November 2000

SEMI-ANNUAL REPORT

April 2000 - September 2000

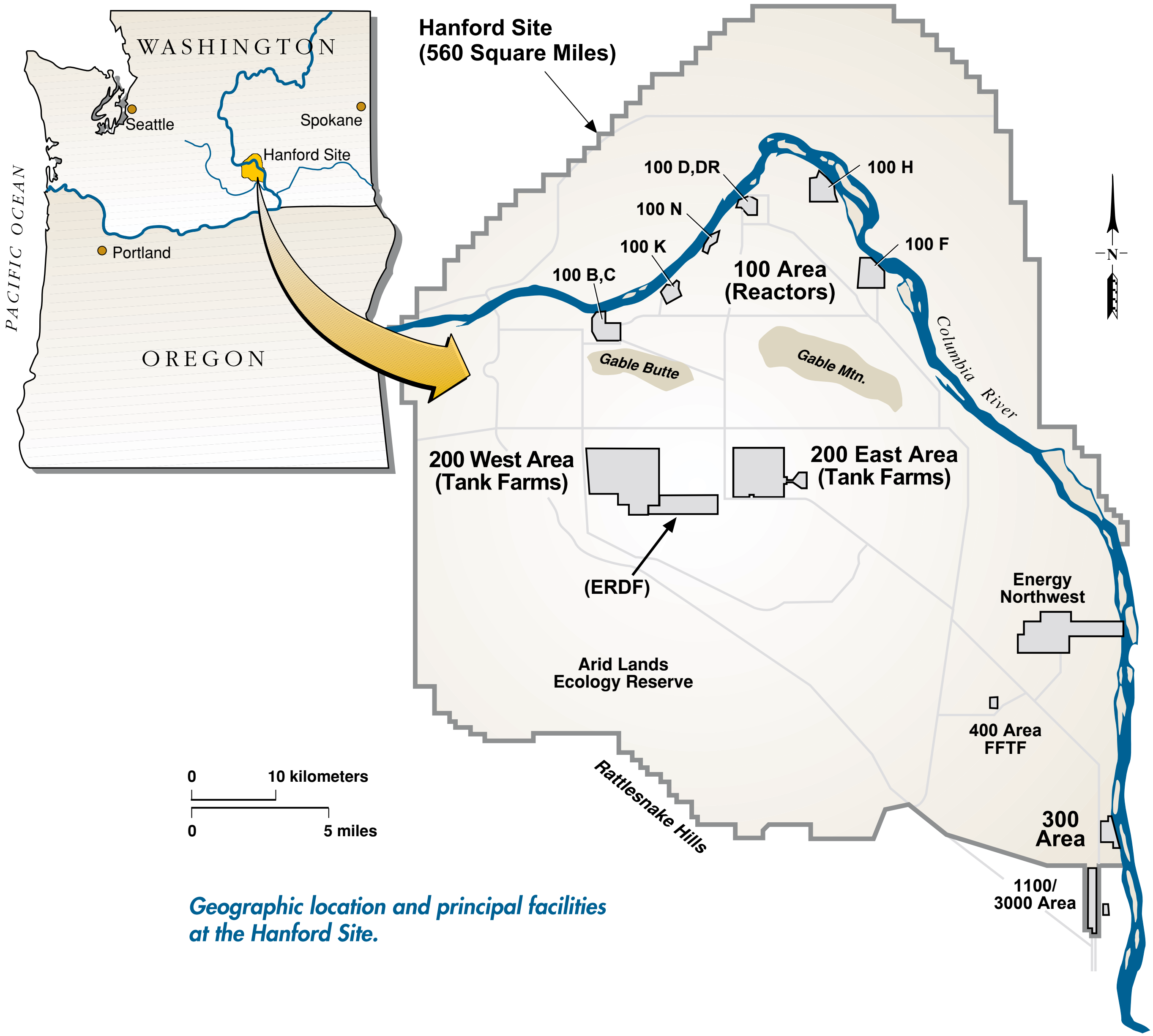
Hanford Site

Groundwater/Vadose Zone Integration Project

Understanding the past,
Defining the present,
Shaping the future.

U.S. Department of Energy
Richland Operations Office

Bechtel Hanford, Inc.
Environmental Restoration Contractor



Geographic location and principal facilities at the Hanford Site.

The Hanford Site is located in a large tract of arid land (approximately 560 square miles) in southeastern Washington. The Columbia River flows through the site, and eventually to the Pacific Ocean. The principal features and facilities of the Hanford Site are shown in the figure above. The arid climate and isolated character of the region made it a particularly attractive site for World War II plutonium production activities, which subsequently continued throughout the Cold War. These activities left a legacy of large volumes of wastes, including toxic chemicals and radioactive substances. Some of these wastes were intentionally (or otherwise) introduced to the vadose zone (the soil above the groundwater), the groundwater, and the Columbia River. The Hanford Site is now committed to an ambitious environmental cleanup mission.

CONTENTS

ACRONYMS

ALE	Fitzner-Eberhardt Arid Lands Ecology Reserve
CHG	CH2M Hill Hanford Group, Inc.
CS	Chemical Sewer
CW	Cooling Water
DNAPL	Dense Non-Aqueous Phase Liquid
DOE	U.S. Department of Energy
Ecology	Washington State Department of Ecology
EMSP	Environmental Management Science Program
EPA	U.S. Environmental Protection Agency
ER	Environmental Restoration
FY	Fiscal Year
HAB	Hanford Advisory Board
HFEP	Hanford Site Features, Events, and Processes
ILAW PA	Immobilized Low-Activity Tank Waste Performance Assessment
IPEP	Integration Project Expert Panel
ISRM	In Situ Redox Manipulation
ITRD	Innovative Treatment Remediation Demonstration
NAS	National Academy of Sciences
ORP	Office of River Protection
PITT	Partitioning Interwell Tracer Test
PNNL	Pacific Northwest National Laboratory
PW	Process Waste
RCRA	*Resource Conservation and Recovery Act of 1976*
REDOX	Reduction-Oxidation
RL	Richland Operations Office
ROD	Record of Decision
S&T	Science and Technology
SAC	System Assessment Capability
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order*
TW	Tank Waste
WSDOH	Washington State Department of Health

Section 1

HIGHLIGHTS

PROJECT PURPOSE

The U.S. Department of Energy (DOE) is responsible for the management, cleanup, and ongoing stewardship of the Hanford Site in southeastern Washington state. To assist with this effort, DOE began an ambitious project in late 1997 to integrate all activities at the Hanford Site that could affect the radioactive and chemical contaminants in the groundwater beneath the site and in the soil between the surface and groundwater (the vadose zone).

The purpose of the Groundwater/Vadose Zone Integration Project (Integration Project) is to inform and influence Hanford Site waste disposal and cleanup decisions by assessing the risks and effects of the site's waste management and remediation activities upon the many users of the Columbia River. Integration and coordination of science and technology (S&T), modeling, monitoring, and ongoing characterization form the basis for Integration Project activities. At the foundation of the Integration Project is a commitment to openness and technical excellence in all its work.

This is the fourth semi-annual report prepared to inform DOE decision-makers, stakeholders, the state of Oregon, Tribal Nations, and regulators (the Washington State Department of Ecology [Ecology] and the U.S. Environmental Protection Agency [EPA]) about Integration Project progress and findings. This report covers the last half of fiscal year 2000 (FY00): April 1, 2000, through September 30, 2000.

THE RIVER, THE PLATEAU, AND THE FUTURE

Soon after Keith Klein was named as the new manager of DOE's Richland Operations Office (RL), he began formulating a vision for the future of the Hanford Site. The three elements of that vision are (1) to restore the Columbia River corridor; (2) complete the transition of the 200 Areas on the Central Plateau to long-term waste management; and (3) prepare the remainder of the site to contribute to the future welfare and well-being of all its neighbor communities.

This vision continues to guide the Integration Project. As part of the Integration Project's commitment to openness, this report outlines how Integration Project work that has been completed, or else is in-process or planned, will help clarify and support a shared vision for the Hanford Site.

FEATURED IN THIS REPORT

The June 2000 Hanford Range Fire. Where were you in late-June 2000? If you were anywhere close to Hanford and the adjoining Tri-Cities (Pasco, Kennewick, and Richland), you will recall in vivid detail the range fire that raced through a major portion of the Hanford Site and into areas of Benton City and West Richland.

The immediate and most visible evidence of the fire was the nearly 192,000 charred acres of land, along with a number of burned homes and other buildings.

On the Hanford Site, the fire consumed vital groundcover needed not only to prevent soil erosion from wind and rain, but also to minimize the infiltration of moisture through the soil into the groundwater.

A major Integration Project endeavor is to provide the tools to identify the likely long-term consequences of potential Hanford Site events, such as a range fire. The feature article on "Fire, Earth, Air, and Water" provides insight into the range fire, and explains how the Integration Project will help decision-makers understand how such events might impact the Hanford Site after current plans for cleaning up the site are completed.

Slant Drilling in the "Hot" Zone. Obtaining the first soil samples from directly beneath one of Hanford's 177 underground waste storage tanks was no small feat. In fact, to collect samples the Integration Project had to look at plans from a "different angle." Instead of drilling a standard vertical sampling well ("borehole") adjacent to the tank, this project drilled the borehole at an angle, reaching right under the tank. This was something new at Hanford.

In addition, the tank selected for the sampling, SX-108, was known to have released high levels of radioactive contaminants to the surrounding soil. The information from these samples will provide invaluable information on the amount, location, and movement of contaminants that either overflowed or leaked from waste tanks.

Stopping a Contaminant Plume. According to Hanford Manager Keith Klein: "It's all about the river." The Integration Project plays a pivotal role in keeping dangerous chemical and radioactive contaminants from reaching the Columbia River and affecting its many users.

The report's third feature article takes an in-depth look at past and current technologies that are being used to protect the Columbia River. One such technology, developed at the Pacific Northwest National Laboratory (PNNL), is providing exciting results in preventing chromium (one of Hanford's harmful chemical contaminants) from reaching the river.

The technology, called In Situ Redox Manipulation (ISRM), prevents a harmful form of chromium from entering the river and potentially harming young Chinook salmon (fry) in spawning beds adjacent to the Hanford Site.

Scientists are hopeful that this technology may be used in other aspects of groundwater cleanup at the Hanford Site.

ENDEAVOR HIGHLIGHTS

Fieldwork. The planning, practice, and successful work to obtain soil and contaminant samples from beneath the SX-108 tank highlighted the Fieldwork Endeavor during the last half of FY00. The Tank Farm Vadose Project, which is managed by the CH2M Hill Hanford Group, Inc. (CHG), has oversight for this operation. Their success is a prime example of how the Integration Project pulls together teams and contractors from across the site to work toward the overall goal of site cleanup.

With submission of the report on the CW-1 group of waste sites (CW refers to cooling water), the first characterization activity under the 1999 Implementation Plan for the 200 Area Waste Site Assessment was completed. The next step for these sites is a feasibility study for remedial actions. Work plans were submitted in August for characterization work at two groups of sites where tank wastes were released to the environment.

The Phase II plan for identifying the source of high levels of tritium contamination in the groundwater near the 618-11 Burial Ground was initiated during this reporting period. Soil gas samples taken near the burial ground are helping to pinpoint the source of the tritium found in groundwater samples obtained since January 1999.

System Assessment Capability (SAC). The Integration Project provided RL with the completed design of the SAC (Rev. 0) on May 9 and the associated software on September 28 for review. In addition, peer reviews were completed for both the technical and management aspects of this first version of the SAC. Such reviews provide independent validation of the work being done by the Integration Project.

Integration of Information. Work is nearly complete on defining a full set of the physical features, events, and processes relevant to Hanford Site cleanup and environmental monitoring. The information in this Hanford Site Features, Events, and Processes (HFEP) database will be used in conceptual models and the computer-based prediction tools used for the SAC and for project-specific assessments. This first phase of HFEP development is also capturing the current state of knowledge about each feature, event, or process in the database.

Science and Technology. A January workshop on advanced technology for characterizing underground contaminants provided the basis for field experiments on transport through the vadose zone. The first phase of these experiments was conducted this past summer.

The S&T team is coordinating extensive laboratory investigations of the soil samples collected under tank SX-108 by the slant borehole project, and is performing advanced modeling to support the Field Investigation Report. S&T also completed work on improved models for the groundwater/river interface in the important 100 H Area.

Technical Review and Public Involvement. In May, an open meeting of the Integration Project Expert Panel (IPEP) gave stakeholders, the Tribal Nations, and regulators an opportunity to express their views on the Integration Project and the IPEP's role. A panel, consisting of three IPEP members, delivered a management review of the SAC (Rev. 0) design in August.

The second and third meetings of a National Academy of Sciences (NAS) study committee on environmental remediation S&T at the Hanford Site were held in June and September.

Bi-weekly open project team meetings were also held throughout this reporting period. The minutes of these meetings are available on the Integration Project's web site. Members of the Integration Project team met with the Hanford Advisory Board (HAB) and its Environmental Restoration (ER) Committee during this period. With input from regulators, stakeholders, and the Tribal Nations, the Regulatory Path Forward Work Group developed a uniform set of requirements and cleanup standards for the 100 Area waste groups.

The Integration Project is a work in progress, and this report is a reflection on its activities. However, the final test of success for the Integration Project is its credibility. If you have questions about this report, or about any element of the Integration Project, we ask you to provide your feedback and become involved with the project. The last page of the report tells you how to reach us.

Keith A. Klein, Manager
U.S. Department of Energy
Richland Operations Office

FIRE, EARTH, AIR, AND WATER:

ARE THERE LONG-TERM CONSEQUENCES OF A HANFORD RANGE FIRE?

A view of the June range fire from the 200 West Area as the fire burned across the Hanford Site.

WILD FIRE AT HANFORD

A wild fire burned across more than a third of the Hanford Site in late June. The fire resulted from a car and truck collision that took place near the northwest corner of the site. For three days, the wild fire burned across the open range, scorching 192,000 acres, including the entire Fitzner-Eberhardt Arid Lands Ecology Reserve (ALE). Within 24 hours, fanned by steady winds gusting to 30 miles per hour, the fire steadily moved toward the interior of the site, threatening facilities and contaminated areas in the 200 West Area.

The Hanford Fire Department provided the initial response to the accident and resultant fire. At the peak of the fire, more than 500 fire fighters from local, regional, and national agencies responded to the fire, using 100 pieces of major equipment, including air tankers and helicopters.

The fire did not reach any major facilities on the Hanford Site, although a trailer and a metal storage shed on the ALE were damaged. The fire also burned a portion of the BC Controlled Area, but did not burn the vegetation covering the waste disposal cribs (subsurface liquid waste disposal sites).

During the fire, fears in neighboring communities for the immediate safety of those in the path of the fire, and for those fighting to control it, were accompanied by additional concerns about the possibility of broader exposure to radioactive contaminants. An important concern was that the fire could release radioactive materials into the air

A view of the Hanford Site after the fire, showing blackened range land west of the 200 Area in the Fitzner-Eberhardt Arid Lands Ecology Reserve.

from burning contaminated vegetation, or from waste facilities and structures that might catch fire. As the fire moved toward buildings and waste sites, monitoring teams began checking for airborne radioactive contaminants. This work continued in the days and weeks after the fire was extinguished.

Shortly after the fire burned through the waste management units in the BC Controlled Area, radiation control teams on the ground took air samples at these units. On Thursday morning, a specially equipped airplane collected atmospheric samples over the fire area (and downwind). None of these air samples indicated radioactivity above normal background levels. During and after the fire, filter samples were collected from the continuous air samplers installed near Hanford Site facilities, as well as around the perimeters of controlled areas and at points along the site boundaries. Because these filter samples concentrate particles from a large volume of air on a small filter, they can detect much lower levels of radioactive materials, with greater reliability, than direct air sampling.

In addition to the filter samples collected and analyzed by the DOE during and after the fire, the Washington State Department of Health (WSDOH) and the EPA collected and analyzed their own samples after the fire. Several samples were analyzed as having radiation slightly above background levels for the surrounding area, but even these levels were well below levels set by the WSDOH and the EPA.[1]

A LONGER VIEW OF RANGE FIRES

Range fires are a recurring feature in a semi-arid shrub-steppe ecosystem like that at the Hanford Site. This ecosystem is dominated by grasses and shrubs that become very dry during the summer. Whether caused by human activities or by natural

[1] Air and surface sampling results from the WSDOH and the EPA are available at the WSDOH web site, at *www.doh.wa.gov/ehp/rp/hanfordfire.htm*.

events (like lightning), fires have burned across the site for centuries. The exact time and location of the next wild fire cannot be predicted. Still, it is reasonable to assume that fires will occur from time to time. Range fires are thus ***a probable event*** in these grass-and-shrub steppe ecosystems, even if the probability of a major fire is only once in 20 to 30 years or longer.

Providing the tools to project the likely long-term consequences of probable—but not exactly knowable—events at the Hanford Site is a goal of the SAC endeavor within the Integration Project. The SAC team, led by Bob Bryce and Dr. Charley Kincaid of PNNL, is assembling computer-based models and databases to give decision-makers a scientific basis for thinking about ***what is likely to happen to the soil and groundwater under probable circumstances*** after site cleanup. Early in August, five weeks after the fire had ended, Bob and Charley described how range fires can be addressed using the SAC tools. Their perspective is useful not only for understanding how an occasional range fire will affect the site, but also for illustrating what the SAC is intended to do.

FIRE IN A SAC CONCEPTUAL MODEL

What is a reasonable and practical way to think about how an event like a major range fire could affect the movement of Hanford's contaminants through the air or into the groundwater and the Columbia River? And how can one begin thinking about all the factors that might come into play?

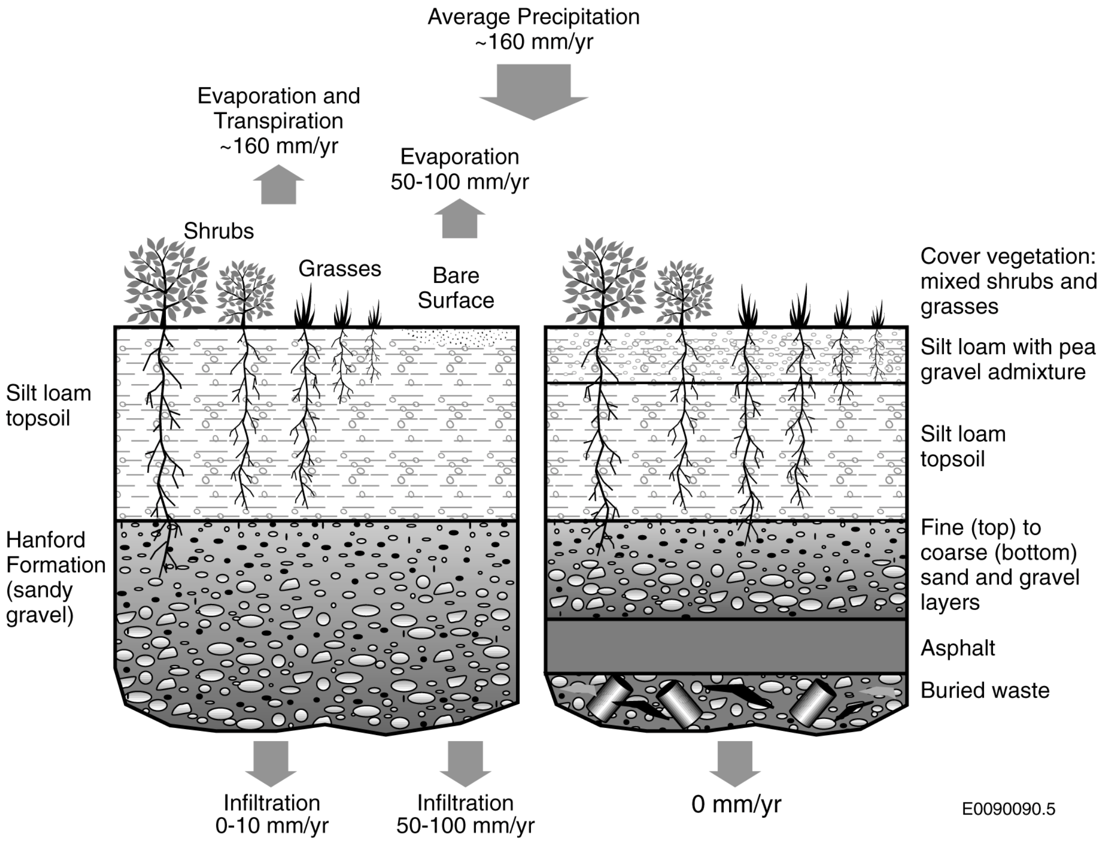
For Bob and Charley, the first step is to develop a ***conceptual model*** as a framework for thinking about the surface environment that is typical of the Hanford range ecosystem. This conceptual model should include all the features that could be changed by a fire, such as the vegetation, plant or animal debris on the ground, and any exposed waste materials. A conceptual model for this purpose, or for any other modeling task, can be more or less detailed, and more or less accurate (or complete) with respect to the features and physical processes that could be involved. A workable model, Bob noted, does not need to be "perfect" (in a sense, it can never be). It just needs to be good enough to give reliable answers to practical questions, within the time available to influence important decisions.

The SAC team has been developing and refining conceptual models for many aspects of the surface and underground conditions found at the Hanford Site. The illustration on page 7 shows parts of a conceptual model for the effects of precipitation, ground cover, and soil types on the movement of subsurface wastes. Charley and Bob used the range fire to illustrate the kinds of issues they think about when defining requirements for a model, or for deciding how an existing model should be expanded or improved.

At the Hanford Site, if radioactive wastes and chemical contaminants other than organic liquids remain buried deeper than about 2 meters (6 feet), the only significant transport pathway is movement by water.[2] Moisture from the surface (from precipitation, or from such human activities as irrigation or leaking water pipes) has to ***infiltrate*** the relatively dry soil layers of the unsaturated zone (vadose zone) to transport these buried wastes down to the water table. Once the infiltrating moisture reaches the water table (the top of a saturated layer, or ***aquifer***), it joins the groundwater flowing slowly toward the Columbia River.

However, if contaminants exist in the top meter of earth, there are more ways they might become mobile. Surface contaminants can be carried in runoff water, as well as being drawn downward with infiltrating water. Fine surface particles can also be picked up by the wind. If contaminants are near the surface, plant roots can absorb them, or burrowing animals can bring contaminated soil to the surface. Once contaminants are absorbed into plants, they may be eaten and begin moving up the food chain, or they may be deposited on the surface in the form of plant litter and animal

[2] Some radioactive elements, such as carbon-14 or tritium, can be carried in vapors to the air (for example, carbon dioxide for carbon-14 or water vapor for tritium). Models for these earth-to-air transport routes are planned for later versions of SAC.



In natural range land on the Hanford Site, shrubs and grasses return nearly all infiltrating precipitation to the air (left side of illustration). With the vegetation cover removed, the amount of moisture infiltrating the topsoil increases. When buried wastes or contaminated soil are covered by a Modified RCRA C barrier system (right side), the same return pathways operate, and an impermeable asphalt layer prevents infiltrating water from reaching the waste. If a fire burns off the ground cover, the infiltration rate into the upper soil layers may increase. However, the sand-to-gravel graded layers, with asphalt underneath, of the barrier system will still prevent any precipitation from infiltrating to the buried contaminant zone.

droppings. One of the concerns about the June fire was that contaminants in plant and animal matter might become airborne (as smoke or other aerosols). Although these are not major pathways for the long-term transport of contaminants, their existence underscores the importance of cleaning up surface and near-surface contamination at the site. The development of modeling scenarios for airborne pathways is planned for later extensions of the basic SAC tool kit.

The foremost objective of the SAC is to project what may occur at the site after the planned cleanup is completed in 2045, and to ensure that any remaining wastes are left in a safe and stable configuration. By that time, former operational areas where wastes were buried, or where concentrations of contaminants escaped into the subsurface, will be protected by ***barrier systems***, or covers, as shown in the illustration above. Underground structures, if they remain in place, would be stabilized to eliminate any potential for future collapse, and would be protected from the direct effects of fire by their earthen cover.

A cover-barrier system that is likely to be used for many areas on the Hanford Site is called a Modified RCRA C cover.[3] It consists of several feet (ideally, at least 2 meters) of clean soil, sand, and gravel underlain by asphalt (see the illustration above). The barrier layers are designed

[3] RCRA refers to the *Resource Conservation and Recovery Act of 1976*, which is a federal law that includes requirements for dealing with underground wastes to prevent groundwater contamination. The Modified RCRA C cover was designed to meet or exceed these RCRA requirements. For discussion of other barrier systems being studied for the Hanford Site, see the Fieldwork Endeavor status update in this issue.

to keep moisture from seeping through any underlying subsurface contaminants. The layers of clean material on top of the impervious barrier hold infiltrating moisture near the surface, minimize wind and water erosion, and keep roots and burrowing animals from transporting the covered contaminants to the surface.

How much of the annual rain and snow at Hanford is likely to infiltrate the soils in these different areas, and how much will evaporate back into the air? Drs. Glendon Gee, Michael Fayer, Janelle Downs, and other scientists at PNNL have studied this question over the past 20 years, and the SAC models for water infiltration incorporate their research results. As the illustration (on page 7) indicates, a healthy growth of shallow-rooted range grasses and deep-rooted shrubs makes a large difference in the infiltration rate. Some of the water absorbed by plant roots is incorporated in the plants, through photosynthesis, but most of it is returned to the atmosphere (as water vapor) through transpiration.

Another important factor is the amount of fine soil particles in the first foot or two of soil. These ***fines*** act like a sponge, soaking up moisture and holding it near the surface, where it can evaporate or else be absorbed by roots and then transpire. Coarse gravel on the surface allows as much as half of the annual rain and snow to quickly soak through. A top layer of silt loam, more than half of which is fines, will retain nearly all the precipitation that is typical at the Hanford Site. Once the water infiltrates more than several feet, plant roots that reach deeper are the main path for returning water to the surface and the air.

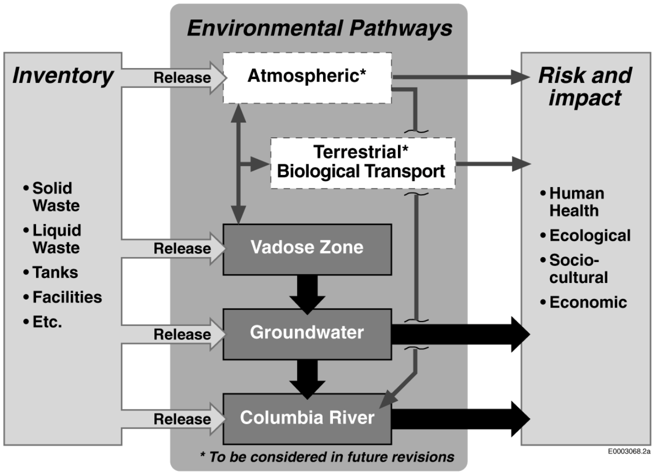
The PNNL scientists estimate that, of the 160 millimeters of annual average precipitation at Hanford, only 2 to 5 millimeters of moisture get deep enough into the subsurface (below the typical grass-and-shrub groundcover) to recharge the deep groundwater. In operational areas where coarse gravel has been added to cover contaminants near the surface, or in natural bare areas with coarse, gravelly soils, the annual recharge rate may rise to between 50 and 100 millimeters.

Using this conceptual model for infiltration, we can begin to see how a range fire would affect the Hanford Site after cleanup. A fire would release very little contamination to the air, because there would be little opportunity for contaminants to get into plant or animal matter or to be present in surface fines. Until the burned areas revegetate, the infiltration rate is likely to increase in areas where the soil lacks enough fines to hold any precipitation in the top meter, where it can evaporate. However, the root systems of bunch grass and other native shrubs were not destroyed by the June fire, and new growth is already appearing in many areas of the burn. So any major increase in deep infiltration, even in the more porous soils, will also depend on another probabilistic factor—the amount of precipitation in the months after a fire.

The special layering of the Modified RCRA C cover, or other covers being studied, will be able to hold all the moisture from an abnormally wet season near the surface. Even if some moisture does seep below the first two meters, the impervious asphalt layer at the bottom of a Modified RCRA C barrier is designed to remain intact for 500 years. Underground contaminants that are protected by a well-designed barrier system should be unaffected by the temporary surface changes resulting from a wild fire that passes over them.

MODELING THE HANFORD ENVIRONMENT

It may seem surprising that the significant effects of a wildfire depend on how much rain or snow falls soon after the fire, and whether there is gravel or silt loam between the subsurface contaminants and the fire above. This exploration of a conceptual model illustrates the complexity of environmental processes. Even so, this article has touched on just a small part of all the factors the SAC must take into account to predict contaminant movement from the vadose zone to the Columbia River through the groundwater.



SAC Technical Elements: Inventory; Environmental Pathways; and Risk and Impact.

The initial versions of the SAC will assume that highly contaminated areas, such as burial grounds or former liquid waste disposal sites, have been remediated and/or adequately covered. But the continuing work of ***site investigation*** and monitoring at the Hanford Site is still turning up new information on the ***soil contaminant inventory***: that is, where the contaminants are, what they are, and how much contamination is present in a given location. The SAC also requires conceptual models for how these contaminants move with moisture through the vadose zone to the water table. Interactions of contaminants with the soil and the pathways through which moisture move are among the many features and processes that these vadose zone models have to capture. Additional models are needed for the conditions and processes that affect how rapidly different contaminants flow horizontally with the groundwater toward the Columbia River. Even in its initial versions, the SAC will also need conceptual models for how contaminants affect the environment and human health after they reach the river.

In addition to defining the conceptual models for a post-cleanup Hanford Site, the SAC team has to implement each model using computer software. Whenever possible, existing software is being used to assemble the SAC. For example, a model of water movement and contaminant transport in groundwater has been developed to meet other site needs. In some cases, new software elements needed to be developed, including (1) software to represent the way that contaminants release from the various types of waste at the site; and (2) software to forecast economic impacts. The models representing transport processes and contaminant impacts have been assembled to allow for the problem to be simulated multiple times, in order to address various uncertainties.

The first version of SAC software, called the SAC Revision 0 (Rev. 0), was delivered to DOE on September 28. This is a “first draft” of the SAC, and it will need to be tested and then improved in subsequent versions. Charley and Bob refer to this as a “proof-of-principle demonstration,” meaning that the SAC (Rev. 0) will show whether the goal of implementing a site-wide projection capability is technically feasible.

Although the SAC (Rev. 0) will not include implementations for some transport pathways, such as uptake in terrestrial plants, there are plans for evaluating the role of these pathways with respect to risk and impact and adding these pieces in future SAC revisions. As Charley noted, there is considerable interest in allowing traditional lifestyles to return to major portions of the site, such as the hunting and gathering activities of Native American peoples. Carefully developed and tested implementations of models for biological transport will be needed to ensure the safety of this land-use option. Other future refinements are likely to include capabilities to model “what if” scenarios for cleanup alternatives, or “end state” options at specific areas on the site, as well as examining alternative scenarios for environmental conditions and site management.

As new cleanup technologies and techniques are developed, and as we learn more about the contaminant inventory in the subsurface (and how it moves), projecting the consequences of these alternatives will become a continuing part of long-term stewardship at the Hanford Site. Range fires and other natural events can sometimes have frightening consequences. Understanding how they affect the Hanford Site environment is important in making wise decisions that affect current site activities, as well as the activities of future generations.

WORKING SAFE IN THE HOT ZONE:

PROTECTING WORKERS DURING THE SX-108 SLANT BOREHOLE PROJECT

A tank farm under construction, before the tanks are buried with backfill. The bottom of the excavation in this photograph is 60 feet below the tank farm surface.

HOW HOT IS HOT?

At the Hanford Site, when someone calls a sample from a waste tank or from contaminated soil "hot," the reference is usually not to the sample's temperature. "Hot" more likely means "highly radioactive."

How hot can this kind of "hot" be at Hanford? The basic unit of radioactivity used in the United States is the curie (abbreviated Ci), which is equivalent to 37 ***billion*** radioactive disintegrations per second.[1] As a comparison, the small amount of radioactive material in a home smoke detector is about a millionth of a curie (1 microcurie). An average person contains about a tenth as much radioactive material (0.1 microcurie, or 100 nanocuries). The total radioactivity in a high-level waste tank at the Hanford Site is, however, measured in thousands or millions of curies because the total amount of material in a tank is also much greater. One waste tank, for example, can contain thousands of gallons of material (over a million gallons in the larger double-shell tanks).[2] For comparing the radiological "hotness"

[1] In one radioactive disintegration, one atom of a radioactive element, or radionuclide, undergoes a change in its nucleus. Each disintegration can give off radiation in the form of an alpha particle, a beta particle, or a gamma ray.

[2] These examples come from R. E. Gephart and R. E. Lundgren, *Hanford Tank Cleanup: A Guide to Understanding the Technical Issues*, Battelle Press, Columbus, Ohio, 1999. This excellent layperson's guide to high-level wastes at Hanford is available from Battelle Press on-line at *www.battelle.org/bookstore*, or by calling 614-424-6393.

of samples, a more useful gauge than total radioactivity is often the ***concentration*** of radioactivity, which is measured in curies per gram of material.

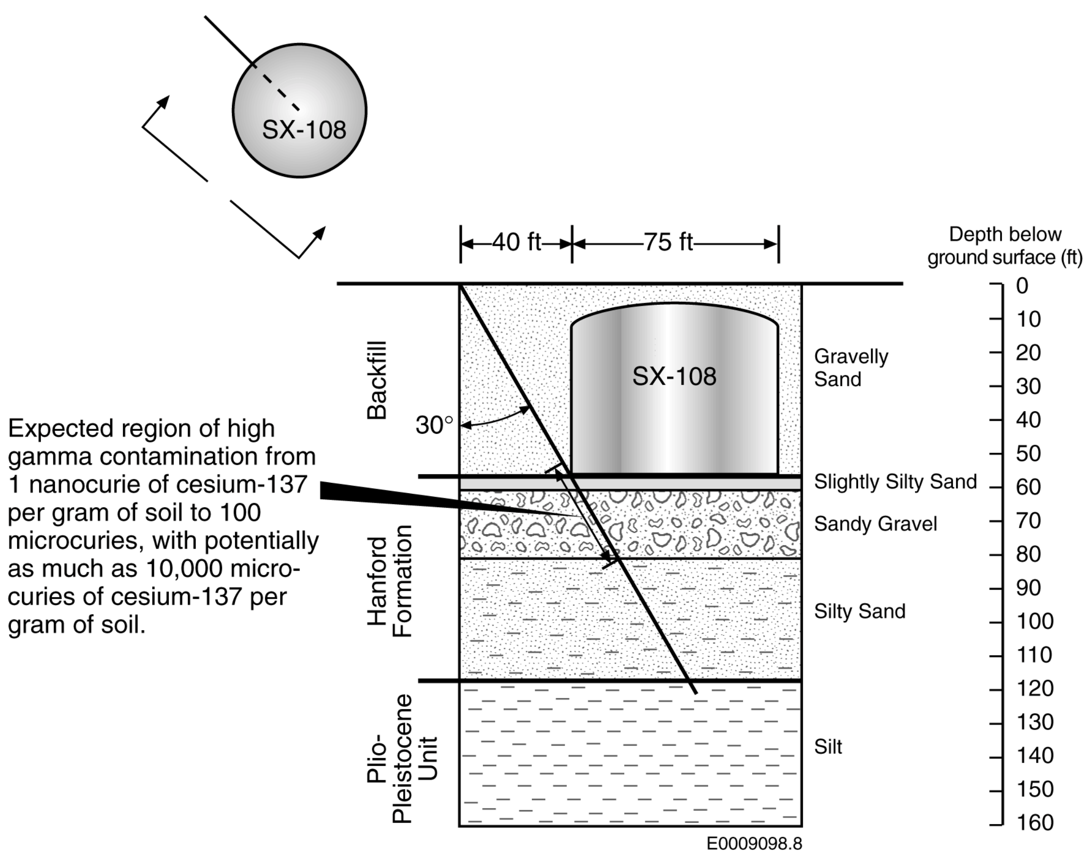
Before the slant borehole project, the hottest samples extracted from contaminated Hanford soil were measured in tenths of a microcurie per gram. To prepare for this first-ever drilling of a borehole directly beneath a single-shell tank at Hanford, project engineers calculated the theoretical maximum concentration of radioactivity that might be encountered. They estimated that samples might be a hundred times hotter than the previous "hot" samples. Consequently, there could be tens of microcuries in each gram of sample.

The high radioactivity under tank SX-108 meant that protecting the workers on the drilling crew would be an important aspect of the project. Special care would be needed to keep their exposure as low as could reasonably be achieved. While minimizing the dose to workers on the drill rig was essential, transporting the samples to the laboratory and safely handling them during analysis were important additional concerns. Although the total radioactivity in a sample could be decreased by limiting the size of a sample, the sample volume had to be large enough to perform the full suite of analyses planned for these important samples.

THE NEED FOR THE BOREHOLE PROJECT

The slant borehole project arose from the need to understand the types and amounts of contaminants in the soil under tanks that had leaked. Physical and chemical changes in the contaminants and in the surrounding soil affect how readily the contaminants will move through the subsurface. Specific questions that needed answers included the following:

- How far beneath the tanks does contamination extend?
- What quantity and kinds of contaminants have been released from the tanks?



- What chemical reactions between the contaminants and the soil column may have impacted waste migration?

- How stable are the contaminants? Under what conditions would they move with infiltrating moisture through the vadose zone to groundwater?

Tank SX-108 was selected as the best candidate for answering these questions, by drilling a slanting borehole under a tank (see the illustration on page 11). The borehole would be driven at an angle so that it passed just beneath the side of the tank, while continuing through the region directly under it. The borehole would extend through the area where the highest contamination levels were expected.

To select the best tank, the project team reviewed existing data on gamma radiation under the tanks. The existing data included gamma radiation measurements taken at intervals down vertical boreholes near the sides of the tanks, and gamma measurements from boreholes (called "laterals") drilled horizontally at a depth of 3 meters (10 feet) below some tanks.Historical records of tank leaks were also used in the selection process.

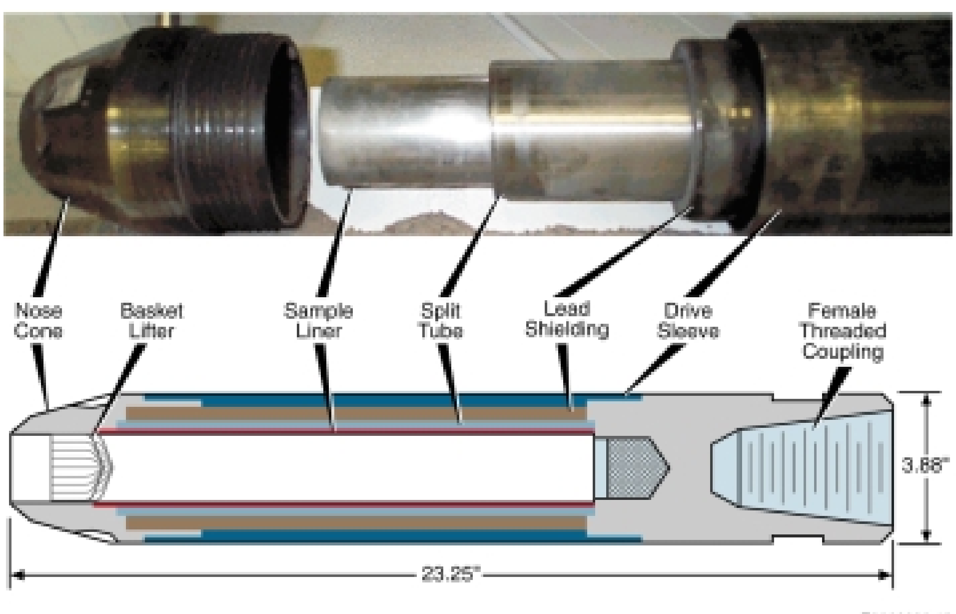
Geophysical surveys were conducted to locate water and waste pipes, electrical services, and other underground utilities. This information helped to define the best place to start a slant borehole, and how the borehole should be aimed to miss any underground utilities (as well as the tank) while passing through the zone of highest suspected contamination.

PREPARING TO DRIVE THROUGH THE HOT ZONE

Once the data requirements about the contaminants beneath a tank had been defined, preparations for the project turned to planning a system to accomplish the task safely. Standard drilling techniques were considered, but they were rejected because they would have generated a large quantity of "hot" waste materials, thereby creating new disposal problems, along with potential health problems.

A pile-driver type of rig had been used recently in a Hanford Site tank farm to drive two new drywells, but no samples had been taken while these holes were being driven. The slant borehole project required taking samples at intervals while advancing the hole, so that contaminants other than those emitting gamma radiation could be measured and the physical and chemical state of contaminants could be studied.

A design team was formed to develop a sampling methodology. This team included members from Waste Management Technical Services, Resonant Sonic International, CHG, CH2M Hill Hanford Inc., and PNNL. The team's final design consisted of a sample tube, 2 inches in



The sampling tube designed for taking core samples in the hot zone under tank SX-108.

diameter by 12 inches long, sheathed with a half-inch of lead to shield the drill crew and sample handlers from radiation in the sample (see the photograph and diagram on page 12). A removable tip for the drive casing also had to be designed, so the sampling tube could be driven ahead of the casing when a sample was extracted. This innovative sampler was designed in parallel with the rig to advance the casing and sampler, pile-driver style.

The best angle for penetrating the hot region under tank SX-108 is 30^o from vertical. However, standard pile-driving equipment is built to drive straight down. If a standard machine were used, much of the pile-driver weight would be located behind the rig, which would place it over the top of an adjacent waste tank—a less than desirable position. Resonant Sonic International proposed an alternative, trailer-mounted design in which the entry hole is beneath the rig platform. This design allows most of the mass of the machinery to be located between tanks. The more compact design was also safer for the rig crew.

The final design also added a remote-controlled arm for handling sections of the casing and the drill string (pipe) inside it. Each time a sample was taken, the entire drill string inside the casing had to be removed, section by section. Then the tool string (with the sampler at its head) was assembled and lowered, section by section. After a sample was extracted, the tool string had to be removed, section by section, and the drill string reassembled with the bore tip. With the remote arm to perform the direct lifting of the sections being added to, or taken off, a string, workers did not have to handle potentially contaminated materials directly. This would prove to be an extremely useful safety feature.

The design and inherent radiation safety concerns meant that the sampling frequency was limited to one sample per five feet of hole advance (the length of a section of casing). Finally, for the analytical laboratory at PNNL that would receive the samples, special sample-opening equipment, specific to the sampler design, was constructed and installed.

A "COOL" FULL-DRESS REHEARSAL

With the drill rig, drill string, and samplers designed and built, the next step in preparing for the hot zone was to demonstrate that this unique system would work in the soil formations below the SX tank farm. This full-scale demonstration outside the hot zone had four objectives:

1. Fully define and test the operating procedures before entering the hot zone.
2. Identify and work out any problems.
3. Train the workers in the specifics of working with this equipment safely, using the same procedures that would be used in the hot zone.
4. Make engineering measurements to assess the potential effects of this drilling method on the integrity of the tank.

The demonstration, which was conducted just south of the SX tank farm, began on March 6 and was completed on April 14. A mock-up of the surface configuration inside the farm was built, and all operations were conducted as though the work was occurring inside the tank farm. The demonstration borehole was driven to the depth planned for the real hole. Test samples were collected and handled just as the real ones would be.

During this full-dress rehearsal, system "bugs" were identified and corrected, crews were trained, and the engineering test for stress on the tank was conducted successfully. The demonstration was invaluable in preparing the crew for what would, and could, happen during deployment inside the tank farm. The diverse work crew gelled into a "dream team" worthy of the Olympics. "The demonstration was invaluable in assuring us that what we needed to do could be done safely and efficiently," said Harold Sydnor, team leader for CHG on the project.

Section 3 – Working Safe in the Hot Zone

The drilling crew at work in the hot zone. The slant drilling rig is on the right. The remote control arm (left) is lifting a section of string (pipe) that has been wrapped in a plastic bag to avoid spreading "hot" soil around the work area.

INTO THE HOT ZONE

With the equipment and procedures demonstrated, the questions about tank stress resolved, and the crews fully rehearsed, the project was ready to move inside the SX tank farm and “go for the gold.” On May 19th, the starter casing was meticulously aligned to aim the advancing hole along the desired path. The drill rig was carefully placed, and actual drilling in the hot zone began on June 2nd. After the casing had advanced to a depth of 50 feet, a borehole gyroscope was lowered to the bottom of the hole, and a careful survey ensured that the hole was aligned according to plan.

The first sample was taken at a depth selected to provide information on the conditions at the base of the original excavation when the tank farm was constructed. When this sample was opened in the laboratory, the top half of the foot-long sample was typical of the backfill used to fill in the excavation. The bottom half was typical of the native soil formation. The crew had scored a bull’s eye on the spot they wanted to hit!

After advancing another five feet, however, the second sample attempt was less than successful. The sediments at this level were very dry and rich in gravel, and the sample was lost from the sampler as it was being withdrawn up the casing. Unfortunately, because this sample was also extremely radioactive, the inside of the casing was contaminated. From that point on, each time a section of the string was removed from the bore, it had to be wrapped in plastic to control the spread of contaminated material. This step initially slowed the pace of work, but the crew soon became adept in sleeving the rods in plastic. Over the course of the operation, little time was lost. Additional safeguards were introduced after the second sample to reduce the chance of losing another one. The remaining 15 samples were successfully extracted and delivered to the laboratory for analysis. The sampling operation at the borehole concluded on July 27th.

Over the course of the project, including both the demonstration and drilling the hole under SX-108, the only industrial accidents were metal slivers that penetrated personnel protective equipment during routine maintenance activities. The radiation doses received by the workers were minimal (as measured by the personal dosimeters each crew member wore). In fact, the doses were less than projected before the work was initiated.

PRELIMINARY RESULTS

Only preliminary results from the field screening of samples, and from initial stages in the laboratory analysis, were available when this article went to press. However, even these limited results show that the slant borehole will provide valuable information about contaminants under the tanks (see the table in the right column). At this time, cesium-137 and strontium-90 are the radionuclides that contribute the most radioactivity to Hanford tank wastes (about 99%), and to subsurface contamination resulting from tank leaks. High concentrations of cesium-137 occur in samples from near the bottom of the excavation that was done during tank farm construction, about 59 feet below the surface. Some cesium-137 was found in the last sample, which was taken from the bottom of the borehole.

The samples are being analyzed for other tank waste components. So far, the waste components appear to be distributed through the sediments under the tank in patterns consistent with the ways scientists expected the wastes to interact with the soil components. These samples have generated much interest throughout DOE science and technology programs. Analyses of the geochemistry of contaminants and the soil matrix are being performed at PNNL and at other DOE national laboratories. After the analyses of SX-108 borehole samples are completed, a future feature in this semi-annual report will describe what has been learned about the soil inventory of contaminants under the tank farms.

Meanwhile, work in characterizing Hanford's contaminated vadose zone beneath the tank farms has not ended with the completion of the SX-108 slant borehole. In FY01, samples will be collected at the B, BX, and BY tank farms. In addition, plans are being developed now for investigating the vadose zone under the T tank farm complex.

Initial Cesium-137 Analyses from Slant Borehole Samples

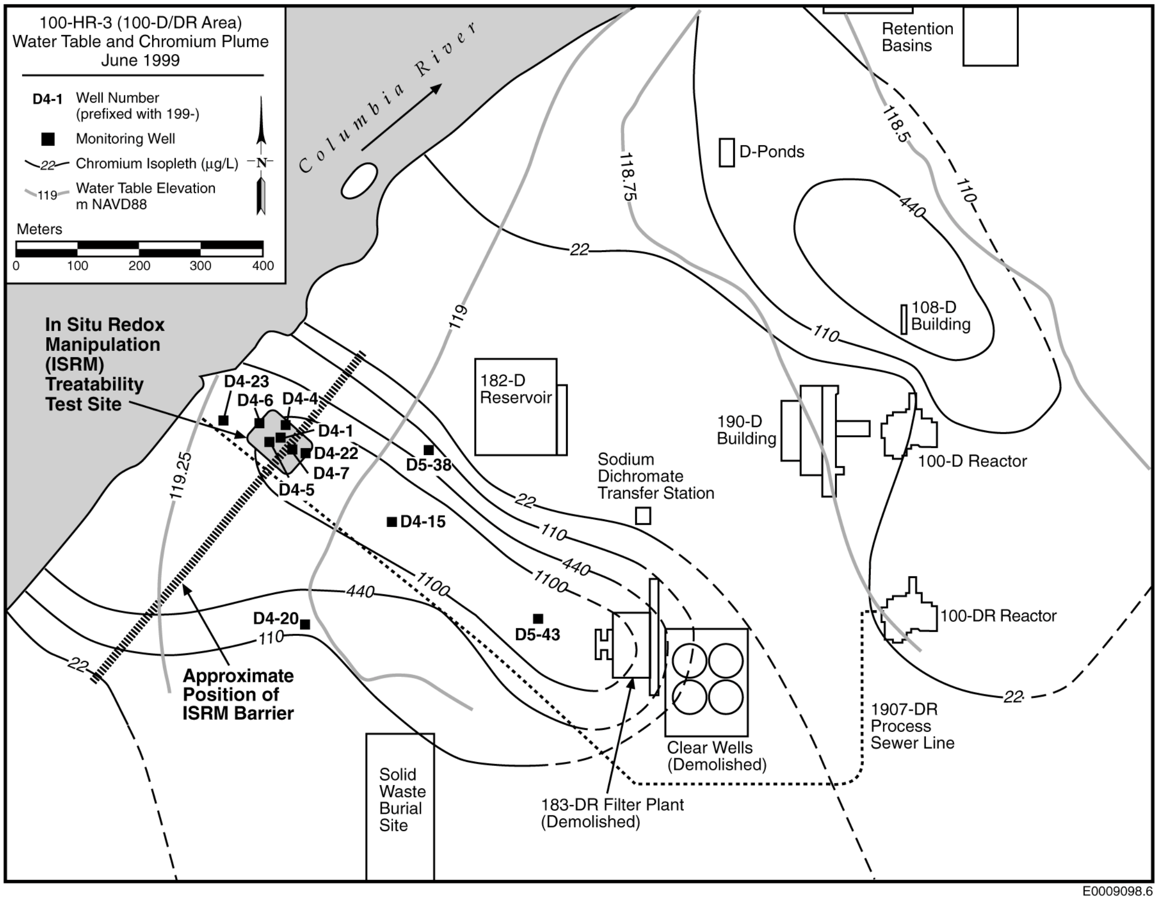
Hole Length[a] (ft)	Approximate Vertical Depth (ft)	Cesium-137[b] (nanocuries/gram)
63.18	54	
63.68	55	3,060
73.18	63	lost
73.68	63	lost
78.2	67	19,500
83.25	72	8,160
83.75	72	1,380
88.25	76	3,780
88.75	76	6,520
93.2	80	36,300
93.7	80	53,100
98.2	84	8,060
98.7	85	21,400
103.2	88	5,030
103.7	89	555
108.2	92	12.9
108.7	93	0.171
113.2	97	0.631
113.7	97	0.451
118.5	101	11.9
119.0	101	0.912
123.2	105	0.781
123.7	105	0.337
133.2	113	5.82
133.7	114	0.521
143.2	121	1.16
143.7	122	0.837
153.2	129	0.531
153.7	130	0.592
163.2	138	4.62
163.7	138	0.0979
171.2	144	0.743
171.7	144	0.175

[a] Each 12-inch core was analyzed for cesium-137 in the front half and the back half, so there are two values for each sample.

[b] Preliminary laboratory analysis results. Standard deviations ranged from 1.5% to 4.5% of the analysis value.

IT SHALL NOT PASS:

STOPPING A CHEMICAL PLUME FROM REACHING THE COLUMBIA RIVER



A chromium plume map for the 100 D Area. The north plume is shown on the upper right. The west plume extends from near the 183-DR Filter Plant to the Columbia River.

THE CHROMIUM PLUME WEST OF THE 100 D AREA REACTORS

The element chromium can have a range of properties, depending on its form, or on what chemists call its ***oxidation state***. In its metallic, unoxidized state, chromium can be dissolved in molten iron, along with other metals, to form rust-resistant steels, such as the chrome steel used on automobiles or other "stainless steels." A partly oxidized form, called chromium III, is nearly insoluble in water and is relatively harmless in the environment. However, when three more electrons are removed from a chromium atom, it becomes the fully oxidized—and environmentally obnoxious—element called chromium VI.

Chromium VI ions typically travel around with some oxygen atoms, forming a complex ion called chromate. Chromate ions, which are highly soluble in water, have many important industrial uses because they are strong oxidizers. For example, even in very low concentrations chromate ions are excellent for preventing corrosion inside water pipes. But the chemical reactivity of chromium VI is also what makes it dangerous in the environment. Unlike some Hanford Site contaminants that are a problem because they are radioactive, chromium VI is hazardous because of its chemical properties.

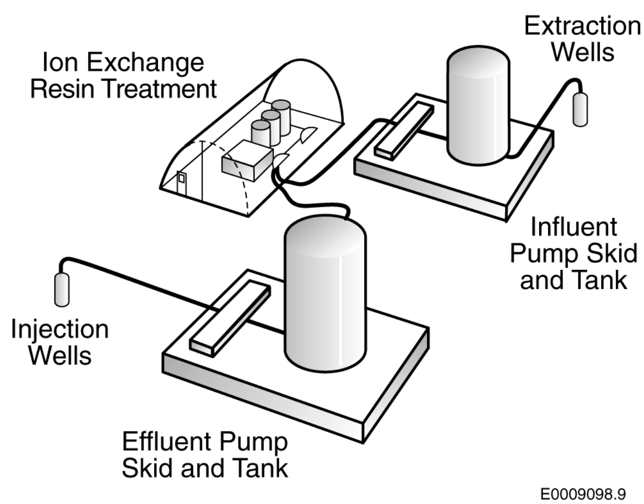
During the years when Hanford's nuclear production reactors were operating, chromate was used to inhibit corrosion within the reactors' piping systems. Operators added the chemical to the Columbia River water that was pumped through the reactor cooling pipes and then dumped back in the river. Because the chromate concentration was very low, and the outflow water from these single-pass reactors was diluted in a much larger volume of river water, the assumption was that no harm would be done. However, the large volumes of cooling water needed for the reactors required a lot of chromate. Large quantities of concentrated solutions of chromate were brought to the Hanford Site and stored in the 100 Area before being diluted for addition to the cooling water taken from the Columbia River.

Somewhere along the way, enough chromate solution either leaked or was disposed to the ground in and around the 100 D Area to build up a high concentration of chromium VI, as chromate, in the vadose zone. When chromate reaches the groundwater, it begins spreading horizontally, forming a plume of contamination. The plume spreads out from the source in the direction of groundwater flow—usually toward the Columbia River.

One plume of chromium VI, north of the 100 D Area reactor sites, was identified and studied in the early 1990s. A 1996 Record of Decision (ROD), which is a formal agreement on how to deal with contamination, selected pump-and-treat technology as the method for limiting the amount of chromium reaching the Columbia River from this plume. However, even as the ROD was being completed, sampling along the river shoreline west of the reactors found elevated levels of chromium there too. The existence of a second chromium plume, transported by the groundwater roughly southeast to northwest toward the river, was confirmed in October 1996. The contours in the chromium plume map (see page 16) are based on 1999 data. The source of this plume—the underground chromate waste that feeds it—has not yet been identified. It appears to be somewhere south and east of well 199-D5-43, in the "upstream" direction of the groundwater flow.

PUMP-AND-TREAT OR IN SITU REMEDIATION?

The pump-and-treat system for removing chromium from the north plume represents a commonly used and conventional approach for controlling a contaminant plume in groundwater. At the leading edge of the plume, a row of extraction wells is drilled, and groundwater is pumped to a treatment facility on the surface. After the water is treated to remove as much contaminant as possible, it is pumped down another set of wells (located at the 100 H Area) to help flush contaminants towards the extraction wells. This process is shown in the diagram below.



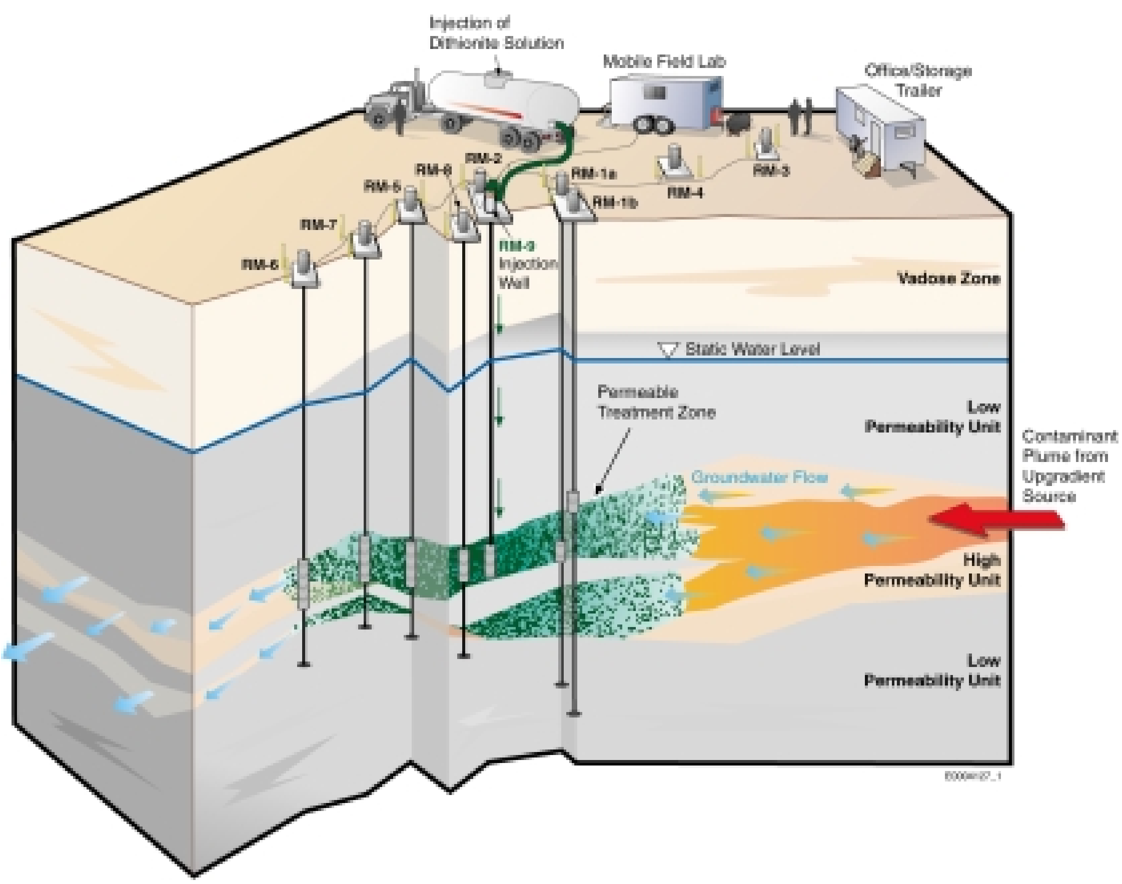
A model of the extraction and treatment portions of the pump-and-treat system. The injection wells are shown here.

Although pump-and-treat is often used for groundwater remediation projects, including several at the Hanford Site, it is far from an ideal solution. First, surface pump-and-treat operations must continue night and day—indefinitely. The considerable cost of operating and maintaining a pump-and-treat system year after year obviously limits the resources available for other pressing environmental remediation needs. Second, a pump-and-treat system creates a secondary waste stream that requires appropriate disposal actions.

Third, and most important, pump-and-treat has a limited ability to truly stop a plume's advance. The Ambient Water Quality Limit set by Washington state for chromium is 10 micrograms of chromium per liter of water (abbreviated as µg/L). To ensure that the chromium concentration in the porewater (that is, the groundwater seeping into the river) at the bottom of the river never gets above this limit, remediation planners want Hanford's post-treatment groundwater to contain no more than 20 µg/L of chromium VI (the compliance limit). The highest concentrations found in the plume are just over 2,000 µg/L. This peak concentration in the plume is a hundred times greater than what it should be after treatment.

Suppose a treatment method removes all the chromate from the water that is pumped to the surface and reinjected in the aquifer. To be sure of reducing the residual concentration in the groundwater below the compliance limit, 99 percent of the groundwater in the plume (or at least in the region of high concentration) must be pumped out and treated. In short, pump-and-treat is at best an interim method to reduce contaminant concentrations in a plume. It is not a permanent solution for stopping contaminants.

For the new plume west of the 100 D Area, Dr. John Fruchter, Mark Williams, Vince Vermeul, and Dr. Jim Szecsody, scientists at PNNL, proposed an alternative to pump-and-treat. Instead of trying to pump all the contaminated groundwater to the surface for treatment, a chemical treatment zone is formed ***in the subsurface, where the groundwater flows***. This ***in situ*** ("at the place") method of treating a contaminant is potentially less costly because, once installed, annual operating costs are minimized as compared to those of pump-and-treat activities. (Eventually the effectiveness of the treatment zone begins to diminish, and the injection process has to be repeated at intervals, as long as chromium VI continues moving toward the river.)



Injecting the dithionite solution for a typical ISRM well.

For example, in a recently prepared cost comparison, a pump-and-treat system for the chromium plume west of the 100 D Area was estimated to cost $3.6 million for installation and $1.1 million a year for operation and maintenance. The ISRM option costs more for installation, $10.5 million, but only costs $50,000 a year for operation and maintenance (chiefly for monitoring to ensure the compliance limit is met). Over a presumed 20-year lifetime of the ISRM barrier, the total life cycle cost (as net present value) will be $11.2 million, compared with $19 million for the pump-and-treat alternative.

An in situ method is also potentially more effective than pump-and-treat, provided that a treatment zone can be established where all the contaminated water above the compliance limit will flow through it.

The key to the proposed in situ remediation of chromium VI is its chemical activity as an oxidizing agent. If the groundwater containing chromium VI could be made to filter through a treatment zone containing something that is easily oxidized (called a chemical reducing agent), the chromium VI would be "reduced" to chromium III. It would then precipitate out of the groundwater as an insoluble chromium III oxide, and would remain permanently in the treatment zone. Chemists call this type of chemical reaction a REDOX (REDuction-OXidation) reaction, so the alternative treatment for the plume is named "In Situ Redox Manipulation," or ISRM for short.

To make ISRM work, an insoluble reducing agent must be dispersed so thoroughly throughout the treatment zone that any chromate ion in the groundwater would come in contact with it. The sediments in the aquifer stratum contain some iron, and the ferrous oxidation state of iron (also called iron II) is a good reducing agent for a redox reaction with chromium VI. However, in the Hanford Site aquifer the native state of the iron is the ferric (or iron III) state. If the natural iron III could be reduced to iron II, then the iron II could serve as the in situ, immobile reducing agent to react with chromium VI.

For ISRM, the PNNL scientists proposed injecting a solution of sodium dithionite into the groundwater to form a chromium "barrier" (see the diagram on page 18). The dithionite would reduce the iron III to iron II. After allowing 24 to 60 hours for the dithionite-iron reaction, the pumping direction would be reversed to withdraw unreacted dithionite and reaction products from the barrier zone.

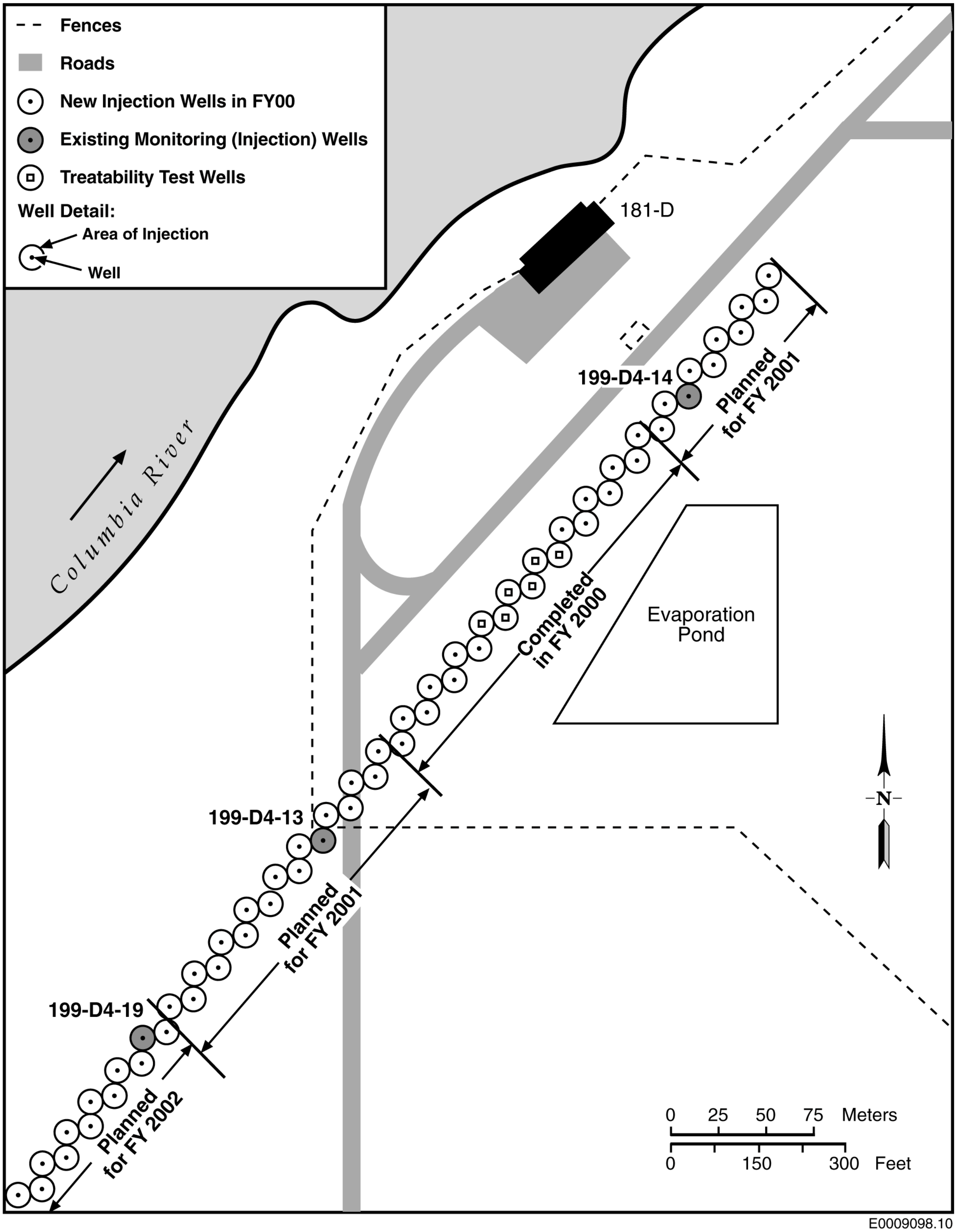
Despite the potential advantages and feasibility of ISRM, there were still some tough challenges and issues for the new technology to overcome before it could be accepted as a remediation strategy for the west plume. First, this would be the initial use of an in situ redox method on chromium VI. Would ISRM convert enough of the chromium VI to chromium III to meet the compliance limit of 20 μg/L in the groundwater downstream from the ISRM treatment zone?

Another issue involved the details of the groundwater flow direction and the shape and extent of the chromium plume. These factors would affect where the treatment zone should be placed, and whether it could effectively stretch across enough of the plume.

A third issue was how to dispose of the volumes of purgewater to be withdrawn from the zone at the end of the injection-reaction period. Several methods for disposing of the purgewater were considered, and eventually the use of a lined evaporation pond was approved by regulators.

TESTING THE EFFICACY OF ISRM FOR THE WEST PLUME

In 1995, a small proof-of-principle experiment with the proposed ISRM method was conducted in the 100 H Area. This experiment demonstrated that a dithionite injection process could reduce enough iron III to iron II in the unconfined aquifer to change the treatment zone from an oxidizing state (the normal condition) to a reducing state. It also showed that the resulting treatment zone would transform the chromium VI to chromium III as the groundwater flowed through the zone.

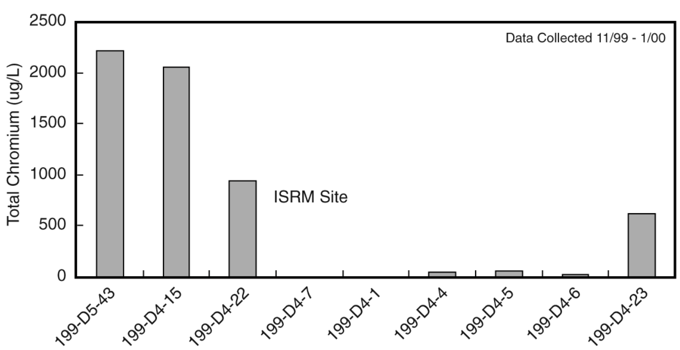


A plan view of the full ISRM barrier, showing segments completed and those scheduled for FY01 and FY02. The well locations and circles (representing treatment zones around a well) are approximations only. Treatment zones actually overlap each other.

A larger treatability test, at the head of the 100 D Area chromium plume, began in the spring of 1997. This test would determine whether the well layout and the injection and withdrawal operations would create a barrier sufficient to lower the chromium VI concentration below the compliance limit. Follow-up measurements would confirm that the barrier was working and would provide estimates of its durability (before retreatment of the barrier zone with dithionite). Five injection wells were drilled across the center of the plume, approximately 150 meters from the river shoreline (see the diagram on page 20).

The injection process creates a cylindrical reduction zone around each well, with the wells drilled in a staggered pattern with 24 percent overlap from one well's zone to the next. The total length of the in situ barrier created in this test was about 46 meters (150 feet). Additional groundwater monitoring wells were installed upstream and downstream, relative to groundwater flow, from the barrier location.

The first injection well was injected with dithionite in September and October of 1997. After six months of monitoring the groundwater around this well, the remaining four wells were injected in the spring of 1998. The chromium concentration in groundwater within the treatment zone dropped to below the limit of detectability, which is 7 µg/L, and has remained below this limit in subsequent testing.[1] Chromium levels in samples from groundwater monitoring wells downstream from this treatment zone have begun decreasing to below the detectable limit (see the graph in the left column below). The chromium values at wells upstream from the zone remain at the chromium levels measured before the treatability study. The treatability test thus demonstrated that ISRM can halt the advance of chromium VI toward the Columbia River.



Results from the ISRM treatability test. The high levels of chromium dissolved in the groundwater upstream from the treatment zone (the first three wells) are reduced to below the limit of detectability at wells in and just downstream from the treatment zone (wells D4-7 through D4-6). The higher level of chromium at well D4-23 represents contaminated groundwater that flowed through the treatment area before the iron II reduction zone was created.

COMPLETING THE ISRM BARRIER

After the successful treatability test, RL requested and received formal regulatory approval to use ISRM as the remediation action for the west plume.[2] The implementation plan calls for completing the ISRM barrier across the chromium plume in three phases. During the summer and fall of 2000, Phase 1 was completed, with the addition of 14 injection wells and 2 compliance-monitoring wells. (Compliance wells are installed downstream from a remediation zone to ensure that the contaminant is being reduced to no more than the compliance limit.) The new injection wells extended the length of the barrier from 46 meters to 195 meters. During FY01, 28 more injection wells will extend the barrier to 495 meters. Four more compliance wells will be added downstream. The third and final phase of implementation, in FY02, will add another 20 injection wells and extend the barrier to its planned operational length of 677 meters. At

[1] A limit of detectability is the concentration below which the sampling and analysis methods being used cannot reliably distinguish between a sample containing nothing (zero concentration of the analyte) and a sample containing something. The limit of detectability depends on a number of factors, including sample size and preparation method, the sensitivity of the analytical technique, and other materials in the sample (the sample matrix) that might interfere with the analysis for the specific analyte.

[2] Department of Energy, Richland Office, *Remedial Design Report and Remedial Action Work Plan for the 100-HR-3 Groundwater Operable Unit In Situ Redox Manipulation.* June 2000. Available from the National Technical Information Service.

completion, the barrier will extend in a line parallel to the river shoreline, from the 20 μg/L concentration contour on the southwest side of the plume to the 20 μg/L contour on the plume's northeast side.

Based on laboratory tests performed on sediment samples taken in the treatment zone, this first round of injections is expected to last for approximately 20 years (give or take 6 years). When the barrier shows sign of chromium VI "breakthrough," the dithionite injection and withdrawal process will be repeated to replenish the supply of chromium-stopping iron II in the treatment zone. The groundwater upstream and downstream from the barrier will continue to be monitored at least annually, in order to assess how much chromium is reaching the barrier and how well the barrier captures it. Operating and maintenance costs will be tallied to provide a detailed comparison of costs for ISRM versus the pump-and-treat approach.

Beyond the primary objective of stopping the chromium plume from reaching the Columbia River, the installation west of the 100 D Area will also help the partners in the Hanford Site cleanup effort assess the potential for ISRM to assist in solving other remediation problems.

Section 5

INTEGRATION PROJECT STATUS UPDATE

PROJECT OVERVIEW AND BUDGET

The Integration Project Endeavors and Core Projects

The Integration Project began to take shape, in late 1997, to integrate and coordinate ongoing work at the Hanford Site, and to focus on site-wide objectives and requirements.

The FY00 funding for the activities managed by the Integration Project totaled $11.32 million. These activities are overseen by RL. The core fieldwork projects at the Hanford Site with which the Integration Project is most fully involved received a total of $34.10 million in FY00 (see the project budget summary table on page 24). RL and the DOE Office of River Protection (ORP) share in the oversight of these core projects for cleanup, characterization, restoration, and monitoring activities.

A successful Integration Project requires site-wide cooperation among Hanford's contractors and core fieldwork projects. The Integration Project has developed six ***endeavors*** to help coordinate this site-wide effort to protect the Columbia River. The work under each of the endeavors supports the efforts of the other five. The six endeavors include the following:

- Fieldwork (with emphasis on coordinating and integrating the work performed by the core projects)
- Integration of information
- System Assessment Capability
- Science and technology
- Technical review
- Public involvement.

The status reports in the remainder of this section are organized according to these endeavors.

Detailed planning for FY01, and beyond, in all six endeavors is now focused on the three main outcomes (or goals) developed over the past year by RL as a vision for the cleanup of the Hanford Site. These three goals include (1) restoring the Columbia River Corridor; (2) transitioning the Central Plateau to long-term waste management; and (3) preparing for potential multiple future uses of the Hanford Site. The three goals, along with a detailed schedule for accomplishing most of the Columbia River Corridor restoration work by 2012, were presented in a recent report to Congress by RL (*Hanford Site Columbia River Corridor Cleanup*). During the current reporting period (April to September 2000), the Integration Project management team and senior technical staff contributed to a major RL study of schedule options for achieving the Columbia River Corridor restoration. Results of the schedule options study are already influencing the direction of 200 Area Waste Site Characterization work, as discussed in the status update for the Fieldwork Endeavor.

Integration Project Resources: Past, Present, and Future

There were two significant and substantive changes in the Integration Project budget from FY99 to FY00. During this time, the SAC and S&T endeavors progressed from planning to project development, and the major increases in their budgets reflect this progress. For example, in FY99, developing the S&T Roadmap was a major activity (additionally, some S&T projects got an early start). For FY00, the S&T endeavor focused on projects that characterize the soil inventory of contaminants, and the transport and fate of these contaminants in the vadose zone. In addition, the Environmental Management Science Program (EMSP) awards for FY00 included a category for vadose zone research that effectively adds $25 million over a three-year period for S&T activities potentially supporting Hanford's three overarching goals.

Section 5 – Integration Project Status Update

The budget for FY01 includes $10.83 million for the Integration Project activities, and $43.10 million for the core projects. The largest increases in the core projects will be for Tank Farm Vadose Characterization, 200 Area Waste Site Characterization, and groundwater remediation in the 100 Area. The increase in 100 Area remediation reflects a major expansion in operational deployment of the ISRM treatment for the chromium plume west of the 100 D reactors, as described in the Section 4 feature article. The increased effort in the 100 Area is integral in helping achieve the Hanford vision to Restore the Columbia River Corridor.

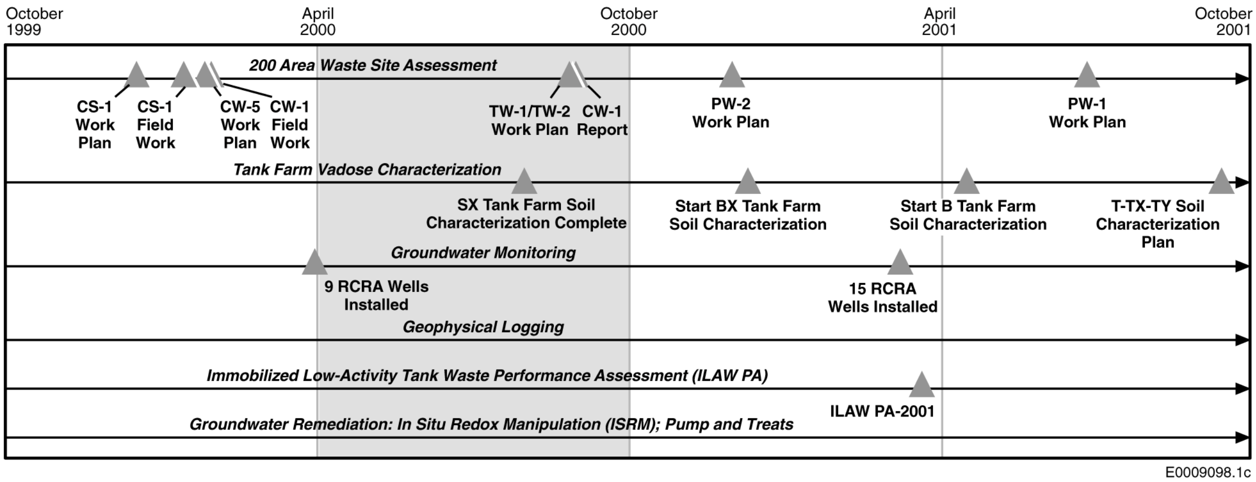
Funding for the Integration Project and Core Projects by Fiscal Year.
(millions of dollars)

	FY 1999 Funding	FY 2000 Funding	FY 200l Budget	Responsible DOE Office[a]
System Assessment Capability	$1.90	$2.85	$2.36	RL
Science and Technology	$1.33	$4.70	$4.90	RL
Technical Review	$1.03	$0.99	$0.60	RL
Public Involvement	$0.30	$0.33	$0.29	RL
Integration of Information				
Project Management	$1.82	$0.83	$0.46	RL
Data Management and Issues Resolution		$1.62	$2.22	RL
Integration of Information Subtotal	**$1.82**	**$2.45**	**$2.68**	
Integration Project, Total Funding	**$6.38**	**$11.32**	**$10.83**	
Core Projects (Fieldwork)				
Groundwater and Vadose Zone Monitoring	$12.73	$11.66	$12.66	RL
Well Installation and Maintenance	$1.68	$0.72	$1.85	RL
River Protection Project Vadose Characterization	$5.57	$7.11	$9.00	ORP
Tank Farm Geophysical Logging	$1.81	$1.08	$1.50	ORP
ILAW Characterization	$1.00	$2.04	$2.10	ORP
ILAW Performance Assessement	$0.50	$0.46	$0.30	ORP
Cone Penetrometer Development & Demonstration	$1.51	$0.00	$0.00	ORP
Columbia River Monitoring	$0.39	$0.39	$0.40	RL
200 Area Waste Site Characterization	$1.99	$3.53	$4.90	RL
100 Area Pump and Treats (HR, KR, NR) and ISRM	$5.06	$5.35	$7.36	RL
200 Area Pump and Treats (UP, ZP)	$1.02	$1.51	$1.78	RL
200 ZP Vapor Extraction	$0.43	$0.25	$1.29	RL
Core Projects, Total Funding	**$33.69**	**$34.10**	**$43.14**	
Integration Project and Core Projects, Total Funding	**$40.07**	**$45.42**	**$53.97**	
Headquarters Programs				
Environmental Management Science Program ($25 M over FY 2000 - FY 2002)		$10.00	$10.00	HQ
Total Funding, All Activities in Status Report	**$40.07**	**$55.42**	**$63.97**	

[a] RL = DOE Richland Office
ORP = DOE Office of River Protection
HQ= DOE Headquarters (Office of Environmental Management)

FIELDWORK

(Vadose Zone and Groundwater Monitoring, Characterization, and Remediation)



The Fieldwork Endeavor includes the 200 Area Waste Site Assessment Project, which is managed under the Integration Project, and Tank Farm Vadose Zone Characterization, which is an Integration Project core project managed under the River Protection Program. Although managed by two different contractors, these projects will provide the Integration Project with a more complete understanding of the existing contaminants in the vadose zone.

The 200 Area Waste Site Assessment Project is defined in DOE Report No. DOE/RL-98-28, Revision 0, titled *200 Areas Remedial Investigation/Feasibility Study Implementation Plan—Environmental Restoration Program (Implementation Plan)*. This project will investigate 23 groups of waste sites, representing more than 800 individual liquid waste disposal sites in the 200 Area. This assessment work will help identify options for final cleanup of these subsurface wastes.

The Tank Farm Vadose Zone Characterization Project performs fieldwork to collect information needed to determine soil cleanup options in and around the underground waste storage tanks. Information generated by this project also aids in understanding the potential consequences of removing wastes from tanks, while exploring options for final tank closure.

Other projects linked closely to the Fieldwork Endeavor are the groundwater monitoring program, the geophysical logging program, the immobilized low-activity tank waste performance assessment (ILAW PA),[1] groundwater remediation activities using ISRM, and ongoing groundwater pump-and-treat operations.

TIMELINE AND KEY MILESTONES

Note: Items that appear in bold, below, are "keyed" to match milestones presented in the timeline (above) for this section.

A number of key project and *Hanford Federal Facility Agreement and Consent Order* (*Tri-Party Agreement*) milestones were met during the reporting period. These included the **CW-1 Report** (cooling water and associated wastes group), and the work plans for TW-1 and TW-2 waste groups (tank and scavenged wastes group). Also completed during the reporting period were the **SX Tank Farm Soil Characterization** and Phase 1 of ISRM implementation.

In the 200 Area Waste Site Assessment Project, the work plan for the PW-2 waste group (uranium-

[1] This purpose of this assessment is to ensure that Hanford's low-activity tank wastes can be safely disposed on Hanford's Central Plateau after it is immobilized through the vitrification process.

rich process waste) is due in December 2000 (**PW-2 Work Plan**). A milestone change under the *Tri-Party Agreement* has been requested to substitute work on the higher-priority PW-1 waste group (plutonium-rich organic process waste) next year, rather than the PW-4 waste group (general process waste). The timeline shows the proposed milestone for the proposed delivery of the **PW-1 Work Plan** at the end of June 2001.

The Tank Farm Vadose Zone Characterization Project will start characterization of the soil in April 2001 (**Begin B Farm Soil Characterization**). Planning for vadose zone characterization in the T-TX-TY Tank Farms will proceed during FY01, with plan completion scheduled for September 2001 (**T-TX-TY Soil Characterization Plan**).

The continuing activities for **groundwater monitoring, geophysical logging**, and **ILAW PA** are represented by straight lines through the time periods shown in the timeline on page 25. So, too, are the operations in the 100 and 200 Areas for pumping groundwater at the leading edge of plumes and treating it to remove contaminants (**pump and treat**). **ISRM** operations for the chromium plume west of the 100 H Area are described in the article presented in Section 4.

SIGNIFICANT EVENTS THIS PERIOD

200 Area Waste Site Assessment Project. The completion of the **CW-1 Report** this summer represents the first completed field characterization under the April 1999 Implementation Plan. The report, which was submitted to regulators in August, summarizes all the work done to characterize the Gable Mountain/B Pond and Ditches Cooling Water Group, consisting of two former multi-acre waste ponds and two trenches in the 200 Area. The next step for this waste group will be a feasibility study to examine remediation options and propose specific remedial actions for these four sites.

Work plans were submitted to regulators in August for the TW-1 and TW-2 waste groups (tank waste and scavenged waste groups). The work plans propose work schedules that would complete the characterization of sites in these groups in August 2001.

Tank Farm Vadose Zone Characterization Project. The completion of sampling in July at the SX-108 slant borehole concluded characterization fieldwork in the SX Tank Farm. The effort to drill a slant borehole under Tank SX-108 and extract a series of core samples for detailed analysis represents the first-ever attempt to collect soil samples from directly under a single-shell tank. This work is described in the feature article presented in Section 3.

The work plan for the next major soil characterization activity, inside the B-BX-BY Tank Farm complex, was submitted in May to regulators and has been approved.

Work began this period, and will continue in FY01, to seal off unnecessary water lines inside the tank farms. The importance of reducing the infiltration of moisture from leaks in these water lines was established by previous soil characterization work. The water line leaks contribute significantly to the amount of moisture flowing through the vadose zone under the tank farms. As explained in the feature article in Section 2, moisture from the surface is the principal route of concern for transport of soil contaminants.

Tritium at the 618-11 Burial Ground. The Phase II sampling plan to identify the source of the unexpectedly high tritium levels from a monitoring well just east of the 618-11 Burial Ground continued during this period. Nearly 50 soil gas monitors were installed around the perimeter of the burial ground to detect the helium (helium-3) produced by the radioactive decay of tritium. High readings for helium-3 were obtained at sampling points on the northern perimeter of the burial ground, as well as adjacent to Well 699-13-3A, which is the monitoring well that gave the initial high readings for tritium. Additional groundwater samples were scheduled to be obtained in October 2000 from two new sample points – one at the northern perimeter burial ground, and the other about 80 meters east (downstream via groundwater flow) from Well 699-13-3A.

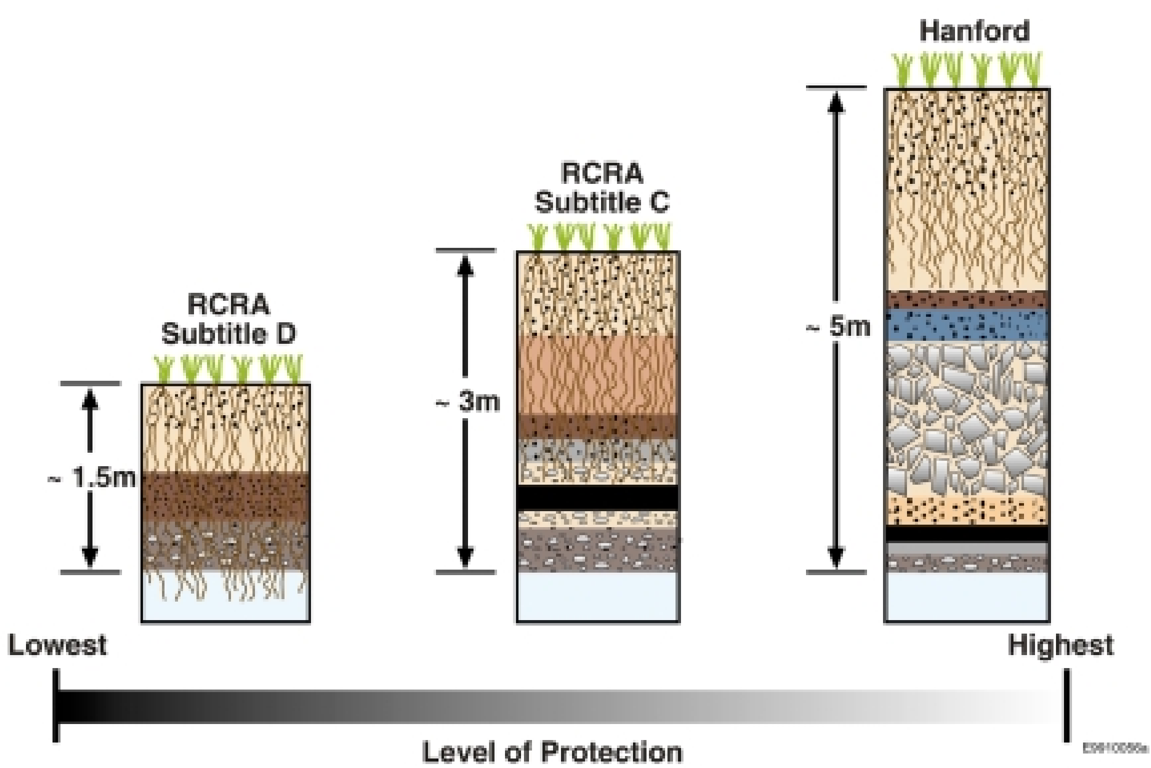
SIGNIFICANT EVENTS NEXT PERIOD

200 Area Waste Site Assessment Project. The 200 Area Waste Site project is awaiting regulatory approval for a proposal to begin work on characterizing the PW-1 waste group this year, rather than characterizing the PW-4 group as scheduled under the 1999 Implementation Plan. The PW-1 waste group includes sites where plutonium-rich organic wastes, containing significant amounts of carbon tetrachloride, were released to the environment. Determining how much carbon tetrachloride is in the vadose zone, and the extent of its movement, are higher priorities than characterizing the general process wastes with lower total quantities of radioactive and other hazardous waste that were disposed at the PW-4 sites. If regulators approve the schedule change, the **PW-1 Work Plan**, which represents the first step in characterization and remedial action feasibility assessment, will be due at the end of June 2001. A work plan for the PW-2 waste group is being prepared, with delivery scheduled for December 2000 (**PW-2 Work Plan**).

Another significant event in the next period for the 200 Area Waste Assessment Project will be characterization of one of three representative sites in the chemical sewers waste group. This characterization will confirm the decision, based on last year's work, to defer full characterization of the chemical sewers waste sites until later in the schedule, while accelerating evaluation of the higher priority PW-1 and PW-2 sites.

Tank Farm Vadose Zone Characterization Project. Characterizing the soil contaminant inventory inside the B-BX-BY Tank Farm complex will begin in FY01. Work will start in the BX Tank Farm in December 2000, with work in the B Tank Farm beginning in April 2001. Meanwhile, work will begin on the work plan for soil characterization inside the T-TX-TY Tank Farm.

Barrier Study. Fieldwork is planned for FY01 to continue studying ***barrier cover systems*** for use in



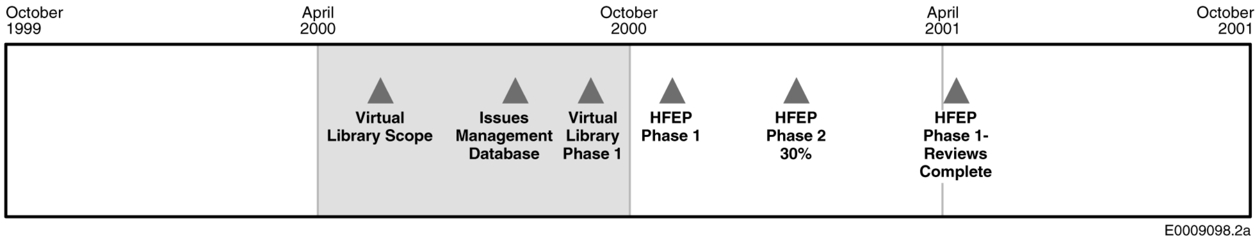
Graded barrier concepts being studied for application at the Hanford Site.

covering buried wastes or contaminated subsurface regions that will remain after the planned cleanup and remediation activities at the Hanford Site are completed. Three types of barrier systems, for different contaminant situations, will be studied (see the illustration on page 27). The system that is likely to be used most frequently is a barrier designed to meet the specifications for RCRA Class C wastes, with specific modifications for the Hanford environment. This ***modified RCRA C*** barrier system has a design life of 500 years before moisture from the surface would begin to penetrate to the contaminants below the asphalt layers near the bottom of the barrier. For wastes whose radioactivity exceeds that of RCRA Class C, the more robust Hanford Barrier system would be appropriate. Wastes that are specified in RCRA as Class D wastes may be covered with a modified version of the RCRA D barrier.

Groundwater Monitoring. Installation of additional RCRA wells will continue during FY01. The 15 new wells scheduled to be installed by March 2001 will bring the total number of wells monitored under RCRA requirements to more than 300.

Groundwater Remediation. As noted in the feature article in Section 4 of this report, 28 additional injection wells will be installed in FY01, extending the barrier across the chromium plume west of the 100 D reactors to 495 meters. The existing pump-and-treat operations for other plumes will continue.

INTEGRATION OF INFORMATION



The role of the Integration of Information Endeavor is to ensure that the wealth of technical information and data about the Hanford Site is well integrated, effectively managed (to ensure its integrity, quality, and configuration control), and easily accessible for a wide range of potential uses. The endeavor is particularly important in preparing data sets, interpreting data, and describing the current best understanding (in the form of conceptual models) for the SAC. A second major objective is to provide open and useful access to the data for a wide range of users inside Hanford operations, as well as from the outside scientific, technical, regulatory, and stakeholder communities.

TIMELINE AND KEY MILESTONES

Note: Items that appear in bold, below, are "keyed" to match milestones presented in the timeline (above) for this section.

The **Virtual Library Phase I Scope** was completed in April, and the **Virtual Library Phase 1** became operational in September. The **Issues Management Database** became operational in June.

Phase 2 of developing the HFEP database has been restructured in terms of three completion milestones. By the end of January 2001, the highest-priority features, events, and processes (~30% of the total) identified during Phase 1 are scheduled to be fully characterized and evaluated **(HFEP Phase 2—30%)**. The next major milestone involves a completed evaluation of 60% of the features, events, and processes by April 2002 (not shown on the timeline). Technical and management reviews of HFEP Phase 1 are scheduled for April 2001 (**HFEP Phase 1—Reviews Complete**).

SIGNIFICANT EVENTS THIS PERIOD

HFEP Database. During this period, work continued on (1) defining all the features, events, and processes that are of technical relevance to assessments at the Hanford Site; and (2) capturing these definitions in an automated database system (**HFEP Phase 1**). This phase has included capturing the current state of knowledge about each feature, event, or process, to include how much is known about it, as it occurs at the Hanford Site; where the information is captured; and how the information is used.

Conceptual Models and Process Relationship Diagrams. HFEP development has benefited from lessons learned in developing performance assessment tools for the nuclear waste depositories at the Yucca Mountain Project (in Nevada) and the Waste Isolation Pilot Plant (in New Mexico). An external audit of the performance assessment tools for Yucca Mountain Project noted that it did not have adequate tracking from the underlying features, events, and processes data into the final performance modeling tools. To apply this lesson at the Hanford Site, the HFEP development team has been developing ***process relationship diagrams*** for all the processes identified in the HFEP database. These diagrams specify how each process relates to other processes within its technical element (e.g., inventory, vadose zone, or groundwater), and to the processes before and after it in the transport pathways from one technical element to the next. Each diagram provides a template for a conceptual model that represents the process in modeling tools, such as the numerical modeling programs in the SAC. These diagrams allow the features and events relevant to a process to be traced into their representations in, for example, SAC software components. The process relationship diagrams will be completed as part of **HFEP Phase 1**.

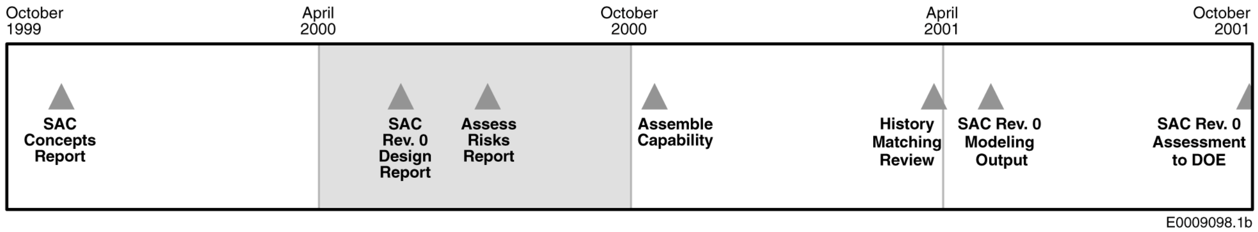
Virtual Library. In addition to release of Phase 1 of the Virtual Library in September, the Integration Project team also implemented a software engineering methodology incorporating a spiral development life cycle. An Automation Control Board was established to oversee the work of preparing the diverse technical data sources about the Hanford Site for access by a wide range of potential users, including Hanford Site project staff, DOE staff, regulators, and stakeholders.

SIGNIFICANT EVENTS NEXT PERIOD

The **HFEP Phase 1** activity, as discussed above, will be completed in November 2000. The Phase 1 database and information products will then undergo both technical and management reviews by external groups. After the reviews are delivered in April 2001 (**HFEP Phase 1—Reviews Complete**), the project team will prepare a response by mid-May.

The second major phase of HFEP development is to fully evaluate and characterize the features, events, and processes defined during Phase 1 as relevant to the Hanford Site cleanup. This work will be prioritized to meet the needs of key HFEP users—principally, the SAC development team. Evaluation and full characterization within the HFEP database of 30% of the features, events, and processes is set for the end of January 2001. Completion of work on the top 60% (by priority to the SAC and other users) is scheduled for April 2002. The team estimates that this level of completion will cover all the significant features, events, and processes needed for the SAC (Rev. 1) by September 2002. The 90% completion goal is set for FY03.

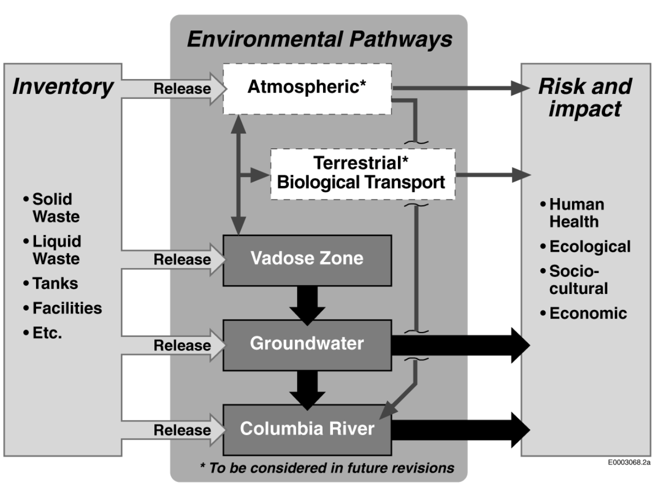
SYSTEM ASSESSMENT CAPABILITY



The SAC will provide a set of tools for assessing future cumulative and site-wide impacts from the environmental release of contaminants during past Hanford operations, or from an existing stored inventory. The SAC is also envisioned as a tool for assessing the merits of remediation, isolation, and containment alternatives for specific areas of the Hanford Site.

At the heart of the SAC is a set of models for simulating two layers of ***technical elements*** (see the diagram below). There are six technical elements in the Environmental Layer of the SAC. First is the ***inventory*** of potential contaminants from past Hanford operations. Next is the ***release*** of contaminants to the environment through deliberate disposal actions or accidents (such as spills and leaks). The third element follows the transport and fate of contaminants as they move through the unsaturated strata of the ***vadose zone***. When contaminants reach the ***groundwater*** (the fourth element) beneath the Hanford surface, they can flow toward the ***groundwater-river interface*** (fifth element). From there they enter the ***Columbia River*** ecosystem (sixth element).

The Risk and Impact Layer of the SAC will include four technical elements to model ***human risks***, ***ecological risks***, ***economic impacts***, and ***socio-cultural impacts***.



SAC Technical Elements: Inventory; Environmental Pathways; and Risk and Impact.

TIMELINE AND KEY MILESTONES

Note: Items that appear in bold, below, are "keyed" to match milestones presented in the timeline (above) for this section.

The **SAC Rev. 0 Design Report** was released in May 2000. A draft interim report on assessing risks (**Assess Risks Report**), titled *Looking at Risk: Hanford's Site-Wide Approach*, was submitted to DOE-Richland for review in June. A copy of the SAC software was provided to the DOE in September, along with a summary of software testing results and a description of the hardware assembled to run the capability (**Assemble Capability**).

The modeling runs from SAC (Rev. 0) have been rescheduled from March to April 2001. A new milestone has been added in March 2001 for peer review of history matching work for the SAC (Rev. 0) (**History Matching Review**). An assessment summary document for the SAC (Rev. 0) is scheduled for delivery to RL for review in September 2001 (**Rev. 0 Assessment to DOE**).

SIGNIFICANT EVENTS THIS PERIOD

SAC (Rev. 0) Design Report. The major report from the design process for the SAC (Rev. 0), the *System Assessment Capability (Revision 0) Assessment Description, Requirements, Software Design, and Test Plan*, was released for public review in May. This report explains the basis for the first SAC assessment, and the software to be used for that assessment. The intended audience includes technical reviewers and potential users of the SAC. The report can be downloaded from the Integration Project web site at *www.bhi-erc.com/vadose/sac.htm*.

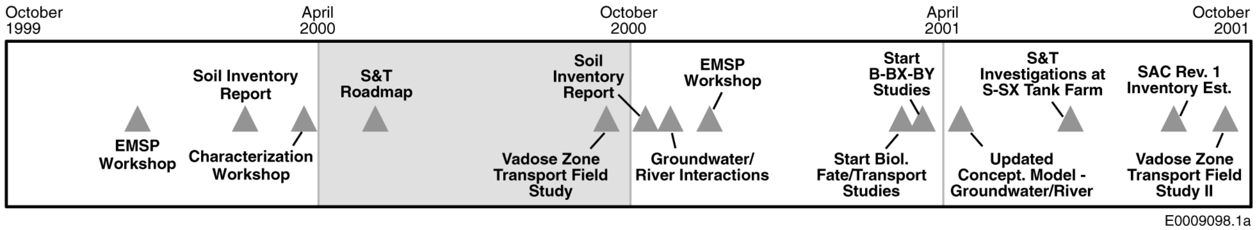
During this period, the software for the SAC (Rev. 0) was assembled and tested. Whenever possible, existing software was used. For example, a model of water movement and contaminant transport in groundwater, which was developed to meet other needs at the site, will be used in the SAC. New software elements were developed for several aspects of the capability, including the ***release*** and ***economic impacts*** technical elements. The ***release*** software represents how contaminants are released from the various types of waste at the Hanford Site. Models representing transport processes and the impacts of contaminants from Hanford have been assembled in a way that allows a scenario to be simulated multiple times, so that the effects of uncertainties in the data, and the process representations, can be studied. Each component (e.g. vadose zone, groundwater, river risk, etc.) was tested to ensure that it functions correctly. Several integration tests were performed to ensure smooth information transfer between components.

Data gathering for use in the SAC (Rev. 0) continued during this period. These data are needed to describe the site-wide waste inventory, to simulate the transport of contaminants in the environment, and to estimate impacts. Data gathering was completed for the ***release***, ***vadose zone***, ***groundwater***, ***Columbia River***, ***human risks***, and ***ecological risks*** technical elements. Work will continue through the end of October 2000 to assemble the information needed for the ***inventory*** technical element.

SIGNIFICANT EVENTS IN THE NEXT PERIOD

The principal SAC development activity during the next period will be a model-testing technique called history matching. Models used to represent each technical element will be run to simulate conditions in the past. The results will be compared with available field measurements. In some cases, the period from 1944 to the present will be simulated. In other cases, a shorter period will be chosen. Beginning in March 2001, a group of outside experts will review the results of the history matching (**History Matching Review**).

SCIENCE AND TECHNOLOGY



The role of the S&T endeavor is to provide new knowledge, data, and tools for the cleanup and stewardship mission at the Hanford Site. In addition to promoting new technologies and methods to solve Hanford's problems, this endeavor seeks to improve the scientific basis for decisions on protecting the Columbia River, and its ecological systems, while preparing the Hanford Site for the future. S&T activities are funded by the Integration Project, by the DOE EMSP, and by the DOE Office of Science and Technology Subsurface Contaminants Focus Area.

TIMELINE AND KEY MILESTONES

Note: Items that appear in bold, below, are "keyed" to match milestones presented in the timeline (above) for this section.

Revision 1 of the **S&T Roadmap** was released in May 2000. The Vadose Zone Transport Field Experiment for Phase I of the **Vadose Zone Transport Study** was also completed. The S&T endeavor completed a set of enhanced conceptual and numerical models of **Groundwater/River Interactions** in the 100 H Area. These models will be used in the SAC (Rev. 1).

A **Soil Inventory Report** for use in the SAC is scheduled for October 2000. The milestone for **S&T Investigations at S-SX Tank Farm** has been moved from November 2000 to June 2001 to accommodate delivery of contaminated soil samples from the slant borehole project. A second **EMSP Workshop** for DOE-funded investigators doing work of interest to the site will be held in November. In March 2001, laboratory studies will begin on biological fate and transport issues relevant to contaminant transport pathways at Hanford (**Start Biological Fate/Transport Studies**). Experimental studies for the S-SX Tank Farm will be completed in March 2001. Work in the B-BX-BY Tank Farm will start in March (**Start B-BX-BY Studies**).

In April 2001, S&T will deliver an updated conceptual model for groundwater-river interactions to the SAC development team (**Updated Conceptual Model—Groundwater/ River**). Soil inventory estimates for use in the SAC (Rev. 1) are due to the SAC development team in August 2001 (**SAC Rev. 1 Inventory Estimates**). The phase 2 results from the Vadose Zone Transport Field Studies are due in September 2001 (**Vadose Zone Transport Field Study 2**).

SIGNIFICANT EVENTS THIS PERIOD

The second half of FY00 represents the end of the first year of implementing the **S&T Roadmap,** and the start of field and laboratory activities. During earlier periods, generating the roadmap and planning field and laboratory studies were principal Integration Project activities.

S&T Roadmap. Revision 1 of the S&T Roadmap, which was released in May 2000, updated the activities and outcomes for the first four technical elements (Inventory, Vadose Zone, Groundwater, and Columbia River), and added the Risk technical element to the roadmap. This revision of the roadmap included changes resulting from the risk workshops (activities, outcome, and schedule for the risk technical element) that were conducted in the previous two periods.

In the near-term, the Roadmap provided the basis for preparing S&T input to the FY01 detailed work plans for the Integration Project. It also provides the basis for review of the S&T endeavor and the Integration Project by the NAS committee (see the Technical Review status update). In the longer-term, the results of the planned S&T investigations will help to develop the SAC and improve the scientific basis for all of the site's characterization and ER projects.

Vadose Zone Transport Field Study. In July, the S&T endeavor completed the first field experiment at the Vadose Zone Transport Field Study Site in the 200 East Area. In this controlled field experiment, which involved five national laboratories, three subcontractors, and the U.S. Salinity Laboratory, water and tracers were injected into the vadose zone. The movement of the water and tracers was measured using several methods of advanced characterization. These technologies and methods had been discussed during the Advanced Characterization Workshop, as reported in the May 2000 semi-annual report. Several of the participants in the field experiment are funded through the EMSP.

Work continued on developing improved estimates of the **Soil Inventory** for contaminants released to Hanford Site soils at specific locations. The principal investigators on this task were diverted during September to provide tank-leak estimates for the SAC (Rev. 0), as this team had the expertise and models necessary to provide the necessary estimates.

The **S&T Investigations at the S-SX Tank Farm** included laboratory measurements on uncontaminated and contaminated sediments from tank farm characterization projects being performed by ORP. The S&T Endeavor completed laboratory studies on subsurface materials collected as part of field investigations at the S-SX Tank Farm. In collaboration with three other national laboratories and several EMSP projects, S&T staff from PNNL completed transport experiments and characterization studies of these subsurface samples. The laboratory work will help Hanford's scientists and engineers understand what happens when caustic, highly radioactive tank waste leaks into the subsurface, so that informed decisions can be made on corrective measures to protect the groundwater. The laboratory measurements and the simulation results will be incorporated into the field investigation report for this tank farm, to be prepared by ORP during FY01. S&T staff from PNNL and the other national laboratories also worked together to complete numerical simulations, using advanced computational capabilities, to assess the validity of key assumptions used in tank farm assessments.

Groundwater/River Interactions. In September, S&T staff completed development of enhanced conceptual and numerical models of the groundwater/river interface in the 100 H Area. This S&T result provides dilution factors for use in the SAC (Rev. 1), and in establishing cleanup criteria for soil and groundwater contamination along the Columbia River.

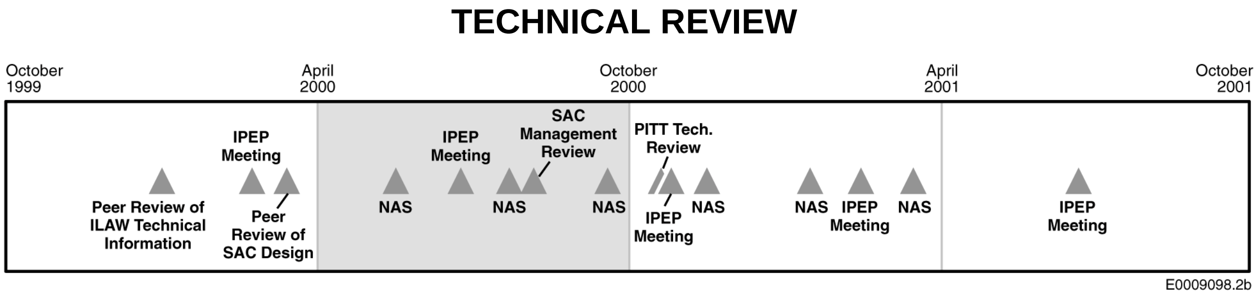
SIGNIFICANT EVENTS IN THE NEXT PERIOD

During the next reporting period, S&T staff will issue a report documenting the model being used in the SAC and by the core projects to estimate the **Soil Inventory** of subsurface contaminants at specific soil waste site locations. This team will continue developing inventory estimates for additional soil sites. Improving and documenting these site-specific inventory estimates are essential steps in creating accurate and credible soil inventory estimates for use in site cleanup and stewardship decisions.

Ongoing Wrap-Around Science. Coordination with the Fieldwork endeavor and the core projects to perform wrap-around science, in conjunction with planned characterization work, will continue throughout the next reporting period. Laboratory and advanced numerical modeling evaluations of transport processes at the S-SX Tank Farm, using contaminated materials, will proceed. Results from this work were rescheduled for delivery to ORP in June 2001 for use in tank farm cleanup. Planning with the Fieldwork Endeavor for wrap-around science during the B-BX-BY Tank Farm characterization will continue. The S&T studies are likely to begin near the end of the period (**Start B-BX-BY Studies**).

Evaluation of the data from the first Vadose Zone Transport Field Study experiment will continue. The Phase 2 field experiment during FY01 will use the same location as this year's test, but a high-salt tracer will be used. This tracer will help scientists understand how wastes with a high ionic strength, such as tank leaks, move in the vadose zone. The conceptual and numeric models of the Groundwater/River Interface for the 100 H Area, which were refined and documented during this period, will be extended during the next period to other key cleanup areas along the Columbia River.

In March, laboratory work will begin on refining the understanding of how aquatic life in the Columbia River is affected by (and adapts to) exposure to Hanford Site contaminants. These studies will focus on the biological transport of contaminants up the food chain, and the fate of contaminants after uptake by river plants or animals (**Start Biological Fate/Transport Studies**). In the next reporting period, S&T staff will team with other Integration Project staff to identify the contaminants of concern for the study, and to prepare for laboratory work.



The Technical Review Endeavor ensures that outside, independent reviews are conducted for the scientific merit, technical content, and managerial leadership of Integration Project activities. Technical review activities in support of the Integration Project include the IPEP, study committees of the NAS/National Research Council, reviews of the Hanford consolidated groundwater model, and other project-specific reviews.

The IPEP, which has eight members from diverse disciplines, provides broad and independent oversight for all Integration Project activities. Panel members review and comment on key programmatic, managerial, technical, and stakeholder issues. The IPEP operates primarily as a merit review panel, but periodically conducts technical reviews.

TIMELINE AND KEY MILESTONES

Note: Items that appear in bold, below, are "keyed" to match milestones presented in the timeline (above) for this section.

The full **IPEP** met in May 2000 and will meet again in October 2000 and April 2001. A management review panel reviewed the SAC (Rev. 0) design document and gave its report in August (**Management Review of SAC Design**). A technical review panel's report on the proposed Partitioning Interwell Tracer Test (PITT) is scheduled for October 2000 (**PITT Technical Review**).

The NAS Committee on Environmental Remediation Science and Technology at the Hanford Site (**NAS**) met in Richland during April, June, and September. Three more committee meetings are tentatively scheduled for November 2000 and January and March 2001.

SIGNIFICANT EVENTS THIS PERIOD

IPEP. A management review panel consisting of three IPEP members provided a detailed management review of the SAC (Rev. 0) Design Report. The review panel's report, which was delivered on August 27, is available on the Integration Project web site, at *www.bhi-erc.com/vadose/peer.htm*.

The reviewers noted the progress made by the SAC team in clarifying the capabilities and limitations of the SAC for potential users. The SAC (Rev. 0), they said, is generally sound for a "proof of principle" stage, and they recommended a number of actions to help it meet the stated objectives. However, the management review panel found the goals and objectives for the SAC (Rev. 0) to be too general, lacking the specificity needed to know where this first version of SAC succeeded and how it is linked to the next version (Rev. 1).

NAS Committee on Environmental Remediation Science and Technology at the Hanford Site. The first three meetings of the NAS committee (April, June, and September) were held in Richland, and focused on gathering information for use in the committee's deliberations. The committee's statement of task, its members, and the agendas of the meetings held to date are available from hyperlinks provided at the Integration Project web page listed above. Many of the presentations to the committee by

Integration Project staff (and others) are also available from this web page.

SIGNIFICANT EVENTS IN THE NEXT PERIOD

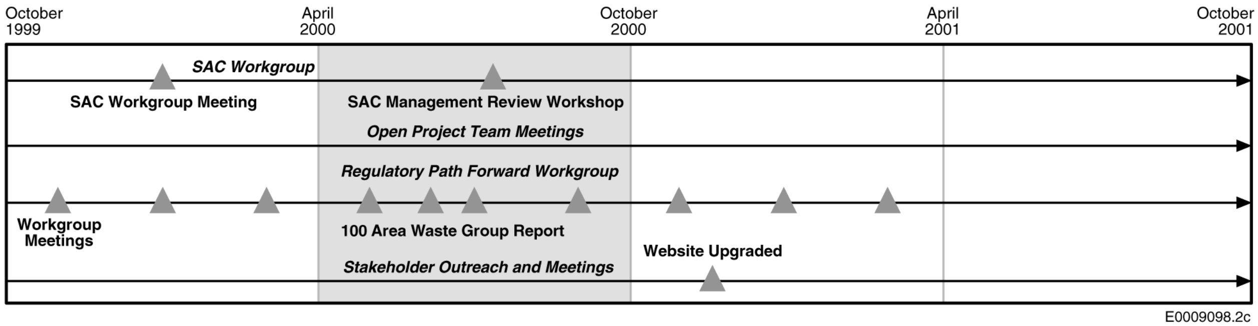
IPEP. At the May 2000 meeting, the IPEP recommended establishing a technical review panel to provide a technical peer review for the PITT plan to investigate the presence of dense non-aqueous phase liquids (DNAPL) in Hanford's subsurface. The PITT was recommended by an Innovative Treatment Remediation Demonstration (ITRD) Technical Advisory Group. The ITRD program is funded by DOE to recommend the best available remediation technologies for selected contamination problems, by considering cost, performance, and regulatory issues. Selection and funding of a remediation technology is then made by DOE and the regulators.

An ITRD Technical Advisory Group was formed in 1999 to consider technologies to address carbon tetrachloride contamination at the Hanford Site. (Carbon tetrachloride is the principal DNAPL found in Hanford Site soil.) Uncertainties about the extent of carbon tetrachloride contamination in the vadose zone and groundwater led the Technical Advisory Group to request more characterization work before it could recommend a long-term remediation technology. The group recommended that PITTs be conducted. The first test would be conducted in the vadose zone, to help determine the best location for a subsequent PITT of the groundwater.

A technical review panel was formed in September 2000 to assess whether the PITT is the right technology for the Hanford situation, and to assess potential design and performance issues associated with the proposed PITT technology and test design. The report of this technical review panel is scheduled for delivery in October 2000.

NAS Committee. At its last three Integration Project meetings (November 2000, January and March 2001), the NAS Committee will develop its findings and recommendations. The procedural rules under which the National Research Council conducts studies for the NAS require that committee deliberations and report drafts be kept confidential until after the report completes a strenuous peer review. The report will undergo peer review some time after the last committee meeting in March 2001, with release and publication planned for late summer or fall of 2001.

PUBLIC INVOLVEMENT



The role of the Public Involvement Endeavor is to provide opportunities for Hanford's community of affected people to (1) share information and views; (2) consult with DOE and Integration Project staff; and (3) collaborate on Integration Project activities. This community, which is large, passionate, diverse, and geographically dispersed, is united by a common interest in protecting the Columbia River and exercising a role in future decisions about the Hanford Site. Building the mutual trust and support to move ahead on difficult issues requires a fully open, accessible, and inclusive program for involving all elements of this community.

Outreach. Integration Project staff members continued to meet with interested groups and organizations to discuss the continuing work of the Integration Project, and to receive feedback. During this period, Integration Project staff met with or provided presentations to these organizations and Tribal Nations entities:

- The U.S. Environmental Protection Agency and Washington State Department of Ecology
- The Hanford Advisory Board, including the Environmental Restoration Committee
- Richland city officials
- The Oregon Office of Energy and Oregon Hanford Waste Board
- Technical representatives of the Nez Perce Tribe
- Technical representatives of the Yakama Nation.

TIMELINE AND KEY MILESTONES

Ten open project team meetings were held during the reporting period. These meetings will continue throughout FY01. Additional public involvement activities occur as part of the other Integration Project endeavors, and are shown on the timelines of those endeavors. The web site upgrade previously scheduled for September 2000 will not be released until FY01.

SIGNIFICANT EVENTS THIS PERIOD

SAC Workshop. A management review panel met in Richland on June 20-21 to review the SAC Assessment Design from a management perspective. A favorable peer review of the technical aspects of the Assessment Design had been completed in the previous reporting period.

The management review panel praised Integration Project progress in defining and developing the SAC, and provided key recommendations for further management involvement and better defining SAC outcomes, limitations, and end users. "The panel's review and recommendations have provided good insight into areas within the SAC needing more focus," says Bob Bryce of PNNL, who is the task lead for the SAC.

Hanford Advisory Board. The Integration Project continues to have a strong link to the HAB and its committees. The HAB held three board meetings during the reporting period, as well as several committee meetings.

Open Project Team Meetings. The principal topics discussed at the ten open project team meetings are listed below. Detailed minutes of each meeting, which are distributed to over 200 individuals and organizations, are also available on the Integration Project web site at *http://www.bhi-erc.com/vadose/minutes.htm#general*.

- **April 3, 2000.** Test drilling for the slant borehole at tank SX-108; update on Phase II planning for investigation of tritium at 618-11 Burial Ground; discussion of tasks, membership, and the first meeting agenda of the NAS committee to review the S&T Plan.

- **April 17, 2000.** Update on Phase II plan for investigation of tritium at 618-11 Burial Ground; report on first meeting of the NAS committee; plans for the Partitioning Inter-Well Tracer Test.

- **May 1, 2000.** SAC (Rev. 0) Design Document; closeout report from the January 2000 IPEP meeting and agenda for the May 24-26 IPEP meeting; slant borehole at tank SX-108; question/answer discussion on impacts of the vitrification plant closure.

- **May 15, 2000.** Issues management tracking database; SAC (Rev. 0) Design Document; plans for May 24-26 IPEP meeting; update of S&T Roadmap.

- **June 5, 2000.** Starting drilling of slant borehole at tank SX-108; planning for second meeting of the NAS committee; May meeting of the Regulatory Path Forward Work Group; discussion of closeout comments from the May IPEP meeting.

- **June 19, 2000.** Plans for second NAS committee meeting; issues tracking database; technical review panel to review SAC (Rev. 0); first samples taken from SX-108 slant borehole.

- **July 17, 2000.** Continued sampling at SX-108 slant borehole; NAS committee progress; results from technical review of the SAC (Rev. 0).

- **August 7, 2000.** Detailed Work Plan review schedule; progress (and issues) on adding RCRA monitoring wells; Phase II tritium sampling begun at 618-11 Burial Ground; SX-108 slant borehole drilling completed; SAC software development.

- **August 21, 2000.** Tank Farm Vadose Characterization—summary on SX-108 slant borehole samples and drilling plans for other tank farms; plans for September NAS meeting; progress in tritium sampling at 618-11 Burial Ground; ISRM status (well drilling and dithionite injection); features, events, and processes database.

- **September 18, 2000.** ISRM progress (dithionite injection and withdrawal); RCRA well progress; progress in tritium sampling at 618-11 Burial Ground; release of three work plans for 200 Area Assessment; changes in the Detailed Work Plan.

SIGNIFICANT EVENTS IN THE NEXT PERIOD

The Integration Project will continue to provide updates to the HAB and its subcommittees.

Outreach efforts will be continued. The Integration Project will seek opportunities to provide updates to and seek input from local, regional, and national groups. This effort will broaden stakeholder, regulator, Tribal Nation, and technical groups, with a broader understanding of the various elements of the Integration Project.

The Integration Project staff will continue to hold semi-monthly open project team meetings.

Section 6

FOR MORE INFORMATION

GENERAL INFORMATION ABOUT THE GROUNDWATER/VADOSE ZONE INTEGRATION PROJECT

Published reports and documents, along with many other sources of background information on the Integration Project, are available at the following Internet locations:

Integration Project home page:
http://www.bhi-erc.com/vadose/vadose.htm

Hanford Site home page:
http://www.hanford.gov/

Office of River Protection home page:
http://www.hanford.gov/orp/index.html

Hanford stakeholders:
http://www.hanford.gov/misc_info/stakehld.html

The Integration Project home page has links to other DOE, national laboratory, and community or stakeholder sites that have information related to the Hanford Site and environmental remediation work.

FURTHER INFORMATION ON SIGNIFICANT EVENTS AND FEATURES IN THIS REPORT

Additional Internet locations for information on the Hanford Site range fire include the following:

- Hanford Site Fire Information home page:
  http://www.hanford.gov/hanfordfire.html

- Washington State Department of Health:
  http://www.doh.wa.gov/ehp/rp/wildfire.htm
  http://www.doh.wa.gov/ehp/rp/continued.htm
  http://www.doh.wa.gov/ehp/rp/handfordfire.htm

Additional technical descriptions of conceptual models and their role in the SAC can be found in the following:

- The SAC concepts report: *Preliminary System Assessment Capability Concepts for Architecture, Platform, and Data Management*, September 1999. Available from the Integration Project web site at *http://www.bhi-erc.com/200Area/200Area.htm.*

- The SAC (Rev. 0) Design Report: *System Assessment Capability (Revision 0) Assessment Description, Requirements, Software Design, and Test Plan*, June 1999. Available from the Integration Project web site at *http://www.bhi-erc.com/vadose/sac.htm.*

PNNL research on moisture infiltration is provided in the following published technical articles:

- M. J. Fayer, G. W. Gee, M. L. Rockhold, M. D. Freshley, and T. B. Walters, "Estimating recharge rates for a groundwater model using a GIS," *Journal of Environmental Quality* 25: 510–518. 1995.

- G. W. Gee, M. J. Fayer, M. L. Rockhold, and M. D. Campbell, "Variations in recharge at the Hanford Site," *Northwest Science* 66: 237–250. 1992.

- G. W. Gee, P. J. Wierenga, B. J. Andraski, M. H. Young, M. J. Fayer, and M. L. Rockhold, "Variations in water balance and recharge potential at three Western desert sites," *Journal of the Soil Science Society of America* 58: 63–72. 1994.

Background information about the Hanford high-level wastes, the storage tanks, and the problems of tank leakage and spills can be found in R. E. Gephart and R. E. Lundgren, *Hanford Tank Cleanup: A Guide to Understanding the Technical Issues*, Battelle Press, Columbus, Ohio, 1999. Available from Battelle Press on-line at *http://www.battelle.org/bookstore*, or by calling 614-424-6393.

The work involved in reconstructing the history of tank spills and leaks is described in the feature article ("What's Past is Prologue") in the May 2000 issue of this semi-annual report. The May semi-annual report is available from the Integration Project web site.

Technical documents on the chromium plume west of the 100 D reactors and the ISRM technology include the following:

- M. D. Williams, V. R. Vermeul, J. E. Szecsody, J. S. Fruchter, and C. R. Cole, *100 D Area In Situ Redox Treatability Test for Chromate-Contaminated Groundwater: FY 1998 Year-End Report*, Pacific Northwest National Laboratory, March 1999.

- V. J. Rohay, D. C. Weekes, W. J. McMahon, and J. V. Borghese, *The Chromium Plume West of the 100-D/DR Reactors: Summary and Fiscal Year 1999 Update*, Bechtel Hanford, Inc., Report BHI-01309. Available through the ER Project Internet Library, at *http://www.bhi-erc.com/library/bhi/bhi01309.pdf*.

- DOE Richland Office, *Remedial Design Report and Remedial Action Work Plan for the 100-HR-3 Groundwater Operable Unit In Situ Redox Manipulation*, Report DOE/RL-99-51, Rev. 1, June 2000. Available through the ER Project Internet Library, at *http://www.bhi-erc.com/library/doerl/rl99-51.pdf*.

The 200 Area Implementation Plan (*200 Areas Remedial Investigation/Feasibility Study Implementation Plan - Environmental Restoration Program*, DOE/RL-98-28, Rev. 0, April 1999), is available through the ER Project Internet Library, at *http://www.bhi-erc.com/library/doerl/rl98-28.pdf*.

Information on the Science and Technology Endeavor is available on the Internet at *http://www.bhi-erc.com/vadose/s&t.htm*.

For more information, or to become involved with the Integration Project, contact Karen Strickland at (509) 372-9236.

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