Section 2

GROUNDWATER MONITORING PROGRAM

INTRODUCTION

This section presents a description of the Groundwater Monitoring Program currently in place at the Rocky Flats Environmental Technology Site (Rocky Flats or Site). It presents a general description of the groundwater hydrology at the Site, groundwater monitoring objectives and procedures, monitoring well categories, contaminants and parameters monitored, sampling frequencies, and the criteria used to evaluate the overall groundwater quality.

The groundwater at Rocky Flats has been contaminated with radionuclides, chemicals, metals, and other substances from past spills, leaks, former waste management and disposal practices, and releases from Industrial Area activities. The contaminated areas have formed several groundwater contaminant plumes which are slowly migrating. Much of the groundwater discharges to the surface water and may impact the water quality. Therefore, the Groundwater Monitoring Program is vital for protecting surface water and minimizing potential offsite contaminant migration.

Rocky Flats maintains an integrated network of monitoring wells to monitor the groundwater quality across the Site. Groundwater monitoring activities include groundwater analyses for chemical and radionuclide contamination, identification and tracking the extent and movement of polluted groundwater, and measurements to interpret and define the groundwater hydrology.

HYDROGEOLOGY

The groundwater at Rocky Flats occurs in three water-bearing units: two shallow water-bearing layers and a deep aquifer. The shallow groundwater system consists of two unconfined, relatively permeable water-bearing layers identified as the upper hydrostratigraphic unit and the lower hydrostratigraphic unit. The third water-bearing unit is a deep regional aquifer known as the Laramie-Fox Hills Aquifer.

An aquifer is defined as a water-bearing layer of rock that will yield water in a usable quantity to a well or a spring. Although the two shallow water-bearing units have the same hydrologic characteristics as an aquifer, neither unit yields sufficient water to be characterized as an aquifer.

A geologic formation having hydrologic properties similar to an aquifer, but producing insufficient water yield, is referred to as a "hydrostratigraphic unit."

The upper hydrostratigraphic unit (UHSU) is the primary water-bearing unit of concern at Rocky Flats. It is referred to as the "uppermost aquifer," defined by federal regulations (RCRA) to be "the geologic formation nearest the natural ground surface that is an aquifer." The Site uses this regulatory definition and refers to the UHSU as an uppermost aquifer.

The UHSU is an unconfined groundwater system. It is present in a series of layered geologic formations derived from surface deposits. Overall these formations consist of mixed layers of unconsolidated (loosely arranged, uncemented particles) coarse gravel and sandy/gravelly clay, interspersed with clay, silt or sand lenses, weathered sandstone, and claystone bedrock. The groundwater in the UHSU flows generally from west to east. It follows the topography and flows toward the stream drainages, with minor deviations around permeable clay lenses and man made or subsurface geologic structures. Depth to the water table (UHSU) at the Site is influenced by short-term precipitation events and variations in recharge. These depths can range from 2 to 70 feet below ground surface at Rocky Flats.

The lower hydrostratigraphic unit (LHSU) underlies the UHSU and occurs in unweathered claystone and silty claystone bedrock interbedded with siltstone and sandstone deposits. For the most part, the bedrock claystone separates the LHSU from the UHSU and presents a confining layer that inhibits vertical groundwater migration to the Laramie Fox-Hills Aquifer. There are significant differences in the ability of the two shallow water-bearing units to transmit the groundwater. Because the LHSU contains less sandstone and more claystone, the groundwater moves through this unit more slowly than in the overlying UHSU. Generally, the hydraulic conductivity of the UHSU is three orders of magnitude greater than the LHSU groundwater. Wells completed in the UHSU and LHSU generally have poor water-yielding characteristics that prevent their development as viable water sources for residential use. However, there are some UHSU well locations in Walnut Creek near Indiana Street, and on the west side of the Site that have sustainable well yields during surface water recharge periods.

The deep Laramie-Fox Hills Aquifer underlies the two shallow water-bearing units, and is separated from them by the low permeability of the claystone deposits in the Lower Hydrostratigraphic Unit. This aquifer is generally confined within unweathered bedrock sandstones and siltstones. The Laramie-Fox Hills Aquifer, regionally important in the Denver Basin as a drinking water supply, flows toward the east or southeast at Rocky Flats.

There are local areas of discharge and recharge at Rocky Flats. Water enters the groundwater systems in recharge areas and moves through them to discharge areas. A recharge area is an area that allows water to enter the aquifer. This area is particularly vulnerable to pollutants that could impact the quality of the groundwater. Discharge areas are where groundwater reappears at the ground surface.

At Rocky Flats, the shallow groundwater system is recharged by infiltration from precipitation, snowmelt, irrigation, and from stream, ditch and pond seepage during periods of high flow. Most precipitation occurs in the western part of Rocky Flats near the foothills of the Rocky Mountains. The UHSU, first to receive recharge waters, is dynamic and exhibits rapid changes in water levels in response to precipitation and seasonal variations. A significant amount of the groundwater from Rocky Flats discharges to the stream drainages and contributes to the surface water flow at and adjacent to Rocky Flats. The interaction between groundwater and surface water is an important consideration at Rocky Flats.

HISTORIC GROUNDWATER MONITORING ACTIVITIES

The first monitoring wells at Rocky Flats were installed in the Solar Ponds area in 1954 to monitor radionuclide concentrations. In response to regulatory compliance and site investigation objectives, the number of wells ultimately increased to a monitoring network consisting of 1,055 wells and piezometers at the Site. Although earlier wells were primarily monitored for radionuclides, over time the groundwater monitoring program evolved to include an analyte suite composed of water quality parameters, volatile organic compounds (VOCs), metals, dissolved ionic constituents (such as nitrate, sulfate, chloride), and minor pesticide screening.

Until 1974 well sampling frequencies were performed on an annual basis, then increased to biannual and triennial sampling schedules. From 1982 to 1995, designated monitoring wells were sampled on a quarterly basis. In 1995 sampling frequencies changed to a combination of quarterly and semiannual sampling in response to the prevailing regulatory requirements.

Following completion of a Site-wide Well Evaluation Project conducted from 1993 to 1995 and delineation of the groundwater contaminant plume boundaries, the existing well sampling monitoring network was assessed and the number of monitoring wells was substantially reduced.

CURRENT ONSITE GROUNDWATER MONITORING PROGRAM

In concurrence with the objectives of the Rocky Flats Cleanup Agreement (RFCA) approved in 1996, the Groundwater Monitoring Program at Rocky Flats was reappraised and an Integrated Monitoring Plan (IMP) for groundwater monitoring and surveillance was developed. This Plan combines the regulatory requirements historically managed under separate programs into a single plan. The groundwater IMP was developed using a Data Quality Objective (DQO) process. This process was used to qualitatively and quantitatively review the requirements and rationale for all required elements of the Groundwater Monitoring Program at Rocky Flats. The IMP is reviewed annually and revised as needed for each Fiscal Year.

The present Groundwater Monitoring Program incorporates groundwater analyses for chemical and radionuclide contamination, measurements to determine the gradient and direction of groundwater flow, and assessments of the nature and extent of the groundwater contaminant plumes present in the UHSU within the Site boundaries. The groundwater sampling monitoring network is designed to monitor areas of known or suspected groundwater contamination based on composite groundwater plume information and specific source characterization activities for each defined Operable Unit (OU).

REGULATORY DRIVERS

Groundwater monitoring is required and governed by federal and state regulations as well as DOE orders and specific policies. Table I lists the key regulatory drivers that govern groundwater monitoring at the Site.

GROUNDWATER MONITORING GOALS

The primary focus of the Groundwater Monitoring Program is to comply with applicable regulatory requirements and protect surface water quality in order to reduce risks to public health and the environment. The goals of the current Groundwater Monitoring Program are as follows:

- Protect surface water quality;
- Comply with regulatory requirements;
- Minimize further degradation of the UHSU groundwater;
- Support the design and selection of remedial measures and assess the impact of future remedial actions.

TABLE I
GROUNDWATER MONITORING REGULATORY DRIVERS

Federal Regulations	Resource Conservation and Recovery Act (RCRA), 40 CFR, Part 265, Subpart F
	Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)
	Superfund Amendments and Reauthorization Act (SARA)
Colorado State Regulations	Colorado Water Quality Control Commission (CWQCC) Groundwater Standards for RFETS
	Site-specific Water Quality Classifications and Standards for Groundwater, 5CCR 1002-8, 3.12.7
	Colorado Hazardous Waste Management Act, Title 25 CRS, Article 15
	6 Code of Colorado Regulations, CCR 1007.3
	6 Code of Colorado Regulations, CCR 1007-2
Department of Energy (DOE)	Rocky Flats Clean-Up Agreement (RFCA), DOE 1996

MONITORING RATIONALE AND INTENDED DATA USE

The current Groundwater Monitoring Program is designed to collect relevant information necessary to support the stated objectives.

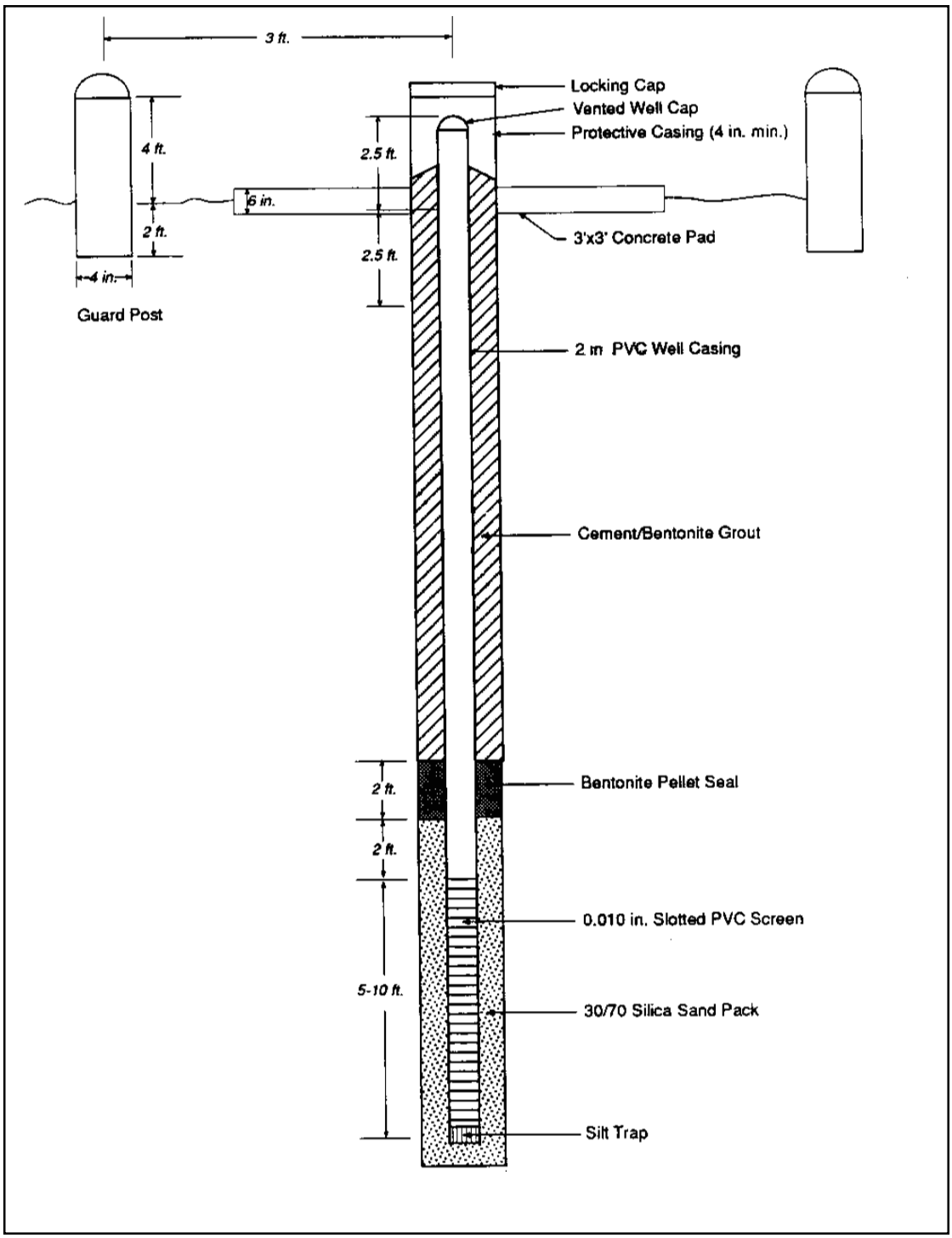
The groundwater monitoring activities specified in the program are intended to provide the following information:

- Identify potential contaminants;
- Identify and control contaminant sources and groundwater pathways to the surface water;
- Monitor groundwater contaminant concentrations and evaluate impacts to the surface water;
- Monitor remedial and D&D actions;
- Protect groundwater sources from new sources of contamination.

GROUNDWATER MONITORING WELLS

Groundwater at Rocky Flats is monitored using a system of monitoring wells installed at locations throughout the Site. These monitoring wells are used to access the groundwater for sampling and hydrologic measurements. Figure 1 depicts the general components of a typical monitoring well.

FIGURE 1 - TYPICAL MONITORING WELL



There are presently 262 active monitoring wells included in the Groundwater Monitoring Program at Rocky Flats, comprised of both new and existing wells. Water level measurements are routinely collected from all 262 wells, and water samples are collected and analyzed from 89 of these wells.

The groundwater samples are collected on a semiannual basis and analyzed for the presence of radionuclides, chemical contaminants, volatile organic compounds, inorganic compounds, trace metals, and other substances.

The wells are monitored according to the following schedule:

- 89 wells sampled for specific analytes on a semiannual basis;
- Monthly measurements of water elevations at 77 wells;
- Quarterly measurement of water elevations at 59 additional wells;
- Semiannual measurements of water elevations at another 157 wells;
- Real-time measurement of water elevations at 25 wells.

The established monitoring frequency was determined based on a statistical analysis of historical groundwater data from several wells and existing knowledge of the groundwater hydrology at Rocky Flats.

The 89 monitoring wells used to sample groundwater are primarily located along known or suspected pathways between contaminated areas and surface water outlets and within surface water drainages. The majority of the wells are located around the perimeter of the Industrial Area and Current Landfill. Other wells are situated along the eastern boundary of the Site to monitor potential offsite contaminant migration.

The 89 groundwater wells designated for sampling are divided into seven different well categories, based on the specific objectives for the target area monitored. The Groundwater Monitoring Program comprises the following well categories:

- Plume Definition Wells
- Plume Extent Wells
- Drainage Monitoring Wells
- Boundary Wells
- D&D Monitoring Wells
- Performance Monitoring Wells
- RCRA Monitoring Wells

Figure 2 depicts some of the monitoring well locations.

FIGURE 2

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GROUNDWATER MONITORING ANALYTE LIST

The groundwater samples are analyzed for a long list of constituents and chemical compounds that represent the major contaminants of concern identified or suspected to be present at Rocky Flats. The list of major contaminants of concern was developed from an extensive evaluation of historical records, studies, assessments, and other information sources that identified the chemical compounds and wastes stored, used, or spilled at Rocky Flats.

Groundwater samples from monitoring wells in each well category are analyzed for the analyte suites described in Tables III-VIII. These analyte suites are comprised of the compounds identified as the major "Chemicals of Concern" associated with the groundwater plumes or specified target areas. Target concentration levels are based on the Action Levels for the analytes listed in the RFCA Action Level Framework document. The groundwater samples may be analyzed for the following general target categories:

- **Radionuclides**—A total of 7 radionuclides are listed;
- **VOCs** —Volatile Organic Compounds, includes 35 listed compounds;
- **SVOCs—**Semivolatile Organic Compounds, includes 39 listed compounds;
- **Metals—** includes 26 listed analytes;
- **Inorganic Compounds—**includes 3 listed compounds.

In the event that insufficient water sample volume is collected to perform all the specified analyses, the groundwater analyses are prioritized according to the following order:

1) Radiation Screen
2) Volatile Organic Compounds
3) Semivolatile Organic Compounds
4) Pesticides and PCBs
5) Nitrate/Nitrite
6) Metals
7) Specific metals for a given well
8) Uranium isotopes
9) Plutonium and americium isotopes
10) Inorganic compounds
11) Tritium

GROUNDWATER MONITORING ACTION LEVELS

Groundwater monitoring at Rocky Flats is required and governed by federal and state regulations as well as DOE orders and specific policies. Regulatory standards and guidelines set the permissible level of contamination in the groundwater and are referred to as Action Levels.

Different Action Levels are established for each pollutant on the groundwater analyte list. If results from laboratory analysis show a contaminant in the groundwater exceeds the established Action Level, certain response actions must be taken to manage the elevated pollutant concentration.

Because a significant amount of groundwater emerges as surface water prior to leaving Rocky Flats, the groundwater Action Levels are based on protecting the surface water. Response actions to elevated pollutant concentrations are primarily focused on preventing contaminated groundwater from reaching the surface water.

These Action Levels are based on the intended use of the onsite groundwater, with the assumption that human consumption or direct contact is excluded. Groundwater use at Rocky Flats is restricted to cleanup activities and onsite domestic use is prevented by prohibiting well installations for drinking water. The site-specific groundwater standards were revised to reflect this restricted use and the UHSU groundwater was classified for surface water protection.

The groundwater Action Levels at Rocky Flats are derived from the Maximum Contaminant Levels (MCLs) established by the federal Safe Drinking Water Act and the State of Colorado groundwater quality standards. The MCL is the maximum permissible level of a contaminant in drinking water. Where an MCL does not exist, the calculated values from the residential, ingestion-based Programmatic Risk-Based Preliminary Remediation Goal (PPRG) were used. PPRGs were established as Site-wide cleanup targets in 1995 by DOE, EPA, and CDPHE. In combination with the MCLs, Action Levels are established based on a statistical analysis of historical contaminant concentrations.

The MCL for certain contaminants is used to establish two allowable levels of groundwater contamination at the Site. Two tiers of groundwater Action Levels are used at Rocky Flats:

Tier I Action Levels are based on 100 times the MCL (drinking water standard) for listed contaminants and are intended to identify high concentration groundwater contaminant sources that pose a risk to surface water quality. If Tier I Action Levels are exceeded, the potential contamination source is evaluated for an accelerated response action.

Tier II Action Levels are based on the MCL standards and are intended to prevent contaminated groundwater above the MCLs from reaching surface water. Groundwater management actions are triggered if the groundwater exceeds Tier II Action Levels.

GROUNDWATER CONTAMINANT PLUMES

Many contaminant sources were characterized during previous Site studies and designated as Individual Hazardous Substance Site (IHSSs). These IHSSs have been prioritized for remediation based on relative risk.

In a several areas the contaminants from the IHSSs have leached into the groundwater and formed zones, or plumes, of contaminated groundwater. The Site has delineated several areas of groundwater contamination that exceed the Action Levels. Table II summarizes some of the major groundwater contaminant plumes identified to date.

TABLE II
SUMMARY OF GROUNDWATER CONTAMINANT PLUMES

PLUME ID	LOCATION	DESCRIPTION	POTENTIAL CONTAMINANTS
Plumes >100 X MCLs			
881 Hillside Drum Storage Area	South central Site on north slope of Woman Creek	Drum storage area for chlorinated solvents, oils, scrap metals.	Volatile organic compounds, dissolved metals, radionuclides
Mound Site	North of Central Ave. at SE corner of Protected Area	Drum storage and burial area for radioactive and hazardous wastes.	Plutonium, uranium, beryllium, volatile organic compounds
903 Pad and Ryan's Pit	Southeast corner of Site S of the inner east gate	903 Pad drum storage area for radioactive oils and organic compounds. Ryan's Pit used as waste chemical disposal site.	Radionuclides, metals, volatile/ semivolatile organic compounds
East Trenches	Near East Access Rd, E of inner east gate	Burial site for radioactive sewage, chemical sludges, crushed drums, assorted wastes.	Radionuclides, volatile organic compounds, metals, nitrates
Carbon Tetrachloride	Due north of Bldg 776 and E of Bldg 730	Ruptured 5,000 gal carbon tetrachloride underground storage tank.	Carbon tetrachloride, including free product
Industrial Area	IHSS 117.1 NE of Bldg 552 & W of Bldg 559	North Chemical Storage Site, general storage yard and burial site.	Plutonium, uranium, beryllium, volatile organic compounds, PCBs, various metals
	IHSS 117.2-E of Bldg 551	Middle Chemical Storage Site, multipurpose chemical storage area.	
	IHSS 157.1-Adjacent to Bldg 442 Laundry	Radioactive area, solvents & radionuclides leaks/spills from laundry operations.	
	IHSS 158-N of Bldg 551	Laundry dock and staging & loading area for offsite radioactive waste shipment.	
	IHSS 160-West side of Bldg 444	Parking lot, formerly a storage area for leaking waste drums and boxes.	
	IHSS 171 E of Bldg 335	Solvent Burning Ground, used for fire training (diesel, gasoline, waste solvents).	
Plumes < 100 X MCL			
Existing Landfill	Buffer zone north of Protected Area	Disposal area for muncipal wastes and limited quantities of hazardous wastes. Tritium detected in the landfill leachate.	Plutonium, uranium, strontium, tritium, volatile/semivolatile organic compounds, nitrates, sulfates, metals
Solar Evaporation Ponds	Northeast section of Protected Area.	Five storage ponds for radioactive process wastes containing acids, nitrates, metals, various chemicals.	Radionuclides, metals, volatile/ semivolatile organic compounds, nitrates/nitrites
Property Utilization & Disposal Yard	Northwest of Industrial Area	Drum storage area for spent solvents, hazardous materials, metal shavings,	Radionuclides, metals, volatile/ semivolatile organic compounds

MONITORING WELL CATEGORIES

The current Groundwater Monitoring Program at Rocky Flats is designed to monitor areas of known or suspected groundwater contamination based on composite groundwater plume information and specific source characterization activities. The 89 monitoring wells used for groundwater sampling are subdivided into seven different groundwater monitoring well classifications.

The seven well classifications are described below. The groundwater data collected from each well is reviewed quarterly. Monitoring revision decisions are made on an annual basis.

Plume Definition Wells

Plume Definition Wells are installed within locations of known groundwater contaminant plumes. These wells are used to monitor the concentration of contaminated groundwater that exceeds the Tier II Action Levels, but is below Tier I Action Levels.

There are currently 21 monitoring wells classified as Plume Definition Wells. These wells are installed within the contaminated groundwater plumes along suspected pathways to the surface water. Individual well locations were determined from groundwater computer modeling, historical records, and known plume characteristics.

Groundwater from the Plume Definition wells is sampled and analyzed on a semiannual basis. If analytical results show an increase in historical contaminant levels or Action Level exceedance, the data will be reviewed for the potential impacts to surface water and the groundwater from the well may be prioritized for remedial action.

Table III summarizes the general location of the Plume Definition Wells, the contaminants monitored, frequency of field measurements, and the specific monitoring objective for each well.

Plume Extent Wells

Plume Extent Wells are installed at the edge of known groundwater contaminant plumes along subsurface pathways to surface water. These wells are used to monitor the potential lateral migration (movement) of the contaminated groundwater plumes.

TABLE III
PLUME DEFINITION WELLS

PLUME/ AREA	NO. OF WELLS	WELL ID	MONITORING PURPOSE	FIELD MEASUREMENTS	CONTAMINANTS MONITORED
881 Hillside	1	0487	Monitor 881 Hillside plume	12/yr	(1), Sulfate
903 Pad	5	6386, 6286 3087, 2987	Monitor pathway to Woman Creek in 903 Pad/Ryan's Pit plume	4/yr (each well)	(1), Plutonium, Americium
		00491	Monitor 903 Pad VOC plume	4/yr	
Carbon Tetrachloride	3	P219189	Monitor contaminant migration from Carbon Tetrachloride plume	12/yr	(1), Plutonium, Americium, Tritium, Strontium, Fluoride, Sulfate
		P209389 P209289	Monitor Carbon Tetrachloride plume	4/yr (each well)	
Industrial Area	2	P416889	Monitor S. of Bldg. 664 along pathway to Woman Creek	12/yr	Volatile organic compound and Metals Only
		P416789	Monitor S. of 400 area along pathway to Woman Creek	12/yr	
Landfill	1	77392	Monitor eastward migration of PU&D Yard plume	4/yr	(1), Tritium, Fluoride, Sulfate
Solar Ponds	4	P209489*	Monitor Carbon Tetrachloride plume	4/yr	(1), Tritium, Plutonium, Americium, Strontium , Fluoride, Sulfate **Well not analyzed for Strontium*
		1786 1386	Monitor Nitrate & Carbon Tetrachloride plumes	12/yr (each well)	
		New Well	Monitor southern migration of Solar Ponds plume		
East Trenches	2	05391	Monitor eastward contaminant migration from East Trenches plume	4/yr	(1), Plutonium, Americium
		03991	Monitor East Trenches plume	4/yr	
PU&D Yard	2	70493 70393	RCRA upgradient/Monitor edge of PU&D Yard plume	4/yr (each well)	(1), Tritium, Fluoride, Sulfate
PU&D/ Landfill	1	6687	Monitor Landfill/PU&D Yard plume	4/yr	(1), Tritium, Fluoride, Sulfate

(1) ALL WELL SAMPLES ARE ANALYZED FOR VOLATILE ORGANIC COMPOUNDS, METALS, URANIUM, NITRATE, AND THE ANALYTES INDICATED

There are currently 44 Plume Extent Wells installed adjacent to the plume areas, and includes designated Tier II groundwater wells (listed in the RFCA Action Level Framework). Groundwater from these wells is monitored for increases in contaminant concentrations that exceed the Tier II Action Levels and for increases in historic background concentration levels (natural constituents).

Groundwater samples are collected and analyzed from each well on a semiannual basis. If groundwater analyses from a Plume Extent well indicate the contaminant concentrations exceed Tier II Action Levels, the historical well data is reviewed to evaluate the potential impacts to surface water quality. When a contaminant exceedance is detected in a Tier II well, an evaluation is required to determine if remedial or management actions are needed to protect surface water quality. As necessary, the well is sampled monthly for a three month period to confirm the exceedance.

Table IV summarizes the location, contaminants monitored, field measurement frequency, and the specific monitoring objectives for each Plume Extent Well.

TABLE IV
PLUME EXTENT WELLS

PLUME/ AREA	NO. OF WELLS	WELL ID	MONITORING PURPOSE	FIELD MEASUREMENTS	CONTAMINANTS MONITORED
881 Hillside	3	4887, 4787, 5387	South of 881 Hillside	4/yr	(1), Sulfate
903 Pad	2	23196	South migration of Ryan's Pit/903 Pad plume	4/yr	(1), Plutonium, Americium
		23096	South migration of Ryan's VOA plume	4/yr	
East Trenches	7	23296, 04091	North migration of East Trenches plume	4/yr (all wells)	(1), Plutonium, Americium
		10194	South migration of East Trench plume	4/yr	
		06091	Northeast migration of East Trenches plume	12/yr	
		05091, 04991	East migration of East Trenches plume	4/yr (all wells)	
		04591	South migration of East Trenches plume	4/yr	
Indust. Area/ Old Landfill	2	10994	IA/Old Landfill plumes near Woman Creek	2/yr	(1), Strontium, Sulfate
		7086	IA/Old Landfill plume pathway	4/yr	
Industrial Area	12	P416689	South migration of IA plume S. of Bldg 440	12/yr	Volatile organic compounds & Metals
		P314289	South migration of IA plume near Bldg. 850	12/yr	
		P313589	East migration of IA plume near Bldg. 881	12/yr	
		P114389	PU&D Yard plume pathway to Walnut Creek	12/yr	
		6186	East migration of IA plume	4/yr	
		43392	South migration of IA plume	4/yr	
		22896	North migration of IA VOA plume	4/yr	
		22796	North migration of Carbon Tetrachloride plume	4/yr	
		22696	West migration of Carbon Tetrachloride plume	4/yr	
		22596, 2186, 1986	North migration of IA plume	12/yr (22596, 1986) 4/yr (2186)	
Landfill	4	52994, 52894, 4087, B206989	RCRA; monitor downgradient of Landfill plume	4/yr 12/yr(4087 only)	(1), Tritium, Fluoride, Sulfate
Mound	1	75992	Monitor S. Walnut Creek drainage below Mound plume	4/yr	(1), Plutonium, Americium, Strontium
Mound/East Trenches	1	08091	South migration of Mound/East Trenches plumes	4/yr	(1), Plutonium, Americium, Strontium
Old Landfill	1	New Well	Old Landfill Plume		(1), Tritium, Strontium, Sulfate, Fluoride
PU&D Yard	4	2 New Wells	PU&D Yard plume		(1), Tritium, Sulfate, Fluoride
		70193	RCRA, upgradient; monitor PU&D Yard plume	4/yr	
PU&D/ Landfill	1	76992	East migration of PU&D Yard/Landfill plumes	4/yr	(1), Tritium, Sulfate, Fluoride
		5887	RCRA, upgradient; monitor PU&D Yard/Landfill plume	4/yr	
Solar Ponds	6	P219489, P218389	North migration of Solar Ponds Nitrate plume	4/yr (P219489) 12/yr (P218389	(1), Tritium, Plutonium, Americium, Strontium-..
		B208289 B208789	Northeast migration of Solar Ponds Nitrate plume	4/yr (all wells)	Fluoride, Sulfate
		3386	South migration of Solar Ponds/Carbon Tet plume	12/yr	*Well not analyzed for Strontium*
		3586*	Track migration of Solar Ponds Nitrate plume	12/yr	

(1) ALL WELL SAMPLES ARE ANALYZED FOR VOLATILE ORGANIC COMPOUNDS, METALS, URANIUM, NITRATE, AND THE ANALYTES INDICATED

Drainage Monitoring Wells

Drainage Monitoring Wells are located downgradient of the groundwater contaminant plumes within surface water stream drainages. These wells are used to monitor contaminated groundwater plume migration.

There are currently fivc Drainage Monitoring Wells installed in the Walnut Creek and Woman Creek drainages. Groundwater from these wells is monitored for increases in contaminant concentrations that exceed Tier II Action Levels and background levels.

Groundwater is sampled and analyzed from each well on a semiannual basis. Any contaminant detected in a Drainage Monitoring Well has presumably impacted the surface water and migrated offsite. When a Tier II Action Level exceedance or increase in background levels is detected, historical well data is evaluated and a surface water impact analysis is performed. If the data confirms the exceedance, monthly confirmation sampling is performed for a three month period.

Table V summarizes the general well locations, well monitoring objectives, field measurement frequency, and the contaminants monitored for each Drainage Monitoring Well.

TABLE V
DRAINAGE MONITORING WELLS

PLUME/ AREA	NO. OF WELLS	WELL ID	MONITORING PURPOSE	FIELD MEASUREMENTS	CONTAMINANT MONITORED
881 Hillside	3	6486	Monitor Woman Creek drainage downgradient from 881 Hillside Plume	12/yr	(1), Metals, Nitrate, Sulfate
		5587	Monitor Woman Creek drainage south of 881 Hillside Plume	12/yr	
		38591	Monitor Woman Creek drainage below 881 Hillside Plume	4/yr	
903 Pad	1	6586	Monitor North side of Woman Creek below 903 Pad/Ryan's Pit Plumes	12/yr	(1), Metals, Plutonium, Americium, Nitrate
Mound Site	1	3786	Monitor below Pond B-4 in S. Walnut Creek drainage	12/yr	(1), Plutonium, Americium, Strontium

(1) ALL WELL SAMPLES ARE ANALYZED FOR VOLATILE ORGANIC COMPOUNDS, URANIUM, AND THE ANALYTES INDICATED.

Boundary Monitoring Wells

Boundary Monitoring Wells are installed in downstream locations along the eastern boundary of Rocky Flats. These wells are used to monitor the quality of the groundwater before it leaves the Site.

There are currently six Boundary Wells situated along the eastern Site boundary. Groundwater from these wells is monitored for exceedance of Tier II Action Levels and groundwater contaminant concentrations above previously recorded levels.

Boundary Wells are sampled and analyzed on a semi-annual basis. Any groundwater contaminants detected above the Action Levels or background conditions may have impacted the surface water and migrated offsite. If contaminants are detected, historic well data is evaluated and, if not previously performed, potential surface water impacts are evaluated. If indicated, monthly sampling is initiated for a three month period to confirm the exceedance and appropriate parties are notified.

Table VI summarizes the general well locations, frequency of field measurements, and the groundwater contaminants monitored for each Boundary Well.

TABLE VI
BOUNDARY WELLS

AREA/ LOCATION	NO. OF WELLS	WELL ID	FIELD MEASUREMENTS	CONTAMINANTS MONITORED
Walnut Creek drainage at Indiana Street boundary	1	41691	12/yr	(1)
Small drainage near East Access Gate	1	41591	12/yr	(1)
Woman Creek drainage at Indiana Street boundary	1	10394	4/yr	(1)
Drainage below Pond D-2 in southeast Site corner	1	10294	4/yr	(1)
Small drainage East of Site at Indiana Street	1	06491	4/yr	(1)
Small drainage north of East Access Gate	1	0386	12/yr	(1)

(1) ALL WELL SAMPLES ARE ANALYZED FOR VOLATILE ORGANIC COMPOUNDS, TRITIUM, PLUTONIUM, AMERICIUM, URANIUM, NITRATE, FLUORIDE, AND SULFATE

D&D Monitoring Wells

D&D groundwater monitoring is performed to monitor for contaminant releases from building-specific D&D activities in the Industrial Area. This monitoring is initiated when existing information indicates a proposed D&D activity would pose a threat to surface water by impacting a groundwater pathway. Upgradient and downgradient wells are used to establish a water quality baseline one year prior to commencement of the D&D monitoring activity.

There is currently one D&D Monitoring Well installed near Building 886. Building 886 was used to conduct safety experiments for equipment design and nuclear criticality experiments (using uranyl nitrate metal powder). Groundwater is monitored at this location to establish the baseline groundwater condition prior to commencement of D&D activities. Post-D&D monitoring results will be compared to the baseline data to evaluate impacts from the D&D activities.

The D&D monitoring well is currently sampled on a semiannual basis and is identified as follows:

Well Identification	Well No. 22996
Well Location	Near Building 886
Monitoring Purpose	Monitor potential radiological contamination near Bldg. 886
Field Measurement Frequency	12 per year
Contaminants Monitored	Plutonium, Americium, Uranium, Strontium, Volatile organic compounds

It is anticipated that more wells will be added for future D&D monitoring as D&D plans progress.

Performance Monitoring Wells

Performance Monitoring Wells are used to evaluate the effectiveness of remedial actions, source removal activities, or remedial treatment systems for soil or water. Performance monitoring is required by RFCA and is initiated whenever historical data indicates the remedial activities could impact groundwater pathways to surface water.

Performance Monitoring Wells are located downgradient from the remediation project area. Analytical parameters, field measurements, Action Levels, and well locations are determined on a case-by-case basis, as defined in the project-specific planning documents.

At present, 12 Performance Monitoring Wells are installed in known areas of contamination where established Action Levels have been exceeded. Groundwater from each well is sampled and analyzed on a semiannual basis. If an increase in contaminant concentration is detected, the well is evaluated to identify the source and appropriate parties are notified.

Table VII describes the locations, specific monitoring objectives, and the contaminants monitored for each Performance Monitoring Well.

TABLE VII
PERFORMANCE MONITORING WELLS

PLUME/ AREA	NO. OF WELLS	WELL ID	MONITORING PURPOSE	FIELD MEASUREMENTS	CONTAMINANT MONITORED
881 Hillside	6	35691	Monitor 881 footing drain sump	4/yr	(1) , Sulfate
		11092, 10992, 10792, 10692, 10592	Monitor French Drain	4/yr (each well)	
903 Pad	1	07391	Monitor effects of remediation downgradient of Ryan's Pit	4/yr	(1), Plutonium, Americium
East Trenches	5	11891	Monitor effects of remediation downgradient from Trench T-3	4/yr	(1), Plutonium, Americium
		3687, 12691, 0569	Monitor effects of remediation downgradient from Trench T-4	730/yr (3687) 4/yr (other wells)	
		12191	Monitor edge of T-3 soil excavation	4/yr)	

(1) ALL WELL SAMPLES ARE ANALYZED FOR VOLATILE ORGANIC COMPOUNDS, METALS, URANIUM, NITRATE, AND THE ANALYTES INDICATED.

RCRA Monitoring Wells

Groundwater monitoring is required in areas of RCRA (Resource Conservation Recovery Act) interim status units, facilities where hazardous or solid waste is stored, treated, and/or disposed. The State of Colorado, under the authority of EPA, regulates hazardous/solid waste at Rocky Flats. Designated RCRA-management units include the Existing Landfill, the New Sanitary Landfill, and other existing and future waste repositories.

RCRA Monitoring Wells are located upgradient and downgradient from the RCRA-management units. These wells are used to detect and assess potential releases to the groundwater from waste management activities. Comparisons between analytical results from the upgradient and downgradient locations are used to identify a contaminant exceedance and evaluate the impacts on groundwater quality from the RCRA-management units. If an exceedance is suspected, appropriate parties are notified, surface water impacts are assessed, and groundwater monitoring is continued.

There are currently 14 RCRA Monitoring Wells. These monitoring wells are incorporated with the groundwater monitoring programs presented above, serving to support dual monitoring objectives. Groundwater from the RCRA Monitoring Wells is sampled and analyzed on a semiannual basis. The RCRA Monitoring Well locations and the contaminants monitored are summarized in Table VIII.

TABLE VIII
RCRA MONITORING WELLS

PLUME/ AREA	NO. OF WELLS	WELL ID	MONITORING PURPOSE	FIELD MEASUREMENTS	CONTAMINANT MONITORED
Landfill	4	B206989, 52994, 52894, 4087	Downgradient, Plume Extent Wells monitor downgradient from Landfill plume	12/yr (4087) 4/yr (other wells)	(1)
PU&D Yard	4	70493, 70393	Upgradient, Plume Definition Wells monitor edge of PU&D Yard plume	4/yr	(1)
		70193	Upgradient; Plume Extent Well monitors PU&D Yard plume	4/yr	
		77392	Plume Definition Well monitors eastward migration of PU&D Yard plume	4/yr	
PU&D Yard/ Landfill	3	5887	Upgradient, Plume Extent Well monitors PU&D Yard/Landfill plumes	4/yr	(1)
		76992	Plume Extent Well monitors eastward migration of PU&D Yard/Landfill plumes	4/yr	
		6687	Plume Definition Well monitors PU&D/Landfill plumes	4/yr	
Carbon Tetrachloride	3	P219189, P209389, P209289	Plume Definition Wells monitor Carbon Tetrachloride plume	12/yr (P219189) 4/yr (other wells)	(1), Plutonium, Americium, Strontium

(1) ALL WELL SAMPLES ARE ANALYZED FOR VOLATILE ORGANIC COMPOUNDS, METALS, URANIUM, TRITIUM, SULFATE, FLUORIDE, NITRATE, AND THE ANALYTES INDICATED.

FIELD MEASUREMENTS AND SAMPLING PROCEDURES

General procedures for sample collection, field tests, and water level measurements are summarized below. Detailed sampling and analytical requirements are presented in the Rocky Flats Standard Operating Procedures.

Water Level Measurements

Monitoring well water level measurements are performed to provide additional information needed to define the groundwater flow regime at the Site. This information is used to estimate the magnitude, direction, veolocity, and volume of groundwater flow. Presently, water level measurements are performed at all 262 wells included in the Rocky Flats Groundwater Monitoring Program. Water level measurements are collected from 77 wells on a monthly basis, 59 wells on a quarterly basis, and 157 wells on a semiannual basis. Real-time water elevation measurements are collected from 25 of these wells. Water levels are typically measured using an electric tape, such as the Solinst Water Level Sounder.

Water Quality Field Measurements

Well-site field parameters are measured semiannually from the 89 sampled water quality monitoring wells. Water quality measurements identify the basic characteristics of the groundwater quality in the well. Field measurements include temperature, pH, specific conductance, turbidity, and alkalinity. In addition, water samples are collected for laboratory analyses to determine the total dissolved solid (TDS) concentration for each water sample.

Groundwater Sampling

Representative groundwater samples are collected using closed-bottomed Teflon-coated bailers, peristaltic pumps, or gas-powered piston pumps. The sampling procedure used depends on the recharge rate of the well and is determined from prior sampling data or well drilling logs. Collected samples are transferred directly to designated sampling containers and preserved for shipment to the laboratory for analysis.

ANALYTICAL PROCEDURES

Laboratory analytical procedures are prescribed in the Rocky Flats General Radiochemistry and Routine Analytical Protocols. This protocol provides guidance to the contract analytical laboratories for required holding times, detection limits, and reporting procedures. The contract laboratories are pre-qualified in accordance with EPA's Contract Laboratory Program (CLP) requirements. Samples requiring radionuclide analysis are sent to the laboratories licensed to perform radiochemical analysis.

Generally, standard EPA methods for laboratory analysis of drinking water are used to analyze groundwater samples for volatile organic compounds, metals, nitrate, fluoride, and sulfate. Analysis for uranium, plutonium, and americium isotopes are performed using alpha spectroscopy analytical methods.

Laboratory data qualification and/or validation is performed at the Site prior to archiving into the database. This process is accomplished electronically and through automated error checks of the electronic laboratory deliverables.

REPORTING

All the field and laboratory information is maintained in the Rocky Flats Environmental Data System (RFEDS). This is a relational database that holds all environmental data for each monitored environmental media. Reporting and data analyses are accomplished by extracting the data from the RFEDS database. Specific Standard Operating Procedures for verification of the input data from both direct input and subcontractors are a part of the quality assurance program at Rocky Flats.

Groundwater monitoring data is reported on a quarterly and annual basis, as follows:

Quarterly Reporting is required by EPA and CDPHE. Quarterly reports include summaries of the collected data and any exceedances of the groundwater quality standards. Because the groundwater is sampled on a semiannual basis, the quarterly reports only include data results from groundwater samples analyzed during the designated reporting quarter.

Groundwater monitoring data are also reported quarterly at public environmental data exchange meetings and are published in a Rocky Flats Quarterly Environmental Monitoring Report. Data from all Site environmental monitoring programs are presented at the data exchange meetings and in quarterly reports.

Annual Reporting provides an annual assessment of the groundwater conditions. This comprehensive report provides the following information:

- ⊙ General description of the various monitoring program elements, including any new sampling activities;
- ⊙ Interpretation of the geochemical data from the past years and trends that may show contaminant movement;
- ⊙ Actions taken when exeedance is noted with respect to a particular contaminant;
- ⊙ Interpretation of the Site groundwater flow through analysis of water levels;
- ⊙ Recommendations for changes and improvements to the monitoring network.

CRITICAL ANALYSIS

INTRODUCTION

This section presents a critical analysis of the Groundwater Monitoring Program currently in place at the Rocky Flats Environmental Technology Site (Rocky Flats or Site).

The critical analysis is based on information provided by the Site staff and other knowledgeable parties, including staff from Kaiser-Hill and its subcontractors, adjacent communities, Colorado Department of Public Health and Environment (CDPHE), EPA, DOE, and public stakeholders. Information sources include various reports, documents, studies, articles, personal interviews, and telephone conversations.

SUMMARY

The primary goals of the Groundwater Monitoring Program are to protect surface water quality, minimize impacts to the shallow groundwater, and comply with the regulations.

The Groundwater Monitoring Program consists of 262 monitoring wells that monitor groundwater quality and determine groundwater flow characteristics. Groundwater levels are measured in all 262 wells. Groundwater from 89 of the 262 wells is sampled and analyzed for contaminant concentrations. The 89 sampled wells are subdivided into seven groundwater monitoring classifications. These wells are sampled to monitor the migration of groundwater contaminant plumes, assess the groundwater quality leaving the Site, and to comply with regulatory requirements.

Groundwater wells are monitored according to the following schedule:

- The network of 89 wells are sampled semiannually for contaminant concentration;
- Monthly water elevation measurements in 77 wells;
- Quarterly water elevation measurements in 59 additional wells;
- Semiannual water elevation measurements in 157 more wells;
- Real time water level measurements are recorded in 25 of these wells.

The Groundwater Monitoring Program is dynamic and adjusted as needed when new information becomes available. Monitoring wells are added or deleted from the program as necessary, well measurements and analyses may be altered, or the sampling frequency may be revised.

ANALYSIS OF THE GROUNDWATER MONITORING PROGRAM

GROUNDWATER MONITORING PLAN

The Groundwater Monitoring Program for Fiscal Year 1997 is presented in the annual *Rocky Flats Environmental Technology Site Integrated Monitoring Plan*. This plan describes the required monitoring program elements for each environmental media and provides a means to revise the requirements as needed for the upcoming fiscal year. The fiscal year begins October 1 and ends on September 30 of the next calendar year. The Site plans to review the Integrated Monitoring Plan (IMP) annually and revise the Plan as necessary each year. The first IMP was published in Fiscal Year 1997 (FY 1997).

The Groundwater Water Monitoring Program for FY 1997 was presented in two versions of the IMP. The first IMP version was released in March 1997, six months after the year began. The second version, Revision 1, was released on June 31, 1997, nine months into the fiscal year. The IMP states that "this plan is to be fully implemented during FY97."

The IMP is an important, useful document and a valuable aid to the citizens. In a single document, the IMP presents all the environmental monitoring to be performed by DOE and its subcontractors, CDPHE, and the cities for the upcoming Fiscal Year. However, the IMP for FY 1997 was not released until six months into the fiscal year, then was revised with only three months of the year remaining. The IMP needs to be planned, completed and distributed prior to commencement of the next fiscal year and distributed to the stakeholders and Site personnel for review prior to finalization.

GROUNDWATER QUALITY MONITORING WELLS

The Groundwater Monitoring Program is designed to collect hydrogeological and analytical data to identify and assess the potential impacts of contaminated groundwater on the surface water. Monitoring activities consist of water level measurements, field water quality measurements, and laboratory analysis of the groundwater for selected parameters and contaminants of concern.

Semiannual laboratory analyses of groundwater samples are conducted for 89 wells, which are subdivided into seven groundwater monitoring classifications based on the specified monitoring objectives for each well class.

- 21 Plume Definition wells
- 44 Plume Extent wells
- 5 Drainage wells
- 6 Boundary wells
- 12 Performance wells
- 1 D&D well

The critical analysis for each well classification is presented below.

Plume Definition Wells

Twenty-one Plume Definition Wells are installed at locations within six known groundwater contaminant plumes and are used to monitor the contaminant concentrations within each plume. The wells are intended to alert the Site to movement of the high concentration portion of the plume. The six groundwater plumes are defined by contaminant exceedances of Tier I Action Levels. The following groundwater plumes were identified to contain contaminants that exceed the Tier I Action Levels: IHSS 119.1 Plume, Mound Plume, 903 Pad and Ryan's Pit Plume, Carbon Tetrachloride Plume, East Trench Area Plume, and the Industrial Area (IA) Plume. One or more monitoring well is installed at various locations within each of these plumes.

The location of each Plume Definition Well was selected based on suspected or known pathways to the surface water. The number and spacing (interval) of the wells is determined from historical groundwater data, hydrologic characteristics, the spatial variability of the groundwater quality, potential and existing contaminants, and the plume area.

The rationale for the number and spacing of wells within each specific plume area is not detailed in the Groundwater Monitoring Plan. The primary objective and anticipated use of each monitoring well within a plume area should be specified.

The analytical suite for some of the Plume Definition wells does not include analyses for all the contaminants of concern identified for the plume being monitored. The deficiencies are summarized below:

Plume	Well ID	Monitoring Purpose	Unmonitored Contaminants of Concern
881 Hillside	0487	Monitor 881 Hillside Plume	Plutonium, Americium, Beryllium,
Industrial Area	P416889, P416789	Monitor along pathway to Woman Creek	Plutonium, Americium, Polycyclic aromatic hydrocarbons (PAHs)
PU&D/Landfill	6687	Monitor Landfill & PU&D Yard Plume	Strontium

The groundwater analyte list for the Plume Definition Wells should be expanded to monitor the contaminants of concern listed above.

Plume Extent Wells

The 44 Plume Extent Wells are located along perimeters of known contaminant plumes and used to monitor the migration of contaminated groundwater that may exceed the Tier II Action Levels. These wells are located upgradient and downgradient along the boundaries of the groundwater plumes where the Plume Definition Wells are installed. The wells are suitably positioned to detect the lateral migration of contaminated groundwater and monitor potential groundwater impacts to the surface water. As an example, there are seven Plume Extent Wells installed near the East Trenches plume area to monitor the plume migration toward the north, northeast, east, and south.

Because these wells are used to monitor potential plume migration, the groundwater samples should be analyzed for all the contaminants of concern identified for each plume. The analyte list for the Plume Extent Wells for the monitored plume area is the same as the analyte list for the associated Plume Definition Wells. Similarly, the analyte list is also deficient for the Plume Extent Wells installed at locations intended to monitor the migration of the 881 Hillside, Industrial Area, East Trenches, and PU&D/Landfill plumes.

Drainage Monitoring Wells

The five Drainage Wells are located downgradient from known groundwater contaminant plumes and are used to monitor potential plume migration within the surface water stream drainages. Four of the Drainage Wells are installed in the major Woman Creek drainages, and one well is located in South Walnut Creek. There is no designated Drainage Well installed in North Walnut Creek.

Both South and North Walnut Creeks receive runoff from a large portion of the Industrial Area. A Drainage Monitoring Well should be located within North Walnut Creek immediately upgradient from the A-series Ponds. The analyte list for groundwater samples collected from both the proposed new well and the well in South Walnut Creek (well no. 3786) should include all the contaminants of concern identified for the Industrial Area.

The groundwater from the South Walnut Creek monitoring well (well no. 3786) is not analyzed for polycyclic aromatic compounds, a listed contaminant of concern for the Industrial Area. Moreover, groundwater samples collected from the three wells located downgradient from the 881 Hillside plume on Woman Creek (well nos. 6486, 5587, and 38591) are not analyzed for plutonium or americium, which are designated as contaminants of concern for this plume. The analyte list for the aforementioned wells is deficient.

Boundary Monitoring Wells

The six Boundary Wells are located downgradient along the eastern Site boundary and are used to monitor the groundwater quality migrating offsite. These wells are located within the major Site drainages (North Walnut Creek, South Walnut Creek, and Woman Creek) and subdrainages.

The Boundary Wells are the last opportunity to monitor the groundwater before it leaves the Site. The groundwater from all six wells is analyzed for plutonium, americium, uranium, tritium, nitrate, fluoride, and sulfate. This analyte list is insufficient. Although there are several monitoring wells located upstream, the purpose and location of the Boundary Wells commands prudent monitoring. At the very least, the groundwater at these well locations should be analyzed for the same contaminants monitored in the upgradient wells, in particular the analytes monitored in the Plume Definition and Plume Extent wells.

The semiannual sampling frequency is unsatisfactory for two reasons. These are the last wells to monitor the groundwater before it leaves the Site, and there is extensive interaction between the groundwater and surface water. The increased sampling frequency would provide greater protection to the surface water.

Performance Monitoring Wells

The 12 Performance Monitoring Wells are located within former and currently active remediation and source removal areas. The wells are installed within three known areas where the groundwater

Action Levels have been exceeded: 881 Hillside, 903 Pad, and the East Trenches. The Performance Monitoring Wells are used to assess the effectiveness and contaminant impacts from the remedial and source removal activities. The monitoring results will be used to establish Action Levels for future remediation or source removal activities. Additional well installations should be considered for future remedial activities at other Site locations.

The groundwater from the five monitoring wells located near the 881 Hillside plume area (well nos. 35691, 11092, 10792, 10692, and 10592) is not analyzed for plutonium or americium, which are contaminants of concern in that area. The analyte list for these wells should include these contaminants.

There is no record that indicates the groundwater was monitored for the Mound Site cleanup project. Contaminated soils were excavated, treated, and returned to the Mound Site excavation pit during FY 1997. There was no designated Performance Monitoring Well specified for monitoring this source removal activity. Although it is possible that a monitoring well from a different category was used to monitor the effectiveness of this remedial activity before, during, and after the project, neither the well, analyte list, or sampling frequency was described or reported. The Groundwater Monitoring Plan for the upcoming fiscal year should identify all the wells proposed to monitor each cleanup project planned for the year.

The semiannual sampling frequency may not be sufficient for some high-risk projects. The potential for cross-media contaminant migration is greatly increased during cleanup activities. It would be acceptable to sample and analyze the groundwater on a semiannual basis only after the groundwater monitoring results indicate that the groundwater contaminant levels have stabilized. The sampling frequency should be increased immediately before, during, and after remedial project activities.

Decontamination & Decommissioning (D&D) Well

The single D&D Well is located near Building 886 (Nuclear Safety Facility) and is used to monitor contaminant impacts to the groundwater from D&D activities within the Industrial Area. The purpose of the D&D Well is to establish baseline data to determine the specific groundwater Action Levels appropriate for monitoring during and following closure of D&D activities. The baseline data provides vital background information of the existing groundwater quality in the area and is used determine the effect of project activities to groundwater quality.

If the purpose of the D&D Well is to establish a baseline for planning and monitoring future D&D activities, the sampling frequency should be re-evaluated. A statistical estimate of the quantity of data required to establish baseline data is typically 15 measurements for each analyte monitored. Based on the semiannual sampling frequency established for the D&D monitoring well, 7.5 sampling events, or 3.75 years, will be required to establish the baseline. Consequently, baseline data may not be available until after the D&D activities are well underway. Therefore, a semiannual sampling frequency for the D&D Well does not meet the stated objectives for this network, nor does it provide timely data needed for decision-making.

GROUNDWATER PATHWAYS

One of the objectives for sampling and analyzing groundwater from the monitoring wells at Rocky Flats is to evaluate the migration pathways of the contaminants of concern in the shallow water bearing units (UHSU and LHSU). This information is vital for future assessments to help identify and evaluate potential exposure routes and meet regulatory compliance.

A recent study (RMRS, 1996) was performed to assess the potential vertical (downward) migration of contaminated groundwater at the Site. Possible vertical groundwater pathways to the LHSU and Laramie-Fox Hills aquifers were investigated. The investigation found fractured areas associated with shallow faults provided pathways for contamination to reach the LHSU groundwater, but determined the extent of fracturing was limited in areas of high contamination. The study concluded that the bedrock claystone layer in the LHSU effectively restricted downward migration of the shallow groundwater system to the Laramie-Fox Hills aquifer and hydraulic connectivity below the LHSU was unlikely.

The study recommended the LHSU be monitored for potential downward contaminant migration from the UHSU groundwater using approximately 13 wells located within the Individual Hazardous Substance Sites or at known UHSU groundwater contaminant plume locations. Presently, only two wells out of the 89 sampled monitoring wells are installed in the LHSU. One Plume Definition Well is installed at the 903 Pad, and one Plume Extent Well located in the Industrial Area. These two wells do not provide sufficient analytical data to confirm or disprove the existence of vertical hydraulic connectivity between the UHSU and LHSU at the Site. There is no contingency to specifically monitor the LHSU for potential contaminant impacts via downward vertical migration in the current Groundwater Monitoring Program.

GROUNDWATER MONITORING ANALYTE LIST

The analyte list for specific monitoring wells was determined from reviews of historical groundwater data and the contaminants of concern identified for the Individual HazardousSsubstance Sites (IHSSs).

During development of the analyte list, analytical results for radionuclides and inorganic compounds from each well were initially screened against average historical concentrations using statistical calculations to account for data variability. The resulting data was then compared to the Action Levels established for each contaminant and confirmed exceedances were noted for each well. This process was used to establish the analyte list for each sampled monitoring well.

The overall process for establishing the analyte list for groundwater monitoring is technically supportable. However, the analyte list should be re-evaluated for the following wells:

- Alpha-BHC, a known pesticide, was identified as a chemical of concern in the groundwater contaminant plume at 881 Hillside. None of the wells located at or near 881 Hillside are monitored for this chemical. Alpha-BHC is also absent from the analyte list for the Boundary Well monitoring categories. Because of the crucial function of the Boundary Wells to detect potetial offsite migration of contaminated groundwater, water samples should be analyzed for alpha-BHC from wells monitoring the 881 Hillside plume and the Boundary Well locations.

- The analyte suite selected for the D&D Monitoring Well does not support the intent to establish baseline data for use in monitoring future D&D activities. The D&D Well is monitored only for volatile organic compounds and radionuclides (plutonium, americium, uranium, and strontium). The baseline for future D&D decision-making should provide sufficient information for all known and potential contaminants of concern in the Industrial Area to establish a comprehesive analyte list for all future D&D activities and to adequately monitor the impacts. The data results from the present monitoring provides baseline information only for the analytes currently monitored and is therefore deficient. The current monitoring will not provide sufficient data needed to establish a comprehenseive analyte list for monitoring future D&D activities or will it produce an adequate baseline to evaluate the impacts.

FIELD MEASUREMENTS AND SAMPLING PROCEDURES

Water level and water quality parameters are measured in the field in accordance with the Site's Standard Operating Procedures. Water quality parameters are measured in the 89 sampled wells for pH, temperature, conductivity, turbidity, alkalinity, and for total dissolved solids (TDS). Water level measurements are taken from all 262 active monitoring wells and used to generate water elevation maps and hydrographs to characterize the hydrology at Rocky Flats.

Groundwater level measurements provide valuable information needed to assess potential groundwater migration pathways at the Site and identify groundwater discharge patterns to the surface water. Water level data is incorporated into water table maps and used in computer groundwater flow models to estimate the direction and velocity of groundwater flow, the local recharge and discharge rates of the water bearing units, and to predict the potential migration of contaminant plumes. Water level measurements are also useful for monitoring hydraulic gradient control during remediation and D&D activities.

The water level measurements are collected from select wells on a monthly, quarterly, and semiannual basis, sufficiently recording expected seasonal variations in the groundwater flow regime. Updated groundwater modeling results and interpretations should be reported along with the analytical data during the quarterly technical meetings and other public meetings. The modeling is a valuable tool for characterizing the groundwater flow regime and to determine the fate of potential contaminants introduced into the groundwater system. In addition, the model can be used for future monitoring planning purposes and to assess potential groundwater impacts to the surface water.

Groundwater samples are collected from 89 monitoring wells and analyzed for radionuclides and various chemicals in accordance with the analyte list established for each well. Monitoring wells must be properly designed and constructed to ensure the groundwater monitoring objectives or downgradient wells are not compromised. Different standards and practices may be necessary depending upon the monitoring objectives at an individual site. Monitoring wells constructed to meet multiple objectives should employ the standards of the most rigorous monitoring objectives.

Materials used in construction of a monitoring well should not contaminate the groundwater being monitored. Well construction components in contact with the groundwater include, but are not limited to, well casing, riser pipe, well screen, centralizers, annular sealant, and filter pack. The components of a typical monitoring well are depicted in Figure 1 (page 2-6).

Many of the monitoring wells installed at the Site, particularly the newer wells, are economically constructed with polyvinyl chloride (PVC) well casing and PVC well screens. All of the 89 water quality wells are sampled for a long list of volatile organic compounds, which includes several chlorinated compounds, including vinyl chloride. If the groundwater is in contact with the PVC well casing or screens for any period of time, vinyl chloride may leach from the PVC into the groundwater. Also, other organic compounds, particularly those containing chloride, could react with and degrade the PVC well materials. Leached chemicals from the well construction materials could influence analytical results from the groundwater samples and result in inaccurate reporting. It is also possible the leached chemicals would mask the presence of other organic compounds during sample analysis and impair their detection. Although volatile organic compound concentrations in the groundwater are dilute, ranging in the parts-per-billion concentration levels, the appropriateness of the well design and construction materials used should be carefully evaluated to ensure that cross-contamination does not occur.

The low yielding wells at the Site present special sampling problems in that it sometimes takes hours (or days) for the well to recover so sufficient water is available for sample collection. This waiting period could allow changes in water quality to occur between the time that sample water enters the casing and when it is collected, especially with regard to volatile constituents. If the low yield wells are pumped dry and sampled the following day, the water sample may not be truly representative of the well water because of the loss of volatile compounds or oxygenation of the water during the waiting interval.

To mitigate these problems, the Site has prioritized the sample collection in low yield wells for different analytical parameters, collecting water samples for laboratory analyses for compounds in the order of decreasing volatility. The prioritized water sampling should be performed within two hours if full well recovery is not achieved. To avoid exposing the formation to the atmosphere, well purging should be completed to ensure the water level in the well does not drop below the well screen or water bearing zone being sampled. The Groundwater Monitoring Plan should clearly describe the procedures used to mitigate the problems associated with sampling low yield monitoring wells to ensure that representative water samples are collected for analysis.

Historical data from several wells was reviewed to establish the semiannual sampling frequency for the 89 water quality wells. Results from the historical data analysis and estimated variability of the data indicated that two to four samples per year would be needed to monitor groundwater for exceedance of the RFCA Action Levels. Based on the known hydrogeological characteristics at the Site, a semiannual sampling frequency was determined to be sufficient for all the wells.

ANALYTICAL PROCEDURES

Laboratory analyses provides qualitative and quantitative data for use in decision-making. To be valuable, the data must accurately describe the characteristics and concentrations of constituents in the samples submitted for laboratory analyses. Approximate or incorrect results can lead to faulty interpretations.

Groundwater well samples are analyzed using standard U.S. EPA drinking water methods. However, the analytical method used to analyze groundwater samples for volatile organic compound concentrations (EPA method #524.2) may produce incomplete or erroneous results. Using this method to analyze water samples that contain elevated concentrations of certain volatile organic compounds, the compound with the highest concentration may mask (or hide) the presence and concentration of other volatile organic compounds included on the groundwater analyte list. This could result in deficient laboratory analyses that fail to report the full range of volatile organic contaminants actually present in the groundwater sample.

REPORTING PROCEDURES

The reporting of groundwater sampling results needs improvement. Specific reporting deficiencies found in recent groundwater monitoring reports are discussed below:

- Each method used for sample analysis has a limited range of detection for each compound analyzed. The term “detection limit” is typically associated with an established Method Detection Limit (MDL) and Practical Quantitation Limit (PQL), which is defined by EPA as the lowest concentration that can be determined, with 99 percent confidence, to be greater than zero in a given sample matrix. By definition, MDLs do not address the accuracy of measurements made at or near this concentration and PQLs and Reporting Limits (RLs) are used to provide more meaningful information for analytical data. PQLs are typically defined as 5 to 10 times the corresponding MDL and represents the lowest concentration a laboratory has confidence in quantifying. A RL is the concentration in the sample that is equivalent to the lowest standard routinely run for that analyte by a given method or instrument combination.

- In several Site reports presenting analytical results for the groundwater monitoring, the concentration values for some analytes are reported below the detection limit. Analytical results

below the detection limit are not reliable or quantifiable and, at most, may indicate that the particular analyte is present in the sample at very low concentrations or a laboratory "glitch" in the equipment has occurred. It is inappropriate to report or use laboratory results that are lower than the analytical detection limit. Methods chosen for monitoring purposes should undergo rigorous method validation with regard to the proposed application. These methods are published by the EPA, in the U.S. Federal Regulations for water analysis, and detasiled in the *Standard Methods for the Examination of Water and Wastewater*, published jointly by the American Public Health Association, American Water Works Association, and Water Pollution Control Federation.

- Negative concentrations of radionuclides are reported. Analytical results showing negative concentrations suggest problems in the laboratory or insufficient quality assurance and quality control procedures. Negative analytical results should not be used or, if included, their use should be explained and justified. Including negative analytical results in a data set could distort overall data interpretation and lead to poor decision-making based on a faulty data set.

- Several analyzed samples were reported with missing laboratory results that were unexplained. Unexplained data gaps are not acceptable and provide an incomplete report.

RECOMMENDATIONS FOR IMPROVEMENTS

INTRODUCTION

This section presents recommendations for improvements to the Groundwater Monitoring Program currently in place at and adjacent to Rocky Flats. These recommendations are based on the recent review and critical analysis of the groundwater monitoring activities being implemented the Site during fiscal year 1997.

The critical analysis and recommendations were derived from information provided by the Site, CDPHE, EPA, and other related parties. The majority of the information requests to support this effort were fulfilled and form the basis of this report.

OVERVIEW

The primary focus of the Groundwater Monitoring Program is to protect the surface water from contaminant impacts and to comply with the prevailing regulations. The existing program is comprised of 262 monitoring wells used to measure water levels and determine the groundwater flow characteristics. Water samples are collected and analyzed from 89 of the 262 wells to assess the groundwater quality and comply with regulatory requirements. The 89 water quality wells are subdivided into six different interactive well classifications based on the objectives for the area being monitored. The six well classifications are defined as follows:

- 21 Plume Definition Wells
- 44 Plume Extent Wells
- 5 Drainage Wells
- 6 Boundary Wells
- 12 Performance Wells
- 1 D&D Well

The 89 classified wells are installed within areas of known contamination and groundwater pathways to monitor the lateral migration of contaminated groundwater in the unconfined “uppermost aquifer” (UHSU). Only two of the 89 wells penetrate the underlying lower hydrostratigraphic unit (LHSU) to detect and monitor the vertical migration of contaminants.

BACKGROUND MONITORING

Background groundwater concentrations are calculated from data presented in the Background Geochemical Characterization Report (DOE 9/93), which represents statistical analytical results from samples collected from the Site groundwater during 1989 through 1992. Background values

for americium^{241}, plutonium$^{239/240}$, and uranium$^{233/234, 235,238}$ are derived from the draft Background Comparison for Radionuclides in Groundwater (DOE 1997).

The background groundwater samples were collected from representative areas near Rocky Flats that were undisturbed by Site operations (buffer zone). The background groundwater samples were analyzed for radioactive isotopes, EPA target analyte list metals, organic compounds, anions and water quality parameters (i.e., bicarbonate, chloride, fluoride, nitrate), and indicator parameters (i.e., pH, conductance, total dissolved solids). The two studies produced a voluminous database of background concentrations for a range of analytes listed as contaminants of concern at the Site. The background values are compared statistically with analytical data from downgradient groundwater samples to evaluate the presence of contaminants in the groundwater.

GROUNDWATER MONITORING PROGRAM

The Groundwater Monitoring Program is an amalgamation of different types of monitoring to support multiple objectives, as summarized below:

- Assessment monitoring to document and evaluate groundwater contamination and potential pathways to the surface water;
- Compliance monitoring to determine if groundwater has been impacted by unexpected contaminant releases;
- Ambient monitoring to establish background water quality conditions and characterize the Site hydrology;
- Remediation monitoring to determine the impacts and effectiveness of source removal and cleanup activities on groundwater.

Recommendations for improvements to the Groundwater Monitoring Program are presented below.

PLUME DEFINITION AND PLUME EXTENT WELLS

There are 21 Plume Definition Wells installed within six known groundwater contaminant plumes and 44 Plume Extent Wells located along the perimeters of these plumes. In combination, these 65 wells are used to assess the extent, magnitude, and lateral migration of contamination in the groundwater from the defined plume areas.

The analyte suite for the Plume Definition and Plume Extent Wells that monitor groundwater from the 881 Hillside, Industrial Area, East Trenches, and PU&D/Landfill plume does not include some of the contaminants of concern identified for those plumes. The analyte list should be increased to analyze the groundwater for the following contaminants:

Well Classification	881 Hillside		Industrial Area		PU&D/Landfill	
Plume Definition Wells	0487	Plutonium Americium Beryllium	P416889 P416789	Plutonium Americium PAH(1)	6687	Strontium
Plume Extent Wells	4887 4787 5387	Plutonium Americium Beryllium	7086 P416689 6186 43392 22896 22596 2186 1986	Plutonium Americium PAH(1)	76992 5887	Strontium

(1) PAH = Polycyclic Aromatic Hydrocarbon

Although not described in the Groundwater Monitoring Program Plan (Integrated Monitoring Plan), multiple Plume Definition Wells installed within certain plume areas are likely used to monitor the different groundwater pathways identified in the subsurface geometry. Certain geologic factors and subsurface structural features such as buried channels, folds, faults and fractures can produce areas where the groundwater movement varies in velocity or direction. It is recommended that the purpose of multiple well installations within each plume area be fully specified in the Groundwater Monitoring Plan to substantiate their intended use.

Information collected from the Plume Definition and Plume Extent Wells can be used to determine plume remediation methods. These wells, if appropriately located, can be utilized during remediation activities to treat, monitor, and confirm plume cleanup activities. This long range anticipated use of the installed wells should be integrated with the stated objectives in the Groundwater Monitoring Plan. Knowledge of groundwater flow directions, aquifer properties, and contaminant distribution is vital prior to commencement of groundwater remediation activities. Other techniques, such as geophysical surveys, soil vapor studies and aquifer tests, can also be used to assess the extent and magnitude of contamination in a plume area and to ensure the monitoring wells are properly positioned.

The groundwater level measurements, used to determine the groundwater gradient and direction, should be applied in computer models to produce three dimensional flow maps for better definition of the Site hydrology and extent of contamination. These maps would help evaluate the impact of a remediation method on groundwater flow paths in a specific area. These measures should be considered and integrated with the stated objectives in the Groundwater Monitoring Plan.

DRAINAGE AND BOUNDARY WELLS

There are five Drainage and six Boundary Wells located downgradient from the groundwater plumes. These wells are used to monitor migration of contaminated groundwater to the surface water and offsite. Because these wells are located downgradient from the Industrial Area and the groundwater contaminant plumes, the wells should be sampled and analyzed for all the analytes monitored in the upgradient wells and include the potential contaminants of concern identified for the Industrial Area. An expanded analyte list for all 11 wells is recommended and should include both plume and Industrial Area analytes in order to sufficiently monitor the migration of all potential contaminants to the surface water and offsite.

Installation of an additional Drainage Well in North Walnut Creek is also recommended. This well should be installed just upgradient of the A-series ponds within the North Walnut Creek drainage.

PERFORMANCE MONITORING WELLS

The 12 Performance Monitoring Wells are used monitor the impact to groundwater and evaluate the performance of remedial treatment or source removal activities at Rocky Flats. There are currently six wells installed at 881 Hillside, one well at the 903 Pad and five wells at the East Trenches. These wells are currently sampled and analyzed on a semiannual basis.

There was no Performance Well designated to monitor the groundwater before, during, and after the source removal activity at the Mound Site. Contaminated soils were excavated, treated, and returned to the excavation pit during Fiscal Year 1997. The groundwater downgradient from the Mound Site should be monitored to ensure that the cleanup activity has not impacted the groundwater and to evaluate the effectiveness of the action. The annual Groundwater Monitoring Plan developed for each fiscal year should identify all the wells proposed to monitor future cleanup projects planned for the upcoming year.

The Performance Monitoring Well procedures and plans are not well defined in the current Groundwater Monitoring Plan. The plan should be revised to address the following issues:

- The rationale for well installations at the three monitored areas is not described. Any source removal/remedial activities performed or planned in these or other areas at the Site should be presented;

- The wells are currently analyzed for volatile organic compounds, metals, plutonium, americium, uranium, and nitrate at the 903 Pad and East Trenches areas. At 881 Hillside, groundwater samples are analyzed for volatile organic compounds, metals, uranium, nitrate, and sulfate. The rationale for the analyte list at these locations should be presented;

- The contaminant Action Levels for each monitored area are determined on a case-by-case basis, but the basis for selecting the Action Levels is not described. The Action Levels for the groundwater sampled from the wells currently monitored have not been determined and are unexplained.

The semiannual sampling frequency established for the Performance Monitoring Wells should be modified to sufficiently support the monitoring objectives. During and following start-up of any source removal or remedial action, a more frequent sampling interval should be considered for a limited time in order to sufficiently evaluate the effectiveness of the remedial activity and identify any additional monitoring needs. If the initial monitoring indicates there are no negative impacts to the groundwater and demonstrates a steady, predictable decrease in the contaminant concentrations, the sampling frequency can then be reduced. The long-term sampling interval should be determined based on the groundwater gradient, the proximity of downgradient receptors, and the initial monitoring results.

D&D WELL

The single D&D Well installed near Building 886 is used to monitor contaminant impacts from D&D activities and to establish baseline data for the existing groundwater quality in the Industrial Area to determine future monitoring needs. The well is sampled on a semiannual basis. Additional well installations are planned as D&D activities progress.

The Groundwater Monitoring Program Plan (IMP) indicates the D&D Well is currently monitored for volatile organic compounds and radionuclide concentrations, specifically plutonium, americium, strontium$^{89/90}$, and uranium. The 1996 "Fourth Quarter RFCA Groundwater Monitoring Report for RFETS" (May 1997) shows D&D Well samples were analyzed for the listed radionuclides plus tritium, volatile organic compounds, metals, and water quality indicator parameters (sulfate and nitrate). The Groundwater Monitoring Program Plan should be corrected to reflect the actual analyte list used to monitor the D&D Well.

The semiannual sampling frequency is insufficient for establishing a credible baseline database for pre-D&D activity monitoring and should be increased, at a minimum, to quarterly sampling. Quarterly sampling would help account for any seasonal influences to groundwater quality and provide an adequate number of samples to develop a valid statistical database. New wells added to the program should also be sampled at least quarterly. Monitoring results should be compared to representative background levels, rather than contrived Action Levels.

The analyte list for D&D monitoring needs to account for both non-site related variations and any impacts from the Site that may have influenced the groundwater quality. The D&D Well(s) should be monitored for all analytes stored or generated by past, current, or future Industrial Area activities, including potential degradation products of known contaminants. The D&D analyte list should be reviewed and updated, as necessary, to include all known or suspected contaminants and their degradation products. The revised D&D monitoring well analyte list should be presented in the Groundwater Monitoring Program Plan (IMP).

Because of the influence from man-made structures and activities on the groundwater hydrology in the Industrial Area, additional well installations should be considered to expand the pre-D&D ambient monitoring activities to cover up to 85 percent of the Industrial Area. Computer models should be used in concert with the existing knowledge of the area activities, groundwater flow characteristics, and the presence (suspected and known) of contamination. The computer models combined with existing knowledge should be utilized to estimate and refine the number and location of new wells needed to sufficiently define the hydrology and spatial variability of the groundwater quality in the Industrial Area. This information will be useful in identifying and targeting the remediation options in portions of the aquifer considered to be the most contaminated and source areas for contaminant migration. The Groundwater Monitoring Plan should be revised to document and justify the number of wells required to adequately perform reliable pre-D&D monitoring.

GROUNDWATER SAMPLE COLLECTION

An evaluation of the well construction materials used at certain monitoring well locations is recommended to ensure that false analytical results are not generated. In particular, PVC-constructed monitoring wells installed in areas with suspected volatile organic compounds concentrations and the downgradient capture wells should be evaluated to ensure that organic compounds do not leach from well materials into the stagnant well water. Inert alternative well construction materials, such as Teflon or stainless steel, should be considered for well screens and well casings in these and other sensitive areas.

Strict procedures should be established to ensure that representative groundwater samples are collected from low yield wells. In practice, low yield wells are often pumped dry to purge the well and sampled the following day after the well has recovered. During the waiting period, changes in water quality could occur due to loss of volatile constituents and oxygenation of the water. To mitigate this, the specific well purging and sampling techniques for low yield wells should be strictly followed and described in the Groundwater Monitoring Plan.

Rather than purging a set number of borehole volumes prior to water sampling, well stabilization should be determined using field measurements of indicator parameters (temperature, pH, specific conductance, and dissolved oxygen) during purging to determine the amount of water to purge and when to sample a well. During purging, the water level should not be allowed to fall below the well screen. Time series sampling should be considered wherein water samples are collected every two hours as the groundwater becomes available.

Although more costly, the use of larger diameter wells should be considered. A large diameter well may deliver the required amount of sample water sooner than the small diameter wells in current use. Rather than the usual periodic monitoring schedule, low yield well sampling could be conducted when the wells are active, after significant precipitation has occurred.

Finally, the monitoring wells should be evaluated to verify that the well screen is properly positioned to obtain the maximum available yield. Also, additional field analysis techniques should be considered to obtain useful data with smaller sample volumes.

ANALYTICAL PROCEDURES

The analytical procedures used in the laboratories should reflect EPA approved methods that are capable of properly determining whether or not any and all analytes are present. A screening procedure to reduce the number of analytes to be analyzed per sample is reasonable. Alternative field methods should be considered, which would allow real-time sample analysis in the field that provide the same or similar results as a standard laboratory analysis but at a much lower cost. Technological innovations have provided reliable portable GC/MS units useful for field testing groundwater samples for the presence of organic compounds. Test kits available from the Hach Company and other suppliers enable a broad ranges of field tests to be performed tests with an accuracy comparable to the laboratory analysis using EPA-approved methods. The Site should consider utilizing these types of technologies to reduce analytical costs and improve data analysis. The field analysis would provide an economical means to increase the sampling frequencies at certain wells to meet the statistical data requirements. These newer field techniques are reliable, easy to use and provide timely responses in a cost-effective manner.

The analyses performed in fixed laboratories should undergo rigorous QA/QC testing procedures. The selected laboratory should also comply with, or become, EPA test certified. This will ensure that a more rigorous process will be followed during all sample analyses and reduce the number of data gaps or apparent errors seen in previous groundwater data reports.

DATA ANALYSIS

The overall monitoring process can only produce limited quantities of useful data. The number of wells and semi-annual sampling frequency should follow established statistical methods outlined in the US EPA guidance document (EPA/530-R-93003, 1992) on proper statistical analysis of groundwater monitoring data. The existing database should be reviewed with respect to the defined procedures to ensure that reliable, statistically defensible analytical data is being generated. The specific statistical methods currently employed for data analysis needs to be fully described and justified in the Groundwater Monitoring Plan.

HYDROLOGICAL CHARACTERISTICS

The most shallow unconfined water table “uppermost aquifer” (UHSU), which is recharged from direct infiltration of precipitation, is the primary target zone for monitoring contaminated groundwater at the Site. This is sufficient for monitoring areas contaminated with chemicals and substances that are less dense than water. However, materials that exhibit a specific gravity greater than water, such as the chlorinated solvents currently monitored in many areas, can accumulate into distinct layers in subsurface boundaries. The Groundwater Monitoring Plan does not, but should, describe the methodology used to delineate or conduct discrete zone monitoring of these "heavier" contaminants.

At present, only two wells are installed in the lower hydrstratigraphic unit (LHSU) to monitor the potential vertical migration of contaminated groundwater. Although this may be justified because pathways to the surface water have not yet been identified, the rationale for eliminating LHSU wells from the monitoring program is not addressed in the Groundwater Monitoring Plan. There is insufficient information available to verify that hydraulic connectivity between the two shallow water-bearing units does not exist in all monitored Site areas. The justification for not monitoring the potential for vertical migration of contaminated groundwater to lower aquifers needs to be clearly explained and documented.

The natural ability of the groundwater to decrease contaminant concentrations through physical, chemical, and biological processes and its significance should be addressed in the Groundwater Monitoring Plan, particularly its influence on groundwater monitoring and remediation decisions.

The groundwater quality under the Site needs to be better defined in order to assess contaminant impacts. In particular, the groundwater underlying the Industrial Area has not been fully characterized. A larger area-wide network of wells is needed to generate sufficient information to accomplish this assessment. This includes assessment of impacts that may occur beyond the Site due to migration of contaminants in surface water as well as groundwater.

RELATIONSHIP TO SOIL CONTAMINATION AND OTHER MEDIA

Although the Groundwater Monitoring Plan is media-specific, the groundwater should not be evaluated (or remediated) independently of other environmental media. Because contaminated soils are potential sources of contaminants in the groundwater, interactions between contaminated soils and groundwater should be considered. There is no soil monitoring program currently in

place at Rocky Flats, but past studies may have identified potential areas of subsurface soil contamination. The Groundwater Monitoring Plan needs to fully address this issue.

MONITORING REPORTING

Groundwater monitoring results are reported quarterly at public exchange meetings and presented in quarterly published reports, as required by RFCA. The report organization and presentation could use considerable improvement. The report format is cumbersome and difficult to sort through without an intimate familiarity with all elements of the Groundwater Monitoring Program. Although narrative summaries of sampling results are provided, the significance or interpretation of the results are not discussed. The reports contain unexplained missing data, and include “errata” sheets to correct previous sampling reports rather than issuing a final report. Numerous, long data tables are used to present analytical results for well and quality control samples, as well as trend plots for selected analytes in certain wells.

Report format would improve if additional discussions describe the significance of the interpreted monitoring results and how it compares to standards or normal background levels. Generous use of graphical and diagram formats would be valuable. Graphed or plotted data, subdivided by target areas, would be easier to understand than tables filled with numbers.

All environmental data reporting could be improved if easily understood graphs and figures were included that would compare measured values to standards or normal background levels. Additional discussion relating the interpreted results to its significance to public health and the environment would also be helpful.