definition is inexact; however, because of limitations in well coverage, variability of hydrostratigraphic conditions, and local variations in groundwater transport velocity. Published plume maps for individual constituents can be found in the 1993 *Well Evaluation Report* (EG&G, 1994a), the annual RCRA groundwater reports [EG&G, 1992, 1993, 1995; Rocky Mountain Remediation Services (RMRS), 1996a], and in individual OU RI/Resource Conservation and Recovery Act (RCRA) feasibility investigation (RFI) reports.

The VOC contaminant plumes in groundwater at the Site have the most potential to impact surface water or to migrate off Site. These plumes have been defined on the basis of exceedances above the maximum contaminant levels (MCL) for individual constituents. To delineate areas of highly contaminated groundwater, the groundwater action levels of 100 times the MCLs were compared against all groundwater data for the most common VOCs in groundwater. The exceedances were plotted and are shown on Plate 3.

TABLE D-1
Summary of Potential Chemicals of Concern for Groundwater Plumes

Potential Chemicals Of Concern	Groundwater Contaminant Plumes									
	X = Chemicals > Tier I Levels, X = Chemicals > Tier II Levels, x = Minor Detections > Tier II Levels									
	881 Hillside	903 Pad	Mound	E. Trenches	Solar Ponds	Carbon Tet	Ind. Area	Old LF	PU&D	Present LF
Metals/Indicator Parameters:										
Aluminum	x	x		X	x	x	X	x	X	
Antimony	X	X	X	X	X	X	X	x	x	X
Arsenic						X	x			x
Barium		x		X		x	X	x	x	X
Beryllium	x	X	x	X		X	X	X	X	x
Cadmium	x	X	x	X	X	x	x	x	X	x
Chromium	X	X	x	X		X	X	X	X	X
Cobalt					X					
Copper	x			x			x		x	x
Cyanide				x						
Fluoride	x	x			X	x	x	x	x	x
Lithium				x	X	x				
Manganese	X	X	X	**X**	X		X	X	X	X
Mercury										
Molybdenum	x	x								x
Nickel	X	X	x	X	X	X	X	X		X
Nitrate	X	X		X	**X**		X	x		X
Selenium	X				X		x			x
Silver									x	x
Strontium										
Sulphate	X	X			X					X
Vanadium	x	X		X		X	X	x	X	
Zinc					x					
Radionuclides:										
Americium-241	x	X	x	X	X	X	X			x
Cesium 137		x		x	x	x				
Plutonium-239/240		X	x	X	X	X	X	x	x	x
Strontium 89/90	x				X		x	X		x
Tritium					X					X
Uranium-233/234		x			**X**					
Uranium-235	X	x			X					
Uranium-238		X			X		X	**X**		

TABLE D-1
Summary of Potential Chemicals of Concern for Groundwater Plumes

Potential Chemicals Of Concern	Groundwater Contaminant Plumes									
	X = Chemicals > Tier I Levels, X = Chemicals > Tier II Levels, x = Minor Detections > Tier II Levels									
	881 Hillside	903 Pad	Mound	E. Trenches	Solar Ponds	Carbon Tet	Ind. Area	Old LF	PU&D	Present LF
Organic Compounds:										
1,1,1-Trichloroethane									X	
1,1,2-Trichloroethane	X	x	x				X			
1,1-Dichloroethane							**X**	x		
1,1-Dichloroethene	**X**	**X**	x	X		X	**X**	x	X	X
1,2-Dichloroethane			x							
1,2-Dichloroethene	X	X	x				X			
1,2-Dichloropropane			x							
2,6-Dinitrotoluene	x									X
4-Methyl-2-Pentanone										X
Acenaphthene										
Acetone		x		x						
Alpha-BHC	x									
Aroclor-1232										x
Aroclor-1242										x
Benzene		**X**	x	X		x	x			X
Benzo(a)anthracene							x			
Benzo(a)pyrene							x			
Benzo(b)fluoranthene							x			
Bromomethane		X								
bis(2-Ethylhexyl)phthalate	x	X		X	x		X	X	X	X
Beta-BHC	x									
Carbon Disulfide					x					
Carbon Tetrachloride	**X**	**X**	X	**X**	X	**X**	**X**		X	X
Chlorobenzene		x				x				
Chloroform		**X**	x	X		X	x			
Chloromethane		**X**	X				X			
cis-1,3-Dichloropropene		x	X			X	x			
Dibromochloromethane		x	X							
Fluoranthene										
Hexachlorobutadiene		**X**	x	x						
Hexachloroethane		X								
Methylene Chloride	X	**X**	X	**X**	X	**X**	X	x		X
Pyrene										
Tetrachloroethene	**X**	**X**	**X**	**X**		**X**	**X**	X	X	X
Toluene										
trans-1,3-Dichloropropene		x	X	x						
Trichloroethene	**X**	**X**	**X**	**X**	X	**X**	**X**	X	X	X
Vinyl Chloride		X	X	x		x	X		X	X

The most probable sources were identified using the results of recent field sampling programs and process knowledge (RMRS, 1996b). A flow diagram (RMRS, 1996b) describes the method used to locate the contaminant plumes and corresponding sources, and to determine which areas should be targeted for remedial action. Other contaminants also will be addressed where there is an impact to surface water exceeding action levels.

There are six groundwater contaminant plumes identified where contaminant concentrations exceed 100 times the MCLs. These groundwater contaminant plumes include: 1) IHSS 119.1 Plume, 2) Mound Plume, 3) 903 Pad and Ryan's Pit Plume, 4) Carbon Tetrachloride Plume, 5) East Trenches Plume, and 6) Industrial Area Plume. In addition, there are three plumes with contaminant concentrations that do not exceed 100 times the MCLs, but that have the potential to impact surface water. These plumes are the Existing (Present) Landfill, Solar Ponds, and the Property Utilization and Disposal (PU&D) Yard Plumes (RMRS, 1996b).

D.2.1 Groundwater Contamination at 881 Hillside (OU1)

The 881 Hillside is located in the south-central portion of the Site on the north slope of Woman Creek as shown on Figure A-3. Figure D-1 presents detail of the IHSSs for OU1. The area was selected as a high priority site because of the elevated concentrations of VOCs detected in the alluvial groundwater, the relatively permeable soils, and the proximity to Woman Creek. The *Final Phase III RFI/RI Work Plan Revision 1, Rocky Flats Plant 881 Hillside Area OU1* (EG&G, 1991), outlines the activities that were required to identify the extent of contamination.

D.2.1.1 Individual Hazardous Substance Site 119.1 Plume

The drum storage area (IHSS 119.1) within OU1 is the site of historic releases of chlorinated VOCs to the environment. These releases have resulted in the contamination of shallow alluvial groundwater (i.e., the UHSU) and have formed a small, relatively stable contaminant plume extending down the 881 Hillside. Trichloroethylene (TCE), perchloroethylene (PCE), and 1,1,1 trichloroethane (TCA) are the most common organic contaminants at 881 Hillside.

In 1992, a French drain was installed to intercept contaminated groundwater perceived to be flowing down the 881 Hillside. The French drain is excavated as deep as 28 feet into bedrock and intercepts UHSU groundwater flowing in paleotopographic depressions. A three-foot diameter recovery well located within the source area also was installed to recover water containing high levels of dissolved VOCs.

The French drain is still in operation and is collecting relatively uncontaminated groundwater for treatment at the Building 891 Treatment Plant. The plume is upgradient of the French drain and does not appear to be migrating. The area immediately downgradient of the French drain is unsaturated, indicating that the French drain has dewatered much of the area. A small seep located south of IHSS 119.1 and downgradient of the French drain along Woman Creek was sampled once. This sample contained a trace amount of VOCs. However, it is not clear if the VOC concentrations in the seep water are related to the contaminant plume.

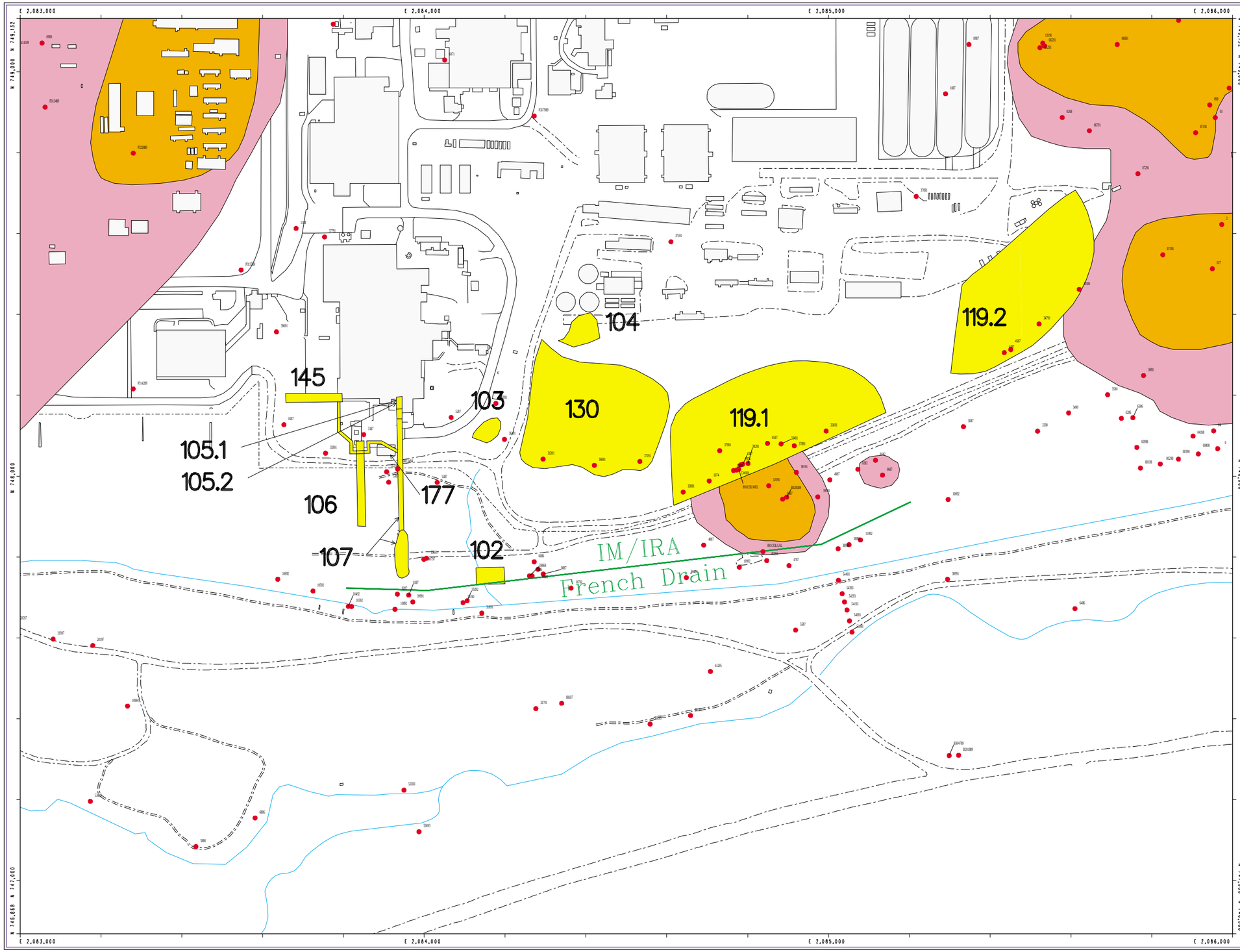


Figure D-1

Individual Hazardous Substance Sites of OU 1, 881 Hillside Area

EXPLANATION

- Groundwater Monitoring Well Locations
- Individual Hazardous Substance Sites
- Composite VOC Groundwater Plume (100 X MCL)
- Composite VOC Groundwater Plume (concentration equal to MCL)

Standard Map Features

- Buildings
- Lakes and ponds
- Streams, ditches, or other drainage features
- Fences
- Rocky Flats boundary
- Paved roads
- Dirt roads

DATA SOURCE:
Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by EG&G RSL, Las Vegas. Digitized from the orthophotographs. 1/95

N

Scale = 1 : 2920
1 inch represents approximately 243 feet

100 0 200 400ft

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

Prepared by:

RMRS
Rocky Mountain Remediation Services, L.L.C.
Geographic Information Systems Group
Rocky Flats Environmental Technology Site
P.O. Box 464
Golden, CO 80402-0464

MAP ID: 99-0372

August 17, 1999

NT_Svr w:/projects/fy99/99-0372/ou1a_nt.aml

Groundwater in the unweathered bedrock at 881 Hillside did not appear to be impacted by contaminants transported by the alluvial groundwater system.

Information on groundwater quality for the French drain is documented in quarterly reports that have been produced as required in the French drain interim measures/interim remediation action (IM/IRA) (DOE, 1992a). Additional information on 881 Hillside is reported in the *OU1 Phase III RFI/RI Work Plan Revision 1* (EG&G, 1991) and in the *OU1 Final Phase III RFI/RI* (DOE, 1994a).

D.2.2 Groundwater Contamination Associated with the Former OU2

IHSSs grouped within the former OU2 are shown in Figure A-3. Figure D-2 presents details of the IHSSs for OU2. The 903 Pad is located in the southeast corner of the Site south of the inner east gate. The Mound is located north of Central Avenue at the southeast corner of the Protected Area. The East Trenches straddle the East Access Road, east of the inner east gate.

The 903 Pad and the Mound were historically used for the storage and burial, respectively, of radioactively contaminated wastes. Radioactively contaminated sludge and other materials were buried in the trenches (DOE, 1992b). The 903 Pad and Ryan's Pit Plume, Mound Plume, and East Trenches Plume are part of a large composite plume on the east side of the Site. Even though these contaminant plumes overlap, differing sources and flow paths make it effective to treat these parts of the large plume individually.

D.2.2.1 Mound Plume

The Mound site groundwater contaminant plume is poorly defined, but it is suspected to extend northward from the former location of the Mound where drums were buried to a point of discharge along South Walnut Creek, upstream of the Site Sewage Treatment Plant. Depending on the season, there may be many unsaturated areas within the plume. Dense nonaqueous phase liquids (DNAPLs) in the Mound area are suspected to be the source of the groundwater contamination and the potential exists for contaminant concentrations to increase over time. There is a possibility that Trench 1 could contribute to this plume; however, evidence indicates that the Mound site is the primary source.

Contaminated groundwater from the plume contains vinyl chloride, tetrachloroethene, and trichloroethene. The contaminant plume is discharging through surface and subsurface seepage into South Walnut Creek. The contaminated groundwater discharges at a rate of 0.5 gallons per minute (gal/min) or less at seep SW059, where it is collected and stored, then later treated at the Building 891 Treatment Plant

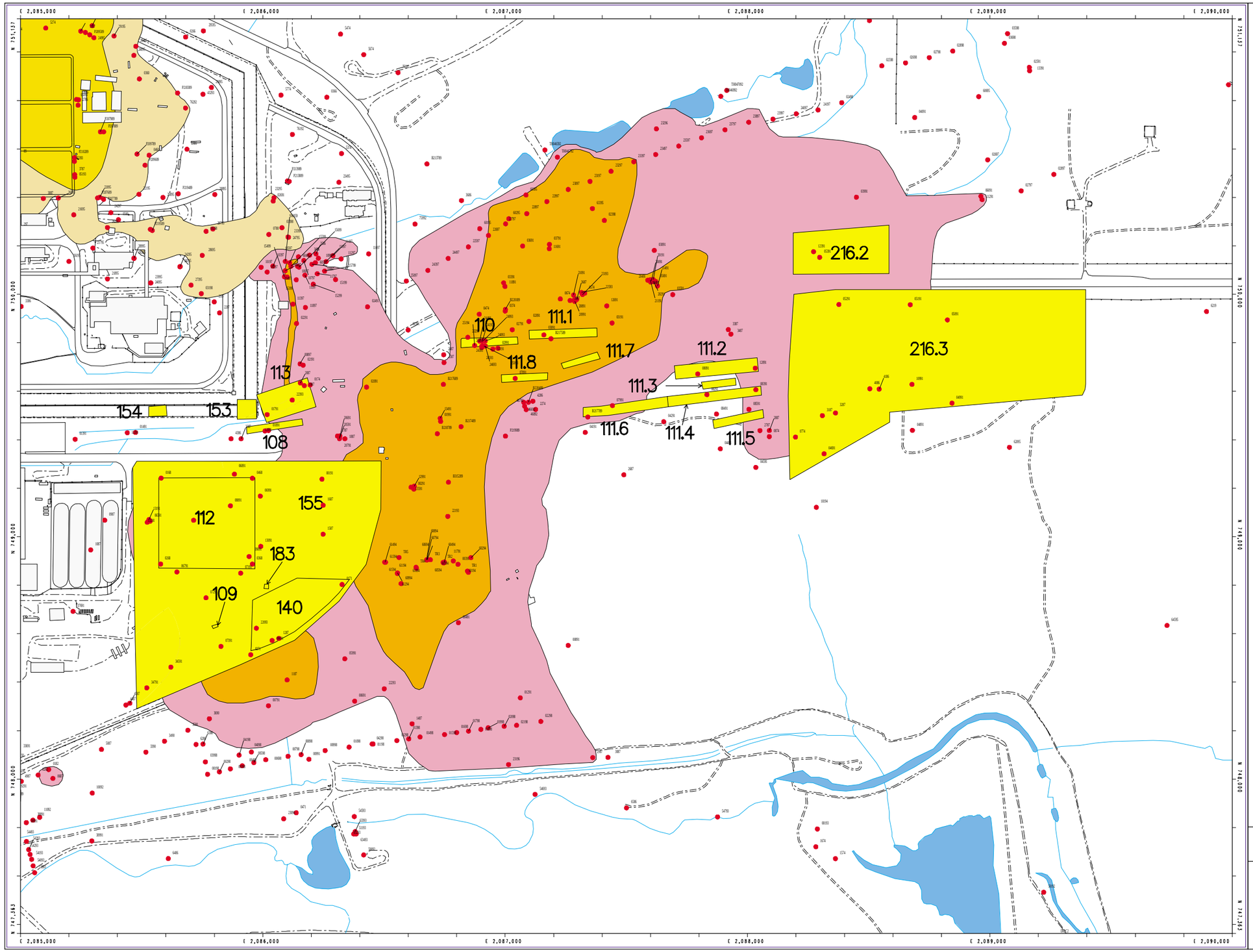


Figure D-2

Individual Hazardous Substance Sites of OU 2, 903 Pad, Mound, East Trenches

EXPLANATION

- Groundwater Monitoring Well Locations
- Individual Hazardous Substance Sites
- Composite VOC Groundwater Plume (100 X MCL)
- Composite VOC Groundwater Plume (concentration equal to MCL)
- 100 x Nitrate Standard (1000 mg/l)
- Nitrate Standard (10 mg/l)

Standard Map Features

- Buildings
- Lakes and ponds
- Streams, ditches, or other drainage features
- Fences and other barriers
- Rocky Flats boundary
- Paved roads
- Dirt roads

Scale = 1 : 4870
1 inch represents approximately 406 feet

100 0 200 400 ft

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

Prepared by:

RMRS
Rocky Mountain Remediation Services, L.L.C.
Geographic Information Systems Group
Rocky Flats Environmental Technology Site
P.O. Box 464
Golden, CO 80402-0464

MAP ID: 99-0372

August 18, 1999

NT_Svr w:/projects/fy99/99-0372/ou2a_nt.aml

D.2.2.2 903 Pad and Ryan's Pit Plume

This contaminant plume has two, closely spaced sources: 1) VOCs associated with drums formerly stored at the 903 Storage Area, where the contents of the drums leaked into the subsurface and groundwater, and 2) Ryan's Pit where VOCs were disposed of in a trench. The contaminated groundwater flows southward from these two source areas, toward the South Interceptor Ditch and Woman Creek. The groundwater is contaminated with carbon tetrachloride, tetrachloroethene, trichloroethene, and other VOCs. The highest concentrations of VOCs in groundwater are near the 903 Pad and Ryan's Pit sources, although isolated areas of high concentration have been observed within the plume away from these sources. Pure-phase tetrachloroethene and motor fuel constituents were found during the excavation of Ryan's Pit. Pure-phase DNAPLs are also suspected to exist underneath the 903 Pad.

Groundwater flow paths in alluvial materials in the 903 Pad and Ryan's Pit area are relatively well defined by contact seeps with the underlying bedrock materials and by numerous wells. However, groundwater flow through the hillside colluvium and bedrock is poorly understood. Areas of unsaturated colluvium are fairly common and prediction of local flow paths is difficult. Depending on the season, there may be many unsaturated areas within the plume. Discharge of contaminated groundwater has not been observed from the colluvium or weathered bedrock portion of this plume.

Contaminated groundwater containing tetrachloroethene and trichloroethene may eventually enter the South Interceptor Ditch and Woman Creek surface water pathways if no actions are taken to manage this plume. Discharge of contaminated groundwater into Woman Creek would pose a potential risk to the environment. Collection and treatment of contaminated groundwater from the 903 Pad and Ryan's Pit Plume will reduce the risk to the environment posed by uncontrolled releases to surface water.

D.2.2.3 East Trenches Plume

A large plume of contaminated groundwater is located in the East Trenches area. The principal sources are IHSS 110 (Trench 3) and 111.1 (Trench 4), with a minor contribution from the VOCs in the 903 Pad area. The trenches were used to bury sewage sludge from the Sewage Treatment Plant, but also contain DNAPLs, crushed drums, and other miscellaneous waste. Contaminated groundwater occurs within the UHSU, in the alluvium, and in the bedrock sandstone that is in hydraulic connection with the alluvium. The major contaminants are carbon tetrachloride, tetrachloroethene, and trichloroethene, as well as other VOCs.

The downgradient boundary of the contaminant plume is located at a spring-and-seep complex on the south bank of South Walnut Creek above Ponds B1 and B2 where the bedrock sandstone subcrops. Concentrations of VOCs above 100 times the MCLs have been detected by a recent sampling program conducted at the seep complex. There are potential ecological impacts because water from the contaminant plume containing tetrachloroethene and trichloroethene has reached South Walnut Creek. If concentrations in the seep complex increase over time, a greater contaminant mass may reach surface water.

A lobe of this contaminant plume also extends to the east of the East Trenches area in the alluvium, but has not reached surface water. Uncontaminated alluvial groundwater discharges downgradient of this lobe as seeps in an unnamed tributary drainage to South Walnut Creek. This groundwater will continue to be monitored.

Additional background information on groundwater quality for OU2 is reported in *the Phase II RI/FS Work Plan, Rocky Flats Plant, 903 Pad, Mound, East Trenches Areas OU2* (Rockwell, 1989) and in the *Final Phase II RFI/RI OU2 Report* (DOE, 1995).

D.2.3 Solar Evaporation Ponds Groundwater Contamination (OU4)

The Solar Evaporation Ponds (SEPs)(IHSS 101) are located in the northeast section of the Protected Area as shown in Figure A-3. Figure D-3 presents details of the IHSS for OU4. The groundwater flow beneath the SEPs originates southwest of the Industrial Area and diverges flowing toward unsaturated areas above Walnut Creek and South Walnut Creek as shown on Plate 2.

The five ponds at IHSS 101 were used to temporarily store and treat various process aqueous wastes by evaporation. This included waste streams with low-level radioactivity, nitrates, acids, and sewage effluent. The configuration of these ponds has changed several times since they were initially installed in 1953. Previous hydrologic investigations of the SEP area indicated that the groundwater had been impacted by leakage from the ponds.

D.2.3.1 Solar Ponds Plume

Because contaminants were detected downgradient of the SEPs, a RCRA Assessment Groundwater Monitoring Program was instituted. Table D-1 lists contaminants detected in downgradient wells as reported in the annual RCRA groundwater monitoring reports (EG&G, 1992, 1993, 1994b, 1995; RMRS, 1996a). Groundwater monitoring data from UHSU wells indicate that nitrate contamination from the SEPs has migrated downgradient of the ITS in unconsolidated surficial deposits and weathered bedrock.

The released nitrates have contaminated UHSU groundwater and have formed a plume that extends northward from the SEPs to the North Walnut Creek drainage above Pond A1 (see Plate 3). A small lobe of this nitrate plume extends to the southwest for a short distance. This contaminant plume contains nitrates at concentrations above 100 times the MCLs. Nitrate concentrations within the plume are decreasing with time but still exist at high levels. The analytical data indicate that the maximum concentrations of all the contaminants occurred in the immediate area of the SEPs with concentrations declining rapidly downgradient.

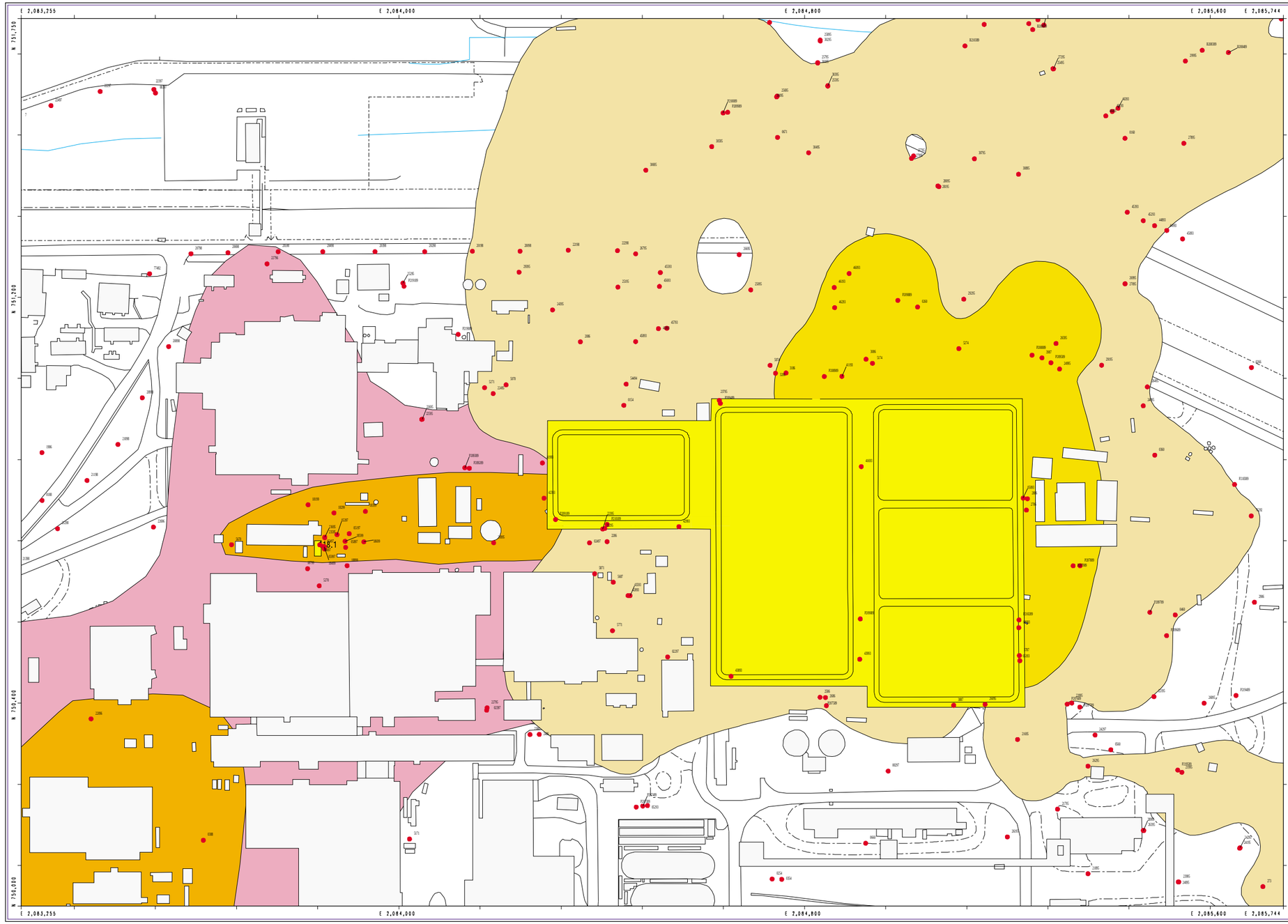


Figure D-3

Individual Hazardous Substance Sites of OU 4, Solar Evaporation Ponds and IHSS 118.1

EXPLANATION

- Groundwater Monitoring Well Locations
- Individual Hazardous Substance Sites
- Composite VOC Groundwater Plume (100 X MCL)
- Composite VOC Groundwater Plume (concentration equal to MCL)
- 100 x Nitrate Standard (1000 mg/l)
- Nitrate Standard (10 mg/l)

Standard Map Features

- Buildings
- Lakes and ponds
- Streams, ditches, or other drainage features
- Fences
- Rocky Flats boundary
- Paved roads
- Dirt roads

N

Scale = 1 : 2500
1 inch represents approximately 208 feet

50 0 100 200ft

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

Prepared by:

RMRS
Rocky Mountain Remediation Services, L.L.C.
Geographic Information Systems Group
Rocky Flats Environmental Technology Site
P.O. Box 464
Golden, CO 80402-0464

MAP ID: 99-0372

September 07, 1999

NT_Svr w:/projects/fy99/99-0372/ou4a_nt.aml

In response to nitrate/nitrite contamination detected in Walnut Creek, a series of trenches and sumps were installed north of the SEPs from 1971 to 1974. The trenches and sumps were replaced by a more extensive interceptor trench system (ITS) in the early 1980s. The purpose of this ITS was to collect surface water and shallow groundwater immediately downgradient of the SEP area. Water collected by the ITS was originally transferred back to one of the SEPs (Advanced Sciences, 1991); but now the ITS water is pumped to the Building 374 treatment system. The ITS was replumbed in 1993 to increase its effectiveness. The ITS captures approximately 2.7 million gal of water per year but is not entirely effective in preventing nitrate contamination from impacting the North Walnut Creek drainage (DOE, 1994b)

Drainage of liquids and removal of sludge were completed at SEPs 207-A, 207-B North, 207-B Central, and 207-B South in 1994. The remaining pond, 207-C, has been drained and sludge has been removed to on-Site storage tanks.

The *Annual RCRA Groundwater Monitoring Reports for Regulated Units at the Site* contain available analytical data for the SEPs (EG&G, 1992, 1993, 1994a, 1995). Data are available for the second quarter 1988 through 1995. Additional information can be found in the *Draft IM/IRA Decision Document for OU4 Solar Evaporation Ponds* (EPA, 1994b) and the *OU4 Solar Evaporation Ponds Phase II Groundwater Investigation Final Field Program Report* (DOE, 1996a).

D.2.4 Industrial Area Groundwater Contamination

The Industrial Area has not received the same level of characterization as other portions of the Site. This is because the OUs associated with the Industrial Area had not completed RFI/RI investigations before the decision was made to integrate all remedial activities at the Site. Prior to the elimination of the OU-based investigations, OUs 8, 9, 10, 12, 13, and 14 were combined for purposes of remedial investigation. Preliminary surface soil investigations had been completed prior to cessation of activities on the Industrial Area OUs but no groundwater investigation had been started. However, two groundwater plumes have been generally defined; the Carbon Tetrachloride Plume and the Industrial Area Plume.

D.2.4.1 Carbon Tetrachloride Plume

Preliminary borehole drilling around tanks T9 and T10 in the former OU8 uncovered carbon tetrachloride free product that is associated with the Carbon Tetrachloride Plume. The carbon tetrachloride spill (IHSS 118.1) is located due north of Building 776 and east of Building 730. There are several documented past releases of carbon tetrachloride at this site. This area also overlaps other IHSSs [i.e., 121-T9, 121-T10, 131, and 144(N)]. Different spills are associated with these IHSSs.

IHSS 118.1 is the site where a 5,000-gal, underground steel storage tank for carbon tetrachloride and associated piping were formerly located. Numerous reported spills have occurred before 1970, some between 100 to 200 gal, as documented in the Historical Release Report (DOE, 1992b). The tank ultimately failed in June 1981 and subsequently was removed along with a limited amount of soil surrounding the tank. The numerous releases of carbon tetrachloride from IHSS 118.1 have contaminated surrounding soils and formed a contaminant plume in UHSU groundwater which extends from the vicinity of the former tank location eastward to the SEPs. The plume may eventually reach the Walnut Creek drainage.

D.2.4.2 Industrial Area Plume

The IM/IRA for the Industrial Area (DOE, 1994c) compiled groundwater and surface water data for use in designing a monitoring program for decontamination and decommissioning (D&D) activities. From these data, a groundwater plume composed of VOCs was discovered in groundwater in the Buildings 300 and 400 areas that later was defined as the Industrial Area Plume (see Plate 3). The Industrial Area Plume is suspected to be a coalesced plume of contaminated groundwater containing trichloroethene thought to emanate from IHSSs 117.1, 117.2, 157.1, 158, 171 and 182; tetrachloroethene thought to emanate from IHSSs 117.1, 117.2, 158, 157.1, 160, and 171; and carbon tetrachloride thought to emanate from IHSSs 117.1, 117.2, and 158.

Currently, the Industrial Area Plume does not appear to be migrating rapidly downgradient, and there are no known surface water impacts. However, groundwater pathways exist to both Woman Creek and to Walnut Creek. Groundwater recharge in the Industrial Area caused by water losses from sewers and water-supply pipelines may be substantial. Reduction of recharge from these sources could significantly reduce the potential for contaminant migration in the subsurface.

Treatment of contaminated groundwater within the Industrial Area does not appear to be necessary to protect surface water because the plume appears to have limited potential for migration. However, ongoing monitoring and evaluation of the groundwater through the monitoring program will continue and will detect any possible movement or expansion of the plume. Groundwater remedial actions may become necessary if the contaminant plumes expand and migrate significantly, thereby becoming a threat to surface water.

Further investigation of the plume or plumes in the Industrial Area has been suspended until D&D activities have been completed on buildings in the Industrial Area. Wells in the Industrial Area will be monitored for the known contaminants detected in the Industrial Area Plume.

D.2.5 Groundwater Contamination at the Existing Landfill (OU7)

The Existing (Present) Landfill began operation in 1968 with the closure of the Original Landfill (now IHSS 115). The Existing Landfill is located in the Buffer Zone north of the Protected Area as shown on Figure A-3. Figure D-4 presents detail of the IHSSs included in OU7. The local recharging groundwater flow direction is from the west-southwest toward the Existing Landfill, then is focused toward the Landfill Pond and the portion of the Walnut Creek drainage designated as "No Name Gulch" as shown on Plate 2.

In addition to typical sanitary landfill wastes, limited quantities of hazardous wastes were disposed of in the landfill, particularly in the early years of operation between 1968 and 1970. In September 1973, tritium was detected in leachate draining from the landfill. In response, a sampling program was initiated to determine the location of the tritium source and interim response measures were also undertaken to control the generation and migration of landfill leachate. Interim response measures included the construction of two ponds, of which the East Landfill Pond remains, and a subsurface leachate collection system and a subsurface intercept/slurry wall system for diverting upgradient groundwater.

Evaluation of groundwater quality data (EG&G, 1994) specifically within the Existing Landfill revealed elevated radionuclide activities and high concentrations of VOCs, metals, and inorganic constituents. The Existing Landfill has been under a RCRA Alternate Groundwater Monitoring Program. Table D-1 lists the chemicals detected in the Existing Landfill based on data generated from the groundwater monitoring program. Aluminum, manganese, zinc, 2-methylnaphthalene, naphthalene, benzene, and possibly methylene chloride are present in leachate below the current landfill, with average values exceeding action levels. Organic contaminant plumes exist in groundwater south and west of the current landfill pond, including a portion of OU7. Groundwater in downgradient wells below the landfill pond show elevated concentrations of nitrate, sulfate, chloride, lithium, barium, strontium, magnesium, and uranium with respect to upgradient wells (RMRS, 1996a).

D.2.5.1 PU&D Yard Plume

In 1993, newly installed upgradient wells at the Process Simulation Laboratory (PSL) detected significant concentrations of VOCs in the alluvial groundwater. These data and data from wells on the south side of the PSL suggest that a VOC plume exists upgradient of the PSL and has migrated eastward (see Plate 3). The suspected source of the contamination is the PU&D yard located west of the landfill. Activities are being planned to evaluate the source of this plume.

Additional information on water quality at the PSL can be found in the *Annual RCRA Groundwater Monitoring Reports For Regulated Units* (EG&G, 1992, 1993, 1994a, 1995; RMRS, 1996a), *Technical Memorandum - Final Work Plan for OU7* (DOE, 1994d) and *Draft IM\IRA Decision Document for OU7 Present Landfill* (DOE, 1996b).

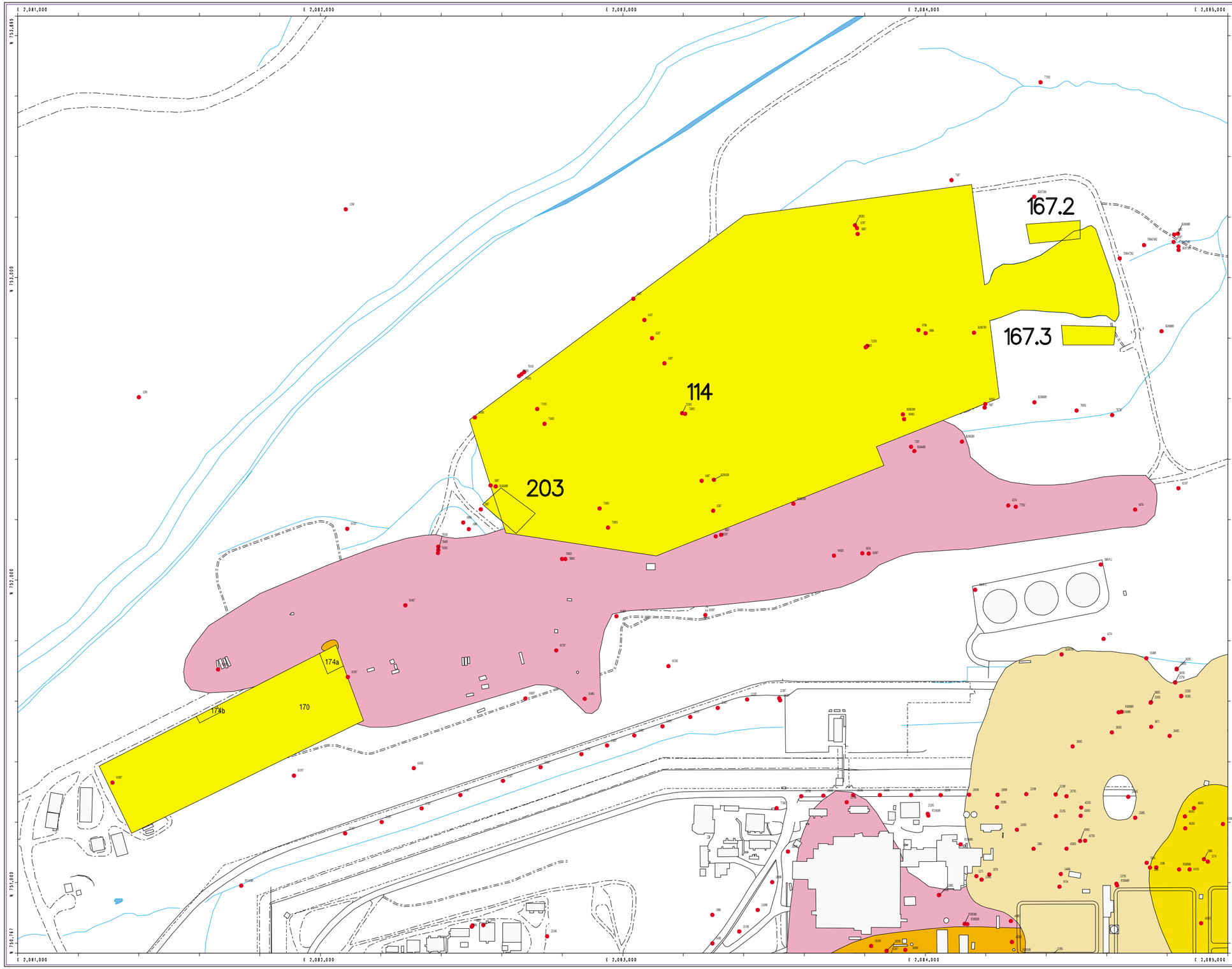


Figure D-4

Individual Hazardous Substance Sites of OU 7, Present Sanitary Landfill and IHSSs 170, 174a & 174b

EXPLANATION

- Groundwater Monitoring Well Locations
- Individual Hazardous Substance Sites
- Composite VOC Groundwater Plume (100 X MCL)
- Composite VOC Groundwater Plume (concentration equal to MCL)
- 100 x Nitrate Standard (1000 mg/l)
- Nitrate Standard (10 mg/l)

Standard Map Features

- Buildings
- Lakes and ponds
- Streams, ditches, or other drainage features
- Fences
- Rocky Flats boundary
- Paved roads
- Dirt roads

DATA SOURCE:
Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by EG&G RSL, Las Vegas. Digitized from the orthophotographs. 1/95

Scale = 1 : 3830
1 inch represents approximately 319 feet

100 0 200 400ft

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

Prepared by:

RMRS
Rocky Mountain Remediation Services, L.L.C.
Geographic Information Systems Group
Rocky Flats Environmental Technology Site
P.O. Box 464
Golden, CO 80402-0464

MAP ID: 99-0372

August 18, 1999

NT_Svr w:/projects/fy99/99-0372/ou7a_nt.aml

D.2.6 Old Landfill (OU5)

The Old Landfill (OLF) is geographically located along the north side of Woman Creek and is designated as IHSS 115. The OLF was investigated as part of the OU5 RFI/RI project (DOE, 1996c). Figure A-3 shows the IHSSs covered in OU5.

Elevated concentrations of a few metals, water quality parameters, radionuclides and VOCs were encountered in wells monitoring the OLF (see Table D-1). TCE and TCA were the only volatile organics encountered. Though contamination from the OLF is at low levels, and a downgradient contaminant plume has not been defined, the proximity of the IHSS to Woman Creek has made it a priority for monitoring

D.3 References

Advanced Sciences, Inc., 1991. *Solar Pond Interceptor Trench System Groundwater Management Study, Rocky Flats Plant: Task 7 of the Zero-Offsite Water-Discharge Study*. January.

EG&G Rocky Flats, Inc., 1991. *Final Phase III RFI/RI Work Plan Revision 1 for 881 Hillside Operable Unit 1*. Golden, Colorado. March.

EG&G Rocky Flats, Inc., 1992. *1991 Annual RCRA Groundwater Monitoring Report for Regulated Units at the Rocky Flats Plant.* Golden, Colorado. March.

EG&G Rocky Flats, Inc., 1993. *1992 Annual RCRA Groundwater Monitoring Report for Regulated Units at the Rocky Flats Plant..*, Golden, Colorado. March.

EG&G Rocky Flats, Inc., 1994a. *Well Evaluation Report Final*. Golden, Colorado. April.

EG&G Rocky Flats, Inc., 1994b. *1993 Annual RCRA Groundwater Monitoring Report for Regulated Units at the Rocky Flats Plant*. Golden, Colorado. February.

EG&G Rocky Flats, Inc., 1995. *1994 Annual RCRA Report for Regulated Units at the Rocky Flats Environmental Technology Site..*, Golden, Colorado. March.

Rockwell International, 1989. *Phase II RI/FS Work Plan, Rocky Flats Plant, 903 Pad, Mound, East Trenches Areas OU2.*

Rocky Mountain Remediation Services, L.L.C./Kaiser-Hill Company, L.L.C., 1996a. *1995 Annual RCRA Report for Regulated Units at Rocky Flats Environmental Technology Site*. February.

Rocky Mountain Remediation Services, L.L.C., 1996b. *Groundwater Conceptual Plan for the Rocky Flats Environmental Technology Site*, Final Revised. March.

U.S. Department of Energy, Rocky Flats Plant, 1992a. *Interim Measure/Interim Remedial Action French Drain Performance Monitoring Plan*. Golden, Colorado. June.

U.S. Department of Energy, 1992b. *Final Historical Release Report for the Rocky Flats Plant*. Rocky Flats Plant, Golden, Colorado. June.

U.S. Department of Energy, Rocky Flats Plant, 1994a. *Final Phase III RFI/RI, Rocky Flats Plant, 881 Hillside Area, Operable Unit No. 1*., Golden, Colorado. June.

U.S. Department of Energy, 1994b. *OU4 Solar Evaporation Ponds, Interim Measure/Interim Remedial Action, Environmental Assessment Decision Document, Part IV, Recommended Interim Measure/Interim Remedial Alternative and Part V, Post-Closure Monitoring and Assessment Plan Rev.: Draft Proposed*. Rocky Flats Plant, Golden, Colorado. May.

U.S. Department of Energy, 1994c. *Final Interim Measures/Interim Remedial Action Decision Document for the Rocky Flats Industrial Area.* Rocky Flats Plant, Golden, Colorado. March.

U.S. Department of Energy, 1994d. *Technical Memorandum, Final Work Plan, Operable Unit No.7*. Rocky Flats Plant, Golden, Colorado. September.

U.S. Department of Energy, 1995. *Final Phase II RFI/RI Report 903 Pad, Mound, and East Trenches Area Operable Unit No. 2.* Rocky Flats Plant, Golden, Colorado. October.

U.S. Department of Energy, 1996a, *OU4 Solar Evaporation Ponds Phase II Groundwater Investigation Final Field Program Report.*, Rocky Flats Plant, Golden, Colorado. February.

U.S. Department of Energy, 1996b. *Phase I IM/IRA Decision Document and Closure Plan for Operable Unit 7 Present Landfill, Revised Draft.* Rocky Flats Plant, Golden, Colorado. March.

U.S. Department of Energy, 1996c. *Final Phase I RFI/RI Report, Woman Creek Drainage, Operable Unit 5*., Rocky Flats Plant, Golden, Colorado, April.

APPENDIX E

Water Quality and Water Level Monitoring Wells

APPENDIX E

Water Quality and Water Level Monitoring Wells

List of Tables

Table E-1 Proposed Monitoring Wells E-2

Table E-2 Proposed Monitoring Wells and Chemicals to be Monitored..... E-4

Table E-3 Water Level Monitoring Wells E-6

APPENDIX E-1
PROPOSED MONITORING WELLS

WELL NO	FREQUENCY	CLASS	PLUME\AREA	DRIVERS	FORMATION	PURPOSE	
5387	Semiannual	PE	881 Hillside	RFCA	AL	Plume Extent south of the 881Hillside Plume	
4887	Semiannual	PE	881 Hillside	RFCA	AL	Plume Extent south of the 881 Hillside Plume	
4787	Semiannual	PE	881 Hillside	RFCA	AL	Plume Extent south of the 881 Hillside Plume	
00797	Semiannual	PM	881 Hillside	RFCA	AL	Performance Monitoring for 881 Footing Drain Sump	
11092	Semiannual	PM	881 Hillside	RFCA, IM/IRA -FD	AL	Performance Monitoring for the French Drain	
10992	Semiannual	PM	881 Hillside	RFCA, IM/IRA -FD	AL	Performance Monitoring for the French Drain	
10792	Semiannual	PM	881 Hillside	RFCA, IM/IRA -FD	AL	Performance Monitoring for the French Drain	
10692	Semiannual	PM	881 Hillside	RFCA, IM/IRA -FD	AL	Performance Monitoring for the French Drain	
10592	Semiannual	PM	881 Hillside	RFCA, IM/IRA -FD	AL	Performance Monitoring for the French Drain	
0487	Semiannual	PD	881 Hillside	RFCA	AL	Plume Definition well for the 881 Hillside Plume	
891COLGAL	Quarterly	PM	881 Hillside	RFCA/IMIRA -FD	NA	Performance Monitoring of groundwater in collection sump in French Drain	
891COLWEL	Quarterly	PM	881 Hillside	RFCA/IMIRA -FD	AL	Performance Monitoring of groundwater in collection well on 881 Hillside	
SW13494	Quarterly	PM	881 Hillside	RFCA/IMIRA -FD	NA	Performance Monitoring of groundwater in footing drain seep below Bldg. 881	
6386	Semiannual	PD	903 Pad	RFCA	AL	Plume Definition well monitoring pathway to Woman Cr. in the 903 Pad/Ryans Pit Plume	
6286	Semiannual	PD	903 Pad	RFCA	BD/USHU	Plume Definition well monitoring pathway to Woman Cr. in the 903 Pad/Ryans Pit Plume	
3087	Semiannual	PD	903 Pad	RFCA	BD	Plume Definition well monitoring pathway to Woman Cr. in the 903 Pad/Ryans Pit Plume	
2987	Semiannual	PD	903 Pad	RFCA	AL	Plume Definition well monitoring pathway to Woman Cr. in the 903 Pad/Ryans Pit Plume	
23196	Semiannual	PE	903 Pad	RFCA	AL	Plume Extent well monitoring the southward migration of the Ryans Pit/903 Pad Plume	
23096	Semiannual	PE	903 Pad	RFCA	AL	Plume Extent well monitoring the southern migration of the Ryans- OU2 VOA Plume	
07391	Semiannual	PM	903 Pad	RFCA	AL\BD	Performance Monitoring well monitoring effects of remediation downgradient of Ryans Pit	
00491	Semiannual	PD	903 Pad	RFCA	BD\UHSU	Plume Definition well monitoring the 903 Pad VOC Plume	
02297	Semiannual	DD	Bldg 779	RFCA, IM/IRA for IA	AL	D&D monitoring downgradient of Bldg. 779	
02497	Semiannual	DD	Bldg 779	RFCA, IM/IRA for IA	AL	D&D monitoring downgradient of Bldg. 779	
02397	Semiannual	DD	Bldg 779	RFCA, IM/IRA for IA	AL	D&D monitoring upgradient of Bldg. 779	
22996	Semiannual	DD	Bldg 886	RFCA, IM/IRA for IA	AL	Building D&D well monitoring potential rad contamination near 886 lab	
10198	Semiannual	DD	Bldg. 123	RFCA -IM/IRA	AL	D & D Monitoring for Building 123 D&D	
10298	Semiannual	DD	Bldg. 123	RFCA -IM/IRA	AL	D & D Monitoring for Building 123 D&D	
10398	Semiannual	DD	Bldg. 123	RFCA -IM/IRA	AL	D & D Monitoring for Building 123 D&D	
10498	Semiannual	DD	Bldg. 123	RFCA -IM/IRA	AL	D & D Monitoring for Building 123 D&D	
10598	Semiannual	DD	Bldg. 123	RFCA -IM/IRA	AL	D & D Monitoring for Building 123 D&D	
41691	Semiannual	B	Boundary	RFCA, AIP	AL	Boundary Well - in the Walnut Cr. Drainage at the Indiana Street Boundary	
41591	Semiannual	B	Boundary	RFCA, AIP	AL	Boundary Well - in small drainage near east access gate	
10394	Semiannual	B	Boundary	RFCA, AIP	AL	Boundary Well - in the Woman Cr. Drainage at the Indiana Street Boundary	
10294	Semiannual	B	Boundary	RFCA, AIP	AL	Boundary Well - in drainage below Pond D-2 in the southeast corner of the Site	
06491	Semiannual	B	Boundary	RFCA, AIP	BD/UHSU	Boundary Well - in small drainage east of the Site at Indiana St.	
0386	Semiannual	B	Boundary	RFCA, AIP	BD/UHSU	Boundary Well - in small drainage north of the east access gate	
P219189	Semiannual	PD	Carbon Tet	RFCA, RCRA	AL	Plume Definition well for VOC contamination comming from Carbon Tet Plume	
P209389	Semiannual	PD	Carbon Tet	RFCA, RCRA	BD	Plume Definition well in the Carbon Tet Plume	
P209289	Semiannual	PD	Carbon Tet	RFCA, RCRA	AL	Plume Definition well in the Carbon Tet Plume	
12191	Semiannual	PM	East Tranches	RFCA	BD\UHSU	Performance Monitoring at edge of T3 soil excavation	
23296	Semiannual	PE	East Trenches	RFCA	AL	Plume Extent well monitoring the northern migration of the East Trenches Area Plume	
10194	Semiannual	PE	East Trenches	RFCA	AL	Plume Extent well monitoring the southern migration of the East Trenches Plume	
06091	Semiannual	PE	East Trenches	RFCA	AL/BD	Plume Extent well monitoring the northeast migration of the East Trenches Plume	
05091	Semiannual	PE	East Trenches	RFCA	AL	Plume Extent well monitoring the eastward migration of the East Trenches Plume	
04991	Semiannual	PE	East Trenches	RFCA	AL	Plume Extent well monitoring the eastward migration of the East Trenches Plume	
04591	Semiannual	PE	East Trenches	RFCA	AL	Plume Extent well monitoring the southward migration of the East Trenches Plume	
04091	Semiannual	PE	East Trenches	RFCA	AL	Plume Extent well monitoring the northward migration of the East Trenches Plume	
03991	Semiannual	PD	East Trenches	RFCA	AL	Plume Definition well monitoring the East Trenches Plume	
11891	Semiannual	PM	East Trenches	RFCA	BD\UHSU	Performance Montoring well monitoring effects of remediation downgradient of Trench T-3	
3687	Semiannual	PM	East Trenches	RFCA	BD\USHU	Performance Monitoring well monitoring effects of remediation downgradient of Trench T-4	
12691	Semiannual	PM	East Trenches	RFCA	BD\USHU	Performance Monitoring well monitoring effects of remediation downgradient of Trench T-4	
05691	Semiannual	PM	East Trenches	RFCA	AL	Performance Monitoring well monitoring effects of remediation downgradient of Trench T-4	
05391	Semiannual	PD	East Trenches	RFCA	AL	Plume Definition well monitoring eastward concentration of VOCs from the East Trenches Plume	
10994	Semiannual	PE	IA\Old Landfill	RFCA	AL	Plume Extent IA VOA Plume\Old Landfill Plume near Woman Cr.	

APPENDIX E-1
PROPOSED MONITORING WELLS

7086	Semiannual	PE	IA\Old Landfill	RFCA	AL	Plume Extent well monitoring IA Plume and Old Landfill Plume pathway in Woman Cr.	
P416889	Semiannual	PD	Ind. Area	RFCA, IM/IRA for IA	AL	Plume Definition of IA Plume south of Bldg. 664 along pathway to Woman Cr.	
P416789	Semiannual	PD	Ind. Area	RFCA, IM/IRA for IA	AL	Plume Definition of IA Plume south of 400 area along pathway to Woman Cr.	
P416689	Semiannual	PE	Ind. Area	RFCA, IM/IRA for IA	AL	Plume Extent to monitor southern migration of IA Plume south of Bldg. 440	
P314289	Semiannual	PE	Ind. Area	RFCA, IM/IRA for IA	AL	Plume Extent to monitor the southern migration of IA Plume near Bldg. 850	
P313589	Semiannual	PE	Ind. Area	RFCA, IM/IRA for IA	AL	Plume Extent to monitor the eastward migration of IA Plume near Bldg. 881	
P114389	Semiannual	PE	Ind. Area	RFCA	AL	Plume Extent well to monitor extent of PU&D yard plume pathway to Walnut Cr.	
6186	Semiannual	PE	Ind. Area	RFCA, IM/IRA for IA	AL	Plume Extent well monitoring easward migration of IA Plume	
43392	Semiannual	PE	Ind. Area	RFCA	AL	Plume Extent well monitoring southward migration of IA Plume	
22896	Semiannual	PE	Ind. Area	RFCA, IM/IRA for IA	AL	Plume Extent well monitoring the northward migration of IA VOA Plume	
22796	Semiannual	PE	Ind. Area	RFCA, IM/IRA for IA	AL	Plume Extent well monitoring the northward migration of Carbon Tet Plume	
22696	Semiannual	PE	Ind. Area	RFCA, IM/IRA for IA	AL	Plume Extent well monitoring the westward migration of the Carbon Tet Plume	
22596	Semiannual	PE	Ind. Area	RFCA, IM/IRA for IA	AL	Plume Extent well monitoring the northern migration of the IA Plume	
2186	Semiannual	PE	Ind. Area	RFCA	BD/UHSU	Plume Extent well monitoring the northern migration of the 'IA Plume	
1986	Semiannual	PE	Ind. Area	RFCA	AL	Plume Extent well monitoring the northern migration of the IA PLume	
B206989	Quarterly	RCRA	Landfill	RFCA, RCRA	BD/UHSU	RCRA\Plume Extent well monitoring downgradient of Landfill Plume	
77392	Semiannual	PD	Landfill	RFCA, RCRA	AL	Plume Definition well monitoring the eastward migration of the PU&D Yard Plume	
52994	Quarterly	RCRA	Landfill	RFCA, RCRA	AL	RCRA/Plume Extent well monitoring downgradient of Landfill Plume	
52894	Quarterly	RCRA	Landfill	RFCA, RCRA	AL	RCRA/Plume Extent well monitoring downgradient of Landfill Plume	
4087	Quarterly	RCRA	Landfill	RFCA, RCRA	AL	RCRA/Plume Extent well monitoring downgradient of Landfill Plume	
02291	Semiannual	PM	Mound	RFCA	BD/UHSU	Performance Monitoring on the Mound Source remediation	
00897	Semiannual	PM	Mound	RFCA	BD/UHSU	Performance Monitoring on the Mound Source remediation	
3586	Semiannual	PE	Mound	RFCA	AL	Plume Extent well tracking migration of Solar Ponds nitrate Plume	
15599	Quarterly	PM	Mound	RFCA	AL	Performance Monitoring for the Mound groundwater treatment system	
15699	Quarterly	PM	Mound	RFCA	AL	Performance Monitoring for the Mound groundwater treatment system	
15799	Quarterly	PM	Mound	RFCA	AL	Performance Monitoring for the Mound groundwater treatment system	
75992	Semiannual	PE	Mound\E. Trench	RFCA	AL	Plume Extent well monitoring So. Walnut Cr. Drainage below Mound Site Plume	
08091	Semiannual	PE	Mound\E. Trench	RFCA	AL	Plume Extent well monitoring the southern migration of Mound and East Trenches Plumes	
6486	Semiannual	D	NA	RFCA	AL	Drainage well monitoring the Woman Cr. drainage downgradient of the 881 Hillside Plume	
5587	Semiannual	D	NA	RFCA	AL	Drainage well monitoring the Woman Cr. drainage south of the 881 Hillside Plume	
38591	Semiannual	D	NA	RFCA	AL	Drainage well in Woman Cr. Drainage below 881 Hillside Plume	
6586	Semiannual	D	NA	RFCA	AL	Drainage well monitoring the No. side Woman Cr. below 903Pad/Ryans Pit Plume	
00997	Semiannual	D	NA	RFCA	AL	Drainage Well - below Pond B-4 in South Walnut Creek Drainage	
1386	Semiannual	D	NA	RFCA	AL	Plume Definition well monitoring the migration of the SEP Nitrate and Carbon Tet Plumes	
00197	Semiannual	PE	Old Landfill	RFCA	AL	Plume Extent well monitoring the Industrial Area Plume	
00397	Semiannual	PE	PU&D	RFCA	AL	Plume Extent well monitoring the PU&D Yard Plume	
02197	Semiannual	PE	PU&D	RFCA	AL	Plume Extent well monitoring the PU&D Yard Plume	
70493	Quarterly	RCRA	PU&D	RFCA, RCRA	BD/UHSU	RCRA upgradient/Plume Definition well monitoring the edge of the PU&D Yard Plume	
70393	Quarterly	RCRA	PU&D	RFCA, RCRA	AL	RCRA upgradient /Plume Definition well monitoring the edge of the PU&D Yard Plume	
70193	Quarterly	RCRA	PU&D	RFCA, RCRA	BD/UHSU	RCRA upgradient/Plume Extent well monitoring the PU&D Yard Plume	
5887	Quarterly	RCRA	PU&D	RFCA, RCRA	AL	RCRA upgradient/ Plume Extent Well monioring the PU&D Yard Plume - LF	
76992	Semiannual	PE	PU&D\Landfill	RFCA, RCRA	AL	Plume Extent well monitoring the eastward migration of the PU&D Yard/Landfill Plume	
00597	Semiannual	PD	PU&D\Landfill	RFCA, RCRA	AL	Plume Definition well monitoring the Landfill/PU&D yard Plume	
00297	Semiannual	PD	Solar Ponds	RFCA	AL	Plume Definition well monitoring the southern migration of the Solar Ponds Plume	
P219489	Semiannual	PE	Solar Ponds	RFCA	AL	Plume Extent well monitoring the northern migration of the SEP Nitrate Plume	
P218389	Semiannual	PE	Solar Ponds	RFCA	AL	Plume Extent well monitoring the northern migration of the SEP Nitrate Plume	
B208289	Semiannual	PE	Solar Ponds	RFCA	BD/UHSU	Plume Extent well monitoring the northeast mitgration of the SEP Nitrate Plume	
3386	Semiannual	PE	Solar Ponds	RFCA	AL	Plume Extent well monitoring the southern migration of the SEP Nitrate and Carbon Tet Plumes	
1786	Semiannual	PE	Solar Ponds	RFCA	AL	Plume Definition well monitoring the migration of the SEP Nitrate and Carbon Tet Plumes	
B208789	Semiannual	PE	Solar Ponds	RFCA	AL	Plume Extent well monitoring the northeast mitgration of the SEP Nitrate Plume	
P209489	Semiannual	PD	Solar Ponds	RFCA	BD\UHSU	Plume Definition well for the Carbon Tet. Plume	
18199	Semiannual	PA	IHSS 118.1	AL	AL	Plume Degredation well monitoring the IHSS 118.1 plume	
18299	Semiannual	PA	IHSS 118.1	AL	AL	Plume Degredation well monitoring the IHSS 118.1 plume	
18399	Semiannual	PA	IHSS 118.1	AL	AL	Plume Degredation well monitoring the IHSS 118.1 plume	
18499	Semiannual	PA	IHSS 118.1	AL	AL	Plume Degredation well monitoring the IHSS 118.1 plume	

18599	Semiannual	PA	IHSS 118.1	AL	AL	Plume Degredation well monitoring the IHSS 118.1 plume	
18699	Semiannual	PA	IHSS 118.1	AL	AL	Plume Degredation well monitoring the IHSS 118.1 plume	
18799	Semiannual	PA	IHSS 118.1	AL	AL	Plume Degredation well monitoring the IHSS 118.1 plume	
18899	Semiannual	PA	IHSS 118.1	AL	AL	Plume Degredation well monitoring the IHSS 118.1 plume	

APPENDIX E
PROPOSED MONITORING WELLS CHEMICALS TO BE MONITORED

WELLNO	FREQUENCY	PLUME\AREA	VOC Suite	METALS Suite	TRITIUM	PU/AM	SR 89/90	URANIUM	NITRATE	FLUORIDE	SULPHATE	CYANIDE	CESIUM	CHLORIDE	SULFIDE	DOC/TOC	METHANE
891COLWEL	Quarterly	881 Hillside	X	X				X									
SW13494	Quarterly	881 Hillside	X	X				X									
5387	Semiannual	881 Hillside	X	X				X	X		X						
4887	Semiannual	881 Hillside	X	X				X	X		X						
4787	Semiannual	881 Hillside	X	X				X	X		X						
00797	Semiannual	881 Hillside	X	X				X	X		X						
11092	Semiannual	881 Hillside	X	X				X	X		X						
10992	Semiannual	881 Hillside	X	X				X	X		X						
10792	Semiannual	881 Hillside	X	X				X	X		X						
10692	Semiannual	881 Hillside	X	X				X	X		X						
10592	Semiannual	881 Hillside	X	X				X	X		X						
0487	Semiannual	881 Hillside	X	X				X	X		X						
891COLGAL	Quarterly	881 Hillside	X	X				X									
6386	Semiannual	903 Pad	X	X		X		X	X		X						
6286	Semiannual	903 Pad	X	X		X		X	X		X						
3087	Semiannual	903 Pad	X	X		X		X	X		X						
2987	Semiannual	903 Pad	X	X		X		X	X		X						
23196	Semiannual	903 Pad	X	X		X		X	X		X						
23096	Semiannual	903 Pad	X	X		X		X	X		X						
07391	Semiannual	903 Pad	X	X		X		X	X		X						
00491	Semiannual	903 Pad	X	X		X		X	X		X						
02297	Semiannual	Bldg 779	X	X		X		X	X								
02497	Semiannual	Bldg 779	X	X		X		X	X								
02397	Semiannual	Bldg 779	X	X		X		X	X								
22996	Semiannual	Bldg 886	X	X		X	X	X									
10198	Semiannual	Bldg. 123	X	X		X		X	X			X	X				
10298	Semiannual	Bldg. 123	X	X		X		X	X			X	X				
10398	Semiannual	Bldg. 123	X	X		X		X	X			X	X				
10498	Semiannual	Bldg. 123	X	X		X		X	X			X	X				
10598	Semiannual	Bldg. 123	X	X		X		X	X			X	X				
41691	Semiannual	Boundary	X	X	X	X	X	X	X	X	X						
41591	Semiannual	Boundary	X	X	X	X		X	X	X	X						
10394	Semiannual	Boundary	X	X	X	X	X	X	X	X	X						
10294	Semiannual	Boundary	X	X	X	X		X	X	X	X						
06491	Semiannual	Boundary	X	X	X	X		X	X	X	X						
0386	Semiannual	Boundary	X	X	X	X		X	X	X	X						
P219189	Semiannual	Carbon Tet	X	X	X	X	X	X	X	X	X						
P209389	Semiannual	Carbon Tet	X	X	X	X	X	X	X	X	X						
P209289	Semiannual	Carbon Tet	X	X	X	X	X	X	X	X	X						
1386	Semiannual	Drainage	X	X	X	X	X	X	X	X	X						
6486	Semiannual	Drainage	X	X			X	X	X		X						
5587	Semiannual	Drainage	X	X			X	X	X		X						
38591	Semiannual	Drainage	X	X			X	X	X		X						
6586	Semiannual	Drainage	X	X		X		X	X								
00997	Semiannual	Drainage	X	X		X	X	X									
23296	Semiannual	East Trenches	X	X		X		X	X								
10194	Semiannual	East Trenches	X	X		X		X	X								
06091	Semiannual	East Trenches	X	X		X		X	X								
05091	Semiannual	East Trenches	X	X		X		X	X								
04991	Semiannual	East Trenches	X	X		X		X	X								
04591	Semiannual	East Trenches	X	X		X		X	X								
04091	Semiannual	East Trenches	X	X		X		X	X								
03991	Semiannual	East Trenches	X	X		X		X	X								
11891	Semiannual	East Trenches	X	X		X		X	X								
3687	Semiannual	East Trenches	X	X		X		X	X								
12691	Semiannual	East Trenches	X	X		X		X	X								
05691	Semiannual	East Trenches	X	X		X		X	X								

APPENDIX E
PROPOSED MONITORING WELLS CHEMICALS TO BE MONITORED

WELLNO	FREQUENCY	PLUME\AREA	VOC Suite	METALS Suite	TRITIUM	PU/AM	SR 89/90	URANIUM	NITRATE	FLUORIDE	SULPHATE	CYANIDE	CESIUM	CHLORIDE	SULFIDE	DOC/TOC	METHANE
05391	Semiannual	East Trenches	X	X		X		X	X								
12191	Semiannual	East Trenches	X	X		X		X	X								
10994	Semiannual	IA\Old Landfill	X	X			X	X	X		X						
7086	Semiannual	IA\Old Landfill	X	X			X	X	X		X						
P416889	Semiannual	Ind. Area	X	X		X		X	X								
P416789	Semiannual	Ind. Area	X	X		X		X	X								
P416689	Semiannual	Ind. Area	X	X		X		X	X								
P314289	Semiannual	Ind. Area	X	X		X		X	X								
P313589	Semiannual	Ind. Area	X	X		X		X	X								
P114389	Semiannual	Ind. Area	X	X		X		X	X								
6186	Semiannual	Ind. Area	X	X		X		X	X								
43392	Semiannual	Ind. Area	X	X		X		X	X								
22896	Semiannual	Ind. Area	X	X		X		X	X								
22796	Semiannual	Ind. Area	X	X		X		X	X								
22696	Semiannual	Ind. Area	X	X		X		X	X								
22596	Semiannual	Ind. Area	X	X		X		X	X								
2186	Semiannual	Ind. Area	X	X		X		X	X								
1986	Semiannual	Ind. Area	X	X		X		X	X								
B206989	Quarterly	Landfill	X	X	X			X	X	X	X						
77392	Semiannual	Landfill	X	X	X			X	X	X	X						
52994	Quarterly	Landfill	X	X	X			X	X	X	X						
52894	Quarterly	Landfill	X	X	X			X	X	X	X						
4087	Quarterly	Landfill	X	X	X			X	X	X	X						
02291	Semiannual	Mound	X	X		X		X	X								
00897	Semiannual	Mound	X	X		X		X	X								
3586	Semiannual	Mound	X	X		X		X	X								
15599	Quarterly	Mound	X			X		X									
15699	Quarterly	Mound	X			X		X									
15799	Quarterly	Mound	X			X		X									
75992	Semiannual	Mound\E. Trench	X	X		X	X	X	X								
08091	Semiannual	Mound\E. Trench	X	X		X	X	X	X								
00197	Semiannual	Old Landfill	X	X	X		X	X	X	X	X						
00397	Semiannual	PU&D	X	X	X			X	X	X	X						
02197	Semiannual	PU&D	X	X	X			X	X	X	X						
70493	Quarterly	PU&D	X	X	X			X	X	X	X						
70393	Quarterly	PU&D	X	X	X			X	X	X	X						
70193	Quarterly	PU&D	X	X	X			X	X	X	X						
5887	Quarterly	PU&D	X	X	X			X	X	X	X						
76992	Semiannual	PU&D\Landfill	X	X	X			X	X	X	X						
00597	Semiannual	PU&D\Landfill	X	X	X			X	X	X	X						
00297	Semiannual	Solar Ponds	X	X	X	X	X	X	X	X	X						
P219489	Semiannual	Solar Ponds	X	X	X	X	X	X	X	X	X						
P218389	Semiannual	Solar Ponds	X	X	X	X	X	X	X	X	X						
B208289	Semiannual	Solar Ponds	X	X	X	X	X	X	X	X	X						
3386	Semiannual	Solar Ponds	X	X	X	X	X	X	X	X	X						
1786	Semiannual	Solar Ponds	X	X	X	X	X	X	X	X	X						
B208789	Semiannual	Solar Ponds	X	X	X	X	X	X	X	X	X						
P209489	Semiannual	Solar Ponds	X	X	X	X	X	X	X	X	X						
18199	Semiannual	IHSS 118.1	X						X		X			X	X	X	X
18299	Semiannual	IHSS 118.1	X						X		X			X	X	X	X
18399	Semiannual	IHSS 118.1	X						X		X			X	X	X	X
18499	Semiannual	IHSS 118.1	X						X		X			X	X	X	X
18599	Semiannual	IHSS 118.1	X						X		X			X	X	X	X
18699	Semiannual	IHSS 118.1	X						X		X			X	X	X	X
18799	Semiannual	IHSS 118.1	X						X		X			X	X	X	X
18899	Semiannual	IHSS 118.1	X						X		X			X	X	X	X

Appendix E-3 Water Level Monitoring Wells

WELL Alluvium	SITE-WIDE[1] WATER QUALITY	INDUSTRIAL AREA	BACKGROUND
0186		730	
1086		730	
1386	12		
1786	12		
1886		2	
1986	12		
2286		12	
2486		2	
2686		2	
2986		2	
3386	12		
3586	12		
3686		2190	
3986		730	
4286		12	
4386		12	
4486		2	
4786			730
5586			730
5686			12
6186	4		
6386	4		
6486	12		
6586	12		
6686		12	
6786			2
6886		2190	
7086	4		
0187		730	
0487	12		
1087		2	
1487		730	
1587		730	
1987		2	
2187		2	
2487		2	
2687		2	
2987	4		
3287		2	
3387		2	
4087	12		
4287		730	
4387		2	
4787	4		
4887	4		
5287		12	
5387	4		
5587	12		
5887	4		
6087		2	
7187		2	

Appendix E-3 Water Level Monitoring Wells

WELL	SITE-WIDE[1] WATER QUALITY	INDUSTRIAL AREA	BACKGROUND
B400389			12
B200589			730
B200889			730
B102289			2
B102389			2
B402689			12
P207689		2	
P207889		2	
B208089		12	
B208789	4		
P209289	4		
P209789		2	
P209889		730	
B210489		2190	
B410589			12
B410689			2
B410789		2	
B110889		2	
B110989			12
B111189			12
B411289			12
P313489		2	
P313589	12		
P213689		730	
P414189		730	
P314289	12		
P114389	12		
P114489		2	
P114689		2	
P114789		2	
P114889		730	
P114989		2	
P115089		12	
P115489		730	
P115589		2	
P115689		2	
P215789		2	
P415889		730	
P415989		2	
P416089		12	
P416189		2	
P416289		2	
P416389		2	
P416489		12	
P416589		730	
P416689	12		
P416789	12		
P416889	12		
P317989		2	
P218089		2	
P218289		2	
P218389	12		

Appendix E-3 Water Level Monitoring Wells

WELL	SITE-WIDE[1] WATER QUALITY	INDUSTRIAL AREA	BACKGROUND
P219189	12		
P119389		730	
P219489	4		
P320089		2	
0190			12
0290			12
0390			12
0990			12
1190			730
1290			2
1390			2
1490			12
00191		2	
00491	4		
01291		2	
01391		12	
03191		2	
03991	4		
04091	4		
04191		2	
04591	4		
04991	4		
05091	4		
05191		730	
05291		2	
05391	4		
05691	4		
06191		2	
06991		2	
07291		12	
07391	4		
08091	4		
13091		2	
13391		2	
13491		2	
13591		2	
20291		12	
20691		730	
34791		2	
37191		2	
37591		730	
37691		2	
37791		2	
38591	4		
41091		12	
41591	12		
41691	12		
10592	4		
10692	4		
10992	4		
11092	4		
43392	4		

Appendix E-3 Water Level Monitoring Wells

WELL	SITE-WIDE[1] WATER QUALITY	INDUSTRIAL AREA	BACKGROUND
46292			2
46492		2	
75292		12	
75992	4		
76792		2	
76992	4		
77392	4		
77492		730	
00293			12
05193		12	
05293		730	
45793		2	
58793		2	
59493		2	
59893		2	
60693		2	
61293		2	
62593			12
62693			12
62893		2	
70393	4		
70693		2	
10194	4		
10294	4		
10394	4		
10594		2	
10694		2	
10794		2190	
10994	4		
11294			12
11494			730
11594			12
50494			2
50694		2	
51094			2
51194		2	
51294		12	
51494			730
51594			12
52894	4		
52994	4		
56994		2	
57094		2	
59594		2	
60294		2	
60994		2	
60195		12	
60295		2	
60395		2	
60695		2	
60795		2	
61295		2	

Appendix E-3 Water Level Monitoring Wells

WELL	SITE-WIDE[1] WATER QUALITY	INDUSTRIAL AREA	BACKGROUND
61495		2	
61595		2	
61695		2	
62395			12
63395		2	
63495		2	
63795			12
63895			12
20196			2
20296			2
20396			2
20496			2
20596			2
20696			12
20796			2
22596	12		
22696	4		
22796	4		
22896	4		
22996	12		
23096	4		
23196	4		
23296	4		
00197	4		
00297	4		
00397	4		
00697	4		
00597	4		
00797	4		
00897	4		
00997	12		
02197	4		
02297	4		
02397	4		
02497	4		
10098	12		
10198	4		
10298	4		
10398	4		
10498	4		
10598	4		
15199	4		
15299	4		
15399	4		
15499	4		
15599	4		
15699	4		
15799	4		
18199	4		
18299	4		
18399	4		
18499	4		

Appendix E-3 Water Level Monitoring Wells

WELL	SITE-WIDE[1] WATER QUALITY	INDUSTRIAL AREA	BACKGROUND
18599	4		
18699	4		
18799	4		
18899	4		
P419689		2	
06091	12		
10894		2	
Bedrock			
0386	12		
2186	4		
6286	4		
3087	4		
3687	4		
B206989	4		
B208289	4		
P209389	4		
P209489	4		
P114589		2	
P416989		2	
03791		730	
06291		12	
06491	4		
11891	4		
12191	4		
12691	4		
20991		730	
10792	4		
70193	4		
70493	4		
	668	25204	5404

Note:
Numbers in columns denote measurement frequency per year

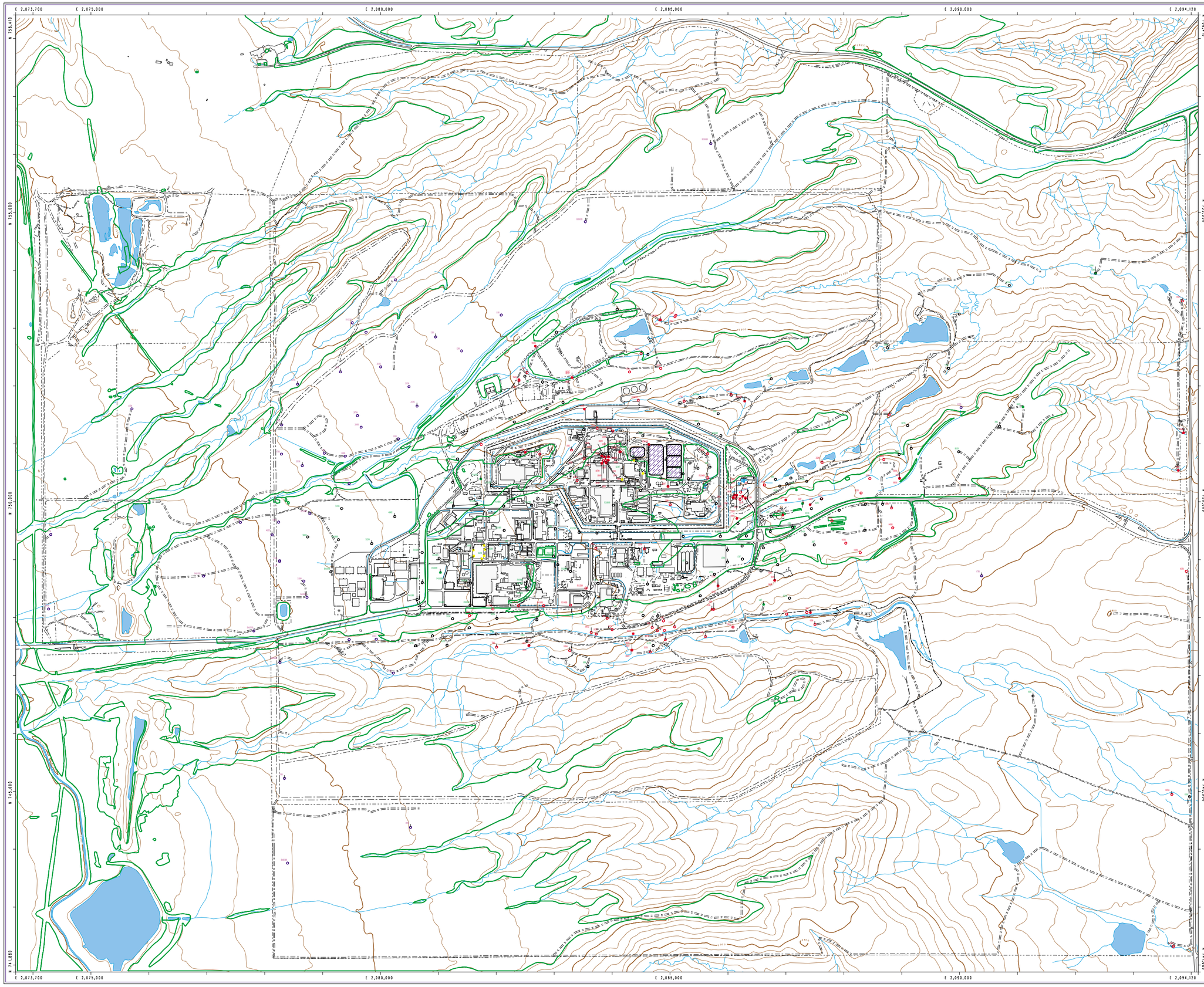


Plate 1

Groundwater Flow Monitoring Well Location Map

EXPLANATION

IMP Well Type

- Water Quality Flow Monitoring
- Industrial Area Flow Monitoring
- Background Flow Monitoring
- Demolition and Destruction Monitoring

Monitoring Well Completion Zone

- Bedrock
- Alluvium
- Alluvium/Bedrock

Other

- Extent of Rocky Flats Alluvium

Standard Map Features

- Buildings and other structures
- Solar Evaporation Ponds (SEP)
- Lakes and ponds
- Streams, ditches, or other drainage features
- Fences and other barriers
- Contour (20-Foot)
- Paved roads
- Dirt roads

DATA SOURCE:

Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by EG&G RSL, Las Vegas.
Digitized from the orthophotographs. 1/95
Topology (contours) were derived from digital elevation model (DEM) data by Morrison Knudson (MK) using ESRI Arc TIN and LATTICE to process the DEM data to create 5-foot contours. The DEM data was captured by the Remote Sensing Lab, Las Vegas, NV, 1994 Aerial Flyover at ~ 10 meter resolution. DEM post-processing performed by MK, Winter 1997.

N

Scale = 1 : 7120
1 inch represents approximately 593 feet

500 0 1000 2000ft

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

Prepared by:

RMRS **Rocky Mountain Remediation Services, L.L.C.**
Geographic Information Systems Group
Rocky Flats Environmental Technology Site
P.O. Box 464
Golden, CO 80402-0464

MAP ID: fy99/rfca-rpt

October 11, 1999

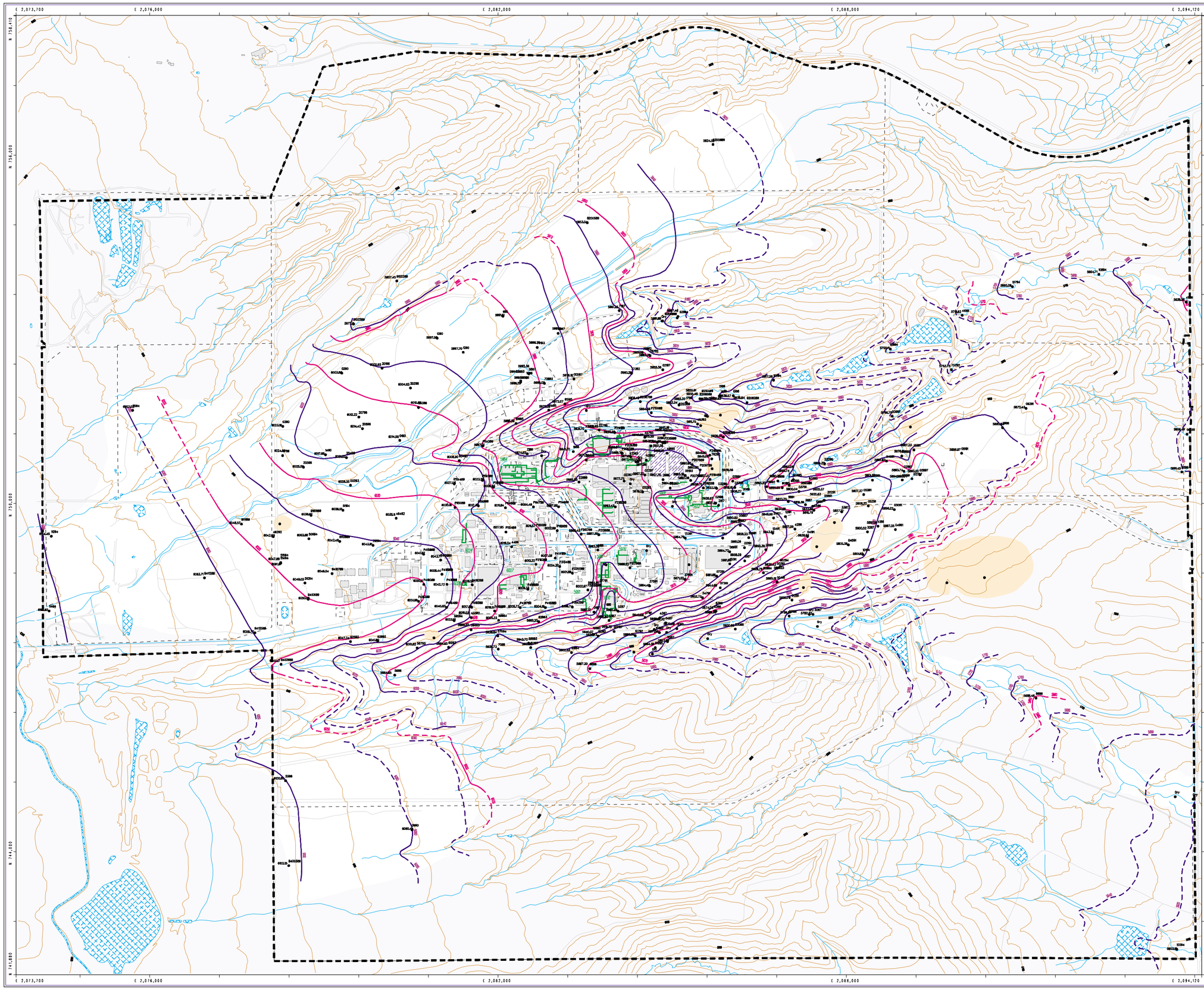


Plate 2

Potentiometric Surface of Unconsolidated Surficial Deposits Second Quarter 1998

- Groundwater Monitoring Well
- Water Level Contour
- Dashed where inferred
- Intermediate Water Level Contour
- Dashed where inferred
- Foundation Drain
- Approximate extent of Unsaturated Area
- Area without Groundwater Elevation Data

Standard Map Features

- Buildings & other structures
- Solar evaporation ponds
- Lakes and ponds
- Streams, ditches, or other drainage features
- Fences and other barriers
- Contours (20' Intervals)
- Roads
- Rocky Flats Boundary

DATA SOURCE:
Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by EG&G RST, Las Vegas. Digitized from the orthophotographs, 1/95

Scale = 1 : 7200
1 inch represents 600 feet

500 0 1000 2000ft

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

Prepared by:

RMRS
Rocky Mountain Remediation Services, L.L.C.
Geographic Information Systems Group
Rocky Flats Environmental Technology Site
P.O. Box 464
Golden, CO 80402-0464

MAP ID: 99-0350

September 28, 1999

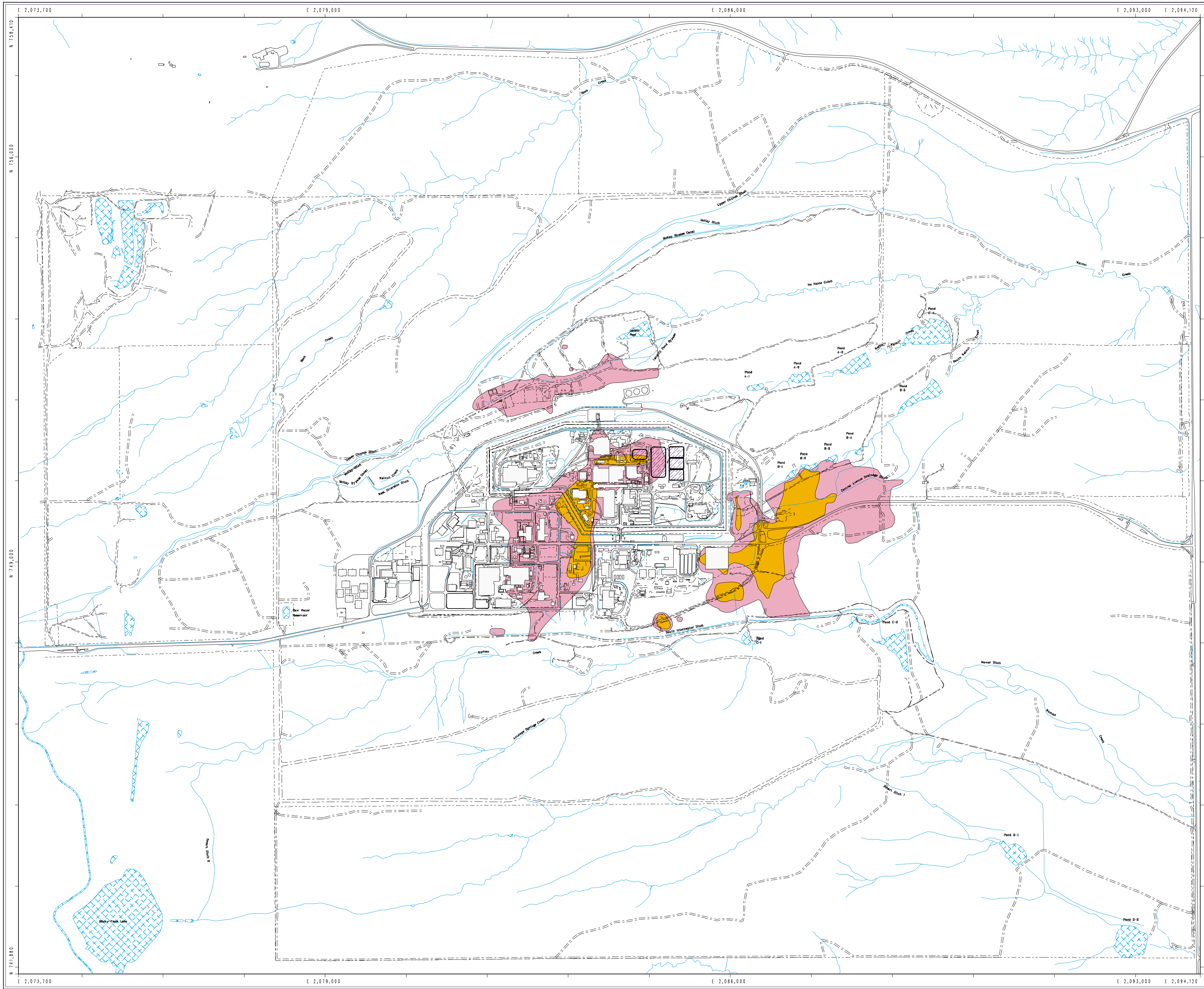


Plate 3

Regulatory Required Groundwater Monitoring Wells Selected VOC & Nitrate Plumes (Nitrate Standard and 100 x Standard) (VOC MCL and 100 x MCL)

EXPLANATION

- IMP Well Locations
- Composite VOC Groundwater Plume (100 X MCL)
- Composite VOC Groundwater Plume (concentration equal to MCL)
- 100 x Nitrate Standard (1000 mg/l)
- Nitrate Standard (10 mg/l)

Standard Map Features

- Buildings and other structures
- Solar Evaporation Ponds (SEP)
- Lakes and ponds
- Streams, ditches, or other drainage features
- Fences and other barriers
- Paved roads
- Dirt roads

DATA SOURCE:
Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by EG&G RSL, Las Vegas.
Digitized from the orthophotographs, 1/95

Scale = 1 : 7200
1 inch represents 600 feet

500 0 1000 2000ft

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

Prepared by:

RMRS
Rocky Mountain Remediation Services, L.L.C.
Geographic Information Systems Group
Rocky Flats Environmental Technology Site
P.O. Box 464
Golden, CO 80402-0464

MAP ID: 99-0302

October 11, 1999