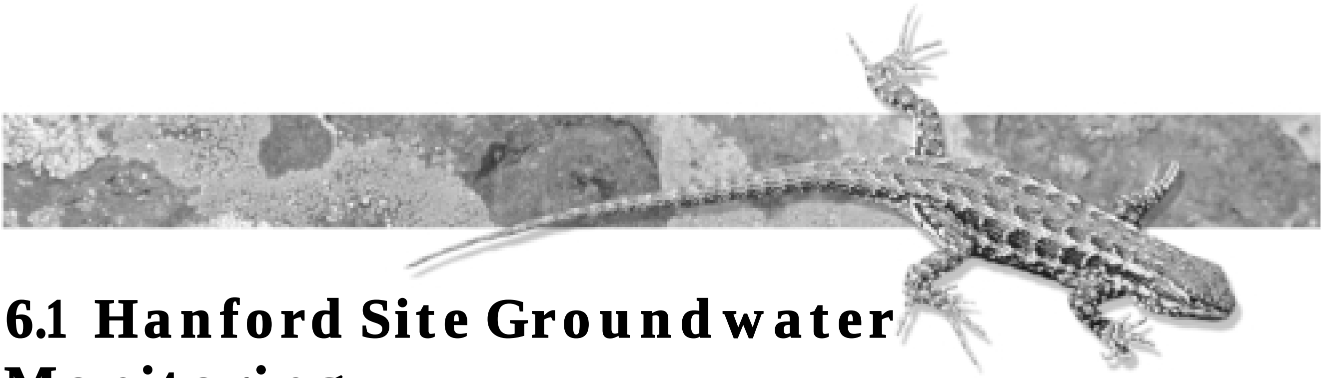

6.1 Hanford Site Groundwater Monitoring

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Groundwater monitoring at the Hanford Site is an integral part of the *Hanford Site Ground-Water Protection Management Plan* (DOE/RL-89-12). That plan assures that monitoring at active waste disposal facilities complies with requirements of RCRA and Washington State regulations, as well as requirements for operational monitoring around reactor and chemical processing facilities and environmental surveillance monitoring. Pacific Northwest National Laboratory staff manage these monitoring efforts to assess the distribution and movement of existing groundwater contamination, to identify and characterize potential and emerging groundwater contamination problems, and to integrate the various groundwater projects to minimize redundancy.

The *Integrated Monitoring Plan for the Hanford Groundwater Monitoring Project* (PNNL-11989) describes how DOE will implement the groundwater monitoring requirements outlined in DOE/RL-89-12 and DOE/RL-91-50. The purpose of the integrated monitoring plan is to (1) describe the monitoring well networks, constituents, sampling frequencies, and criteria used to design the monitoring program; (2) identify federal and state groundwater monitoring requirements and regulations; and (3) provide a list of wells, constituents, and sampling frequencies for groundwater monitoring conducted on the Hanford Site. Federal and state regulations include RCRA, CERCLA, and Washington Administrative Codes (see Section 2.2).

Information on contaminant distribution and transport are integrated into a sitewide evaluation of groundwater quality, which is documented in an annual groundwater monitoring report (e.g., PNNL-13788). Groundwater monitoring is also carried out during CERCLA cleanup investigations. These investigations, managed by Bechtel Hanford, Inc., are documented in annual summary reports (e.g., DOE/RL-2002-01).

6.1.1 Groundwater Monitoring Network

Groundwater samples were collected from 735 wells for all monitoring programs during 2001. A summary that accounts for the number of all groundwater wells monitored during 2001 according to geographic area and monitoring purpose is provided in Tables 6.1.1 and 6.1.2, respectively. The number of wells in Table 6.1.1 is subdivided by geography into the 100, 200, 300, 400, and 600 Areas (see Figure 1.0.1). In Table 6.1.2, the purposes for which monitoring was conducted are divided into restoration, waste management, and environmental surveillance. Restoration refers to wells associated with groundwater remediation activities, including pump-and-treat systems and innovative technology demonstrations. Waste management refers to wells sampled to determine impacts, if any, of a waste management unit (e.g., RCRA facility) on groundwater. Environmental surveillance refers to wells sampled to detect impacts, if any, of site operations on groundwater over the entire Hanford Site and adjacent offsite areas. The number of wells installed and abandoned in 2001 is also shown for each of the tables.

The locations of sampled wells are shown in Figures 6.1.1 and 6.1.2; well names are indicated only for those wells specifically discussed in the text. Because of the density of unconfined aquifer wells in the operational areas, well names in these areas are also shown on detailed maps in the following sections. Figure 6.1.3 shows the locations of facilities where groundwater monitoring was conducted to comply with RCRA (also see Appendix A in PNNL-13788). Wells at the Hanford Site generally follow a naming system that indicates the approximate location of the well. The prefix of the well name indicates the area of the site, as shown in Table 6.1.3. The names for 600 Area wells follow a local coordinate system in which the numbers indicate the distance relative to an arbitrary datum location in the south-central part of the site.

Table 6.1.1. Summary of Groundwater Monitoring Program by Geographic Area, Calendar Year 2001

	Hanford Site	100 Areas	200 Areas	300 Area	400 Area	600 Area[a]
Number of wells monitored	735	218	271	41	4	201
Number of sampling events	2,095	836	810	87	37	325
Number of analyses performed	18,051	5,532	8,046	669	267	3,537
Number of results	66,153	17,548	30,948	2,427	373	14,857
Percent of non-detectable results	41	26	42	68	21	51
Number of installed wells[b]	58	31	23	0	0	4
Number of abandoned wells	99	3	4	2	0	90

(a) Includes the former 1100 and 3000 Areas.
(b) Does not include two wells deepened in the 200 Areas.

Table 6.1.2. Summary of Groundwater Monitoring Program by Monitoring Purpose,[a] Calendar Year 2001

	Restoration	Waste Management	Environmental Surveillance
Number of wells monitored	220	241	450
Number of sampling events	561	636	640
Number of analyses performed	5,272	8,562	10,389
Number of results	18,114	35,918	37,040
Percent of non-detectable results	38	44	44
Number of installed wells	31	27	0
Number of abandoned wells	0	0	99

(a) Because of co-sampling between groundwater monitoring programs, the wells monitored, sampling events, analyses, results, and non-detectable results overlap between monitoring purposes.

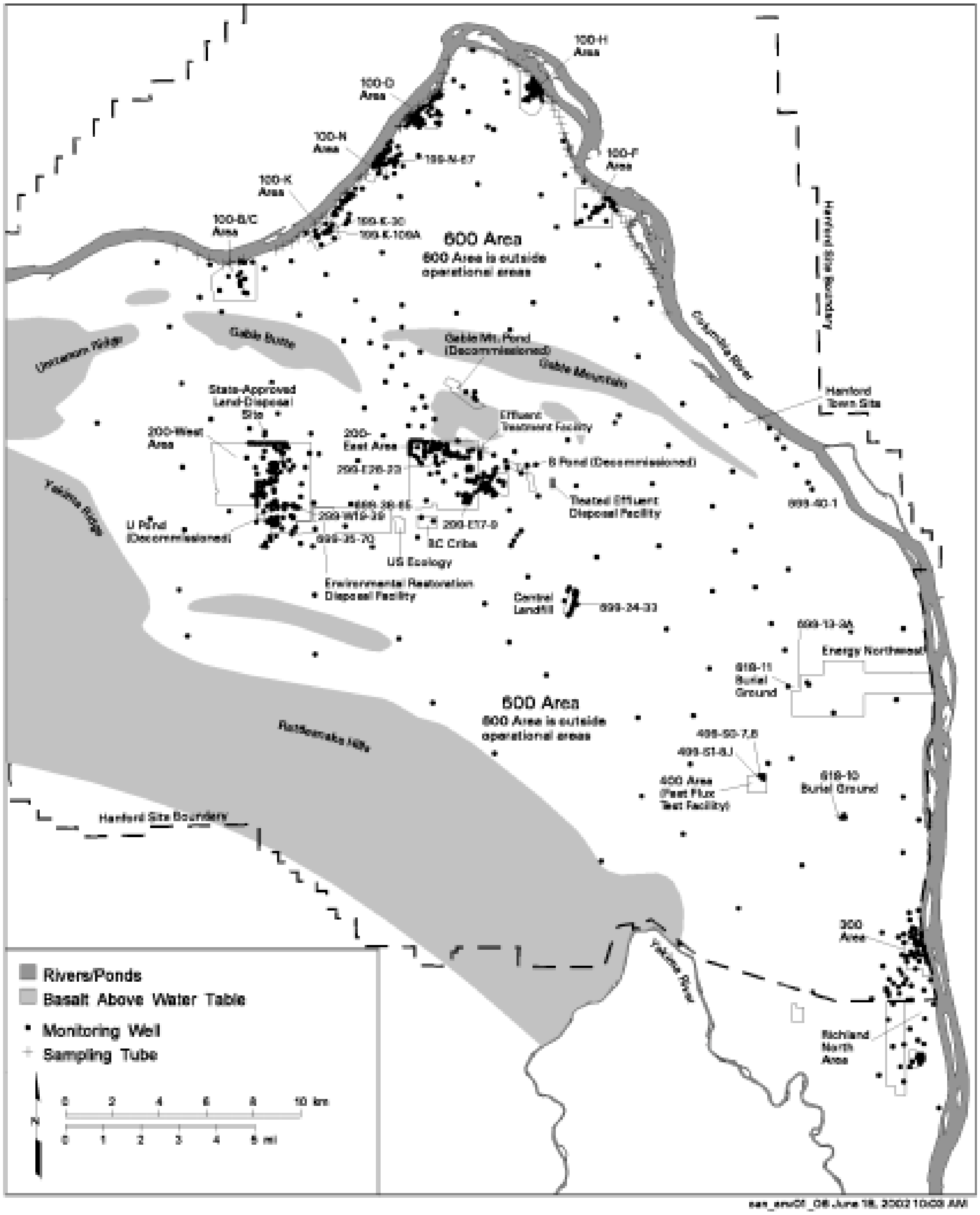


Figure 6.1.1. Unconfined Aquifer Monitoring Well Locations

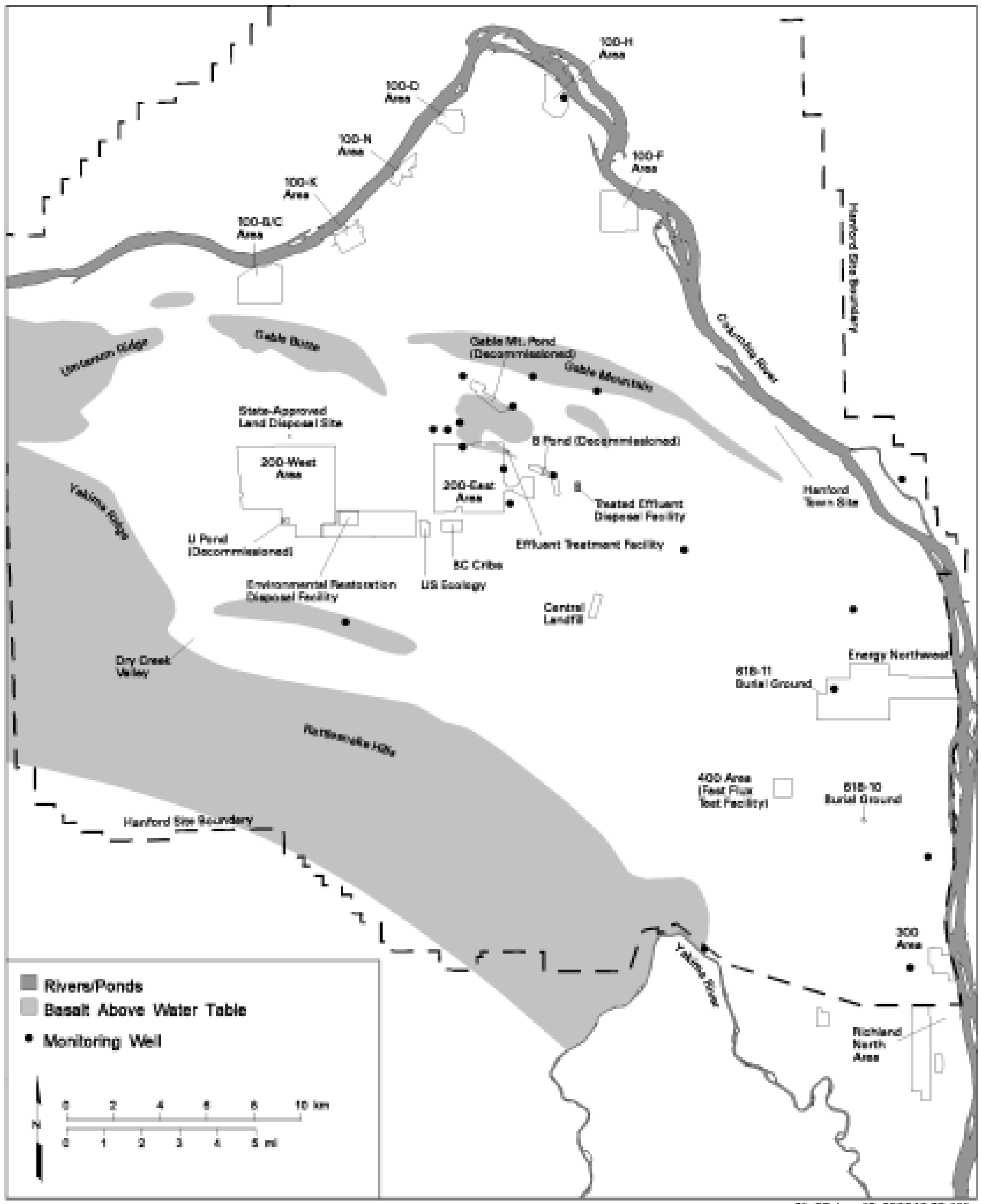
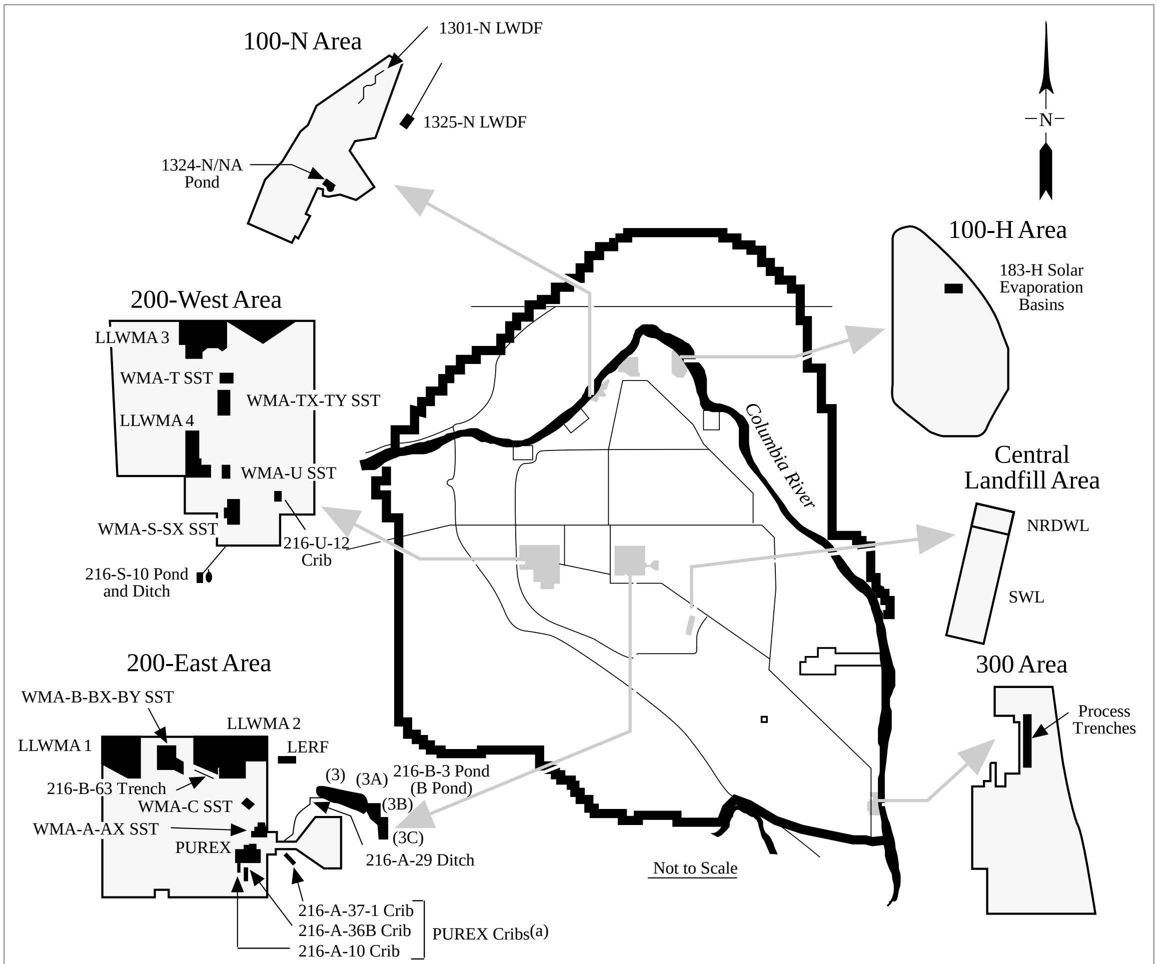


Figure 6.1.2. Confined Aquifer Monitoring Well Locations



LERF	Liquid Effluent Retention Facility	PUREX	Plutonium-Uranium Extraction (Plant)
LLWMA	Low-Level Waste Management Area	SST	Single-Shell Tank
LWDF	Liquid Waste Disposal Facility	SWL	Solid Waste Landfill
NRDWL	Nonradioactive Dangerous Waste Landfill	WMA	Waste Management Area

(a) PUREX cribs are one RCRA groundwater monitoring project

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Figure 6.1.3. Locations of RCRA Groundwater Monitoring Waste Management Areas

The monitoring frequency for the wells was selected based on regulatory requirements, variability of historical data, proximity to waste sources (PNL-6456), and characteristics of the groundwater flow system at the sampling location. Of the 735 wells sampled, 316 were sampled once, 147 twice, 58 three times, 128 four times, and 86 wells were sampled more than four times during the year. The sampling frequency is every 3 years for several wells that have consistently shown concentrations with steady historical trends. Wells showing larger variability are sampled more frequently (annually or more often). Wells that monitor source areas are sampled more frequently than wells that do not monitor source areas. Contaminants with greater mobility (e.g., tritium) in groundwater may be sampled more frequently than contaminants that are not very mobile (e.g., strontium-90).

Most groundwater monitoring wells on the site are 10 to 20 centimeters (4 to 8 inches) in diameter. Monitoring wells for the unconfined aquifer are constructed with well screens or perforated casing generally in the upper 3 to 6 meters (10 to 20 feet) of the unconfined aquifer, with the open interval extending across the water table. This construction allows sample collection at the top of the aquifer, where maximum concentrations of radionuclides and maximum concentrations of chemicals tend to be found. Wells monitoring the shallowest of the basalt-confined aquifers have screens,

Table 6.1.3. Hanford Site Well Naming System

Example Well Name	Area	Example Well Name	Area
199-	**100 Areas**	**399-**	**300 Area**
199-B3-47	100-B/C Area	399-1-17A	300 Area
199-D5-12	100-D Area	**499-**	**400 Area**
199-F8-3	100-F Area		
199-H4-3	100-H Area	499-S1-8J	400 Area
199-K-30	100-K Area	**699-**	**600 Area**
199-N-67	100-N Area		
299-	**200 Areas**	699-50-53A	600 Area north and west of datum
		699-42-E9A	600 Area north and east of datum
299-W19-3	200-West Area	699-S19-11	600 Area south and west of datum
299-E28-4	200-East Area	699-S19-E13	600 Area south and east of datum

Note: Letters at end of well names distinguish either multiple wells located close together or multiple intervals within a single well bore.

perforated casing, or an open hole within the monitored aquifer. Wells drilled before 1985 were generally constructed with carbon steel casing. Since 1985, RCRA monitoring wells and CERCLA characterization wells have been constructed with stainless steel casing and screens. Most monitoring wells on the site are sampled using either submersible or Hydrostar™ pumps (a registered trademark of Instrumentation Northwest, Inc., Redmond, Washington), though some wells are sampled with bailers or airlift systems.

6.1.2 Sampling and Analytical Methods

Samples were collected for all programs following documented sampling procedures that conform to U.S. Environmental Protection Agency (EPA) guidelines (EPA 1986), or other EPA methods, and ASTM standards (American Society for Testing and Materials 1986). The methods used for radiochemical analyses were developed by the analytical laboratory and are recognized as acceptable within the technical radiochemistry industry. Analytical techniques used are listed in PNNL-13080 and CERCLA work plans. The samples were analyzed for ~40 different radiological constituents and ~290 different chemical and biological parameters during 2001 (Table 6.1.4).

The number of sampling events, analyses performed, and results in 2001 is summarized in Table 6.1.1 by geographic area and in Table 6.1.2 by monitoring purpose. A sampling event refers to a groundwater sample collected from a single well at a distinct point in time for the purpose of one or more field or laboratory analyses. An analysis refers to a field or laboratory method used for determining the concentration of one or more constituents in a sample. A result refers to a concentration value associated with a constituent whether it is detected or not. Tables 6.1.1 and 6.1.2 also show the percentage of results where the concentration values were less than the minimum levels of detection. Concentration values less than the minimum levels of detection indicate that no constituents were found.

The percentage of non-detectable results can vary, depending on the analytical method used or constituents analyzed. Some constituents can be analyzed by different methods that yield different minimum levels of detection. A constituent detected using a method capable of low minimum levels of detection may not be detected using a method with a higher minimum level of detection. Different analytical methods have a wide range in the number of constituents analyzed. A method capable of analyzing for a large number of constituents, such as volatile organic analyses, can often yield a high number of non-detectable results. This is because most of the constituents associated with the method are not targeted for analysis. The percent of non-detectable results in Tables 6.1.1 and 6.1.2 is largely attributed to analysis of volatile organic compounds, metals, and gamma-emitting radionuclides. Some constituents, such as chloride, are rarely non-detectable because ambient concentrations are typically greater than the minimum level of detection.

Co-sampling efforts occur between different groundwater monitoring programs to increase monitoring efficiency at the Hanford Site. Co-sampling is incorporated into Table 6.1.2 to account for all wells monitored, sampling events, analyses performed, results, and non-detectable results by each monitoring purpose. A co-sample is defined as a single sample collected from a well, but is used by more than one monitoring program, regardless of the types or number of analyses performed by each monitoring program. Thus, as shown in Table 6.1.2, many of the wells monitored, sampling events, analyses performed, results, and non-detectable results are associated with more than one monitoring purpose.

Most groundwater samples collected on the site in 2001 were analyzed for tritium. Selected samples were analyzed for other radionuclides. Analytical results for radionuclides are generally presented in picocuries (Becquerels) per liter; however, the results for total uranium, which is usually measured by laser fluorescence, are given in micrograms per liter.

Nitrate analyses were performed on many samples collected during 2001 because of the extensive areas with elevated nitrate concentrations that originate from onsite and offsite sources (see Section 6.2.2). However, nitrate concentrations were less than the EPA 45-mg/L drinking water standard (40 CFR 141) for most of the affected areas. Selected monitoring wells were used for additional chemical surveillance.

Table 6.1.4. Groundwater Analyzed for These Radionuclides and Other Parameters in 2001

Radionuclides

Americium-241
Antimony-125
Beryllium-7
Carbon-14
Cerium/Praseodymium-144
Cesium-134
Cesium-137
Cobalt-58
Cobalt-60
Curium isotopes
Europium isotopes
Gross alpha
Gross beta
Iodine-129
Iron-59
Neptunium-237
Nickel-63
Niobium-94
Plutonium isotopes
Potassium-40
Radium isotopes
Ruthenium-103
Ruthenium-106
Strontium-90
Technetium-99
Thorium isotopes
Tin-113
Tritium
Uranium isotopes
Uranium (total)
Zinc-65

General Parameters

Alkalinity
Biochemical oxygen demand
Chemical oxygen demand
Conductance (field and laboratory)
Dissolved oxygen (field)
Hardness
Oxidation reduction potential
pH (field)
Temperature
Total dissolved solids
Total organic carbon
Total organic halogens
Total suspended solids
Turbidity

Metals

Al, As, Be, Co, K, Mg, Na, Se, Si
Ca, Cr, Fe, Hg, Li, Mn, Ni, Pb, V
Ag, Ba, Cd, Cu, Mo, S, Sb, Sn, Sr, silica, Tl, Zn
Hexavalent chromium

Anions

Br^-, Cl^-, F^-, NO_2^-, NO_3^-, PO_4^{-3}, SO_4^{-2}
CN^-, NH_3

Other Parameters

NH_4^+
Pesticides
Polychlorinated biphenyls
Semivolatile organic compounds
Volatile organic compounds
Herbicides
Coliform bacteria
Diesel oil
Gasoline
Oil and grease
Phenols
Total petroleum hydrocarbons
Total petroleum hydrocarbons - diesel range
Total petroleum hydrocarbons - gasoline range

6.1.3 Data Quality

Data quality is assessed primarily by evaluating accuracy, precision, and detection of field and laboratory analytical measurements. Representativeness, completeness, and comparability are also parameters used to evaluate overall data quality. Laboratory quality control checks, replicate sampling and analysis, analysis of blind standards and blanks, and interlaboratory comparisons are used to evaluate these parameters. Data quality is described in Section 9.0 and in much detail in Appendix B, PNNL-13788.

6.1.4 Data Interpretation

The chemical composition of groundwater may fluctuate from differences in the contaminant source, recharge, or groundwater flow field. The range of this concentration fluctuation can be estimated by taking many samples, but there are limits to the number that can be practicably taken. Comparison of results through time helps interpret this variability.

Overall sample uncertainty may be factored into data evaluation by considering the concentration trend in a given well over time. This often helps identify gross errors, and overall, long-term trends can be distinguished from short-term variability. The interpretation of concentration trends depends on an understanding of chemical properties as well as site hydrogeology. The trend analysis, in turn, aids in refining the conceptual model of the chemical transport.

Plume maps presented in Section 6.2 illustrate site groundwater chemistry. Although analytical data are available only at specific points where wells were sampled, contours are drawn to join the approximate locations of equal chemical concentration or radionuclide activity levels. The contour maps are simplified representations of plume geometry because of map scale, the lack of detailed information, and the fact that plume depth and thickness cannot be fully represented on a two-dimensional map. Plume maps are powerful tools because knowledge of concentrations in surrounding wells, groundwater flow, site geology, and other available information are factored into their preparation.

6.1.5 Data Management

Each monitoring program has access to groundwater data collected by other programs through a common database, the Hanford Environmental Information System. This database contains 1,763,494 groundwater monitoring result records as of the end of 2001. The majority of data are loaded into the database from electronic files provided by the analytical laboratories. After the data are verified and/or validated, they are made available to federal and state regulators for retrieval.