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Hanford
Integrated Groundwater and Vadose Zone Management Plan

October 2007

Hanford Integrated Groundwater and Vadose Zone Management Plan

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Assistant Secretary for Environmental Management
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Summary

At the Hanford Site, the U.S. Department of Energy (DOE) is engaged in one of the most complex and challenging environmental cleanup projects in history. From the 1940s through most of the 1980s, the United States used the site to produce nuclear material for national defense. The mission changed in the late 1980s from production to clean up, and the challenge to complete the cleanup of the environment is enormous:

- 1,700 waste sites.
- 450 billion gallons of liquid dumped into the soil.
- Approximately 80 square miles of groundwater contaminated above the drinking water standards.
- 53 million gallons of radioactive liquid waste in 177 underground storage tanks.
- 500 contaminated facilities.

The DOE Richland Operations Office (DOE-RL) and DOE Office of River Protection (DOE-ORP) oversee the cleanup challenges that exist at the Hanford Site, an area of approximately 586 square miles in southeastern Washington State. One major challenge is the groundwater contamination that exists beneath the site. The Groundwater Remediation Project is engaged in gathering and analyzing data, developing and deploying technologies, and translating that information into viable solutions to treat the subsurface contamination.

The remediation of groundwater is complex. DOE, the lead cleanup agency, works collaboratively with the regulatory agencies, the U.S. Environmental Protection Agency (EPA) and the Washington State Department of Ecology (Ecology), to make decisions that guide groundwater protection and cleanup. In addition, DOE continually seeks and considers input on groundwater issues and decisions from Tribal Nations, the Hanford Advisory Board, the State of Oregon, and the public. While each group brings its unique perspective and concerns, they have a common goal – to clean up and protect the Hanford Site.

As a regulatory requirement and policy objective in both the CERCLA and RCRA programs "EPA expects to return usable ground waters to their beneficial uses wherever practicable, within a time frame that is reasonable given the particular circumstances of the site. When restoration of groundwater to beneficial uses is not practicable, EPA expects to prevent further migration of the plume, prevent exposure to the contaminated ground water and evaluate further risk reduction."
– 40 CFR 300.430(a)(1)(iii)(F)

This Integrated Groundwater and Vadose Zone Management Plan discusses the role of the Groundwater Remediation Project, remediation progress and current conditions, new technologies being

"The mission of the Hanford Groundwater Remediation Project is to protect the Columbia River from contaminated groundwater resulting from past, present, and future operations at the Hanford Site and to protect and remediate groundwater. This mission is a key element of the overall Hanford cleanup effort."

– Hanford Site Groundwater Strategy (DOE 2004)

implemented, and an integrated plan to accomplish cleanup and return groundwater to its highest beneficial use.

A groundwater management plan was issued in 2003. That plan identified a five-pronged strategy to accelerate the cleanup and protection of Hanford's groundwater. Since then more technical data has been acquired and new technologies have been developed and deployed at Hanford. This document updates the 2003 plan to reflect the progress DOE has made over the past few years and lays out next steps for addressing groundwater and vadose zone contamination.

Key elements to the plan include:

- Continue to implement remedies that are working.
- Gather characterization data, especially on deep vadose zone contamination to inform the decisions that need to be made.
- Address emerging problems.
- Work with regulatory agencies to make remediation decisions so the remedies can be implemented and cleanup can begin at remaining waste sites.
- Identify new technologies to attack problems that are not responding to or are beyond the reach of conventional approaches.
- Continue to monitor groundwater to detect emerging problems and determine how well remedies are working – make changes where remediation goals are not being attained.

DOE-RL and DOE-ORP have jointly implemented an integrated plan to manage all of Hanford's groundwater and vadose zone activities. This plan implements commitments made to Congress to:

- Integrate groundwater, vadose zone, and source area cleanup decisions.
- Consolidate modeling and risk assessment work for the Hanford Site.
- Consolidate groundwater and vadose zone activities under a single project, i.e., DOE-RL's Groundwater Remediation Project.

In addition to these changes, DOE has instituted a series of business processes to enhance integration across the projects engaged in groundwater and vadose zone activities at Hanford. Integrated Project Teams have been formed to ensure effective coordination of field investigations and timely communication of emerging data. DOE is also implementing a set of results-oriented performance metrics to monitor its progress in implementing the efforts outlined in this document.

The groundwater project continues to have three major objectives: (1) take actions necessary to prevent degradation of the groundwater, (2) remediate groundwater to restore it to its highest beneficial use and protect the Columbia River, and (3) monitor groundwater to identify emerging problems and guide the remediation process. To be successful, the groundwater project needs to obtain sufficient characterization data, evaluate performance of early actions, and develop remedial-action objectives. This document describes the relationship of these elements and identifies the way they will be used to guide and achieve groundwater cleanup decisions.

While progress continues and new information and technologies provide better cleanup approaches to the groundwater and vadose zone, groundwater contamination remains and contaminants continue to enter the Columbia River. Final waste site and groundwater decisions are needed so that remedies can be implemented. The Tri-Party Agreement continues to provide the framework for those decisions, and the Tri-Party Agencies (i.e., DOE, EPA, and Ecology) collaboratively work to obtain realistic, long-term groundwater protection and restoration. This responsibility includes identifying and agreeing on the level of characterization, the contaminants to be remediated, the cleanup options to be evaluated, and the final cleanup. Once implemented, these remedies will be monitored and, where needed, modified to achieve cleanup objectives. Waste site and groundwater cleanup decisions are needed to ensure that the groundwater and the Columbia River are protected and support the overall goal to clean up the Hanford Site.

"The long term goal of the groundwater program is to return groundwater to its highest beneficial use."

– Hanford Advisory Board Consensus Advice #197

Protecting the Columbia River is a major goal of DOE's groundwater and vadose zone activities.

Acronyms

CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act*
CMS	Corrective Measures Study
DOE	U.S. Department of Energy
DOE-ORP	U.S. Department of Energy, Office of River Protection
DOE-RL	U.S. Department of Energy, Richland Operations Office
Ecology	Washington State Department of Ecology
EIS	environmental impact statement
EPA	U.S. Environmental Protection Agency
FHI	Fluor Hanford, Inc.
FS	feasibility study
HAB	Hanford Advisory Board
IPT	Integrated Project Team
NEPA	*National Environmental Policy Act*
RCRA	*Resource Conservation and Recovery Act*
RI	remedial investigation
RFI	RCRA Facility Investigation
WCH	Washington Closure Hanford, LLC

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1.0 Introduction

The U.S. Department of Energy (DOE), in consultation with the U.S. Environmental Protection Agency (EPA) and the Washington State Department of Ecology (Ecology), and through its primary management contractor, Fluor Hanford, Inc., has developed this *Hanford Integrated Groundwater and Vadose Zone Management Plan* to coordinate cleanup activities in the groundwater and the overlying vadose zone (the soil zone between ground surface and the top of the groundwater). The goal of this project is to return groundwater to its highest beneficial use and to prevent further groundwater degradation.

DOE has developed a Hanford Integrated Groundwater and Vadose Zone Management Plan to coordinate cleanup activities in the groundwater and the overlying vadose zone. This management plan identifies the elements of a results-oriented performance measurement program that will be implemented to gauge effectiveness of the program.

In March 2003, DOE issued the *Hanford Groundwater Management Plan* (DOE 2003) that defined a comprehensive project to accelerate the clean up and protection of Hanford's groundwater. The plan, prepared in consultation with EPA and Ecology, was a landmark document in Hanford groundwater protection and cleanup. It proposed that every groundwater cleanup problem be evaluated against criteria in five functional areas to develop unique sets of actions to limit and control the continued migration of contaminants already in the soil and groundwater and ultimately lead to final cleanup. The five functional areas are components of three Groundwater Remediation Project program elements: Prevent Degradation, Remediate Groundwater, and Monitor Groundwater (Figure 1.1). The elements provide a consistent and clear framework for communicating groundwater protection and remediation plans with Tribal Nations, the State of Oregon, Hanford Advisory Board, Natural Resource Trustees, and the public. This framework provided a focus for useful feedback from those parties as activities were developed and implemented. The plan also applied a risk-based approach to select the

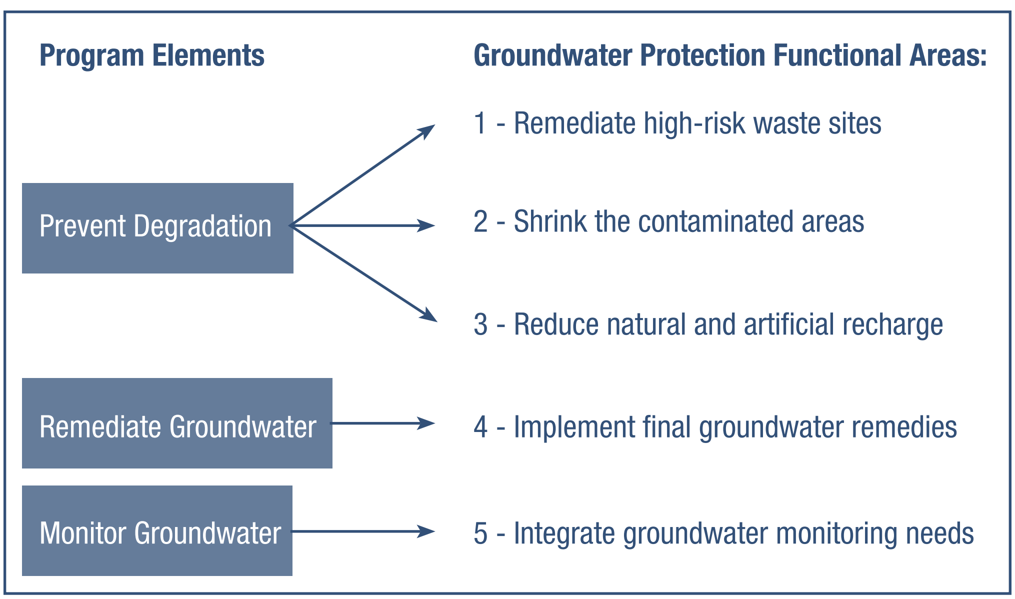

Figure 1.1. The 2003 Hanford Groundwater Management Plan program elements and functional areas.

sequence of cleanup actions and provide an accelerated plan of action for protection and clean up.

Since the plan was issued in 2003, much has been accomplished; much has also changed. Soil and groundwater characterization and monitoring work has moved steadily forward and the understanding of soil and groundwater hazards has improved. In some cases, this information has resulted in the acceleration of protective actions. In others, it has slowed the process in order to collect more focused characterization data. Additional funds were allocated for technology development and more effective cleanup alternatives are now available and being implemented. Also, in the process of implementing the 2003 plan, DOE has considered and incorporated comments and recommendations for improving the project from numerous sources (e.g., regulatory agencies, Tribal Nations, Hanford Advisory Board). The *Hanford Groundwater Management Plan* (henceforth referred to as the 2003 Plan) is being updated in 2007 and being retitled, the *Hanford Integrated Groundwater and Vadose Zone Management Plan*, to reflect those accomplishments, improved understandings, and recommendations.

In response to feedback from many sources, DOE has taken steps to better coordinate and manage groundwater and vadose zone activities.

In August 2006, the United States Government Accountability Office released a report titled *Nuclear Waste: DOE's Efforts to Protect the Columbia River from Contamination Could Be Further Strengthened* (GAO 2006). In response to the report, DOE took steps to better coordinate and manage groundwater and vadose zone activities at the Hanford Site. These steps included (1) consolidating most groundwater and vadose zone activities under a single project, (2) better coordinating groundwater cleanup decisions with decisions about how to address vadose zone contamination, and (3) consolidating responsibility for coordination of risk assessment and modeling efforts under one project. DOE has also identified specific project objectives and developed performance measures to gauge progress. Using those measures, DOE is evaluating the groundwater and vadose zone activities.

This document discusses the recent project changes. It also highlights the elements of the results-oriented performance measurement program that will be implemented to gauge effectiveness of the project. The management approach is also closely linked (Figure 1.2) to the Hanford Site Groundwater Strategy (DOE 2004). The groundwater strategy was developed by DOE, EPA, and Ecology to provide a strategy to protect the Columbia River from contaminated groundwater resulting from past, present, and future operations at the Hanford Site and to protect and remediate groundwater. Actions will be implemented through *Comprehensive Environmental Response, Compensation and Liability Act* (CERCLA) or *Resource Conservation and Recovery Act* (RCRA) evaluation and decision documents, groundwater monitoring plans, and remedial action/corrective action work plans. Performance evaluation will occur through the performance metric analysis described in this document, CERCLA five-year reviews (e.g., DOE 2006b)

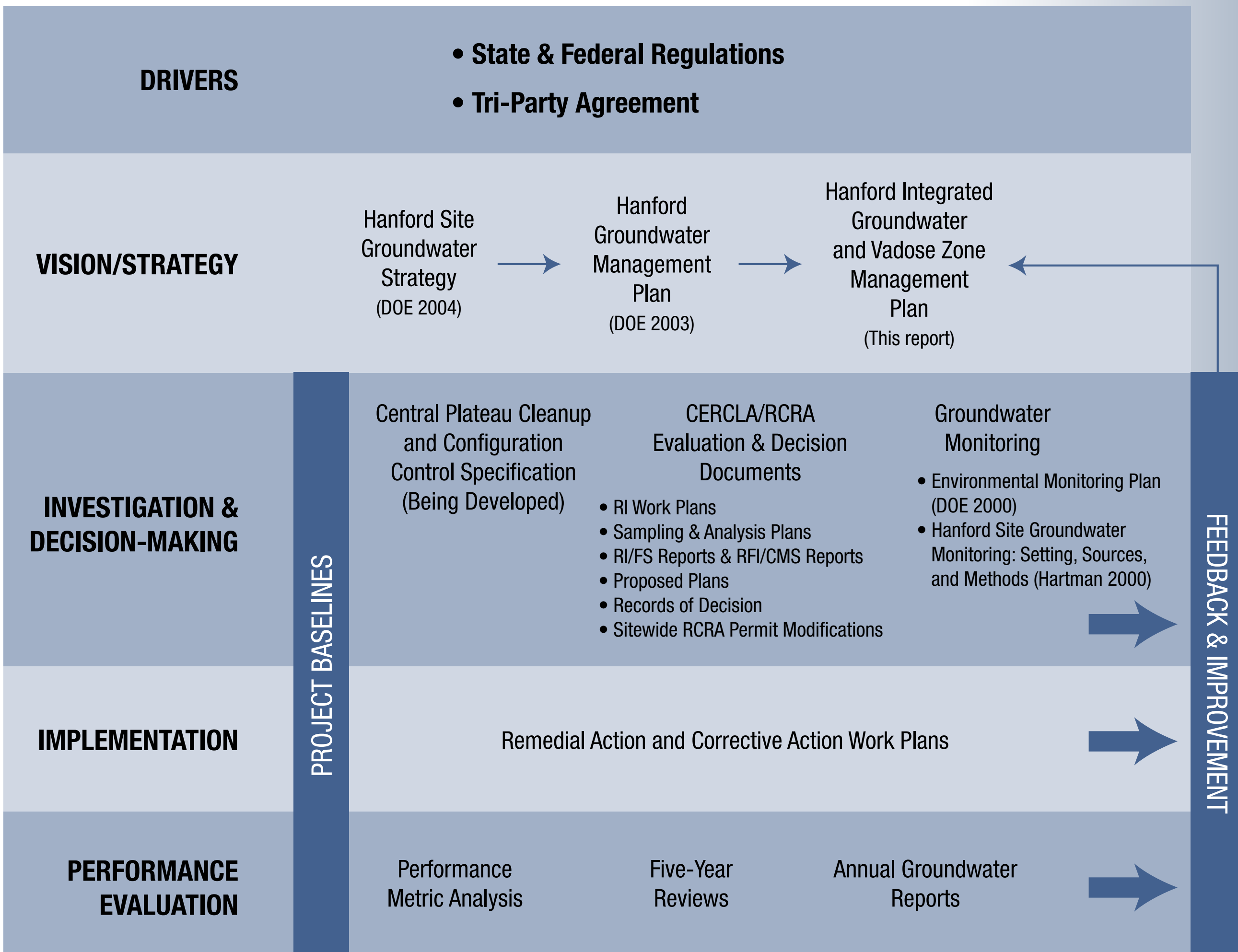

Figure 1.2. This figure shows the relationship between the Integrated Groundwater and Vadose Management Plan and other key Hanford documents.

and periodic groundwater reports (e.g., Hartman et al. 2007). This section summarizes the history, accomplishments, and plans for the future for the Groundwater Remediation Project.

1.1 History

The legacy of 50 years of defense production remains below the surface of the Hanford Site (Figure 1.3). Approximately, 450 billion gallons of liquids, some containing radionuclides and hazardous chemicals, were released to ground on the Hanford Site. Much of the contamination remains above the water table; however, at sites where large volumes of liquid were released, the more mobile contaminants have reached groundwater. Some contaminant plumes from the Central Plateau, such as tritium and nitrate, have reached the Columbia River. Additional contaminant plumes such as chromium, strontium-90, and uranium originating in the 100 or 300 Areas have also reached the Columbia River.

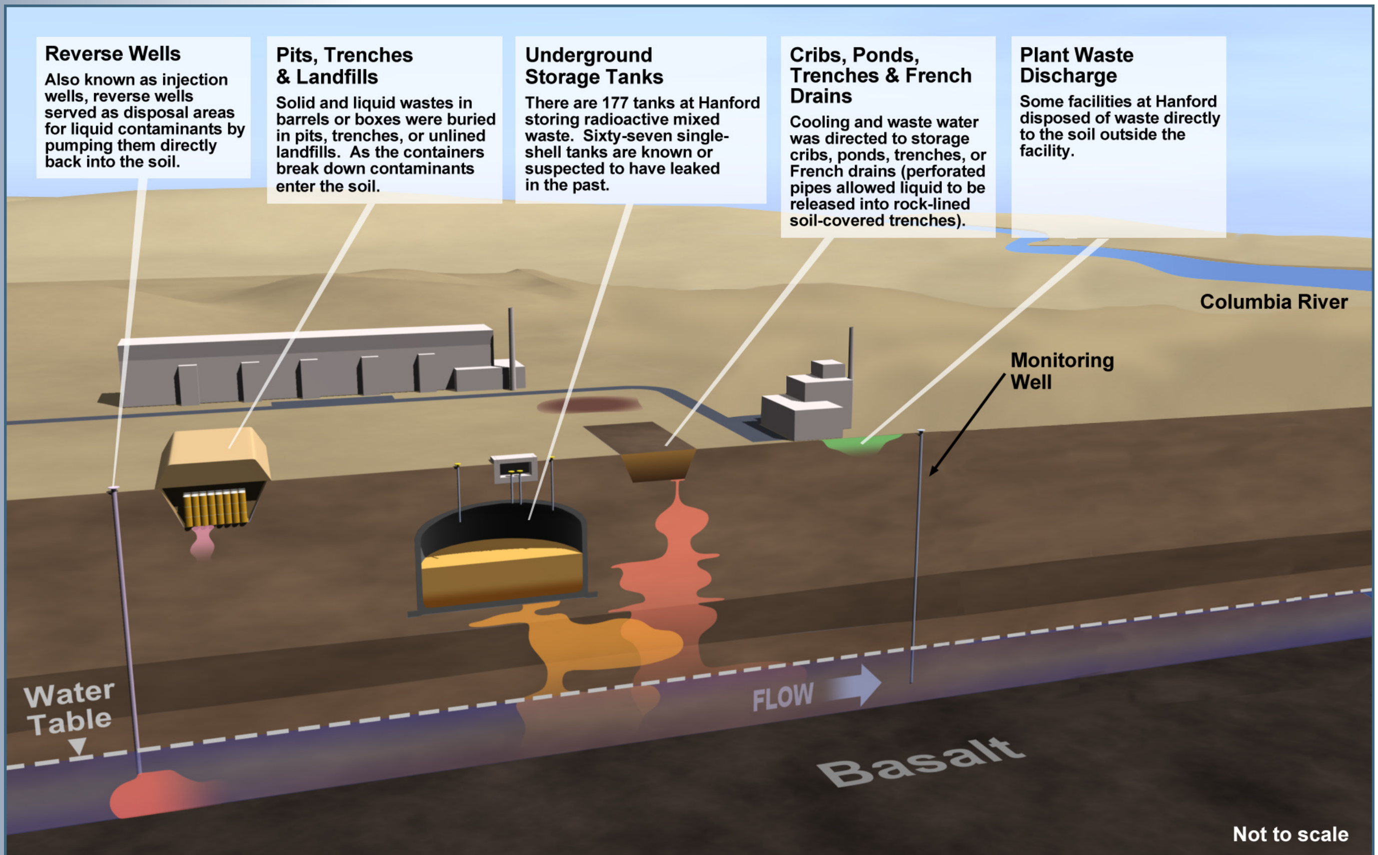

Figure 1.3. These are existing or potential sources of groundwater contamination on the Hanford Site. Processing facilities and waste tanks shown are located in the Central Plateau (200 Areas).

Considerable progress has been made toward each of the 2003 Plan goals.

The major chemical contaminants present in Hanford groundwater include carbon tetrachloride, chromium, and nitrate. Major radioactive contaminants include iodine-129, strontium-90, technetium-99, tritium, and uranium. During the defense-production era, the vast quantities of liquid discharged to the soil resulted in a "mounding" of the groundwater in and around the 200 Areas. Since the discharge of liquid waste ceased in the mid-1990s, these mounds have diminished, which has slowed the transport of contaminants in the groundwater and lengthened travel time to the Columbia River.

1.2 Accomplishments

Considerable progress was made toward each of the major 2003 Plan program elements of preventing degradation, remediating groundwater, and monitoring groundwater.

Preventing Degradation. Significant progress was made to seal off the pathways for contamination to move to the groundwater and reduce or eliminate the natural and artificial sources of water near contaminated soil. These actions reduced the potential to mobilize contaminants already in the soil. Removing from service older wells that were not constructed to current standards (referred to as well decommissioning) was a major focus. The

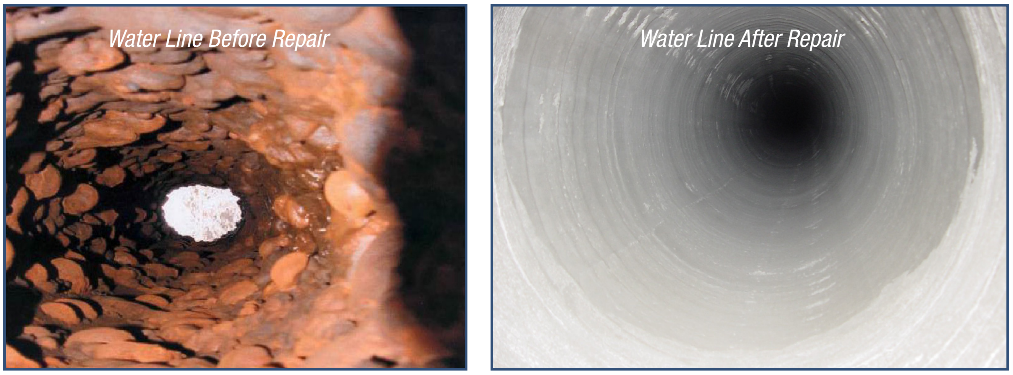

Figure 1.4. Water lines were repaired or replaced to stop water from leaking into the ground.

Hanford Site Well Decommissioning Plan (DOE 2006a) describes the many elements of this complex activity that begins with identifying and classifying the thousands of investigation holes that were drilled on the Hanford Site and evaluating what condition they are in, and if they still serve a useful purpose. From 2003 through 2007, over 453 excess or unusable wells were permanently sealed and the risk of contaminant transport eliminated.

Decommissioning old wells and repairing aging waterlines have helped prevent contamination from moving into the groundwater from the vadose zone.

Another major effort was to identify aging waterlines located in the vicinity of contaminated soil sites, that either had leaked, or had the potential to leak, large volumes of water (Figure 1.4). Pipelines that were no longer needed were removed from service by cutting the pipeline and sealing off or removing the unneeded section. Pipelines that continue to be used have been pressure tested to identify leaking sections to be targeted for repair or replacement. In the past 4 years, 5 miles of pipe that pose some of the greatest risk have been repaired or replaced. Pipes were relined using a concrete-lining technique that refurbished the existing lines. The life of these lines was extended beyond their planned use.

A workshop was held in April 2005 to evaluate technologies that could prevent contaminants that remain in the vadose zone from impacting groundwater. One recommendation from the workshop was that soil desiccation (drying) be evaluated as a way to slow the movement of contamination in the soil zone and thereby mitigate future impacts to groundwater. A treatability test plan for the deep vadose zone is currently being developed to provide information to assist in evaluating remedial alternatives.

Remediating Groundwater. DOE is cleaning up groundwater on a number of fronts across the Hanford Site. An overview of some of the more significant actions is shown in Figure 1.5.

Two approaches are being implemented that are achieving meaningful results in groundwater remediation:

- Groundwater cleanup actions are being integrated with soil contaminant cleanup and/or coupled with actions to eliminate natural or artificial water sources.

Integrated soil and groundwater cleanup actions have resulted in the cleanup of chromium-contaminated groundwater entering the Columbia River from the 100-H Area.

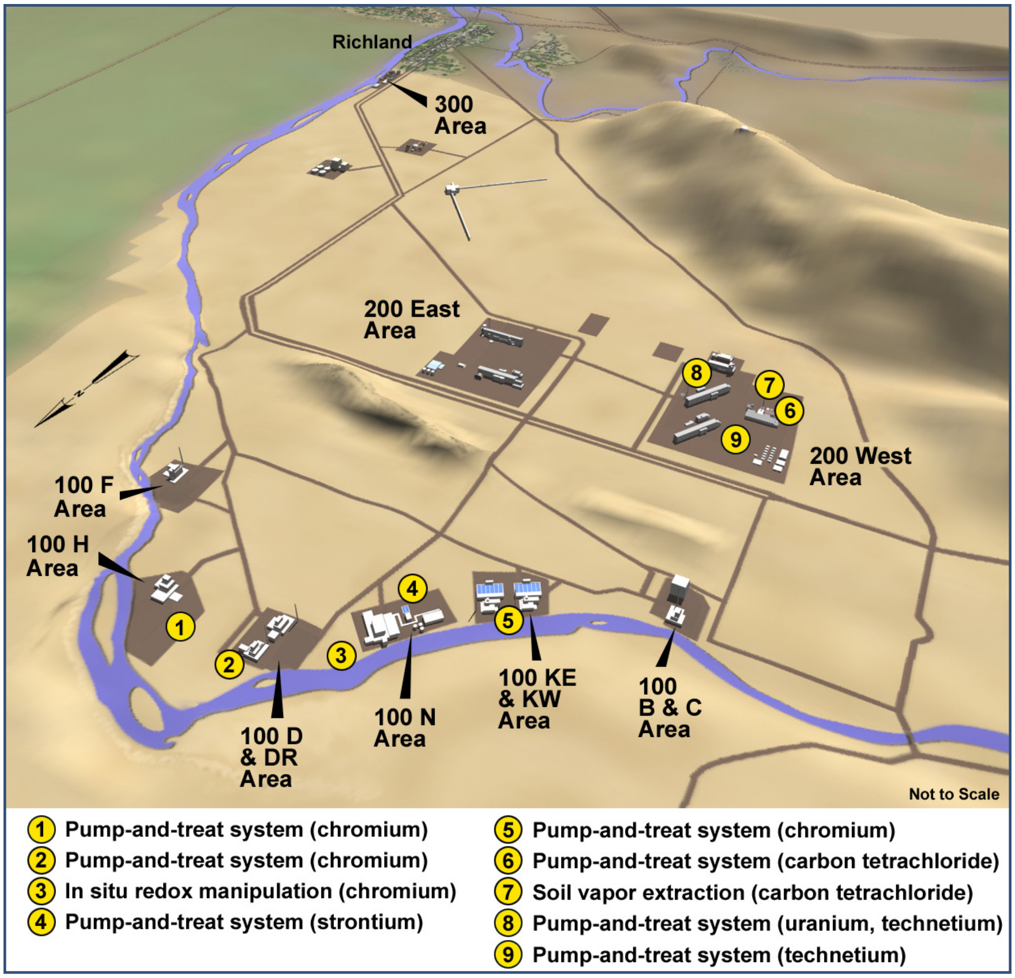

Figure 1.5. Overview of groundwater remediation actions.

- DOE is investing in evaluation and implementation of promising treatment technologies. These technologies are either new or proven elsewhere, but not previously evaluated or implemented at Hanford.

Integrated soil and groundwater cleanup actions are key to Hanford's success. An example is the cleanup of chromium contaminated groundwater entering the Columbia River from the 100-H Area (Figure 1.6). The removal of high priority liquid waste sites and other key chromium sources was completed in 2005 at about the time when an aggressive management approach was taken to move extraction and injection well locations in an effort to isolate and remove the remaining groundwater contamination. The groundwater was cleaned up to remedial action objective levels in April 2006. However, recent analyses indicate that there may be deeper contamination in the soil column and groundwater samples show contamination exists deeper in groundwater. This will be the target of a future remedial investigation/feasibility study to identify remaining actions to cleanup this area. This integrated approach is being pursued in the other 100 Areas that have chromium contamination.

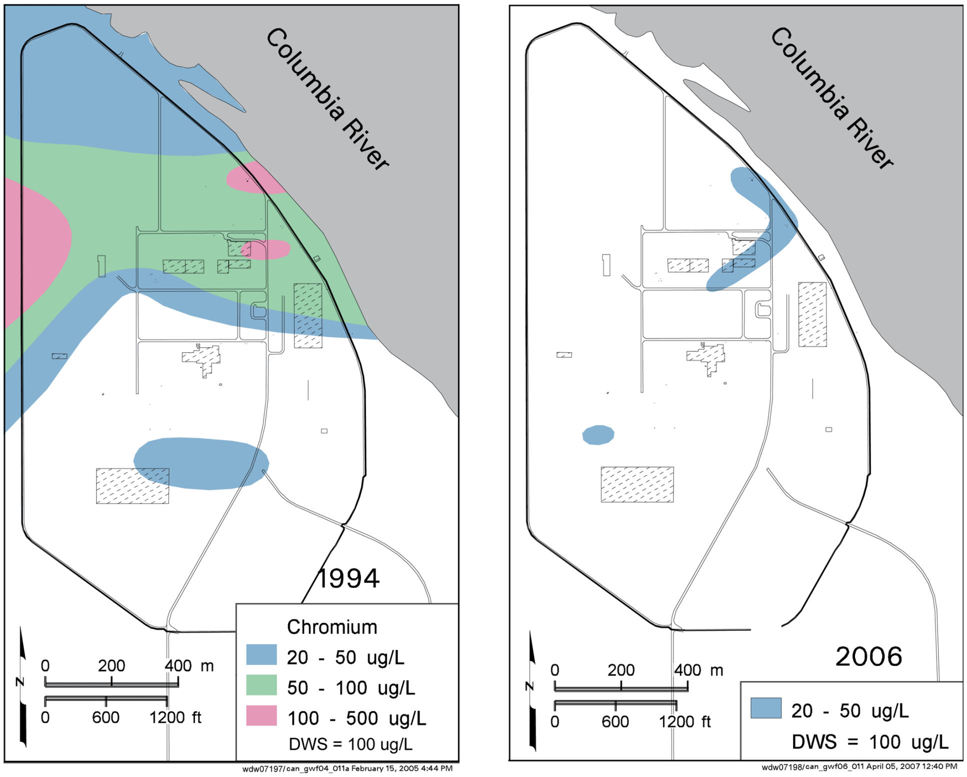

Figure 1.6. A pump-and-treat system in the 100-H Area reduced the amount of chromium entering the Columbia River. Between 1994 and 2006, concentrations decreased through most of the plume.

Another set of integrated actions, based on a different set of cleanup challenges, were taken in the central part of the Hanford Site (200-UP-1 Operable Unit). This effort combines a groundwater pump-and-treat action with the sealing off of old wells, the repair/refurbishment of aging waterlines (see the previous Preventing Degradation discussion), remediation of the 221-U Facility and soil cleanup actions for the 200-UW-1 waste sites. Uranium and technetium-99 groundwater contaminant plumes (Figure 1.7) were cleaned up in early 2005 to remedial action objectives prescribed in the record of decision for interim action (EPA 1997) and have remained below those levels (480 µg/L uranium, 9,000 pCi/L technetium-99) for over 1.5 years. The drinking water standard for uranium was also lowered since the record of decision. In early 2007, DOE restarted the 200-UP-1 pump-and-treat system to further reduce groundwater contamination in the area. At the current time, there is no evidence of any deep vadose source continuing to contaminate the groundwater. A decision for the remediation of the 221-U Facility (U Canyon) was issued in the fall of 2005. The selected remedy for the 221-U Facility is to consolidate items already within the canyon into below-grade portions of the canyon structure, back fill voids with grout, partially demolish the above-grade structure, and bury the remaining structure beneath an engineered barrier. This remedy will effectively sever potential pathways of release or exposure to contaminants left in

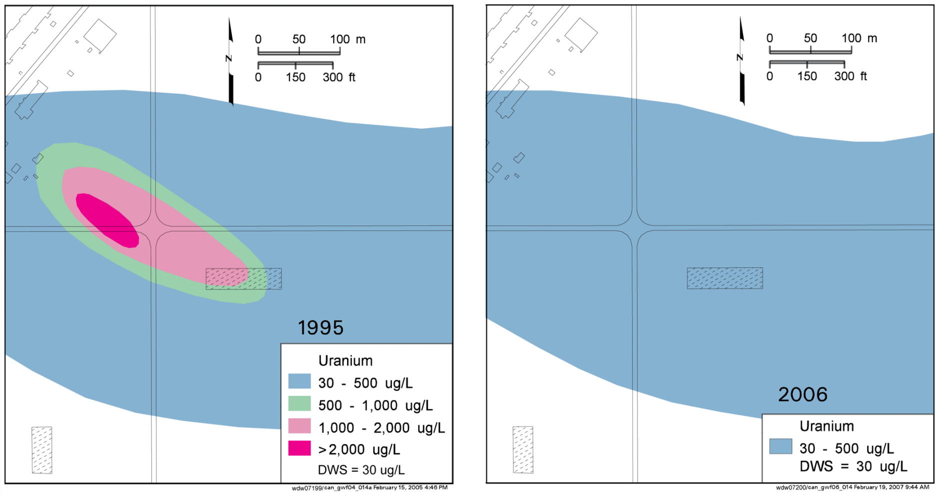

Figure 1.7. Uranium contamination in the Central Plateau is responding to the pump-and-treat system and concentrations are now below the remedial action goal.

New technologies hold promise for reaching final remediation of many of the groundwater contaminant plumes.

the 221-U Facility. A decision on soil cleanup actions for the 200-UW-1 Operable Unit is expected to be issued in calendar year 2007.

Technology development and implementation was emphasized in the 2003 Plan. Two new technologies for chromium cleanup were successfully tested: (1) a new resin-based system for pumping and treating high-concentration plumes and (2) a calcium-polysulfide-based system for in-ground and above-ground treatment. The resin system was implemented in the 100-D Area and is actively removing chromium from the most highly contaminated chromium plume on the Hanford Site. In addition, DOE obtained new funding from the DOE Headquarters Office of Groundwater and Soil Remediation (EM-22) to test three additional treatments (injection of micron-size iron, electrocoagulation, and biostimulation).

Strontium-90 remediation using the injection of a phosphate mineral (apatite) was tested and results are promising for completion of a 300-foot barrier that will immobilize the strontium before it can reach the Columbia River. Also, a focused feasibility test was initiated in the 300 Area to assess alternative treatments for uranium, primarily injecting calcium polyphosphate to create a passive barrier. These accomplishments, as well as a number of significant operational improvements, have all helped to refocus the priorities for groundwater remediation. While much has been accomplished, much remains to be done.

Monitoring Groundwater. DOE has continued its extensive groundwater monitoring effort. In addition, DOE and the regulatory agencies have placed greater emphasis on determining the vertical extent of groundwater contamination, evaluating new and expanding areas of contamination, increasing the number of monitoring locations on the banks of the Columbia River, and establishing long-term priorities for installing new monitoring wells. One example of an improvement to the monitoring project is the advances that were made in interpreting the lateral and vertical extent of the carbon

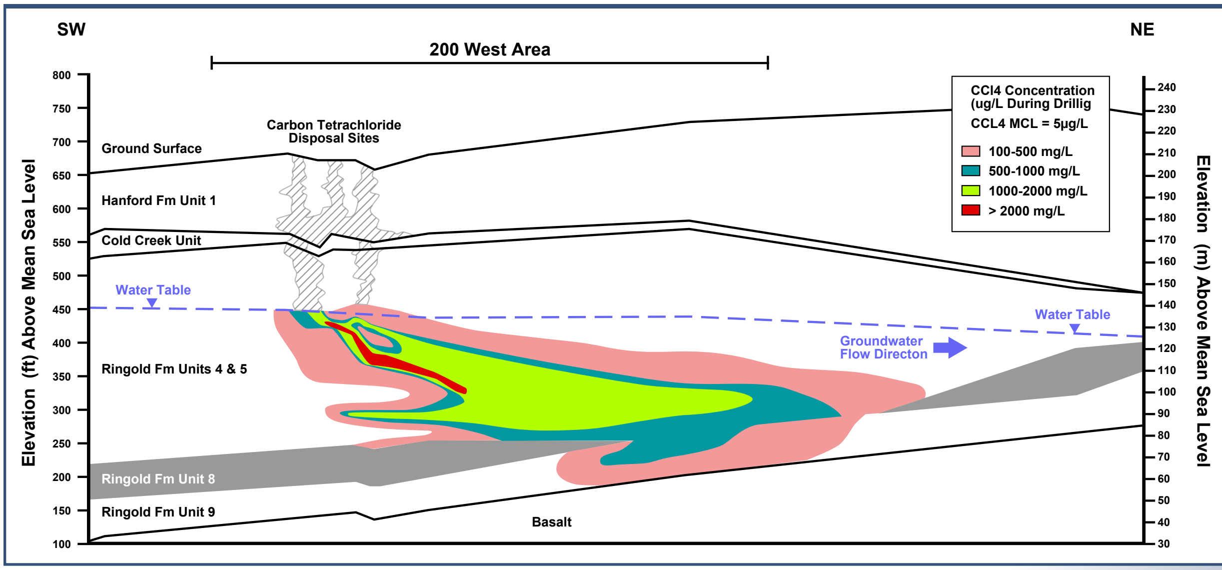

Figure 1.8. Lateral and vertical extent of carbon tetrachloride in the 200 West Area based on recent characterization data.

tetrachloride plume (Figure 1.8) in the 200 West Area, which is a critical factor in evaluating the effectiveness of remediation technologies.

Another result of the monitoring effort was detection of a new chromium plume in the 100-K Area and the initiation of a new pump-and-treat system. An emerging high-concentration technetium-99 plume in the 200 West Area that extends to significant depths in the groundwater was also discovered. A new pump-and-treat system to treat this plume is planned to start in the summer of 2007.

This document reflects substantial progress in groundwater clean-up—preventing degradation, remediating groundwater, and monitoring groundwater. Current and future cleanup and protection work will continue to have the results-oriented focus linked to clear performance objectives.

Remedial investigations and feasibility studies are providing new insights into the complicated nature of cleanup challenges for groundwater protection and restoration.

1.3 Improved Understanding

The last three years have provided a wealth of new information on the nature and extent of contamination across the Hanford Site. The recent emphasis on both source characterization in the 200 Areas and the installation of numerous monitoring wells across the site has increased the knowledge about the nature and extent of contamination in the vadose zone and groundwater.

In the 100 Areas, characterization and remediation efforts continue to enhance understanding of the extent of chromium contamination in the groundwater. In some areas, chromium plumes were found to be larger than previously thought. This appears to be primarily the result of releases from areas where chromium solutions were prepared for use in reactor operations. These releases were not a result of planned disposal of liquids to the soil, but are likely the result of leakage from underground piping used to transport chromium solutions to the reactor buildings. Finding the exact locations of these releases continues to be challenging.

Better understanding of Hanford's unique geotechnical environment and the way contaminants behave in this environment will lead to better cleanup decisions.

In the 200 Areas, remedial investigations and feasibility studies of source and groundwater operable units under CERCLA and field investigations of the tank farm waste management areas under RCRA have provided new insight into the complicated nature of cleanup challenges for groundwater protection and restoration. These investigations have produced information that may change the approach, for example:

- Identification of deep vadose zone uranium contamination found beneath the B-BX-BY Tank Farm.
- Existence of deep groundwater contamination located just downgradient of the T Tank Farm containing commingled plumes of technetium-99 and carbon tetrachloride.
- Additional small plumes of highly concentrated technetium-99 in 200 West Area.

Additional investment in science and technology has led to an enhanced technical understanding of Hanford Site hydrology as well as the behavior of key contaminants in the vadose zone and groundwater. Considerable knowledge regarding the hydrology and geochemical behavior of Hanford wastes in the vadose zone and groundwater has been gained from the following activities:

- Identified and documented key geochemical processes that have acted on contaminants associated with leaked tank wastes and intentional discharges to the vadose zone to control their chemical evolution and mobility, including ion exchange, dissolution and precipitation, colloid formation and migration, complexation, and microbial transformations.
- Resolved the issue of cesium-137 migration beneath the SX-108 waste tank and developed a general model for cesium-137 migration at the site.
- Completed ion-exchange studies that predict low future migration potential for strontium-90 associated with tank leaks and developed a general geochemical model for strontium-90 that is being confirmed at the 100-N Area.
- Characterized uranium migration in the 300 Area and also associated with the BX-102 tank overfill and the TX-104 tank leak. At each of these locations, different behaviors were observed. These observations are being assembled to develop a general geochemical model for uranium fate and transport at Hanford.
- Completed and documented the Vadose Zone Transport Field Study, consisting of four field injection experiments performed at two different locations. This study identified the importance of fine-scale features on lateral migration of contaminants in the vadose zone and also performed initial tests of field characterization technologies such as high-resolution resistivity being applied to the vadose zone.

- Developed new vadose zone flow and transport models that incorporate fine-scale heterogeneities and moisture-dependent anisotropy to better represent transport of mobile contaminants such as technetium-99 in the vadose zone at locations such as the 200-BC Cribs and Trenches.

The use of subsurface electrical resistivity methods in the Central Plateau to examine the distribution of contaminants in the subsurface may provide a level of characterization not attainable with borehole characterization alone. At the 200-BC Cribs and Trenches, this non-intrusive technique revealed the presence of a large region of anomalous low soil resistivity beneath these waste sites. Soil resistivity is reduced by the presence of moisture, especially moisture containing a high concentration of salts. A preliminary conclusion is that the mobile components of the waste released to these waste sites will be located in this low resistivity region. Figure 1.9 shows an example of these resistivity results. Subsurface electrical resistivity was also used to characterize the distribution of low resistivity due to the migration of contaminated liquids beneath the S, U, C and T Tank Farms and is planned for a number of additional locations. Work needs to be done to fully understand the correlation between subsurface electrical resistivity results and contaminant distribution; however, the initial results suggest this will be a valuable tool in guiding the vadose zone and groundwater characterization and cleanup activities.

The challenge is to develop new technologies and respond to emerging issues while maintaining steady progress toward remediation goals.

Another tool that is improving the ability to characterize contaminants in the vadose zone is the hydraulic hammer. The hydraulic hammer drives a hollow pipe into the soil and rotates the pipe as it moves into the soil. At the end of the pipe is a specially designed hardened tip that can push through gravel and compacted soil. Once the tube is at the appropriate depth, a soil sample can be obtained or probes can be lowered down the hollow pipe to

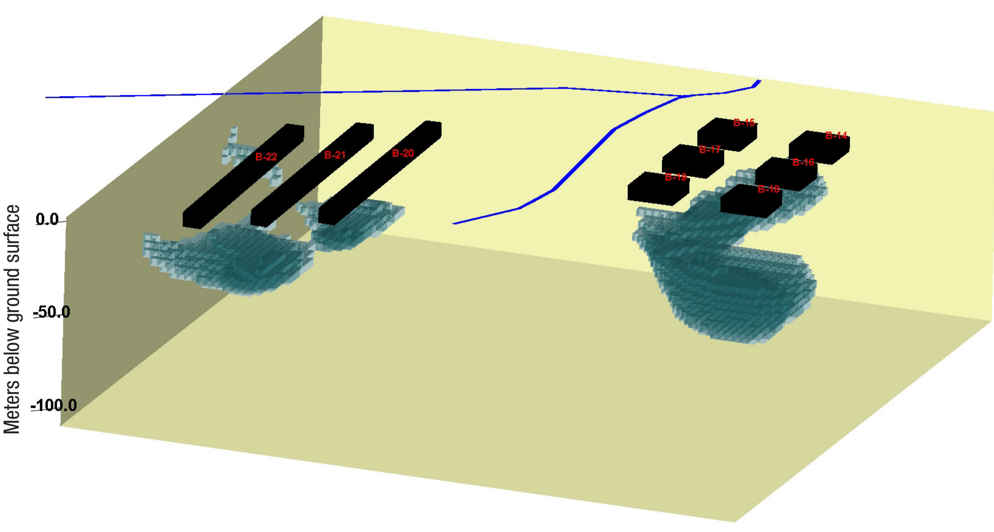

Figure 1.9. Subsurface electrical resistivity results showing regions of anomalous low soil resistivity in a portion of the 200-BC Cribs and Trenches.

obtain readings on soil moisture and radiation. This technology has been used to improve characterization of tank farms and waste sites in the Central Plateau.

The complexity of uranium behavior under certain environmental conditions is also becoming better understood. In the 300 Area, uranium concentrations have not declined to below drinking water standards through monitored natural attenuation following removal of the source as predicted. An alternative remedy may need to be implemented at this location. In addition, recent discoveries of trichloroethene (TCE) at depth in the aquifer will likely require evaluation of additional remedial alternatives.

1.4 Success Factors

A number of factors must be considered for the Groundwater Remediation Project to provide long-term protection of Hanford groundwater. Many of these factors relate to the ability of the Tri-Party Agencies (i.e., DOE, EPA, and Ecology) to collaboratively establish realistic long-term goals and objectives for groundwater protection and restoration.

The hydraulic hammer is a tool that is helping to improve the characterization of contaminants in the vadose zone.

To date, groundwater cleanup goals for the 1100 Area and the 300 Area have used drinking water standards as the goal for the cleanup of groundwater. Actions taken in these areas have focused on the remediation of existing groundwater contamination, with limited future impacts expected from continuing sources. The remedial action objectives were achieved for the 1100 Area leading to the removal of this site from the National Priorities List in 1996; however, the 300 Area has yet to achieve the remedial action goal set there and an investigation is under way to determine what further actions may be warranted.

Future decisions are required to establish the course of groundwater protection and restoration. To make technically defensible cleanup decisions, the Tri-Party Agencies, need to agree on the level of characterization, the contaminants to be addressed, and the cleanup alternatives to be evaluated. Once these parameters are agreed to, preliminary remediation goals are needed to evaluate the performance of the potential cleanup alternatives. An evaluation of remedial alternatives is prepared by DOE and its contractors and is approved by the appropriate lead regulatory agency.

The CERCLA remedy selection process requires each alternative be evaluated objectively against nine criteria (CERCLA §121 (b)) (Figure 1.10). Obtaining future cleanup decisions depends on developing cleanup alternatives that meet the two threshold criteria of overall protection of human health and the environment and compliance with applicable or relevant and appropriate requirements. Once an alternative has met the threshold criteria, the balancing criteria are applied to assess the efficacy of each alternative and select a preferred alternative. The modifying criteria (state

Figure 1.10. The nine CERCLA criteria guide remediation decisions.

The nine CERCLA criteria are divided into three categories: threshold, balancing, and modifying. The remedial actions are evaluated against these nine criteria to select the appropriate remediation.

and community acceptance) are then applied through the public comment process and input gathered during the comment period can influence the selection of the cleanup remedy.

For RCRA waste-management units not subject to the CERCLA remedy selection process, the Groundwater Remediation Project provides compliance monitoring and support for subsurface investigations to develop the requirements for closure and, if necessary, corrective action at RCRA units. Sections 2.1.4 and Section 3.1 provide a summary of the actions being taken to ensure coordination and consistency between CERCLA cleanup and RCRA closure processes.

1.5 Guide to the Plan

The remainder of this document describes an integrated plan for future groundwater and vadose zone cleanup and protection actions that includes:

- Implementing remedies and monitoring their performance to ensure they are successful.
- Testing and implementing new technologies for cases where a remedy is not successful, or no conventional remedy is applicable.
- Taking action to address emerging groundwater contaminant plumes.
- Conducting additional characterization at sites with complex problems so that enduring remedial decisions can be made.

Section 2.0 of this document describes an integrated approach to address these needs. A set of immediate actions are outlined that are being implemented without additional characterization work. These actions will result in near-term control of contamination and provide information on the response of the contamination to active remediation measures, which will aid the final decision-making process. Some of these actions will satisfy final remediation goals while others will not. Specific integrated actions that provide the greatest benefit and likelihood for success are described along with completion strategies for major areas on the Hanford Site.

Section 2.0	Describes the integrated groundwater protection strategy including the immediate actions being taken and the completion strategies for major areas of the Hanford Site.
Section 3.0	Describes the integrated approach being taken at Hanford to manage all of the Site's groundwater and vadose zone activities. The section concludes with a description of the results-oriented performance measures to be used to drive the cleanup process.
Section 4.0	Identifies the Project Public Information and Involvement Opportunities and describes how the project will inform and involve the regulatory agencies, Tribal Nations, stakeholders, and the public.

Program management is presented in Section 3.0. The Groundwater/Vadose Zone Integration Initiative is described as well as DOE and contractor organizational structures. The section concludes with a description of results-oriented performance measures and the evaluation process that is to be implemented. This section also addresses concerns identified by the Government Accountability Office (GAO 2006).

Key to the success of cleanup at the Hanford Site is involving and communicating with the public. Section 4.0 contains the Project Public Information and Involvement Opportunities that describe how the project will inform and involve the regulatory agencies, Tribal Nations, stakeholders, and the public. The public most interested in the Hanford Site is a large, passionate, diverse, and geographically dispersed community, united by a common interest to protect the Columbia River and have a voice in Hanford's future. Building the mutual trust and support to move ahead on difficult issues requires an accessible and inclusive program for involving this community.

The public most interested in the Hanford Site is a large, passionate, diverse, and geographically dispersed community, united by a common interest in protecting the Columbia River and having a voice in Hanford's future.

Groundwater monitoring relies on samples from wells across the Hanford Site.

2.0 Integrated Groundwater/Vadose Zone Protection Strategy

This section summarizes the early actions, continuing investigations, and regulatory processes required to protect the Columbia River and, where practicable, restore Hanford's groundwater resources. In addition to a summary of each of these strategy elements, descriptions of the efforts to integrate the cleanup and protection activities across DOE field offices, contractors, and regulatory processes are also contained in this section.

The groundwater actions are focused on containing the groundwater plume and reducing the mass of the primary contaminants of concern released from the vadose zone into the groundwater. Treating contaminants in groundwater prevents them from entering the Columbia River.

2.1 Protect the Columbia River and Groundwater

Early remedial actions to address principal threats to the Columbia River and groundwater beneath the Hanford Site have been underway since the mid-1990s. One of the key actions that has reduced the threat to groundwater was the cessation of the discharge of all unpermitted liquids in the Central Plateau. Other early actions include both source actions in the River Corridor and groundwater actions in the Central Plateau and River Corridor. The primary goal of the source actions was to remove, treat as necessary, and dispose of contaminated soil, waste, and debris that represent a future risk to surface use and that may also impact groundwater quality. The groundwater actions are focused on containing the groundwater plumes and reducing the mass of the primary contaminants of concern released from the vadose zone into the groundwater. Treating these contaminants in groundwater prevents them from entering the Columbia River.

The River Corridor Closure Contractor (Washington Closure Hanford, LLC) has nearly completed removing the major liquid waste sites responsible for most of the existing groundwater plumes beneath the 100 and 300 Areas. The Central Plateau and site groundwater contractor (Fluor Hanford, Inc.) has focused efforts on preventing chromium and strontium-90 from entering the river in the 100 Area and evaluating the performance of the natural attenuation remedy for groundwater beneath the 300 Area industrial complex. As the source and groundwater actions move toward completion, DOE, EPA, and Ecology have initiated a work group comprised of individuals from the Tri-Party Agencies to develop a River Corridor completion strategy that coordinates source and groundwater decisions (see Section 3).

Figure 2.1 identifies the locations where active remediation technologies were employed to control the spread of groundwater contamination and limit the impacts of these primary contaminants of concern on the Columbia River. The following sections summarize the actions to contain these plumes and the additional efforts planned to enhance the performance of these actions and protect the river.

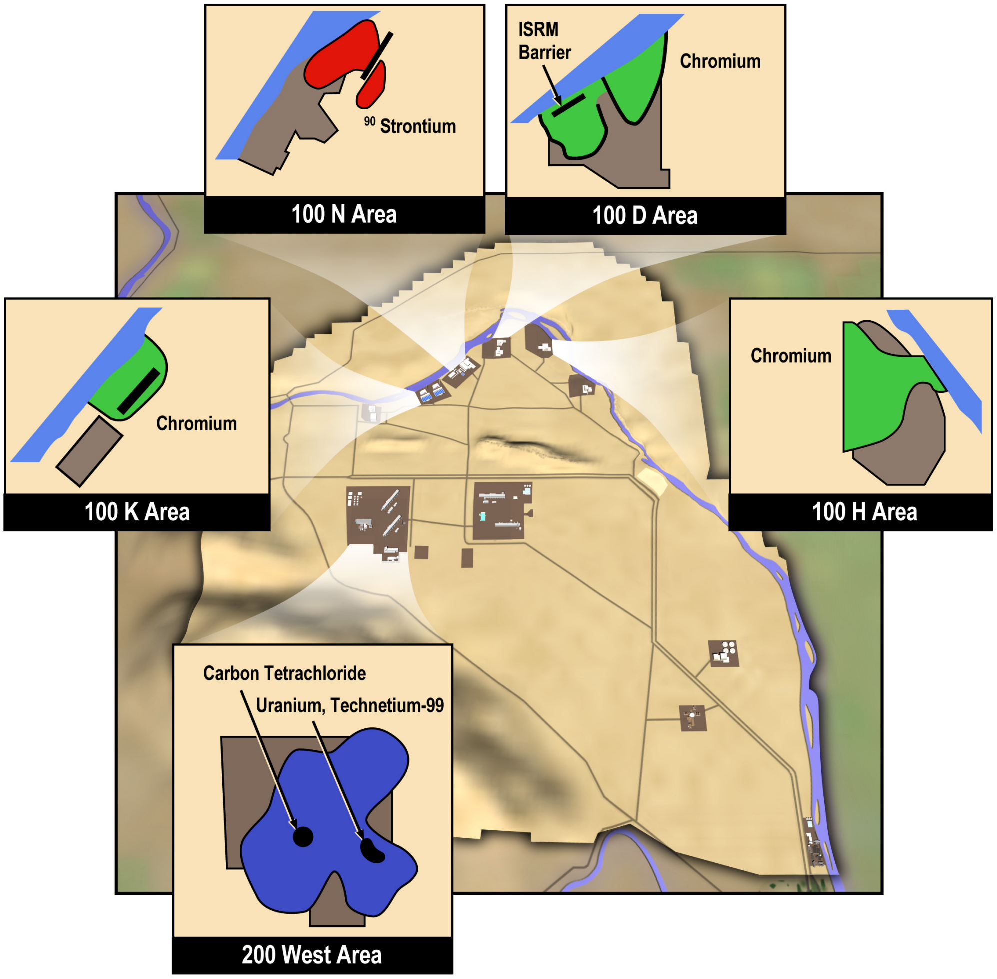

Figure 2.1. Hanford Site groundwater pump-and-treat systems help contain contaminant plumes and reduce the amount of contamination entering the Columbia River.

2.1.1 Stop Key Contaminants from Reaching the Columbia River

While DOE recognizes it is not possible to stop all contamination from entering the river, its goal is to reduce the concentration of contaminants entering the river to below levels that can cause harm. Key contaminants in groundwater adjacent to the river are chromium, strontium-90 and uranium.

Columbia River water is collected from multiple Hanford Reach sampling points each year. Water samples are analyzed for radioactive and chemical materials. Water in the Columbia River continues to be designated Class A (Excellent) by the state of Washington. This designation means that the water is usable for substantially all needs. Small amounts of radioactive material are detected down river from Hanford. However, the amounts are far below federal and state limits. In recent years, there has been no indication of any deterioration of Columbia River water quality resulting from operations at Hanford. (Hanf et al. 2005, 2006).

While DOE recognizes it is not possible to stop all contamination from entering the river, its goal is to reduce the concentration of contaminants entering the river to below levels that can cause harm.

Chromium. Chromium contamination from past operations of eight nuclear reactors located in 100-B/C, 100-D, 100-F, 100-H and 100-K Areas represents a principal threat to the Columbia River and has been the focus of both source and groundwater remedial actions in the 100 Areas since the mid-1990s. Soil contaminated with chromium and other hazardous substances from past liquid waste disposal continues to be removed, treated as necessary, and disposed at the Environmental Restoration Disposal Facility. Most of these liquid disposal sites have been removed and no longer pose a threat to 100 Area groundwater and the Columbia River. Contamination may remain in the vadose zone from former storage facilities, pipelines, and other sources.

Actions to prevent chromium contaminated groundwater from entering the Columbia River through seeps and springs were taken in 100-D, 100-H and 100-K Areas. The goal of these actions is to reduce the levels of chromium in groundwater entering the Columbia River to levels below the aquatic toxicity criteria, which is much lower than drinking water standards. Figure 2.2 presents chromium concentrations entering the river through springs and seeps from 1997 through 2006. This figure illustrates the progress made in reducing the potential impacts of chromium on the Columbia River, but also shows the need for a more robust effort to remediate plumes in 100-D and 100-K Areas.

Remedies applied to reduce chromium concentrations entering the Columbia River fall into two categories: pump-and-treat technologies and in situ remedies. Figure 2.3 illustrates the basic elements of the pump-and-treat approach. Contaminated groundwater is pumped from the aquifer, chromium is removed through a treatment process, and the remediated water is returned to the aquifer in a way that helps push the contaminated groundwater toward the extraction wells. The remedial technology, ion exchange, is being used in the above ground treatment process and electrocoagulation is being tested.

In situ treatment involves the alteration of the aquifer materials to create a permeable barrier. As groundwater carrying the contaminant flows through the barrier, it is altered to a less mobile form, thereby reducing the concentration of the contaminant in the groundwater entering the Columbia River. One application of this technology is illustrated in Figure 2.4. In situ treatment is used to treat chromium contamination in 100-D Area. In situ methods are also used to remediate strontium-90 contamination in 100-N Area, although the implementation is significantly different than that used for chromium treatment.

DOE and their Hanford Site contractors continue to work closely with the DOE Headquarters Office of Groundwater and Soil Remediation (EM-22) to test and develop additional technologies to treat chromium and other primary contaminants of concern in the River Corridor and Central Plateau.

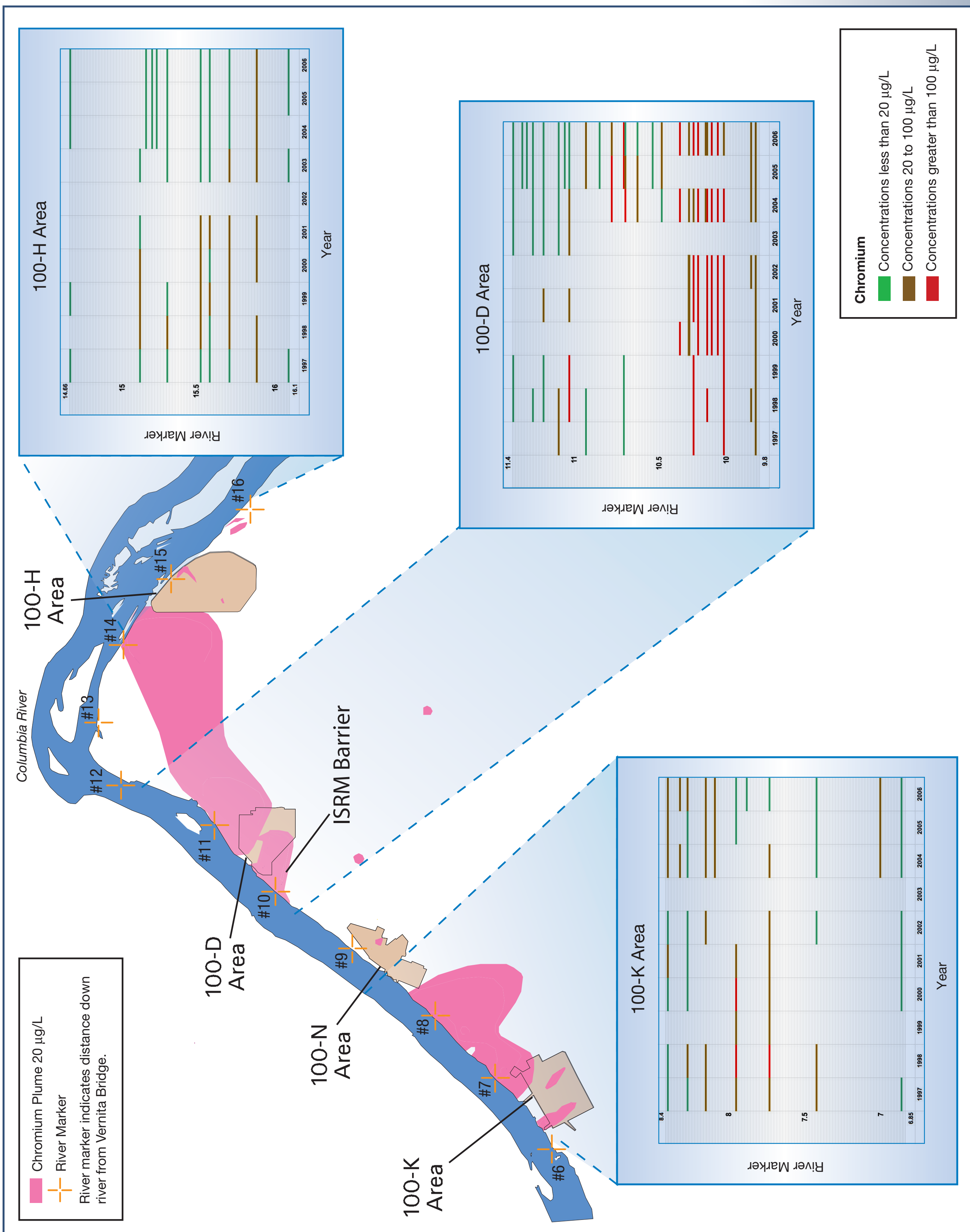

Figure 2.2. Chromium concentrations entering the Columbia River through springs and seeps (1997 through 2006).

A promising method to stop strontium-90 from reaching the Columbia River is being tested. The tests will involve injecting apatite, a natural phosphate material, into the soil to create a reactive barrier. This barrier is designed to chemically bind the strontium-90 to Hanford soils until it decays.

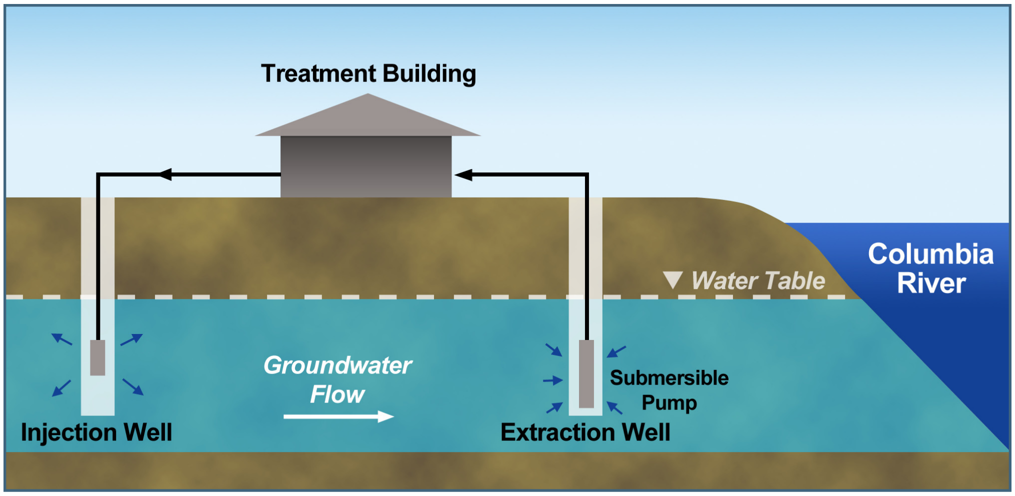

Figure 2.3. A pump-and-treat system removes chromium from groundwater.

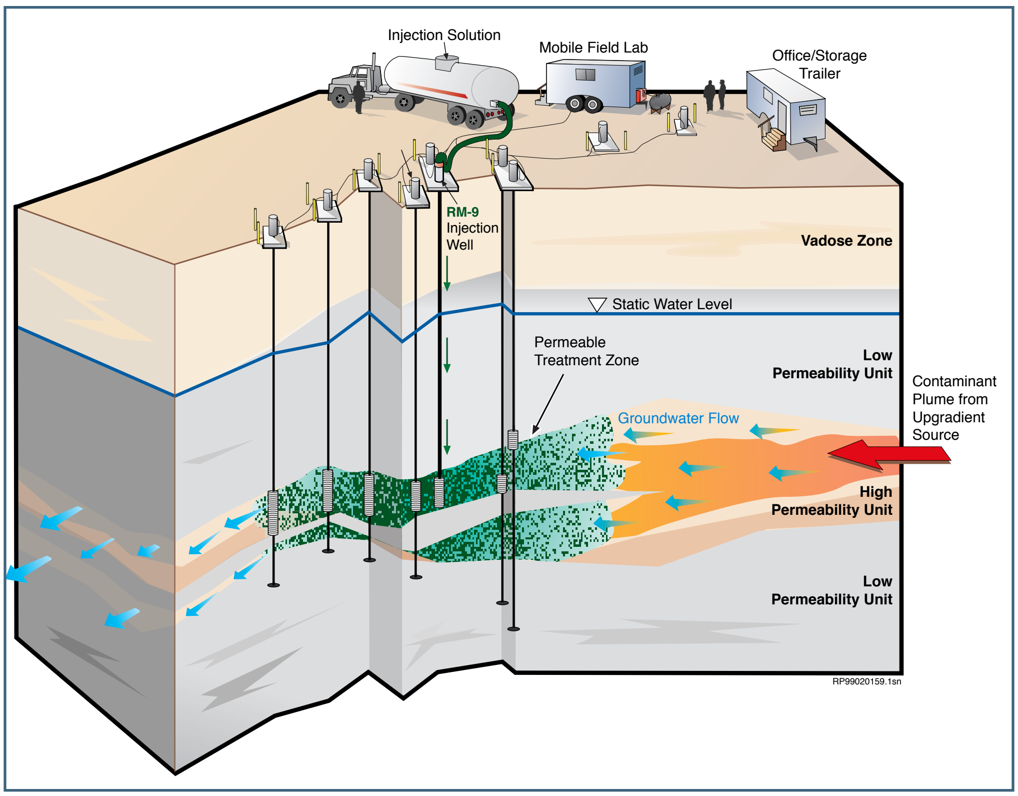

Figure 2.4. In situ redox manipulation is a technology that uses natural processes to change the mobility or form of contaminants in the subsurface.

Efforts are now underway to enhance the performance of chromium groundwater actions. These efforts include expanded and supplemental treatment capacity, additional characterization of emerging areas of contamination, and identification of previously unknown sources of chromium in the vadose zone. These previously unknown sources are likely due to the unintentional release of chromium solutions from leaking process pipelines used to deliver these solutions to the reactor buildings or storage facilities. Remediation of these newly discovered sources is a high priority for protection of groundwater and Columbia River.

Strontium-90. Strontium-90 represents the other primary threat to groundwater and the Columbia River in the 100 Area. Containment efforts have been underway for more than 10 years using pump-and-treat systems to limit the flux of strontium-90 to the Columbia River at N-Springs with questionable results. In addition, the inability of the ion exchange treatment to remove strontium-90 to below the drinking water standards requires the re-introduction of treated groundwater with elevated strontium-90, creating additional areas of groundwater contamination. This remedy has not performed as originally predicted and is now shut down to support testing new and innovative technologies to further immobilize strontium-90 through in situ treatment (Figure 2.5). Many potential technologies were screened for use in the 100-N Area to mitigate the release of strontium-90 into the river.

Though the nature and extent of uranium contamination has diminished, DOE is evaluating alternatives to reach cleanup objectives.

Uranium. Uranium contamination in groundwater beneath the 300 Area was expected to dissipate through natural attenuation to below the drinking water standard over a 3- to 10-year period following cleanup of the source sites. This remedy has not achieved the remedial action objectives as envisioned when the interim action was issued. Figure 2.6 shows the uranium concentrations in groundwater beneath the 300 Area as they were in 1995 and again in 2005. DOE is evaluating alternatives to reach cleanup objectives.

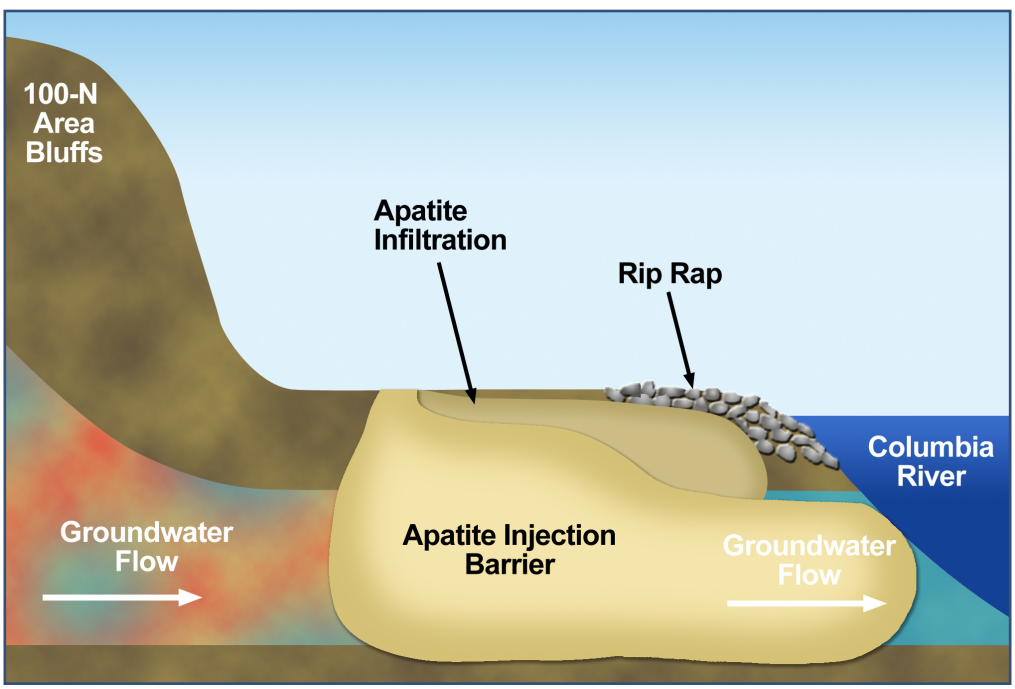

Figure 2.5. Key elements of the strontium-90 sequestration barrier at 100-N Area include apatite (calcium phosphate) injected deep into the soil and shallow apatite infiltration to capture strontium-90 before it can enter the Columbia River.

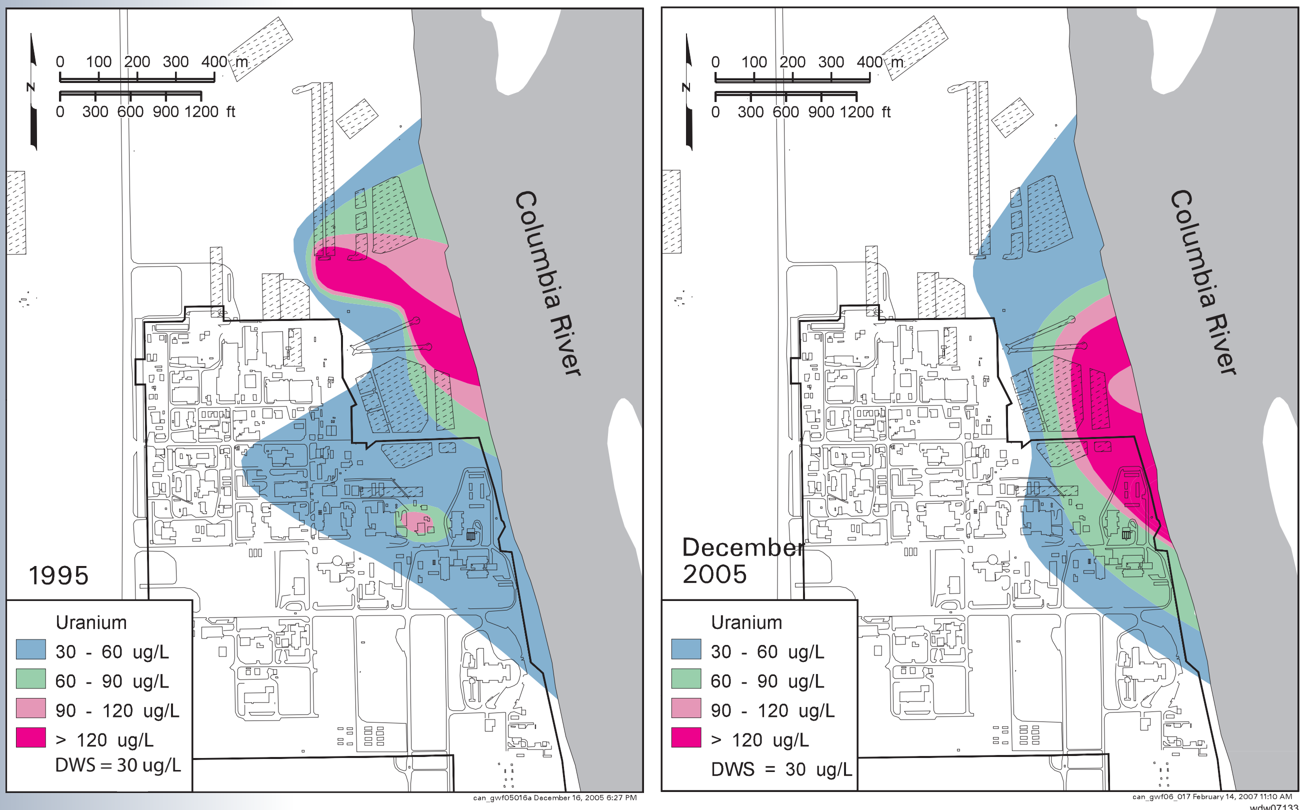

Figure 2.6. The uranium plume in the 300 Area, at the 30-µg/L level, is attentuating slowly. DOE is investigating alternatives for more rapid remediation.

Other technologies are now under evaluation as a replacement for the monitored natural attenuation remedy selected in the earlier record of decision (EPA 1996b). The injection of polyphosphate chemicals into the groundwater is a technology being considered. The injection of polyphosphate chemicals is expected to react with the uranium in the groundwater and form insoluble uranium phosphate compounds that substantially reduce the uranium concentrations in the groundwater and subsequently reduce the amount of uranium entering the Columbia River.

Technetium-99 deep in the groundwater near T Tank Farm is a new cleanup challenge. A pump-and-treat system is being designed and constructed to capture and treat this contamination.

2.1.2 Reduce Mass of Contaminants in Central Plateau Groundwater

The key groundwater contaminants beneath the Central Plateau (200 Areas) are uranium, technetium-99, and carbon tetrachloride. Actions have been underway to reduce the mass and contain the spread of these contaminants in the groundwater in these areas for more than 10 years. Figure 2.7 shows the distribution of these three key contaminants beneath the Central Plateau.

Uranium and Technetium. A pump-and-treat system was installed to contain and reduce the mass of uranium and technetium-99 in groundwater below 200 West Area near U Plant. At present, the concentrations of uranium and technetium-99 have been reduced to levels at, or below, the remedial action objective, which is 10 times the drinking water standard for this interim action. Wells within this plume continue to be monitored to see if the

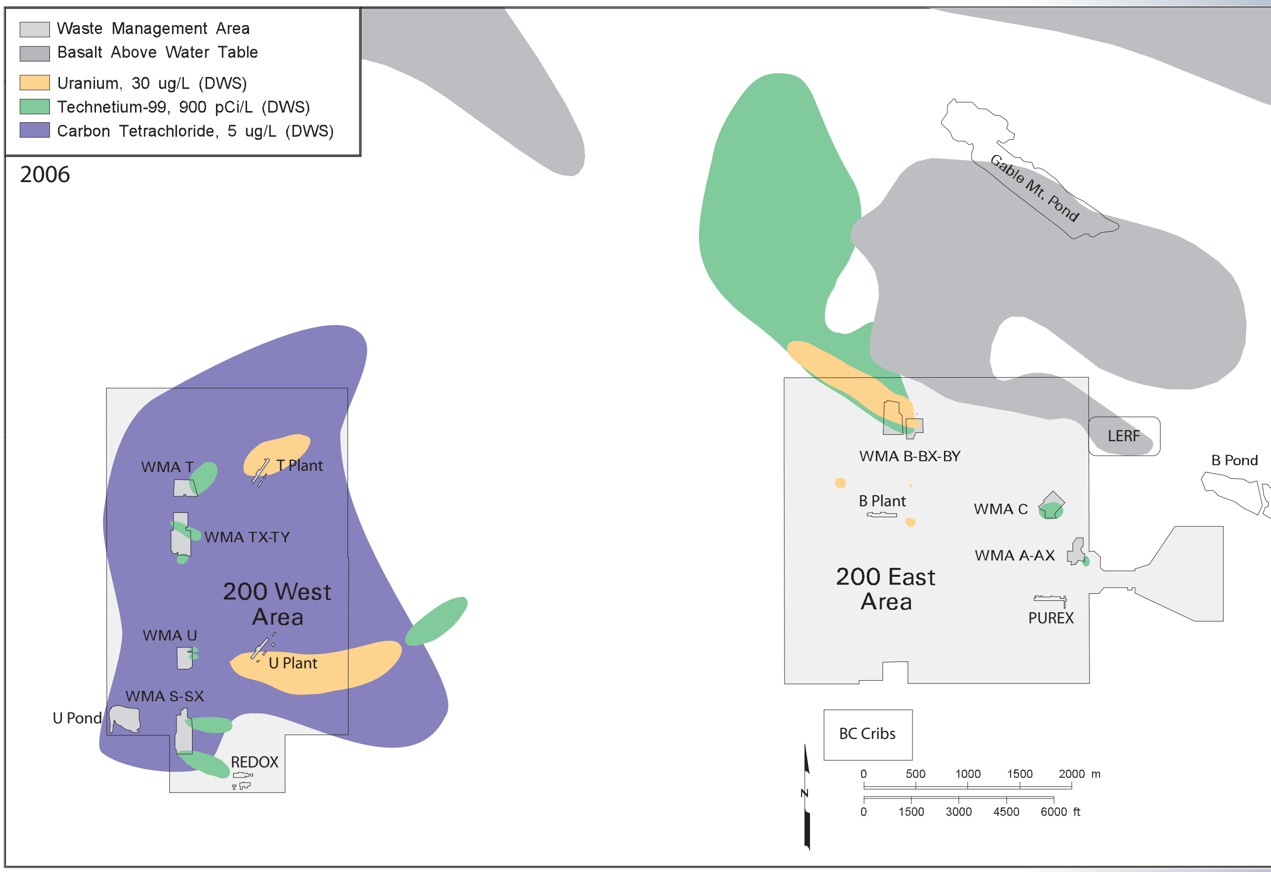

Figure 2.7. The principal threats to groundwater in the Central Plateau are uranium, technetium-99, and carbon tetrachloride.

concentrations of these contaminants rebound, potentially requiring further action. The drinking water standard for uranium has been lowered since the record of decision and DOE has restarted the pump-and-treat system near U Plant.

DOE has also taken steps to address emerging issues. Recent well drilling and monitoring results have identified a number of other plumes containing uranium or technetium-99 in the groundwater beneath the Central Plateau. Of these plumes, technetium-99 contamination deep in the groundwater near the T Tank Farm represents a new cleanup challenge. The distribution of technetium-99 contamination extends deep into the unconfined aquifer and is mixed with high concentrations of carbon tetrachloride. The design and construction of a pump-and-treat system to treat this plume is near completion. Other small plumes of technetium-99 and uranium adjacent to other tank farm waste management areas and contiguous cribs are currently being evaluated to assess the need for interim actions or to postpone remediation of these plumes until after the remedial investigation/field study process for these operable units has been completed. DOE is also investigating options to have additional treatment capacity or quickly add additional treatment capacity to enable a rapid response to any future emerging plumes.

To date, the soil vapor extraction system has removed 173,905 pounds of carbon tetrachloride from the vadose zone and 23,408 pounds from groundwater.

Carbon tetrachloride. Remedial actions have been in place for more than 10 years to recover carbon tetrachloride vapors from the vadose zone and to contain the most concentrated portion of the groundwater plume (>2 ppm carbon tetrachloride). To date, the groundwater pump-and-treat system has removed over 22,046 pounds of carbon tetrachloride from groundwater and the soil vapor extraction system has removed 173,905 pounds of carbon tetrachloride from the vadose zone. With the discovery of carbon tetrachloride deeper in the groundwater beneath 200 West Area, a significant expansion of the current pump-and-treat system is being planned. In addition to expanding the pump-and-treat system, a supplemental soil-vapor extraction system is also being considered to increase the mass of carbon tetrachloride removed from the subsurface.

Resolving the problem of carbon tetrachloride in a comprehensive manner will require a better three-dimensional understanding of the nature and extent of contamination and how pumping of groundwater from this plume can be engineered to best contain carbon tetrachloride contamination. Further, it is likely that some of the extracted groundwater will also require treatment for technetium-99 due to the mingling of plumes.

2.1.3 Reduce Recharge to Groundwater and Control Migration of Contaminant Sources

Water infiltrating into the vadose zone can carry contaminants downward in the vadose zone at the Hanford Site. Reducing natural and artificial recharge will reduce the potential for contaminants in the vadose zone to be carried to groundwater.

Water infiltrating into the vadose zone can carry contaminants downward in the vadose zone at the Hanford Site. Some contaminants are very mobile and move readily with water, while others may be less mobile because they interact with the solid material of the vadose zone. Water in the vadose zone may come from such things as natural precipitation, wastewater disposed to cribs, leaks from tanks, leaking water lines, septic tanks, or drain fields. DOE has taken extensive steps to eliminate on-site discharges of water and eliminate leaking water lines. To further control migration of contaminant sources in the vadose zone, DOE is focusing on the following activities:

- Reduce recharge.
- Maintain a consistent well-decommissioning project.
- Conduct waste site treatability tests.

Reduce Recharge. In 1998, DOE initiated a project to reduce natural and artificial recharge in, and around, the tank farms and near waste sites. The goal was to reduce the potential for vadose zone contaminants to be carried to groundwater. The project has four major components:

1. Design and construct surface water run-on control measures upgradient of single-shell tank farms and waste sites.
2. Remove from service leaking water lines adjacent to single-shell tank farms, waste sites, and other potential sources of contamination.

3. Upgrade monitoring drywells at single-shell tanks to include leak-tight caps.
4. Install an interim surface barrier over single-shell tank farms to reduce recharge until the closure barrier is installed.

Actions associated with the first three elements of this plan were completed in the single-shell tank farms. Berms were constructed around tank farms to prevent water from snow melt or other sources from running onto the tank farms, water lines running through or near the tank farms were cut and capped or rerouted around the farms, and leak-tight caps were installed on monitoring wells. Similar actions were taken near other Central Plateau waste sites.

Well decommissioning remains a high-priority action to eliminate the potential pathways that allow contaminants to reach groundwater.

Work on the fourth element of the plan will begin in 2007. An interim surface barrier demonstration is planned at single-shell tank T-106. An interim barrier will be designed, installed, and monitored to evaluate how an interim surface barrier can reduce water infiltration, and thereby lower the long-term risk from contaminants in the soil and gravel around and below tanks migrating towards the underlying water table.

Well Decommissioning. Nearly 7,000 wells were drilled on the Hanford Site and less than half are currently in use. Many of these wells were drilled prior to the institution of well construction standards to limit the possible migration of water between the well casing and the borehole wall to the groundwater. In many cases, these wells were drilled through waste sites or immediately adjacent to the waste sites for the purpose of monitoring releases to the groundwater. These wells provide potential pathways for surface water runoff or artificial recharge from the surface to enter waste contained within the vadose zone and drive contaminants toward the groundwater. Decommissioning these aging wells is a viable way to protect Hanford groundwater. As mentioned in Chapter 1, 453 wells (through April, 2007) were decommissioned since the 2003 Plan was written.

A two-phase approach was used for well decommissioning. The first phase (initiated in 2003) focused on decommissioning the high-risk wells. The second phase will emphasize well decommissioning associated with ongoing and upcoming remedial or closure actions. This phase will limit preferential pathways, remove impediments to surface barrier installation, and put in place the post-closure monitoring network needed to monitor potential releases to the groundwater. Approximately 680 wells remain to be physically decommissioned; however, 52 of these are casings with a vertical seal that pose little threat to the environment.

Plans are in place to test technologies that have the ability to remove or immobilize contamination in the vadose zone.

Treatability Tests. Plans are in place to test technologies that have the ability to remove or immobilize contamination in the vadose zone and to further advance our knowledge of site-specific chemical and physical processes that control contaminant transport in the vadose zone.

A deep vadose treatability test is planned to evaluate technologies appropriate for treating contaminants in the vadose zone beyond the reach of conventional remedies. The first step in this process will be to produce a treatability test plan that will evaluate several different technologies and choose one or two to test on the Hanford Site. This treatability test plan is scheduled to be finalized in December 2007 and will guide the technology tests.

The interim surface barrier being installed over 241-T-106 tank to reduce recharge until the closure barrier is installed will be used as a treatability test for this technology. It will be instrumented to obtain data on its performance.

2.1.4 Monitor Groundwater

Groundwater monitoring represents an integral part of the Groundwater Remediation Project. Compliance with the requirements of CERCLA, RCRA, and the *Atomic Energy Act* are the primary legal drivers for groundwater monitoring. The objectives of groundwater monitoring are to assess the nature and extent of contamination, identify any releases of contaminants from regulated units, and evaluate the performance of remedial actions. Monitoring wells continue to be installed to attain these objectives. In compliance with the Tri-Party Agreement, additional wells are installed annually to maintain the monitoring network, meet characterization needs, and to meet other data needs.

The Tri-Party Agencies are in the process of identifying additional technologies to reduce the mobility of contaminants in the deep vadose zone and protect groundwater resources.

Results of groundwater monitoring have led to the optimization of groundwater treatment systems, expansion of treatment systems in the 100 Area to reduce the concentration of chromium entering the river, detection of emerging groundwater plumes in the S and T areas of 200 West Area and detection of the expansion of the technetium-99 plume in the northern portion of 200 East Area.

Hanford Site groundwater monitoring also provides much of the data used to develop groundwater flow and transport parameters that are used to develop and improve models for risk assessment and to facilitate the evaluation of remedial alternative performance.

2.2 Cleanup Decision Process

As stated in the introduction, the goal of this project is to return groundwater to its highest beneficial use where practicable and to prevent further groundwater degradation. Key to achieving this goal is making final decisions on remediation of waste site and groundwater operable units so that remedies can be implemented and cleanup can occur. Once implemented, the remedies will be evaluated and modified, as needed, to meet the remedial action objectives. The waste sites will continue to be reviewed every 5 years as required by the CERCLA process to ensure the remedies remain protective. If the remedy is found not to be protective, the remedy will be modified. The Tri-Party Agreement will continue to provide the framework for those decisions, and it is the Tri-Party Agencies who collaboratively will need to identify and work to attain realistic, long-term groundwater protection and restoration.

2.2.1 Decision Strategy

The CERCLA process, the RCRA process, or a combination thereof, will be used to reach final decisions on the remediation of Hanford's waste sites and groundwater. Also, DOE, in consultation with the regulatory agencies, will take early actions on emerging issues. Interim or corrective actions will continue to be used to treat existing and emerging plumes and to provide information that will keep the decision-making process going forward. Potential options for making future interim action decisions could include amending existing decisions through the use of a record of decision amendment or an Explanation of Significant Difference. Types of decisions that may use these processes include near-term interim or corrective actions to address emerging groundwater plumes, interim infiltration barriers or covers over tank farms, or possibly the addition of newly discovered waste sites in the River Corridor.

The Tri-Party Agencies recently established a set of milestones that simplify the decision process for several process-waste-based operable units on the Central Plateau. Waste sites were grouped together for the purpose of identifying additional characterization needs. Shallow contamination sites (approximately 350) whose proposed alternative is remove, treat, and dispose of the waste comprise one group. Many of the remaining waste sites will require additional characterization and evaluation prior to selecting a preferred cleanup alternative. Additional characterization is needed, because contamination at these sites may have moved deeper in the vadose zone and more information is needed to better understand the risk. This approach allows the remediation of shallow waste sites to begin while gathering additional characterization data on the other sites.

The Groundwater Remediation Project will focus on five key elements to support final decisions:

- Gather sufficient characterization data.
- Evaluate performance of early actions.
- Identify cleanup goals that support restoration of groundwater.
- Identify new technologies appropriate for treating deep vadose zone contamination.
- Improve decision integration.

The sections that follow describe a strategy for completing the remediation decisions that need to be made and establishing the technical basis for making those decisions. That technical basis relies on gathering sufficient characterization data and taking advantage of insights gained from implementing early remedial actions. Being able to make remedial decisions and

The performance of early remedial actions is providing valuable information that will be used in selecting and implementing final remedies.

do cleanup work depends on the Tri-Party agencies collaboratively developing appropriate remedial action objectives and identifying technologies appropriate to treat the problems.

Achieving final decisions depends on completing the remedial investigations/feasibility studies process for all CERCLA operable units and completing the closure process for all RCRA units under the Tri-Party Agreement.

2.2.1.1 Gather Sufficient Characterization Data

Recently, the Tri-Party Agencies have agreed to extend the schedule for completing the remaining remedial investigation/feasibility study or RCRA facility investigation/corrective measures study for operable units in the Central Plateau. The Tri-Party Agencies have approved a three-year extension to the major milestone M-15-00 to "Complete the remedial investigation/feasibility study process for all Non-Tank Farm Operable Units" by December 2011. The primary reason for this extension is the need for additional characterization. The supplemental characterization will focus on those sites with deep contamination that are thought to pose a future risk to groundwater.

DOE will use the data quality objectives process to define additional characterization requirements and develop supplemental sampling and analysis plans to strengthen the technical basis for decisions on these sites. In addition, EPA and Ecology have agreed that remedial investigation reports will not need to be revised to include the supplemental data. Instead, the new information along with the screening and evaluation of remedial alternatives will be submitted with the feasibility study.

2.2.1.2 Evaluate Performance of Early Actions

In addition to the need for supplemental characterization data, the development of remedial alternatives represents another primary mission of the regulatory process. Doing actual cleanup work provides valuable experience and information about the performance of potential final remedies. The effectiveness, as well as the costs, of the remove, treat and dispose work being done at shallow River Corridor waste sites provides information that can be applied to cleanup decisions for similar Central Plateau waste sites. Many of the interim actions taken to protect and contain groundwater contamination use technologies considered appropriate for final actions (e.g., pump-and-treat systems to treat contaminated groundwater). Performance information gathered through these interim actions will be considered as the final decisions are made.

2.2.1.3 Identify Cleanup Goals

Cleanup goals established for waste sites must support the long-term remediation of groundwater at Hanford. Important elements of those cleanup goals are remedial action objectives that DOE and the regulatory agencies can agree on. Remedial action objectives may be qualitative performance measures used to control a principal threat prior to the development of more quantitative requirements anticipated for final decisions. In the case of final decisions, remedial action objectives are based on applicable or appropriate requirements. Three general categories of requirements are often used to establish remedial action objectives, including (1) chemical-specific requirements that are risk-based, (2) performance-based requirements for the implementation of process based remedies, and (3) location-based requirements based solely on the special conditions in a specific location.

The Tri-Party Agencies must agree on the application of these requirements to all pathways impacted by the waste site or groundwater operable unit. Agreement on the requirements and their application to the cleanup of the Central Plateau waste sites and impacted groundwater remains one of the key elements left to address for the 200 Area.

2.2.1.4 Identify New Technologies

Sites with deep contamination are a challenge to remediate. Other than surface barriers to limit infiltration and slow the rate at which contaminants in the vadose zone are transported, few other conventional remedial alternatives are feasible to apply to this problem. As a result, DOE is in the process of identifying additional technologies to reduce the mobility of contaminants in the deep vadose zone and protect groundwater resources as well as improve our knowledge base for understanding Hanford-specific physical and chemical processes that control contaminant transport.

The strategy for completing the remedial and corrective actions for each of the National Priorities List Sites and moving into a long-term stewardship and anticipated land use is driven by groundwater conditions.

2.2.1.5 Improve Decision Integration

In addition to these four activities, DOE's two field offices have taken steps to integrate the waste site and groundwater cleanup decisions. In the late 1990s, a number of remedies for groundwater plumes were initiated under records of decision for interim action to address principal threats. The groundwater pump-and-treat system for carbon tetrachloride at the 200-ZP-1 Operable Unit is one example of these actions. As a result of the decision to initiate remedies for groundwater plumes and a recognition that many of the waste sites in the Central Plateau have insufficient inventory of contaminants to impact groundwater, the decisions for groundwater operable units and waste site operable units have been decoupled in this area of the site. The current strategy is to identify the waste sites with potential for impacting groundwater and prepare the waste site decision documents and groundwater decision documents together so the decision will be made jointly for these operable units.

2.3 Attaining Final Cleanup

The development of a strategy for attaining final cleanup and closure decisions is a long-term process. Substantial progress has been made toward cleanup and closure of the River Corridor. However, progress in the cleanup of the River Corridor only came with a clear consensus vision endorsed by DOE, EPA, and Ecology for cleanup along the Columbia River. The same

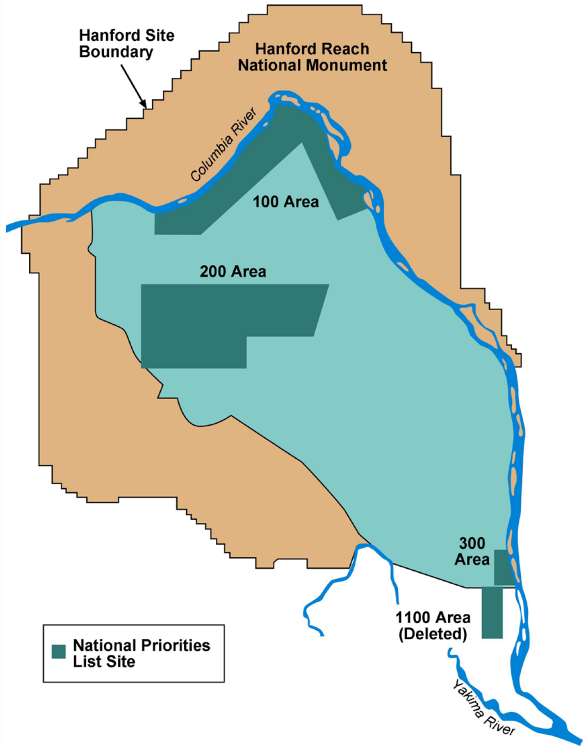

Figure 2.8. Areas of the Hanford Site that are on the National Priorities List.

type of vision and endorsement is needed for a successful, protective cleanup in the Central Plateau.

It is beyond the scope of this document to lay out a closure strategy for the waste sites and groundwater at this time. The Tri-Party Agencies continue to be committed to completing cleanup of past-practice waste sites by September 2024. As cleanup actions become complete for the 100 and 300 Areas in the River Corridor, strategies for making final decisions in these areas will be developed and implemented. These strategies will provide a basis for beginning a dialogue on attaining similar final decisions for the 200 Area.

For the sites in the 200 Area, most of the operable units are early in the remedial investigation/ feasibility study process and consequently many of the key decisions have not been made.

The strategy for completing the remedial and corrective actions for each of the National Priorities List Sites (Figure 2.8) and moving into a long-term stewardship and anticipated land use is driven by groundwater conditions. The groundwater pathway represents the primary exposure route for Hanford contaminants to reach human and environmental receptors. Each National Priorities List site is large and complex. Completion strategies for each of these areas are also impacted by the need to close certain RCRA Waste Management Units.

For the 100 and 300 Areas within the River Corridor, these schedules are better defined due to the completion of records of decision for interim action (EPA 1996a, 1996b, 1999a, 1999b) for all source control actions.

For the sites in the 200 Area, most of the operable units are early in the remedial investigation/feasibility study process and, consequently, many of the key decisions have not been made.

2.3.1 River Corridor Strategy

In late 1992, DOE, EPA, and Ecology began an open process to modify the Tri-Party Agreement and alter the direction of Hanford cleanup. Input was gathered by convening two advisory groups known as the Hanford Future Site Uses Working Group and the Tank Waste Task Force. The advice given to the parties from these groups was to "do no harm" and create a "bias for action" and above all "get on with cleanup."

The discussions that followed lead to the Fourth Amendment of the Hanford Federal Facility Agreement and Consent Order in January 1994. The modifications addressed three primary areas of Hanford Cleanup (1) ceasing and treating liquid waste discharges, (2) refocusing the past practice cleanup process, and (3) removing liquids from single-shell tanks.

For the cleanup of past-practice waste sites and groundwater, the focus was changed to address those problems that represented a near term risk to the public or the environment. That translated into cleaning up contaminated waste sites and principal threats in the groundwater across the site through the use of interim remedial actions. Combined with the requirements for treating, ceasing, and re-routing liquid waste, these interim actions provided the first real steps to protect and restore Hanford groundwater.

The Tri-Party Agencies have formed a work group to develop a strategy for making final decisions for the 100 and 300 Area.

In the process to initiate early actions and "get on with cleanup," some waste site and groundwater operable unit investigations were deferred. Specifically, this included deferral of all groundwater operable unit investigations and waste site investigations in the 200 Area.

After over 10 years of continuous remediation of source and groundwater operable units, as interim actions near completion, it is now time to develop a strategy for completing the cleanup process in the River Corridor. The Tri-Party Agencies have formed the River Corridor Closure Workgroup to develop a strategy for making final decisions for the 100 and 300 Areas.

The tentative approach under consideration by the parties is to develop combined source and groundwater Proposed Plans and final records of decision for each of these geographic areas:

- 100-B/C Area.
- 100-F Area, Isolated Units 2/6.
- 100-N Area.
- 100-K.
- 100-D and 100-H Areas.
- 300 Area and 600 Area waste sites.

Isolated Units 2 and 6 are isolated landfills near the Hanford town site. The strategy must first reconcile the work scope and schedules for the waste site and groundwater operable units to fit the tentative approach described above. In addition, work scope for the source operable unit remedial investigations include completion of waste site cleanup, evaluation of orphan waste sites, and if necessary, cleanup. For the groundwater operable units, the work scope includes identifying the nature and extent of contaminants of concern in the deep vadose zone and groundwater and the development of potential remedial alternatives for secondary contaminants. Schedules for the completion of the remedial investigation/feasibility study process and issuance of final cleanup decisions are expected to be established over the next several months.

After completing response actions in an area, the Tri-Party Agencies will document closure for the 100 and 300 Areas following EPA guidance. Key guidance documents include *Close Out Procedures for National Priorities List Sites* (EPA 540-R-98-016, Office of Solid Waste and Emergency Response [OSWER] Directive 9320.2-09A-P), and *Guidance on Completion of Corrective Action Activities at RCRA Facilities* (68 FR 8757).

2.3.2 Central Plateau Strategy

For the Central Plateau, the Tri-Party Agencies have approved an agreement to extend the schedule for the completion of many of the remedial investigation/feasibility study commitments by three years. The agreement has been documented through a change to Tri-Pary Agreement Milestone M-15-00. In addition, the Parties have realigned their strategy for making future decisions from one based on waste type to one based on the presence or absence of deep contamination. Approximately 350 waste sites in the Central Plateau have shallow contamination that could be effectively remediated through the established remove, treat (as necessary), and dispose process used in the River Corridor. The remaining waste sites have the potential to contain deep contamination that lies beyond the reach of conventional remedies. These waste sites may represent a more immediate risk to the groundwater than contamination located near the surface. Innovative remedies will be considered for their treatment.

The 200 Area cleanup will be based on industrial use for the foreseeable future, appropriate institutional controls, and actions to protect human health and the environment. Once control actions are in place for waste sites, the groundwater monitoring networks for these areas will be reviewed and configured to evaluate the performance of the remedies. In addition, a long-term operation and maintenance plan for groundwater and environmental monitoring will be implemented.

3.0 Management Approach

The activities underway at Hanford to remediate groundwater and protect it from future degradation are varied and extensive. They were initiated by several different organizations within the DOE and within each of the Hanford Site contractors. While these cleanup actions use similar approaches to address similar problems, they are driven by multiple regulatory and contract requirements. Recognizing these factors, DOE-RL and DOE-ORP have jointly implemented an integrated approach to managing all of Hanford's groundwater and vadose zone activities. This approach implements commitments made to Congress:

- Integrate groundwater, vadose zone, and source area cleanup decisions.
- Consolidate modeling and risk assessment work for the Hanford Site.
- Consolidate groundwater and most vadose zone activities under a single project: The Groundwater Remediation Project.

This section addresses the organizational and management approach for Hanford's groundwater and vadose zone integration initiative. Section 3.1 describes the background for the organizational changes that were made and provides an overview of the Memorandum of Agreement between DOE-RL and DOE-ORP that clarifies roles and responsibilities. Section 3.2 describes the DOE and contractor organizational structures, functions and interfaces. Section 3.3 describes the business processes that are being implemented to foster integration including the use of integrated project teams. Finally, Section 3.4 defines a set of results-oriented performance metrics and a routine evaluation process that will provide the feedback needed to ensure successful implementation of the integration initiatives.

3.1 Implement DOE-RL and DOE-ORP Groundwater/Vadose Zone Integration Initiative

In recognition of the need for an integrated systems approach and the inherent linkages between activities relating to the groundwater and vadose zone, DOE established the Hanford Site Groundwater/Vadose Zone Integration Project in the late 1990s. The environment and integration requirements for conducting these activities have evolved significantly since their inception, however, and warrant reassessment as demonstrated by the following items:

- DOE and contractor responsibilities have evolved toward individual closure of remediation projects.
- The projects have matured and developed a strong focus on specific regulatory milestones, decisions, and end points.
- DOE, regulators, Tribal Nations, the State of Oregon and the public have recognized the need for consistency in the analysis and modeling used for risk assessments leading to decisions and remedial action design.

- The focus of source remediation is on the near-surface contamination and remedial actions.
- The focus of groundwater operable unit work is remediating existing groundwater contamination and minimizing future impact to groundwater from contamination in the deep vadose zone.
- The current DOE organizational structure and regulatory framework create a potential integration issue in addressing deep vadose zone contamination.
- There is a need to support remediation decisions and deployment of effective technologies that logically address shallow and deep vadose zone and groundwater contamination across multiple regulatory units and from a site-wide perspective.

In recognition of these changes, DOE-RL and DOE-ORP prepared a memorandum of agreement between the two field offices to improve the integration of groundwater and vadose zone work scope. The key elements of this agreement are shown in the accompanying text box.

Summarized from the Memorandum of Agreement between Office of River Protection and Richland Operations Office for Groundwater and Vadose Zone Work Scope Integration, June 2006

DOE recognizes the need to better coordinate Hanford's groundwater and vadose zone cleanup activities to protect the Columbia River. DOE will centralize the responsibility for groundwater and vadose zone cleanup under the DOE-RL Groundwater Remediation Project. DOE-RL and DOE-ORP agree to cooperate in carrying out the following specific actions in accordance with the delineation of responsibilities set forth in the description of each action:

1. The groundwater/vadose zone Integration function will be strengthened and central leadership will be provided by DOE-RL, with direct participation by DOE-ORP.
2. Fluor Hanford, Inc. (FHI) (Groundwater Remediation Project) will have the lead technical support role for this project, DOE-ORP's Tank Farm Contractor (CH2M Hill) will also provide technical support to this integration function as directed, and Washington Closure Hanford (WCH) will coordinate waste site investigation/remediation schedules.
3. Implementation of the groundwater/vadose zone Integration function will include:
   - An integrated project plan and schedule.
   - An integrated field work plan for all GW/VZ characterization activities
   - Annual reviews of the work plan
   - An integrated set of priorities for conducting deep vadose zone characterization activities
4. The Groundwater Remediation Project will establish and maintain configuration control for all GW/VZ assessment parameters, key assumptions, and approaches and data bases.
5. The Groundwater and Transport Model(s) being developed by the Tank Closure and Waste Management EIS will be periodically reviewed by DOE-RL to ensure their acceptability for project purposes.
6. The Integration function will maintain an internal peer review function to ensure an open exchange of technical results, interpretation, and vetting of results that address the nature and extent, and fate and transport of subsurface contaminants at Hanford.
7. The Groundwater Remediation Project will coordinate sitewide science and technology development and deployment needs applicable to groundwater/vadose zone investigation and remediation.
8. The Groundwater Remediation Project will have the responsibility for coordinating all deep vadose zone sampling, characterization and monitoring activities. Implementation of these services within tank farm boundaries, however, will remain with the Tank Farm Contractor (CH2M Hill).
9. DOE-RL will have the lead responsibility for conducting deep vadose zone treatability studies.
10. The existing FHI, CH2M Hill, and WCH contracts will be modified, if necessary, to implement the provisions of this memorandum of understanding.

3.2 DOE Organizational Structure

Figure 3.1 illustrates the DOE and contractor organizational structure and responsibilities for managing and conducting Hanford's groundwater and vadose zone activities. DOE has established lead responsibility for these activities within DOE-RL's Groundwater Remediation Project. These responsibilities are formalized through the joint DOE-RL and DOE-ORP Memorandum of Agreement as summarized in Section 3.1. In addition, DOE-RL's prime contractor for Central Plateau and groundwater activities (Fluor Hanford, Inc.) has the lead contractor responsibility for integrating all groundwater and vadose zone activities. Fluor Hanford, Inc. leads an integrated work planning and scheduling process that involves the other site contractors who have responsibility for carrying out vadose zone investigations. For example, the Tank Farm Contractor (CH2M HILL Hanford Group, Inc.) coordinates all deep vadose zone investigations in and around tank farms with DOE-RL and the Fluor Hanford, Inc. Soil and Groundwater

DOE has centralized and strengthened the responsibility for groundwater and vadose zone cleanup under the Groundwater Remediation Project.

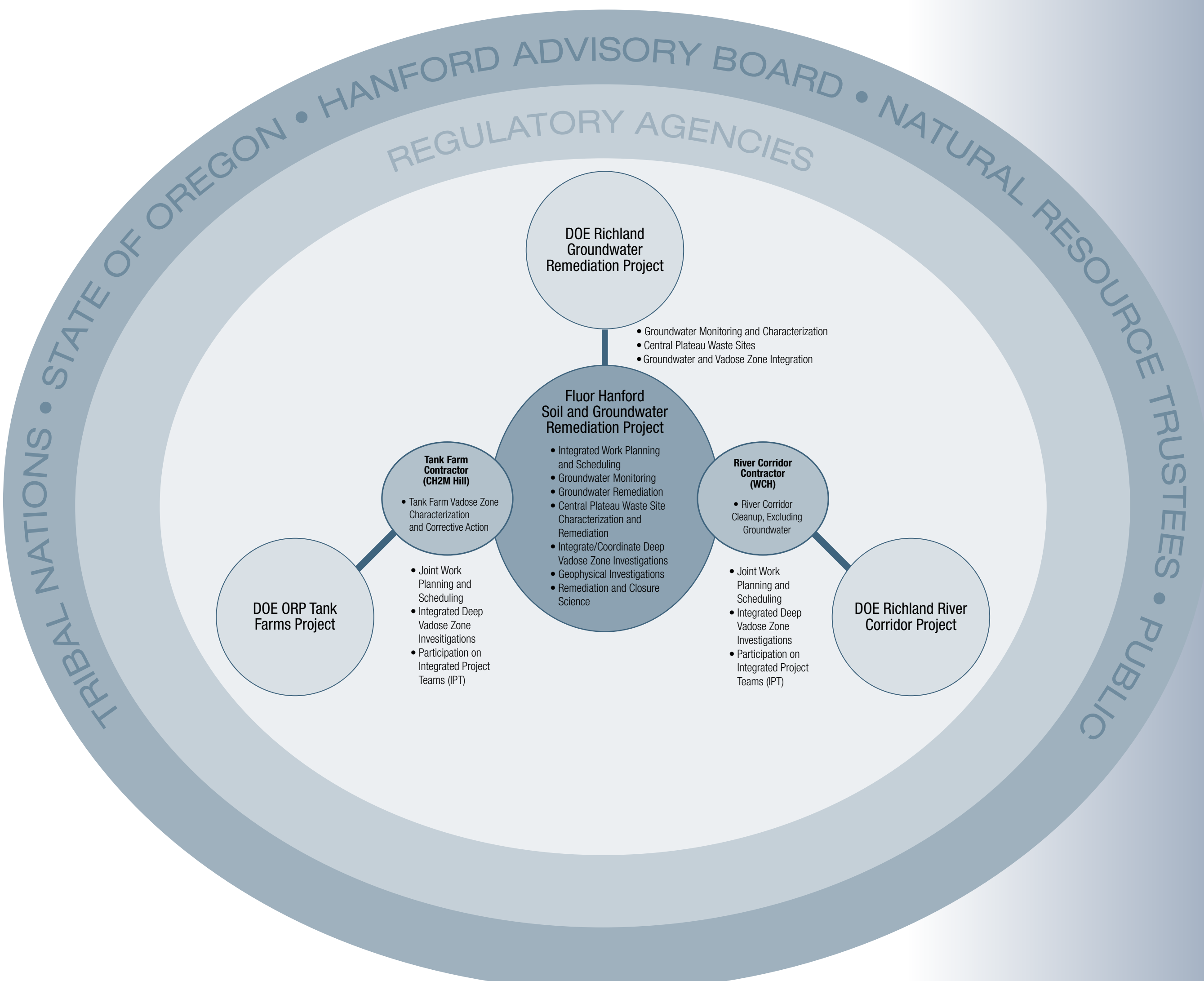

Figure 3.1. Hanford Groundwater and Vadose Zone Program organization.

Remediation Project. This coordination ensures that field investigations support the needs of multiple projects. The Tank Farm Contractor carries out investigations that support the tank farm RCRA corrective action process and retains responsibility for producing required regulatory documentation.

Similarly, Fluor Hanford, Inc. conducts joint work planning and scheduling with the River Corridor Contractor (Washington Closure Hanford, LLC) to ensure that groundwater and waste site investigations are properly integrated. Fluor Hanford, Inc. is responsible for all groundwater activities on the Hanford Site, including the River Corridor. In future contracts, in accordance with the request for proposals dated June 25, 2007, the Fluor Hanford, Inc. function will be in the Plateau Remediation Contract.

3.3 Integrate Protection Activities

The Groundwater Remediation Project maintains a series of business processes that will ensure effective integration of all groundwater and vadose zone activities at Hanford under the new DOE organizational structure. These processes include:

- Integrated project teams.
- Integrated work planning, scheduling, and implementation activities.
- Comprehensive site-wide approach to technology development, testing, and application.
- Integrated risk assessment and modeling.
- Maintain groundwater/vadose zone science and technology investigations.

3.3.1 Integrated Project Teams

DOE has established a Groundwater Vadose Zone Executive Council to oversee the integration function and to establish policy direction for it. The council is chaired by the Assistant Manager for Central Plateau and includes participation from the Assistant Manager for River Corridor, the Assistant Manager for Tank Farms and the office of Project Performance and Regulatory Integration.

Under the guidance of this executive council, DOE-RL and DOE-ORP have implemented an integrated project team (Figure 3.2) approach to facilitate integration of groundwater, waste site, and tank farm vadose zone activities at the Hanford Site. Integrated project teams are formed to address areas or topics with the following characteristics:

- Require close coordination and communication from multiple projects or organizations.
- Involve activities that must meet multiple project needs.

DOE's Groundwater Remediation Project is maintaining a series of business processes that will ensure effective integration of all groundwater and vadose zone activities at Hanford.

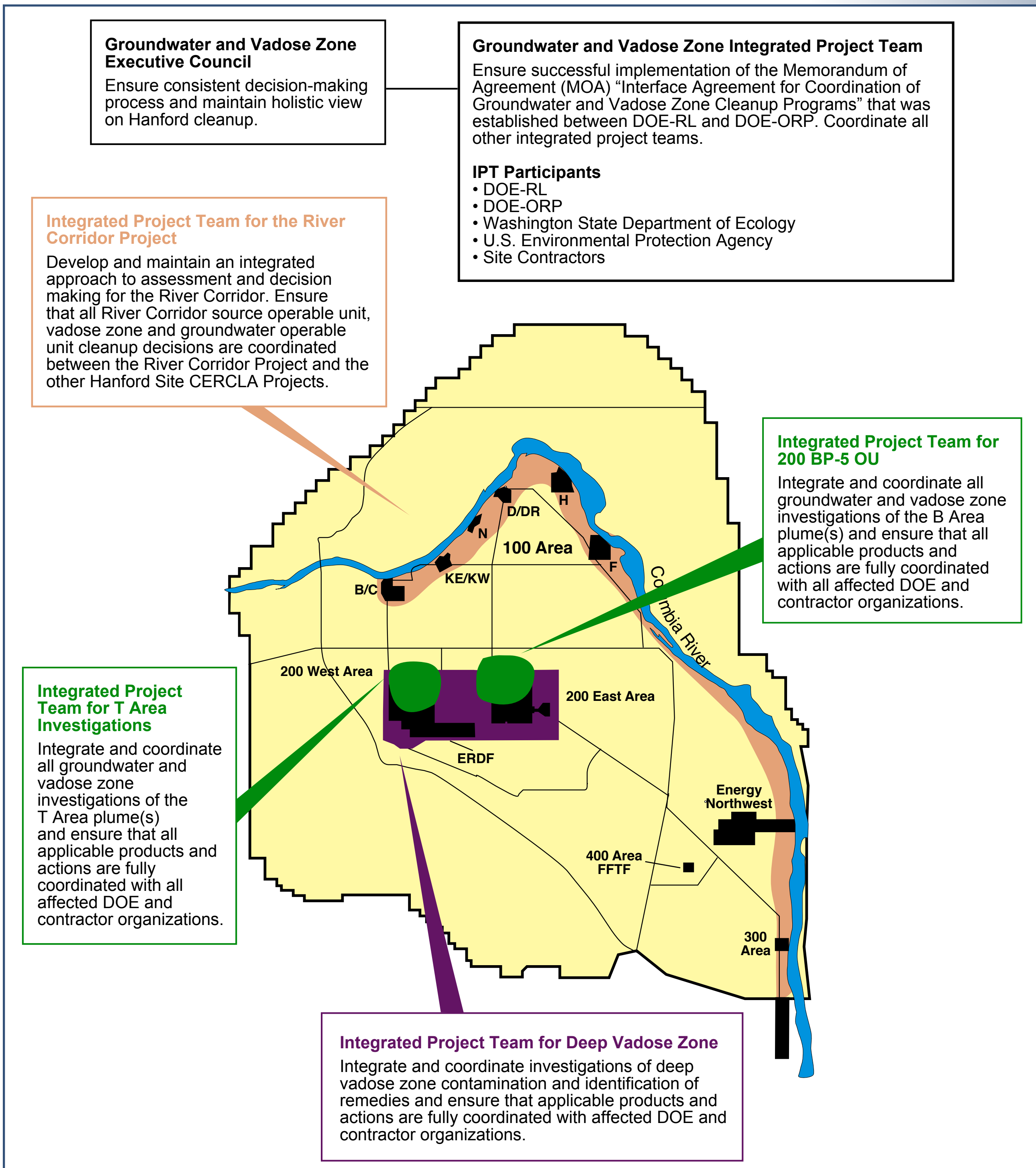

Figure 3.2. DOE-RL and DOE-ORP have implemented an integrated team approach to coordinate groundwater, waste site, and vadose zone activities.

An integrated schedule is developed and maintained for all vadose zone and groundwater investigations.

- Involve investigations or activities that affect the physical or administrative interfaces between projects.

The current set of integrated project teams are shown in Figure 3.2. Participation in each integrated project teams is required from all affected projects and includes project leads from DOE-RL, DOE-ORP, and contractor organizations. EPA and Ecology project leads also participate on these teams. The integrated project teams themselves do not replace or usurp project responsibilities, but provide a single forum for communication with all affected parties to ensure that project-specific products and activities meet the broad set of needs and raise and resolve interface or coordination issues in a timely manner. The integrated project teams also seek to identify integration opportunities by maintaining open communication regarding planned field activities.

The region-specific integrated project teams are monitored by the Groundwater/Vadose Zone Integrated Project Team to ensure that they are properly focused and relevant. Existing integrated project teams will be terminated or restructured as needs changes and new integrated project teams will be formed to accommodate emerging priorities.

3.3.2 Integrated Work Planning, Scheduling, and Implementation

Much of the effort to create integrated work plans occurs during the process to identify data quality objectives for field activities. During this process, the project developing the data quality objectives document involves representatives from other projects with interests in the area to identify characterization needs. Once data needs are identified through the data quality objectives process and field work plans, or sample and analysis plans are developed, the information for a region of the site is assembled to create an integrated field work schedule to facilitate further integration.

Schedules are created on a regional basis; within each region, activities are grouped by sub areas that are related to each other by proximity and common hydrogeologic behavior.

The process of compiling the integrated schedules is used as an opportunity to review planned field activities and realign schedules when appropriate, combine data collection activities planned by multiple projects when efficiencies can be realized, and augment data collected from a single borehole when other data needs can be satisfied cost effectively. The process for creating and using the integrated schedules as a basis for managing characterization activities in the vadose zone and groundwater is presented in Figure 3.3. As indicated in the figure, the integrated schedules are assembled and reviewed to identify opportunities for integration. In many cases, schedules can be easily aligned without affecting project commitments. In other cases, the coordination effort may be more complex. In complex cases, an integrated project team will be formed to optimize the schedules.

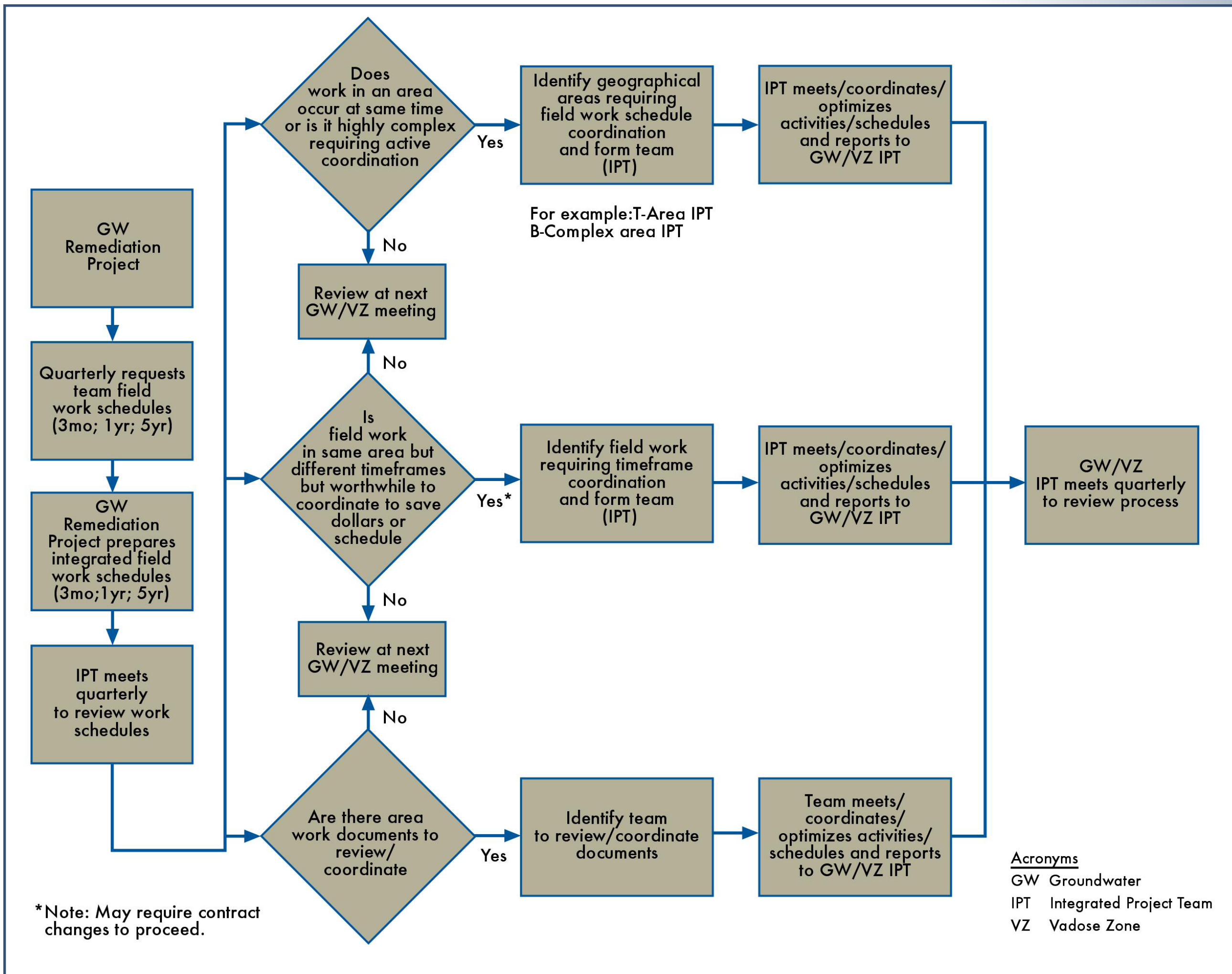

Figure 3.3. Process for creating and using the integrated schedules to manage characterization activities.

In some cases this may lead to renegotiating commitments to achieve efficiency and may require contract modification to revise the work process. All of these tools will be used as needed to attain integration of field activities.

Figure 3.3 also identifies that the schedules will be periodically updated to capture changes that inevitably occur as work progresses. These updates will provide opportunities to communicate changes to all projects and evaluate the impact of the change on other work. Alternatives for mitigating the impact of the change can be discussed and put into effect as needed.

Fluor Hanford, Inc. ensures that the data quality objectives processes and other sampling and field work plans are coordinated with all contractors that have a potential interest in the planned activities. For example, data quality objectives for investigations at the Central Plateau groundwater operable unit will require participation and input from tank farm and waste site personnel. In particular, deep vadose zone investigations that encompass waste sites and tank farms, or that address potentially commingled vadose zone contaminant plumes require coordination with all affected projects to ensure that sufficient data are collected for each project.

Fluor Hanford, Inc. also integrates the documents developed throughout the cleanup process. A series of guidance documents are being developed so that investigations of adjacent regions of the site will be consistent and the work done on waste sites in a region will be consistent with the document completed for the underlying groundwater decisions.

The Soil and Groundwater Remediation Project work is performed under the authority of the Project Hanford Management Contract (PHMC). All PHMC direct-funded work scope is managed in accordance with DOE Order 413.3A, *Program and Project Management for the Acquisition of Capital Assets*, to comply with the American National Standards Institute/Electronics Industries Association (ANSI/EIA) Standard 748-A, *Earned Value Management Systems*. Accordingly, all project activities follow a formal, systematic approach for work organization and definition, work planning and authorization, work performance and measurement, performance analysis and reporting, change control, and surveillance based on budgeting guidance and funding provided by DOE-RL.

3.3.3 Comprehensive Site-Wide Approach to Technology Development, Testing, and Application

An approach for evaluating technologies to fill identified needs has been developed over the last several years and is proving successful. DOE invited and encouraged all Hanford Site contractors, regulators, Tribal Nations, and stakeholders to be involved in this process.

Remediation of Hanford's soil and groundwater is often characterized as one of the most complex environmental cleanup projects in history. In response to that challenge, many innovative approaches have been developed to characterization and remediation of radionuclides and hazardous chemicals. Technical challenges remain however, and several of the overarching technical challenges include the need for:

Improved understanding of the behavior of contaminants that drive risk

The behavior of some contaminants at Hanford is well enough understood to design effective remedies. However, a better understanding of contaminant attributes that control geochemical interactions and reactive transport will lead to implementing more effective and efficient remedies. Key contaminants for the groundwater pathway include uranium, technetium-99, carbon tetrachloride, iodine-129, strontium-90, plutonium and chromium (VI). The influence of waste source composition, groundwater/river interactions, subsurface heterogeneities, and other hydrologic and biogeochemical properties on reaction chemistry requires explicit consideration.

Cost effective methods for characterizing the nature and extent of contamination

Improved technologies are needed for non-intrusive or minimally intrusive methods for identifying burial ground contents and delineating difficult to find waste sites.

Improved, real-time field screening during excavation for radionuclides with emphasis on uranium, plutonium, strontium-90, and technetium-99

Rapid field screening techniques are needed to direct characterization, excavation operations, and release of material for transport to disposal. Field screening techniques for characterization and delineation will assure that high cost, site characterization laboratory analyses are optimized. These techniques will also help assure that operations at excavation sites remove all contaminated material and that excavated materials meet waste acceptance criteria prior to disposal.

Cost-effective, in situ remediation technologies for contaminants in the vadose zone and groundwater

Hexavalent chromium

Strontium-90 and

Carbon tetrachloride

Technetium-99

Uranium

Iodine-129

Methods to monitor long-term performance of remedial actions.

As remedies get implemented at Hanford it becomes more important that the effectiveness of the remedy can be evaluated so that corrective action can be taken when needed and long term costs and maintenance efforts can be minimized.

This effort will require both monitoring the remedy and interpretation of the resulting information. Monitoring is needed for passive barriers, infiltration barriers such as waste site covers as well as pump and treat actions. Interpretation will be needed to identify the amount of material captured, the amount of material remaining to be treated, the impact of leakage and other appropriate metrics to assess the effectiveness of the remedy.

The approach for evaluating technologies to fill identified needs that has been developed over the last several years has proven successful. After a high-priority need or data gap is identified, the following course is generally followed:

- Evaluate potential technologies and report on the outcome of the evaluation.
- Convene an outside panel of experts to comprehensively evaluate the range of technologies and recommend one or two for field testing and/or laboratory evaluation.

A key objective of the regulatory processes developed to guide cleanup is the reduction of human health and ecological risk. As a result, risk assessment, including contaminant transport modeling, plays a key role in the cleanup process.

- If more data are needed to evaluate technologies or design a field test, gather that information through computer simulations and/or lab testing.
- Perform a demonstration of the technology(s), with the goal of gathering the necessary information to make the decision whether to implement the technology as part of a final remediation solution.

This approach was used to evaluate in situ chromium remediation in groundwater, applying innovative geophysical techniques for site investigations, and evaluating decision tools for use in the remedial investigations/feasibility studies process. DOE provides opportunities for all Hanford Site contractors, regulators, Tribal Nations, the State of Oregon, and the public to be involved in these processes.

3.3.4 Integrated Risk Assessment and Modeling

A key objective of the regulatory processes developed to guide cleanup is the reduction of human health and ecological risk. As a result, risk assessment, including contaminant transport modeling, plays a key role in the cleanup process. Risk assessment and modeling are

- Performed to evaluate the baseline risk and establish the need for remediation.
- Used in the process for evaluating remedial alternatives and establishing remedial action goals.
- Used to establish and optimize the remedial design.

As part of DOE's consideration of *National Environmental Policy Act* (NEPA) values, and in compliance with DOE Orders on low-level waste management, the risk assessment and modeling work performed under CERCLA also can be used to consider cumulative impacts.

To improve consistency and quality among risk assessments and modeling done on site, all modeling and risk assessment activities are coordinated with the Groundwater Remediation Project. The Groundwater Remediation Project is establishing a process to define risk parameters and approaches to provide a consistent basis for risk assessment. DOE has established a Groundwater Vadose Zone Executive Council to provide overall leadership for the integration of groundwater and vadose activities and approve any changes that are proposed to the established conceptual models or computer codes. This Council is chaired by the Assistant Manager for the Central Plateau and includes participation from the Assistant Manager for the River Corridor and the Office of River Protection Assistant Manager for Tank Farms and the office of Project Performance and Regulatory Integration.

The Tank Closure and Waste Management Environmental Impact Statement (EIS) is modeling waste activities at Hanford as part of the cumulative impact assessment and using a commercially available groundwater code to support that analysis. The project teams periodically brief the EIS team on progress to ensure that the analyses and approaches are understood.

Once the Tank Closure and Waste Management EIS is completed and the record of decision is published in the Federal Register, the groundwater model developed for the EIS will be maintained by the Groundwater Remediation Project.

3.3.5 Maintain Groundwater/Vadose Zone Science and Technology Base

Maintaining an effective science and technology project requires periodic examination of the technology needs and knowledge gaps facing the various project activities, and applying resources to address the needs and gaps. The existing project also supports characterization and remediation activities by identifying new technologies that hold promise to accelerate, improve, or reduce the cost of work and develop data for predicting contaminant transport in the vadose zone and groundwater required to make remediation and closure decisions and develop final remedies for subsurface contamination. This work also aids in the demonstration of promising innovative technologies by coordinating and assisting in the planning, field implementation, data analysis, and/or reporting of results.

The CERCLA five-year review has served as one tool for identifying technology needs. Identification of remedies that are not performing as predicted is one way of identifying gaps in our understanding of the problem being remediated or of the remedy behavior. Science and technology needs identified through the CERCLA five-year review are considered for research so that problems that cannot be solved today can continue to be investigated until they are solved.

Key elements of the Groundwater Project are identified for external peer review. Through these reviews, the methods used are scrutinized, the conclusions drawn are challenged and the actions proposed are assessed in the light of other options. As a result, the quality of the analysis presented and the credibility of the decisions made are improved. In addition, the Groundwater Protection Project obtains the input of scientists outside the Hanford community who are familiar with similar challenges at other locations and as a result new ideas are brought to bear in solving problem at Hanford. Recent examples of peer review efforts at Hanford include a review of surface geophysical techniques applied to waste sites and a review of unsaturated zone monitoring methods.

3.4 Results-Oriented Performance Measures

DOE-RL and DOE-ORP will use results-oriented performance measures to monitor the status and progress of groundwater and vadose zone integration efforts.

Performance measures are tied to specific high-level objectives for groundwater and vadose zone activities. Three primary goals have been

"To increase the likelihood that DOE will effectively implement and sustain improvements in its program to protect the Columbia River from contamination, GAO recommends that the Secretary of Energy establish results-oriented performance measures and regular evaluations to gauge the improvements' effectiveness."

– GAO August 2006

identified with a series of sub-goals, for which specific metrics will be defined to gauge progress.

- Protect the environment. These measures address the impact of Hanford contaminants on the environment and the impact of implementing remedial actions.
- Complete regulatory decision processes. These measures describe the status of source and groundwater operable units in terms of their degree of completion of the required regulatory decision processes leading to remedial action selection or closure plans.
- Improve and maintain effective integration of groundwater and vadose zone activities. These measures track the status of specific organization initiatives and actions that are intended to enhance the integration of Hanford's groundwater and vadose zone activities.

This section (3.4.4) describes an evaluation process that DOE is implementing to routinely assess the project's effectiveness, review the status of performance metrics, and identify areas for improvement.

The primary elements of DOE's broad vision are to prevent degradation, remediate groundwater, protect the Columbia River, improve understanding of groundwater pathway and risks, and support decision-making. Each of the performance measures described below addresses important near-term actions and identifies the primary benefit of this measure to the broad vision for the project.

3.4.1 Performance Measures for "Protect the Environment"

The following sub-goals support achieve of the goal to "Protect the Environment." Example metrics are provided and these will continue to be refined to support DOE's initial evaluation process to be conducted during FY-2007.

3.4.1.1 River Corridor Sub-Goals and Example Metrics for "Protect the Environment"

- Remediate Groundwater Operable Units (100-BC-5, 100-KR-4, 100-NR-2, 100-HR-3, 100-FR-3, 300-FF-5). Specific metrics address these areas:
  - Area of plume above drinking water standard (Remediate Groundwater).
  - Comparison to remedial action objective (Remediate Groundwater).
- Remediate Source Operable Units (100 Areas, 300 Area). The specific metrics address the following:
  - Number of waste sites completed versus total population requiring cleanup (measured by Cleanup Verification Packages) (Prevent Degradation).
- Control Infiltration. Specific metrics address two areas:

- Number of wells decommissioned versus total population of wells without a casing seal awaiting decommissioning (Prevent Degradation).
- Elimination of other sources of man-made infiltration in areas with likely subsurface contamination (Prevent Degradation).

- Complete CERCLA Five-Year Review Action Items.
  - **Action 1-1**. Submit Draft A of the River Corridor Baseline Risk Assessment Report. (Improved Understanding) (Complete)
  - **Action 1-2**. Submit draft sampling and analysis plan for Inter-Areas Shoreline Assessment. (Improved Understanding) (Complete)
  - **Action 1-3.** Reassess and resubmit to EPA the protectiveness determinations for operable units 100-BC-1, 100-BC-2, 100-DR-1, 100-DR-2, 100-FR-1, 100-FR-2, 100-HR-1, 100-HR-2, 100-HR-3, 100-IU-2, 100-IU-6, 100-KR-1, 100-KR-2, 100-KR-4, 100-NR-1, 300-FF-1, and 300-FF-2 using new information from the River Corridor Baseline Risk Assessment and submit to EPA an addendum with, as appropriate, updated Protectiveness Determinations, Issues, and Follow-Up Actions. (Improved Understanding) (2/15/2008)
  - **Action 2-1**. Submit Draft A of the River Corridor Strategy for Achieving Final Cleanup Decision in the River Corridor. This document will identify issues for integration and provide alternatives for future discussions between the Tri-Party Agencies on milestones for final records of decision in the River Corridor. (Support Decision-making) (Complete)
  - **Action 2-2.** Reach agreement between the Tri-Party Agencies on a strategy and schedule to obtain final records of decision in the river corridor. (Support Decision-making) (11/30/2007)
  - **Action 2-3.** Submit a Tri-Party Aggreement change package with new milestones for submitting remedial investigation/feasibility study work plans and proposed plans for all operable units in the river corridor. New milestones shall require submission of remedial investigation/feasibility study work plans and proposed plans for final actions at all of the following operable units that do not already have these documents approved: 100-BC-1, 100-BC-2, 100-BC-5, 100-DR-1, 100-DR-2, 100-FR-1, 100-FR-2, 100-FR-3, 100-HR-1, 100-HR-2, 100-HR-3, 100-IU-2, 100-IU-6, 100-KR-1, 100-KR-2, 100-KR-4, 100-NR-1, 100-NR-2, 300-FF-2, and 300-FF-5. (Support Decision-making) (2/1/2008)
  - **Action 3-1**. Install three additional wells to further delineate the southeastern (inland) extent of the chromium groundwater plume from the 116-K-2 trench, northeast of the current injection wells.

Performance measures are tied to specific high-level objectives for groundwater and vadose zone activities. Three primary goals have been identified with a series of sub-goals, for which specific metrics will be defined to gauge progress.

The first major goal for which performance metrics are defined is to protect the environment. This goal has two parts, i.e., one focused on the River Corridor and the other on the Central Plateau.

Wells installed as part of the pump-and-treat system expansion or injection well relocation may count towards this effort if appropriately located. (Protect the Columbia River) (08/2008)

- **Action 4-1**. Construct a new pump-and-treat facility to address the chromium groundwater plume in the KW Reactor area. (Protect the Columbia River) (08/2008)
- **Action 5-1**. Expand the 100-K Area pump-and-treat system by 378.5 liters (100 gallons) per minute to enhance remediation of the chromium plume between the 116-K-2 and the N Reactor perimeter fence. (Protect the Columbia River) (08/2008)
- **Action 5-2**. Add additional wells between the 166-K-2 trench and the N Reactor perimeter fence for groundwater extraction, and connect the additional wells to the pump-and-treat system. (Protect the Columbia River) (Will be completed with Action 5-1.)
- **Action 6-1**. Implement the treatability test plan for permeable reactive barrier utilizing apatite sequestration as described in the *Strontium-90 Treatability Test Plan for 100-NR-02 Groundwater Operable Unit* (DOE 2005c). Issue Treatability Test Report. (Protect the Columbia River) (09/2008)
- **Action 7-1**. Perform additional data collection to support risk assessment, provide to Ecology previously collected data, and coordinate with River Corridor sampling efforts to collect additional pore water data from new and existing aquifer tubes along the 100-NR-2 shoreline in order to assess water quality impacts. (Improve Understanding) (09/2008)
- **Action 8-1**. Complete a field investigation to investigate additional sources of chromium groundwater contamination within the 100-D Area. Additional geologic and geochemical investigations of the vadose zone in the 100-D Area. (Improve Understanding) (03/2009)
- **Action 9-1**. Perform additional characterization of the aquifer for chromium contamination between the 100-D and 100-H Area, in the area known as the “horn,” and evaluate the need to perform remedial action to meet the remedial action objectives of the 100-D record of decision for interim action. This issue will also be addressed in the final record of decision. (Improve Understanding) (09/2009)
- **Action 9-2**. Incorporate the “horn” area into the 100-HR-3 interim record of decision treatment zone if Action 9-1 indicates “horn” contains a groundwater chromium plume that needs immediate remediation. (Protect the Columbia River) (09/2009)

- **Action 10-1**. Issue direction to the operating contractor to change operations to further minimize leakage from the 182-D reservoir. (Prevent Degradation) (Complete)
- **Action 11-1**. Initiate limited iron amendments to the in situ redox manipulation barrier to evaluate whether this enhances the performance. (Protect the Columbia River) (Complete)
- **Action 12-1**. Perform additional characterization of the aquifer below the initial aquitard. (Improve Understanding) (09/2009)
- **Action 19-1**. Complete focused feasibility study for 300-FF-5 Operable Unit to provide better characterization of the uranium contamination, develop a conceptual model, validate ecological consequences and evaluate treatment alternatives. Concurrently test injection of polyphosphate into the aquifer to immobilize the uranium and reduce the concentration of dissolved uranium. These activities support a CERCLA proposed plan. (Remediate Groundwater) (09/2008)

3.4.1.2 Central Plateau Sub-Goals and Example Metrics for "Protect the Environment"

- Remediate Groundwater Operable Units (200-BP-5, 200-PO-1, 200-ZP-1, 200-UP-1). Specific metrics will address these areas:
  - Containing plumes (Metrics may address mass removal or size of high concentration portion of plumes.)
  - Reducing area of plume above drinking water standard.
  - Comparing to remedial action objective.
- Remediate Source Operable Units. Specific metrics will address the number of waste sites completed versus total population requiring cleanup measured by Cleanup Verification Packages.
- Remediate past releases from single-shell tank waste-management units. Specific metrics will address the number of interim actions and/or corrective measures implemented for tank farms.
- Control Infiltration. Specific metrics will address two areas:
  - The number of wells decommissioned versus total population of wells without a casing seal awaiting decommissioning.
  - Elimination of other sources of man-made infiltration in areas with likely subsurface contamination (including installation of interim barriers, installation of run-on/off controls for areas with likely subsurface contamination).
- Complete CERCLA Five-Year Review Action Items.

The second major goal for which performance metrics are defined is to complete regulatory decision processes. These metrics track the completion of key steps in the regulatory processes leading to remediation or corrective action decisions.

- **Action 13-1**. Complete a data quality objective process and sampling plan to further characterize the technetium-99 groundwater plume near T Tank Farm. (Improve Understanding) (Complete)
- **Action 14-1**. Assess treatment options to address technetium-99 near T Tank Farm. (Improve Understanding) (Completed by the implementation of an additional pump-and-treat system)
- **Action 15-1**. Complete data quality objective process and sampling plan to further characterize the high soil conductivity measurements detected at B/C cribs and trenches. (Improve Understanding) (12/2007)
- **Action 16-1**. Increase the pump size in 200-ZP-1 extraction wells 299-W15-45 and 299-W15-47. (Remediate Groundwater) (Complete)
- **Action 17-1**. Evaluate expanding the soil-vapor extraction operations. Also, specifically review converting former groundwater extraction well 299-W15-32 to a soil-vapor extraction well. (Prevent Degradation) (complete)
- **Action 18-1**. Prepare an explanation of significant difference for 200-UP-1 interim record of decision. (Support Decision-making) (06/2008)

The schedules for achieving these important objectives for groundwater protection will be clearly identified in the project baselines, tied to the relevant Tri-Party Agreement milestones, and tracked.

3.4.2 Performance Measures for "Complete Regulatory Decision Processes"

The second major goal for which performance metrics are defined is "Complete Regulatory Decision Processes." These metrics track the completion of key steps in the regulatory processes leading to remediation or corrective action decisions. For each groundwater and source operable unit in the River Corridor and Central Plateau, the following steps will be tracked and reported:

- Complete work plan.
- Complete remedial investigation report.
- Complete feasibility study and proposed plan.
- Assist regulatory agencies in the completion of record of decision.

The third major goal for which performance metrics are defined is to improve and maintain effective integration of groundwater and vadose zone activities.

In addition, for single-shell tank farm waste management areas, the following steps will be tracked and reported:

- Completion of work plan.
- Completion of RCRA Facility Investigation Report.
- Completion of RCRA Corrective Measures Study.

- Completion of Permit Modification for Corrective Measures Study implementation.

3.4.3 Performance Measures for "Improve and Maintain Effective Integration of Groundwater and Vadose Zone Activities"

The third major goal for which performance metrics are defined is to "Improve and Maintain Effective Integration of Groundwater and Vadose Zone Activities." The following sub-goals support achieving organizational effectiveness relative to integrating groundwater and vadose zone activities:

- Realign organizations and contracts to centralize the coordination and focus for all groundwater and vadose activities. (Complete and maintain the organizational, administrative, and contractual organizations essential to groundwater and vadose zone activities.)
- Implement and monitor sound business process to foster integration.
- Ensure that products are appropriately integrated.
- Ensure that field activities are appropriately integrated.
- Ensure that emergent data, interpretations of data, and reporting of such results are broadly communicated and reviewed by all affected parties (no surprises, open dialogue and sharing of information).
- Implement routine reporting of the status of and progress of groundwater and vadose zone efforts.

3.4.4 Evaluation Process

The status of performance for each of the previously identified metrics will be evaluated and reported on a routine basis through the following formal processes:

- Integrated Project Team monthly meeting.
- Groundwater/Vadose Zone Executive Council quarterly review.
- Tri-Party Agreement milestones quarterly review.
- Annual groundwater monitoring report.
- Annual site environmental report.
- CERCLA five-year review report.
- Government Accountability Office and DOE Headquarters audits.

Results of these evaluations will be used to select and adjust both technical and project management approaches to ensure continuous success of the Groundwater Remediation Project. Additional specific performance measures may be identified during the evaluation process.

The metrics will be evaluated and the results of these evaluations will be used to continuously improve project management approaches to ensure success of the Hanford Groundwater Remediation Project.

4.0 Public Information and Involvement Opportunities

The Soil and Groundwater Remediation Project is committed to providing Tribal Nations, the State of Oregon, stakeholders and the public with timely information and opportunities to provide early, meaningful input into soil and groundwater activities and cleanup decisions. The Hanford Site Tri-Party Agreement Public Involvement Community Relations Plan (DOE 2002) outlines the public participation processes and identifies several ways the public can participate in Hanford cleanup activities and cleanup decisions. In addition, DOE uses the following guiding principles to identify those decisions requiring public involvement:

- Will the decision have significant impacts?
- Will the decision affect some people more than others?
- Will the decision impact a vested interest or use?
- Does the decision involve a subject or topic that is already controversial?
- Is there significant disagreement or uncertainty about the technical basis for the decision?
- Does the decision involve values, or is it purely technical? If the decision involves values, is there disagreement about which values should be given priority?
- Does the decision have the potential to affect public or worker health and safety?
- Does the decision need active support to be implemented?
- Do stakeholders have information that is needed to make an informed decision?
- Does the decision fall within the jurisdiction of rules and regulations that require public/stakeholder participation?

Key to the success of cleanup at the Hanford Site is involving and communicating with the public.

4.1 Information Resources

The Project provides timely information – both detailed and general. Presentations, site visits/tours, and fact sheets support this flow of information in addition to the other resources listed below:

Updates on Hanford groundwater remediation are available to all interested parties.

- **Technical Reports**. Numerous technical reports are available that summarize, analyze, and interpret groundwater monitoring and remediation activities at the Hanford Site. The annual Hanford Site Groundwater Monitoring Report (Hartman et al. 2006) and the annual Hanford Site Environmental Report (Poston et al. 2006) are examples of these technical reports. Technical reports are available through the Hanford Site Technical Library and on the Internet (***http://www.osti.gov/opennet/ or http://www2.hanford.gov/declass/ or http://www.pnl.gov/tech_lib/home.html***).

- **Web Site**. The Soil and Groundwater Remediation Project maintains a website (http://www.hanford.gov/cp/gpp) that provides updated information about the Soil and Groundwater Remediation Project. Information on the ORP Tank Farm Vadose Zone Project can be found at ***http://www.hanfordcleanup.info/vzp.htm***.
- **Annual Report**. A report (Hartman et al. 2007) is issued each year that summarizes the Project's efforts during the past 12 months. The report is distributed widely to government representatives and the public (***http://groundwater.pnl.gov/reports/gwrep06/start.htm***).
- **Open Project Meeting.** The Soil and Groundwater Remediation Project holds an open project meeting each month. The meeting is used to inform interested stakeholders and the public about ongoing and new project activities and allows for open discussion. The calendar can be accessed at ***http://www.hanford.gov/cp/gpp/public/calendar.cfm.***
- **Other Information Resources**. The Soil and Groundwater Remediation Project may utilize additional resources to provide information on the project to include but not limited to published articles in local and regional newspapers, trade and technical journals, DOE newsletters, Hanford contractor newsletters, compact discs, brochures, and displays.

"Activities must do no further harm to groundwater and groundwater should be cleaned up to its highest beneficial use. The Department of Energy's Hanford Site Groundwater Strategy and Groundwater Implementation Plan, and all DOE plans, strategies and actions should reflect that goal."

– Hanford Advisory Board Consensus Advice #145

4.2 Public Involvement Opportunities

The public is offered a variety of opportunities to provide input and influence Hanford cleanup decisions. These forums include informal and formal public comment periods, such as those described in the Tri-Party Agreement, NEPA, CERCLA, and RCRA (e.g., public comment periods on CERCLA documents including proposed plans); Hanford Advisory Board meetings; Annual State of the Site and Budget meetings; and other Hanford related public involvement/information meetings, workshops or activities. A list of Hanford Site Public Involvement Activities is produced quarterly to provide an overview of anticipated public involvement opportunities for the coming months. It identifies the current forums and emerging opportunities to inform and involve stakeholders and the public. It is available electronically at ***http://www.hanford.gov*** under the Public Involvement section. Also, a list of current public involvement opportunities is posted at ***http://www.hanford.gov/public/calendar/***.

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