6.0 Groundwater and Vadose Zone Monitoring

6.0.1 Groundwater Monitoring

The Hanford Groundwater Monitoring Project includes sitewide groundwater monitoring mandated by U.S. Department of Energy (DOE) Orders and near-field groundwater monitoring conducted to ensure that operations in and around specific waste disposal facilities are in compliance with applicable regulations.

Collection and analysis of groundwater samples to determine the distribution of radiological and chemical constituents were major parts of the groundwater monitoring effort. In addition, hydrogeologic characterization and modeling of the groundwater flow system were used to assess the monitoring network and to evaluate potential effects of Hanford Site groundwater contamination. Other work included data management, interpretation, and reporting. The purpose of this section is to provide an overall summary of groundwater monitoring during 1999. Additional details concerning the Hanford Groundwater Monitoring Project are available in PNNL-13116, "Hanford Site Groundwater Monitoring for Fiscal Year 1999."

6.0.1.1 Monitoring Objectives

Groundwater monitoring was conducted to accomplish the following tasks:

- assess the impact of radiological and hazardous chemicals on groundwater as a result of Hanford Site operations
- provide an integrated assessment of groundwater quality on the Hanford Site
- evaluate potential offsite effects from the groundwater pathway
- verify compliance with applicable environmental laws and regulations
- evaluate effectiveness of groundwater remediation
- identify and characterize new or existing groundwater quality problems.

Sitewide groundwater monitoring is designed to meet the project objectives stated in DOE Order 5400.1 and described above. The impact of Hanford Site operations on groundwater have been monitored for more than 50 years under this project and its predecessors. Near-field monitoring of groundwater around specific waste facilities was performed to meet the requirements of the *Resource Conservation and Recovery Act* (RCRA) (40 CFR 265) and Washington Administrative Codes (WACs 173-303 and 173-304) as well as applicable DOE Orders (e.g., 5400.1, 5400.5). Groundwater monitoring was also performed in conjunction with cleanup investigations under the *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA) (40 CFR 300).

6.0.1.2 Monitoring Design

Groundwater monitoring was designed to satisfy regulatory requirements using various criteria. Specific chemicals and radionuclides analyzed at each monitoring well and their sampling frequencies were selected based on past waste disposal (PNL-6456, WHC-EP-0527-2) and on previous analytical results. Also considered was information on the location of potential contaminant sources and hydrogeology, including groundwater flow directions. Selections involved determining those chemicals and radionu-

clides important in assessing health risk and for understanding contaminant distribution and movement.

Groundwater surveillance was conducted using established quality assurance plans (see Section 8.0, "Quality Assurance") and written procedures (ES-SSPM-001). Computerized data management systems are used to schedule sampling; generate sample labels and chain-of-custody forms; track sample status; and load, store, and report data. The Hanford Environmental Information System is the central, consolidated database for storing and managing the results of groundwater monitoring.

Groundwater samples were collected from both the unconfined and upper confined aquifers. The unconfined aquifer was monitored extensively because it contains contaminants from Hanford Site operations (PNNL-13116) and provides a potential pathway for contaminants to reach points of human exposure (e.g., water supply wells, Columbia River). The upper confined aquifer was monitored, though less extensively and less frequently than the unconfined aquifer, because it also provides a potential pathway for contaminants to migrate off the site. Also, some sampling was conducted at the request of the Washington State Department of Health.

Areas that might be a source of contamination were monitored to characterize and define trends in the condition of the groundwater and to identify and quantify existing, emerging, or potential problems in groundwater quality. These areas included active waste disposal facilities or facilities that had generated or received waste in the past. Most of these facilities are located within the 100, 200, and 300 Areas. However, some sources such as the Solid Waste Landfill are located outside the operational areas.

Wells located within known contaminant plumes were monitored to characterize and define trends in the concentrations of the associated radiological or chemical constituents. These wells were also monitored to quantify existing groundwater quality problems and to provide a baseline of environmental conditions against which future changes can be assessed. Even though releases of liquid waste to ground disposal facilities have for the most part ceased, these wells continue to be monitored as cleanup of the Hanford Site continues. This will provide a continuing assessment of the effect of remediation efforts on groundwater.

Water supplies on and near the Hanford Site potentially provide the most direct route for human exposure to contaminants in groundwater. In 1999, three of the site's 12 DOE-owned, contractor operated drinking water systems provided groundwater for human consumption on the site. One system supplied water at the Fast Flux Test Facility, and one was located at the Hanford Patrol Training Academy (see Section 4.3, "Radiological Surveillance of Hanford Site Drinking Water"). Water supply wells used by the city of Richland are located near the site's southern boundary. Monitoring wells near these water systems were routinely sampled to ensure that any potential water quality problems would be identified long before regulatory limits were reached.

To assess the effect of Hanford Site operations on groundwater quality, background conditions, or the quality of groundwater on the site unaffected by operations, must be known. Data on the concentration of contaminants of concern in groundwater that existed before site operations began are not available. Therefore, concentrations of naturally occurring chemical and radiological constituents in groundwater sampled from wells located in areas unaffected by site operations, including upgradient locations, provide the best estimate of pre-Hanford groundwater quality. Summaries of background conditions are tabulated in PNL-6886 and PNL-7120.

Groundwater samples are collected at various frequencies, depending on the historical trends of constituent data, regulatory or compliance requirements, and characterization needs. Sampling frequencies range from monthly to every 3 years.

Summary results for 1999 are discussed in Section 6.1, "Hanford Groundwater Monitoring Project."

6.0.2 Vadose Zone Monitoring

The vadose zone is defined as the area between the ground surface and the water table. This subsurface zone is also referred to as the unsaturated zone, zone of suspended water, or zone of aeration. The vadose zone functions as a transport pathway or storage area for water and other materials located between the soil surface and the groundwater aquifers. Historically, the vadose zone at industrialized and waste disposal areas at the Hanford Site has been contaminated with large amounts of radioactive and nonradioactive materials through the intentional and unintentional discharge of liquid waste to the soil column, the burial of contaminated solid waste, and the deposition of airborne contaminants to the ground. Depending on the makeup of the soil, the geology of the area, the nature of the waste, the amount of water or other fluids available to mobilize the contaminant, and other factors, contaminants can move downward and laterally through the soil column, can be chemically bound to soil particles (and immobilized), or can be contained by geologic formations.

Because of concerns about the effect of some vadose zone contaminants on the groundwater beneath the Hanford Site, and the potential for contaminated groundwater to reach the Columbia River, characterization efforts are under way to learn more about the nature and extent of vadose zone contamination. At the Hanford Site, the primary method for monitoring radiological contamination in the vadose zone consists of borehole logging (monitoring radiation levels in narrow shafts bored or drilled into the soil column). Borehole logging is conducted in existing boreholes located in and around the 200 Areas single-shell tank farms and beneath former waste disposal facilities also in or near the 200 Areas. Additionally, soil-vapor extraction and monitoring are conducted as part of an expedited response action in the 200-West Area to remove carbon tetrachloride from the vadose zone.

Results for the 1999 vadose zone monitoring program are discussed in Section 6.2, "Vadose Zone Characterization and Monitoring." Section 6.2 has been divided into vadose zone characterization in the 200 Areas tank farms, vadose zone monitoring beneath former 200 Areas waste disposal facilities, surface barrier technology, and soil gas and soil moisture measurements.