Environmental Solutions

FY05

PNNL Contributions to U.S. Department of Energy

Pacific Northwest National Laboratory
Operated by Battelle for the U.S. Department of Energy

PNNL-15570

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Executive Summary

Partnership Helps Protect People and Environment

Part of the U.S. Department of Energy's mission is to clean up the Hanford Site, a former plutonium production site. To make decisions and comply with a complex system of regulations, DOE needs reliable, accurate data about the Site. Where are the contaminants now? At what concentrations? What impact do the contaminants have on workers at the Site and nearby residents?

To answer these questions and others, Pacific Northwest National Laboratory scientists collected and analyzed thousands of soil, groundwater, surface water, plant, and animal samples. The results were then communicated to DOE through reports and conceptual models.

Providing Answers about the State of the Environment

For DOE, PNNL conducts extensive monitoring and surveillance of the Hanford Site and the Columbia River. One significant outcome of this work can be seen in the annual report DOE publishes on the Hanford Site environment. PNNL coordinated input, authored major sections, edited, and designed the 2004 edition, published in FY05. Hanford contractors also wrote major sections.

Pacific Northwest National Laboratory provides technical support to DOE's work to protect the public and the Columbia River environment near the Hanford Site.

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Over the years, questions have been raised about the fate of Hanford-borne contaminants in Columbia River sediment, particularly sediments trapped in hydropower reservoirs. To provide further information, PNNL and the Washington Department of Health, Washington Department of Ecology, and Oregon Department of Energy collected and analyzed samples from the upper layer of sediments at four reservoirs downstream of the Site. Samples were also collected from beaches, where possible.

Cultural and ecological resources on the Hanford Site are an important part of our national heritage, and DOE is dedicated to preserving them for future generations. For DOE, PNNL reviewed 170 projects that could result in adverse impacts.

Building Better Ways to "See" Underground Contamination

For the U.S. Department of Energy, PNNL researchers provided data and conceptual models for decisions on treatment options, environmental compliance, worker safety, public health, and resource protection.

To make decisions about remediation, worker safety, and future land use, DOE needs accurate and reliable information and models of how chemicals and radionuclides move underground. During the past 55 years, enormous amounts of data have been collected on Hanford's geology. Yet, no central format or location for finding the data existed. To establish a consistent set of data and conceptual models for estimating contaminant migration and impact, PNNL researchers assembled the borehole geologic data catalog. The catalog lists the types of existing data and where the data can be found (e.g., published documents, databases). The second edition was published in FY05.

With this and other data, PNNL models depict the behavior of contaminants, invisible to the naked eye, below the ground surface. Based on experimental results, PNNL researchers improved models for the whole of Hanford's vadose zone. Additional work was performed on how a single contaminant, uranium, moved through part of the Site.

Addressing Seismic Hazards at the Waste Treatment Plant

Using seismic monitoring data, PNNL researchers determined several critical parameters that affect the ground motion response to earthquakes at the Hanford Site. In combination with other information, the data indicated that the seismic design-basis ground motions for the Waste Treatment Plant need to be increased by about 40%, resulting in a major re-evaluation of the vitrification facilities design.

Contents

PNNL researchers gathered environmental data from throughout the Hanford Site to assist the U.S. Department of Energy in making decisions.

Introduction

Part of the U.S. Department of Energy's mission is to clean up and safely dispose of nuclear waste at the Hanford Site, where plutonium was produced during World War II and the Cold War. This waste comes in various forms, including reprocessing waste in underground tanks and sealed drums in trenches. The Department is also working to resolve the environmental legacy of the Cold War plutonium production, DOE's most ambitious and far-ranging effort.

To support DOE, Pacific Northwest National Laboratory collects, analyzes, and reports on environmental data related to the Department's mission. This information provides an accurate and reliable basis for decisions regarding treatment options, environmental compliance, worker safety, public health, and protection of ecological and cultural resources.

The Laboratory's support to DOE for FY05 is summarized in this booklet. Work performed for Hanford contractors and the Waste Treatment Plant is summarized in the other booklets in this series.

Protecting Public Resources

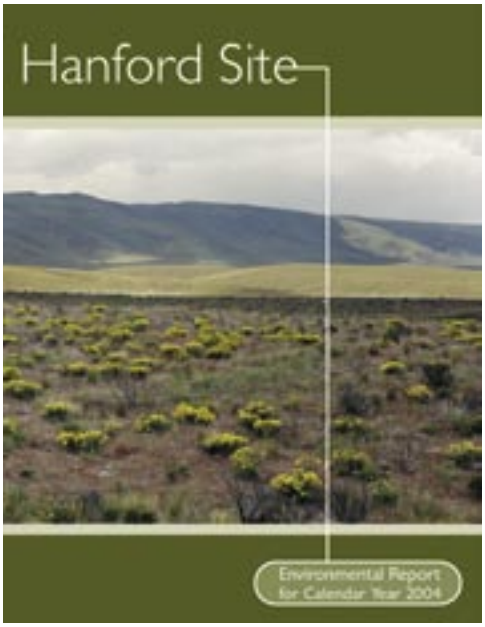
Providing Baseline Environmental Data

PNNL provides the Department's Richland Operations Office with Hanford Site-wide baseline environmental data. This comprehensive information is used in making decisions for protecting the public and the environment.

In FY05, PNNL completed the *Hanford Site Environmental Report for Calendar Year 2004*, PNNL-15222, fulfilling a major DOE Richland Operations Office milestone and a DOE Headquarters reporting requirement. Personnel from Fluor Hanford, Inc.; Bechtel Hanford, Inc.; Bechtel National, Inc.; CH2M HILL Hanford Group, Inc.; and other subcontractors also prepared or provided significant input to selected sections. The report was completed as soon as all of the 2004 data was collected and analyzed.

Vegetation near the Columbia River is sampled and analyzed as part of Hanford Site environmental monitoring.

The report documents the status of the Site's compliance with federal, state, and local environmental laws and regulations, executive orders, and DOE policies and directives. In addition, the report summarizes environmental data used in managing environmental risk at Hanford and protecting the public and environment, assessing the adequacy of Site cleanup actions, and securing the ecological and cultural resources of the Site.



The yearly Hanford environmental report provides a resource for information used in managing environmental risks.

PNNL also completed the *Hanford Site Climatological Summary 2004 with Historical Data*, PNNL-15160. This annual report presents the current year's climatological data along with updated historical information, providing a single, reliable reference for multiple Site uses, such as offsite radiological dose assessments.

These reports are available on the news and publications page of the PNNL website (http://www.pnl.gov).

During FY05, PNNL completed two reports that are used in maintaining and developing environmental data.

Understanding Transport of Hanford Site Contaminants to Four Reservoirs

To determine if the reservoirs at downstream Columbia River dams are affected by Hanford Site contaminants, researchers from PNNL and the Washington Department of Health, Washington Department of Ecology, and Oregon Department of Energy studied the upper-level sediment, and beach sediment where available, in four reservoirs downstream of the Site. The reservoirs were formed by McNary Dam, John Day Dam, The Dalles Lock and Dam, and Bonneville Dam. The researchers collected samples and analyzed them for radionuclides, chemicals, and physical parameters. The results from these analyses were compared to background values from sediment and water samples collected from the pool upstream of Priest Rapids Dam, which is upstream of the Hanford Site.

For more information, see *Survey of Potential Hanford Site Contaminants in the Upper Sediment for the Reservoirs at McNary, John Day, The Dalles, and Bonneville Dams, 2003*, available from the Washington State Department of Health.

Sediment samples from reservoirs formed from dams downstream of the Hanford Site were sampled for radionuclides, chemicals, and physical parameters.

Sediments behind the Bonneville Dam were analyzed for contaminants that may have originated at the Hanford Site.

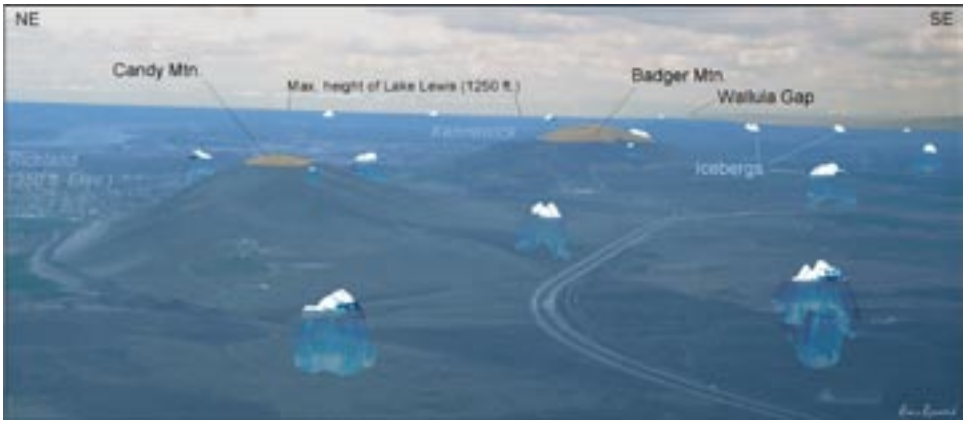
Publishing Annual NEPA Characterization Report for the Hanford Site

With input from Hanford Site contractors, PNNL researchers updated the NEPA characterization report.

Every year, PNNL researchers, with input from Hanford Site contractors, provide a consistent description of the Hanford Site environment for the many environmental documents prepared by DOE contractors under the National Environmental Policy Act (NEPA), State Environmental Policy Act (SEPA), and Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). The report is titled *Hanford Site Environmental Policy Act (NEPA) Characterization*, PNNL-6415. In FY05, they completed revision 17.

The report consists of information typically presented in environmental impact statements and other Site documents. This report describes Hanford Site climate, geology, hydrology, ecology, historical resources, socioeconomics, noise, and occupational health and safety. In addition it describes statutory and regulatory requirements.

The report is available on the news and publications page of the PNNL website (http://www.pnl.gov).



Information updated in the NEPA characterization report includes extensive geologic information such as this conceptualization of the Ice Age Floods near Hanford.

Monitoring and Protecting Ecological and Cultural Resources

PNNL scientists performed approximately 170 ecological and cultural reviews, required by the National Environmental Policy Act (NEPA), for those projects having the potential to adversely impact Hanford's biological or cultural resources. Ecological compliance activities required by the Endangered Species Act were also completed during FY05, including consultation with the U.S. Fish and Wildlife Service and Washington Department of Fish and Wildlife concerning a newly inventoried springsnail found on the Hanford Site.

Ecological reviews were conducted for projects that might adversely impact animals that use the Hanford Site.

Ecological and cultural reviews, required by NEPA, were performed. Ecological compliance activities, required by the Endangered Species Act, were completed.

Protecting the Groundwater

Sampling and Monitoring Groundwater

Groundwater sampling and monitoring activities in FY05 included 2,335 sample trips to 678 wells and 172 aquifer tubes.

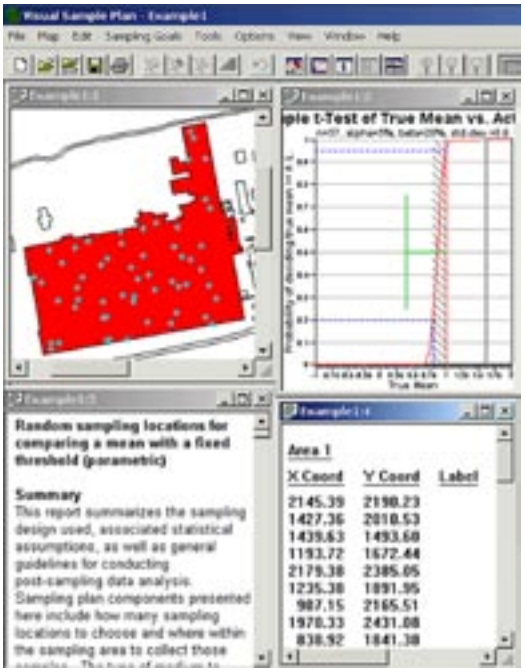
Contamination from sources on the Hanford Site has impacted the groundwater and seeped into the Columbia River. To understand the contamination and its migration, PNNL research staff made 2,335 sample trips to 678 wells and 172 aquifer tubes in FY05.

Scientists collect groundwater samples along the Columbia River shoreline.

Monitoring plans were updated for several locations to maintain sampling efficiency and accurate plume characterization.

Because the underground contaminant plumes migrate, monitoring plans and reports are periodically updated to maintain sampling efficiency and accurate plume characterization. In FY05, PNNL updated monitoring plans for the following locations:

- Low-Level Burial Grounds
- PUREX Cribs
- 216-B-3 Pond
- 216-U-12 Crib
- Single-Shell Tanks Waste Management Area A-AX
- Single-Shell Tanks Waste Management Area T
- 200-PO-1 Operable Unit
- Hanford Site-wide Groundwater Monitoring.



PNNL's Visual Sample Plan software is an important tool in updating groundwater monitoring plans. This image shows a site map, sample locations, and design diagnostics.

Reviewing, Evaluating, and Interpreting Groundwater Data

To provide DOE with decision-making information on contaminant spread, PNNL scientists performed more than 25,560 separate chemical and radiological analyses on groundwater samples taken from the Hanford Site. They then reviewed, evaluated, and interpreted these analyses. The information compiled was reported through several documents, including:

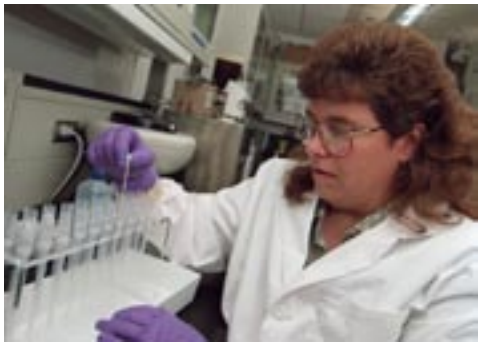
- *Hanford Site Groundwater Monitoring for Fiscal Year 2004*, PNNL-15070
- Groundwater chapter in *Hanford Site Environmental Report for Calendar Year 2004*, PNNL-15222
- Quarterly *Resource Conservation and Recovery Act* monitoring reports
- Annual Hanford seismic monitoring report
- Informal monthly highlight reports.

These reports supported the Central Plateau Closure Strategy, Hanford Federal Facility Agreement and Consent Order milestones, Records of Decision, and Permit Modifications. PNNL researchers also assessed groundwater contamination at Single-Shell Tank Waste Management areas.

Laboratory technical staff continued work on statistical methods for evaluating groundwater data. A paper, "Assessing Spatial, Temporal, and Analytical Variation of Groundwater Chemistry in a Large Nuclear Complex, USA," by Charissa Chou, was accepted for publication in *Environmental Monitoring and Assessment*.

The results of chemical and radiological analyses of groundwater samples were compiled to provide information on contaminant behavior.

Technical staff worked on new statistical methods for evaluating groundwater data.



PNNL performed more than 25,560 separate chemical and radiological analyses on groundwater samples taken from the Hanford Site, as well as an extensive review, evaluation, and interpretation of the data.

Protecting the Soil and Vadose Zone

Understanding How Contaminants Move in Soil

Based on key findings from field studies and experiments, PNNL researchers developed improved conceptual and numerical models of flow and transport in the Hanford vadose zone.

To make decisions about remediation, worker safety, and future land use, DOE needs accurate and reliable models depicting how chemicals and radionuclides from waste sites move through the soil. To build these models, PNNL led a series of experiments on vadose zone transport from FY00 through FY03. The experiments included two major field campaigns, one at a 299-E24-11 injection test site near the PUREX Plant and a second at a clastic dike site off Army Loop Road. The results of these experiments were provided to DOE.

Based on key findings from the field studies, PNNL developed improved conceptual models and numerical models of flow and transport in Hanford's vadose zone. For example, fine-scale geologic heterogeneities, including grain fabric and lamination, were observed to have a strong effect on the large-scale behavior of contaminant plumes, primarily through increased lateral spreading. Conceptual models have been updated to include lateral spreading, and numerical models of unsaturated flow and transport have been revised accordingly. The improved models have also been coupled with inverse models and newly-developed parameter scaling techniques to allow researchers to estimate transport parameters for the vadose zone.

In addition, PNNL researchers investigated geophysical techniques for their potential to provide detailed information on the subtle changes in lithology and bedding surfaces, plume delineation, and leak detection. High-resolution resistivity is now being used for detecting saline plumes at several waste sites at Hanford, including tank farms.

In FY05, in collaboration with a subcontractor, PNNL developed the Soil Inventory Model (SIM) to estimate contaminant inventories at soil sites where liquid waste from Hanford operations was disposed, and in areas where waste has leaked from single-shell tanks. This is part of the inventory estimates for Site-wide assessments, which provide input to cleanup decisions.

PNNL scientists developed the soil inventory model to estimate contaminant inventories at certain sites.

Field-scale transport studies conducted at the Army Loop Road site have led to a better understanding of plume behavior at sites where lateral spreading may have dominated waste migration, such as the BC cribs.

Addressing Concerns About Uranium Transport in the 300 Area Soil

To provide more information about how uranium moves through the Hanford Site's 300 Area vadose zone, PNNL scientists conducted investigations to update the conceptual model of uranium behavior for the 300-FF-5 Operable Unit, located in the southeast portion of the Site. In addition, the research identified and described a geochemical reaction network responsible for uranium retardation. The results are summarized in a report titled *Uranium Geochemistry in Vadose Zone and Aquifer Sediments from the 300 Area Uranium Plume*, PNNL-15121. The report is available on the news and publications page of the PNNL website (http://www.pnl.gov). This work was funded by DOE's Richland Operations Office, as well as through the Environmental Management Sciences Program.

PNNL scientists conducted studies to update a conceptual model on uranium behavior.

A catalog was assembled by PNNL researchers that provides a repository for the extensive Hanford geologic borehole data.

Cataloging Hanford Site Geologic Data

Site characterization and modeling activities to support environmental restoration have been underway for several years and are expected to continue into the future. Part of these characterization efforts involves describing the physical and chemical nature of the vadose zone and aquifer sediment. Although it is necessary to collect new data, an immense volume of data has been collected during the past 55 years. The existing information provides an essential starting point for future investigations and is critical for successful future site characterization and modeling efforts.

U.S. Department of Energy

Data collected from core samples and other Hanford Site field work has been cataloged (PNNL-13653, Rev. 2).

Unfortunately, existing data has not been consolidated into one library or database. Rather, these data are scattered among databases, published and unpublished reports, and individuals' technical files.

The current borehole geologic data catalog contains information on 3,519 boreholes.

To help establish a consistent set of data and conceptual models for estimating contaminant migration and impact, PNNL researchers assembled *A Catalog of Geologic Data for the Hanford Site*, PNNL-13653, Rev. 2, available on the news and publications page of the PNNL website (http://www.pnl.gov). The catalog lists the types of existing borehole geologic data and places where the data can be found (e.g., published documents, formal databases, or informal databases). The current version of the geologic catalog now contains 3,519 boreholes and encompasses boreholes drilled as

The geologic data catalog is being used to identify the depth and breadth of existing data as well as to identify data gaps and technical needs.

of November 2004. The catalog is estimated to represent the majority of borehole geologic data currently available from the Hanford Site.

Addressing Seismic Hazards at the Waste Treatment Plant

At the request of DOE's Office of River Protection, PNNL technical staff delved into questions raised by the Defense Nuclear Facilities Safety Board (DNFSB) about the seismic design basis of the Hanford Waste Treatment Plant. Using data from seismic monitoring, PNNL researchers determined several critical parameters (e.g., attenuation and crustal structure) that affect the ground motion response to earthquakes. The data, in addition to new near-surface shear wave velocity measurements, indicated that the seismic design-basis ground motions needed to be increased by approximately 40%, resulting in a major design re-evaluation.

These results were published in, *Site-Specific Seismic Site Response Model for the Waste Treatment Plant, Hanford, Washington*, PNNL-15089. The report is available on the news and publications page of the PNNL website (http://www.pnl.gov).

Drawing on extensive experience in geology and the Hanford Site, PNNL researchers determined several critical parameters for the Waste Treatment Plant that affect the ground motion response to earthquakes.

Critical parameters that affect ground motion response to earthquakes were evaluated for the Hanford Waste Treatment Plant at the request of DOE's Office of River Protection.

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