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United States Government Accountability Office
Washington, DC 20548

November 4, 2005

The Honorable David L. Hobson
Chairman
The Honorable Peter J. Visclosky
Ranking Minority Member
Subcommittee on Energy and Water Development
Committee on Appropriations
House of Representatives

Subject: *Department of Energy: Preliminary Information on the Potential for Columbia River Contamination from the Hanford Site*

The Department of Energy's (DOE) Hanford site in southeastern Washington state was established in 1943 to produce nuclear materials, especially plutonium, for the nation's defense. The site occupies 586 square miles northwest of the cities of Richland, Pasco, and Kennewick, with a combined regional population of over 200,000. The Columbia River, the nation's second largest river and a source of hydropower production and drinking water for downstream communities, as well as a major route for salmon migration, flows through the site for almost 50 miles. DOE built nine nuclear reactors to produce plutonium and other materials near the river shore to take advantage of river water for reactor cooling. Several miles away from the river, DOE built other facilities used in making nuclear materials. During operations from 1943 to 1989, activity at these reactors and other facilities generated large volumes of hazardous and radioactive waste. Some of this waste was deposited directly into the ground in trenches, injection wells, or other facilities designed to allow the waste to disperse into the soil. Some of the most hazardous and radioactive material was stored in large underground tanks.

Over time, concern has developed about the impact of Hanford's waste moving through the ground and toward the Columbia River. Besides the waste discharged directly into the ground, DOE has assumed, based on tank monitoring data and other techniques to detect contamination in the soil, that 67 of the 177 underground storage tanks have also leaked contaminants into the soil. Many types of hazardous and radioactive waste produced at Hanford can be borne by water through the ground. While Hanford is a near-desert location with limited rainfall and thick layers of soil and rock beneath its surface, water from precipitation and other sources moves through these layers, and the groundwater moves in the general direction of the river. In the center of the site, the groundwater is more than 200 feet below the surface, but at the river, the groundwater is at or near river level. Over time, the movement of these contaminants through the "vadose zone"—the span of soil and

rock between the surface and the groundwater beneath—has resulted in a number of contaminant "plumes." These plumes are volumes of contamination extending downward and outward from their sources. When these plumes reach the level of the groundwater, the contamination they contain enters the groundwater. In some cases, contamination from these plumes has already reached the river.

Since the early 1990s, DOE has shifted its efforts at the Hanford site from production of nuclear materials to cleaning up the contamination and other materials left over from the production era. DOE carries out these activities primarily under the requirements of two environmental laws: (1) the Comprehensive Environmental Response, Compensation, and Liability Act of 1980, as amended (CERCLA), and (2) the Resource Conservation and Recovery Act of 1976, as amended (RCRA). Milestones and requirements for this cleanup are specified in an agreement between DOE and its regulators--the U.S. Environmental Protection Agency and the Washington State Department of Ecology.[1] DOE spends about $2 billion per year on the cleanup of the Hanford site and estimates that the cost of Hanford's cleanup effort will eventually total about $45 billion and will be completed around 2035. The cleanup effort includes exhuming and treating buried waste, cleaning up facilities, and other necessary steps, including protecting the Columbia River by keeping contamination from migrating through the groundwater to the river. To this end, DOE established a groundwater management program at Hanford in 1997. Overall efforts to address groundwater and related activities, such as eliminating contaminated soil and monitoring river water and sediments, received about $100 million in fiscal year 2005.

This report responds to your request for preliminary information about DOE's efforts to address river contamination. It addresses (1) the past, current, and future sources of contaminants to the Columbia River and the status of the contaminant plumes that threaten the river; and (2) DOE's planned approach to prevent contamination from reaching the Columbia River and DOE's efforts to implement its plan.

To address these objectives, we reviewed key documents, including Hanford's 2003 Groundwater Management Plan, the 2004 Hanford Site Groundwater Strategy, and various other DOE technical, budget, and cost related reports. We also reviewed a 2001 National Academy of Sciences study and two recent DOE Inspector General reports on Hanford's groundwater protection program.[2] We visited various groundwater protection projects at the Hanford site and discussed river contamination issues with DOE and contractor officials at Hanford and with state and federal regulators. In reviewing the data related to the groundwater and river

[1]Formally titled the Hanford Federal Facility Agreement and Consent Order, it is better known as the Tri-Party Agreement. The Agreement was signed in May 1989.

[2]National Research Council, *Science and Technology for Environmental Cleanup at Hanford* (Washington, DC: 2001); Office of Inspector General, *Groundwater Remediation Activities at Hanford*, DOE/IG-0655, (Washington, DC: July 22, 2004); and Office of Inspector General, *Well Decommissioning Activities at the Hanford Site*, DOE/IG-0670, (Washington, DC: Jan. 3, 2005). We did not assess the scientific content of these reports.

programs, we determined that it was sufficiently reliable for the purposes of our report. We conducted our work from August through October 2005 in accordance with generally accepted government auditing standards.

On September 21, 2005, we briefed your staff on our results to date. This report summarizes that briefing, and includes the briefing slides we presented. Our work on these objectives is continuing. We plan to complete our work and issue a final report in the spring of 2006.

Sources and Extent of Contamination from the Hanford Site that May Threaten the Columbia River

Sources of contaminants to the groundwater—and possibly the Columbia River—are numerous and stem both from past production activities, current and future cleanup efforts, and the permanent storage of waste on the Hanford site. While some contamination has already reached the river, DOE has found that it is barely detectable in the water because of the high volume of water in the river, which dilutes the contamination. DOE routinely monitors the river's water quality, which meets federal drinking water standards.

Sources of Contamination

Contamination from the Hanford site that may threaten the Columbia River includes (1) contamination that resulted from disposal activities during the era in which DOE produced nuclear material; (2) contamination that could occur during cleanup activities, such as from an accidental spill; and (3) possible future migration of contamination from waste that will be permanently disposed of on the Hanford site in accordance with the cleanup actions DOE and the regulators plan to use.

Contamination from production era. Contamination at Hanford resulting from plutonium production (which occurred from 1943 to 1989) that is currently migrating to the river is primarily[3] from:

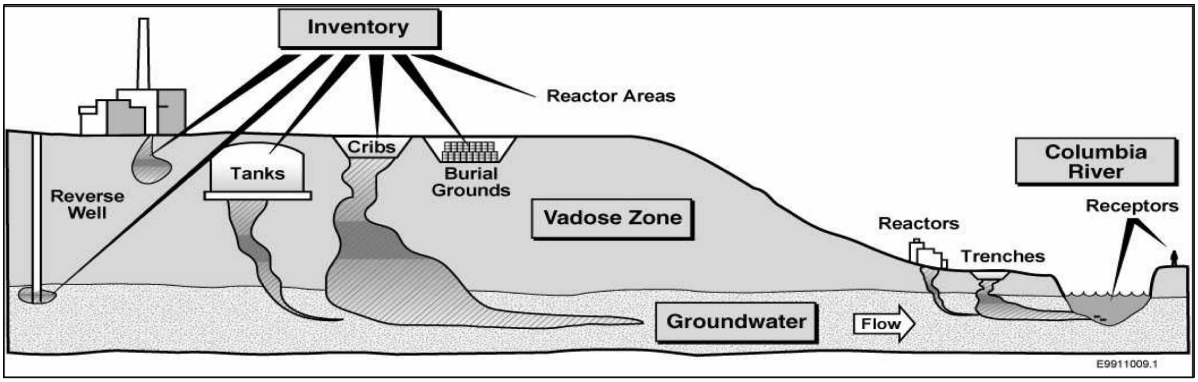
- Intentional disposal of liquid waste and contaminated water to the ground (about 450 billion gallons). DOE and its contractors disposed of this waste in various facilities including trenches, ponds, wells into which waste was pumped, and underground structures known as cribs that allow the waste to percolate to the soil.
- Leaks into the soil from waste tanks and the pipelines that connect them (between 500,000 to 1 million gallons containing about 1,000,000 curies of radioactivity).

[3]In addition, during Hanford's past operations, DOE directly discharged to the river contaminated cooling water from the reactors containing about 110 million curies of mostly short-lived radionuclides. (Radioactivity is measured in curies. One curie equals 37 billion atomic disintegrations per second.) Operations also resulted in air emissions of about 20 million curies from 1944 to 1972. The portion that went to the river is unknown. These discharges are no longer occurring.

- Contamination that has begun to migrate from solid waste (more than 710,000 cubic meters) disposed of on site in burial grounds, pits, and other facilities. The extent of contaminants coming from this waste is unknown but DOE believes it is not a major contributor to the contamination found in the vadose zone.

These past practices, illustrated in figure 1, resulted in chemical and radioactive contamination currently affecting more than 180 of the 586 square miles of the site's groundwater and large areas of the vadose zone. As the figure shows, much of the Hanford site sits above the elevation of the Columbia River, with the groundwater beneath the site at roughly the elevation of the river itself. Contaminants entering the groundwater thus have opportunity to enter the river. While there are numerous contaminants now in the vadose zone and the groundwater below, DOE has reported that the key contaminants in the groundwater include hazardous chemicals (such as carbon tetrachloride, chromium, nitrate, and trichloroethane) and radioactive materials (such as iodine-129, strontium-90, technetium-99, tritium, and uranium). These contaminants are of concern because of the extent of the contamination, its mobility in the groundwater, and the potential health risk. The health risk occurs because at sufficient levels, some of the contaminants are toxic to humans or fish while others are potential carcinogens.

Figure 1: Contamination of the Columbia River



Source: DOE.

Potential contamination from current activities. Current cleanup efforts at the Hanford site could contribute some additional contamination to the vadose zone and groundwater that eventually reaches the river. For example, some of the waste put into underground storage tanks as liquid has since turned into sludge or saltcake.[4] To dissolve it, more water will have to be introduced into the tanks—including tanks known to have leaked. This process may cause additional discharges into the soil. To minimize this risk, DOE is attempting to develop technologies that will reduce the amount of liquid needed. Another source of potential contamination from current activities is DOE's discharge of treated waste water into the river and soil as permitted by Washington state. This treated waste may still contain small amounts of contaminants, including tritium.

[4]Saltcake is a moist sand-like material such as sodium salts that have crystallized from the waste.

Possible future contamination. Under DOE's cleanup plans and with regulator approval, a large amount of contaminants will remain on site even after the cleanup is completed. This contamination may be in buildings, in mostly empty underground tanks, in covered burial grounds and waste disposal areas, and in approved disposal facilities. Contaminants may leach out of these facilities in the future and join existing contamination in the vadose zone and migrate to the groundwater, where they could migrate to the river. DOE is currently using computer modeling to develop an overall analysis to estimate the effects of potential contaminant migration.

Extent of Contamination

Based on groundwater sampling results, DOE reports that plumes of contamination continue to move through the vadose zone and the groundwater and are leaching into the river. DOE estimates that about 80 square miles of groundwater under the site contain contaminants at or above federal drinking water standards.[5] Because the groundwater and the river are at the same relative elevation, these plumes are leaching directly into about 10 of the nearly 50 miles of river shore on the site. Specific examples of this include:

- Groundwater in one such plume leaching into the river contains uranium at up to three times the federal drinking water standard. This groundwater enters the river about four miles above the drinking water intake for the city of Richland, which has about 43,000 residents.

- Strontium-90 is found in the groundwater at up to 900 times drinking water standards near the river and key nesting areas for salmon, which migrate to the Pacific Ocean and return to lay their eggs.

- Chromium is entering the river at more than twice drinking water standards.

- Strontium-90, chromium, and technetium-99 have been detected in river shellfish located near the point that groundwater containing these contaminants enters the river.

According to environmental monitoring studies performed by Pacific Northwest National Laboratory (under contract to DOE), because of the large volume of water in the river, the contamination seeping into the river from the groundwater is generally barely detectable after entering the river and the river water meets all federal drinking water standards. As required by various environmental regulations, DOE performs routine monitoring of water quality and aquatic life, and its

[5]While the groundwater at Hanford is generally not used as a source for drinking water, drinking water standards are still a common measure of the extent of contamination. The EPA sets the maximum contaminant level which is the maximum amount of a contaminant allowed in water delivered to a user of any public water system. This is the federal standard for the contaminant.

conclusions are based on samples taken both above and below the Hanford site. For example, DOE's annual environmental reports state that no uranium above background levels is detectable at the Richland drinking water intake.

DOE's Approach to Addressing Columbia River Contamination from the Hanford Site

DOE's approach to addressing contaminants in the vadose zone and groundwater that threaten the river is to first address threats from contamination at sites located near the river or requiring immediate action and then to address contamination threats that are farther away from the river's edge. In conjunction with these efforts, DOE has a groundwater monitoring program to better understand the threats. These efforts are carried out by several DOE and contractor organizations. Both the National Academy of Sciences and the DOE Inspector General have issued reports noting concerns about DOE's management of the program.

Addressing Threats from Contamination Near the River

DOE's efforts to address contamination near the river take two main forms. The first is actively removing waste and contaminated soil as a way of reducing contaminants that could begin migrating. DOE has removed 6 million tons of soil and debris from waste disposal areas, burial grounds, and buildings since 1996. As of August 2005, it had done so at 354 locations on the Hanford site. DOE has been disposing of this material in a lined trench in the site's central area located about 5 miles from the river.[6] DOE plans to complete cleanup of the river shoreline and areas near the river by 2015.

DOE's second main effort to address contamination near the river is to treat the groundwater to prevent contaminants from further migrating. DOE has three main approaches to treating the groundwater:

- *Pump-and-treat.* With this approach, DOE uses wells to extract contaminated groundwater, treats the groundwater in above-ground facilities, and reinjects the treated water back into the ground. Since 1995, DOE has operated five pump-and-treat systems to remove strontium-90, chromium, carbon tetrachloride, or uranium from the groundwater. Four of the five groundwater pump-and-treat systems that DOE is currently operating are intended to address near-river contamination of chromium and strontium-90. DOE spent about $8 million in 2004 to operate and maintain these 5 systems.

[6]Because the waste will be permanently on the site, it is possible that it will eventually leach out of the lined trench. DOE is currently analyzing the potential long-term impacts of this and other waste that will remain on the site.

- *Chemical treatment*. This approach has been used in one instance: DOE relies on a chemical barrier near the Columbia River to block chromium from entering the river near major fish breeding areas.[7] The barrier consists of a 750-yard series of wells through which DOE injected a chemical into the groundwater that reacts with the chromium to change it to a less hazardous and less mobile form.

- *Natural attenuation*. This approach relies on subsurface processes such as dilution, adsorption, and chemical reactions with subsurface materials to reduce contaminant concentrations to acceptable levels. A large uranium plume in the groundwater from past fuel fabrication activities is entering the river about 4 miles above city drinking water intakes. In 1996 DOE and its regulators agreed to allow the plume to dissipate through natural attenuation of the contamination.

DOE is experiencing problems with all three of these approaches, leading both DOE and its regulators to determine that, in several instances, the results are unsatisfactory. More specifically:

- In a 2004 report, the DOE Inspector General concluded that the pump-and-treat system to remove strontium-90 was ineffective and that the other systems have shown mixed results. A DOE Hanford project manager told us that while the four other pump-and-treat systems are meeting remedial objectives agreed to with Hanford's regulators, the system to remove strontium-90 is largely ineffective. DOE and the regulators have agreed to continue to operate the strontium-90 pump-and-treat system so that some treatment is in place until a more effective remedy is found. DOE has begun field testing of a chemical barrier to prevent the strontium-90 from entering the river.

- In 2004, DOE reported that, based on groundwater samples, the chemical barrier for dealing with chromium was not fully effective, and that the hazardous form of chromium was detected beyond the barrier and close to the river. DOE is currently evaluating alternative approaches to contain the chromium or improve the barrier.

- DOE's approach for addressing a uranium plume near the city of Richland by relying on natural attenuation is failing to control the migration of uranium to the river. According to monitoring well data, the plume has not dissipated over the 10-year period since the natural attenuation strategy was adopted. DOE is currently investigating the plume and ways to mitigate the problem but no treatment decision is expected before 2006.

To improve its groundwater treatment and monitoring programs, DOE funds research and technology efforts totaling about $4 million a year. A 2001 study by the

[7]Chromium is toxic to fish and this portion of the Columbia River is a major salmon breeding area.

National Academy of Sciences criticized DOE's technology development effort and identified several improvements needed, such as the need to develop new methods to understand the nature and extent of contamination in the vadose zone. In addition, site regulators have expressed concerns about the lack of technologies available to address contamination issues. While DOE is investing in some limited technology testing and development to support groundwater remediation, the DOE groundwater project manager at Hanford said that other program activities generally have a higher priority under current funding levels.

Addressing Contamination Threats that Are Farther from the River

For those production activities that took place several miles away from the river, DOE's efforts have involved four main types of actions:

Characterization of the vadose zone and groundwater to help understand the risks. DOE is investigating numerous sites where liquid wastes were discharged into the ground and numerous areas where spills occurred to determine the extent and nature of contamination and how contaminants move through the vadose zone. The investigations involve activities such as reviewing operating records, sampling the soil, and analyzing results in the laboratory. DOE relies primarily on data from monitoring wells to identify the migration of contaminants and the condition of the groundwater. Once the investigation is complete at each group of sites, DOE will prepare a report proposing appropriate remedies. This report is due to regulators by December 2008. Upon regulatory approval, DOE plans to implement the remedies.

Remediation of contaminated sites. DOE is studying potential problems from certain production era disposal areas in Hanford's central plateau which it believes may present a high-risk of waste migration. These disposal areas, which mainly received waste from facilities involved in extracting and purifying plutonium, are located about 8 miles from the Columbia River and between 200 and 300 feet above groundwater. At some sites, DOE is considering installing surface barriers to prevent water from infiltrating the soil and driving existing contamination farther toward the groundwater. For most of these sites, however, DOE is still studying the nature and extent of the contamination and its migration. Under its agreement with regulators, proposed remediation plans for these sites are not due until December 2008.

Decommissioning unneeded monitoring wells. The Hanford site has over 7,000 wells for monitoring groundwater, the vadose zone and other purposes. Monitoring wells are important, but they can also contribute to pollution by serving as conduits for rain, snow melt, or other liquids to flush contaminants into the vadose zone and groundwater. About half of these monitoring wells are no longer used because of shifts in groundwater flow, lower groundwater levels, or problems with individual wells. The Washington State Department of Ecology, one of DOE's regulators, requires well owners, in this case DOE, to decommission unused wells,[8] but no

[8]Decommissioning of wells at Hanford requires removing or shredding the casing and sealing it with special materials.

schedule is prescribed. From fiscal years 2003 to 2005, DOE decommissioned 257 wells.

Reducing water intrusion. Water leaking from pipelines and from surface drainage is a source that can drive contamination from the vadose zone to the groundwater. DOE is modifying surface drainage and repairing leaking water and pipelines to reduce the discharge of water to the ground above contaminated areas. From 2001 through 2002, DOE took steps to eliminate water intrusion above some of the underground waste storage tanks by modifying surface water drainage and eliminating six leaking water lines. Also, from 2003 through 2005, DOE refurbished about 26,000 linear feet of water line to reduce the risk of leaks. DOE officials said that they are repairing Hanford's aging infrastructure of water pipes but much more needs to be done. They said problems will be addressed as funding becomes available.

Groundwater Monitoring Program

Monitoring groundwater and its effect on the river to detect and assess threats involves three interrelated efforts. First, DOE monitors groundwater contamination levels to detect new or increasing levels of contamination. These monitoring efforts have detected emerging plumes containing high levels of technetium-99 and/or tritium in the groundwater from certain waste sites. Second, DOE conducts studies to detect radionuclide and chemical contamination in river life and river sediments that could impact human health and the environment. DOE has detected such contamination but the effects of the contamination are not fully understood. Third, DOE uses the results of these monitoring efforts to identify, propose, and evaluate remedial actions and treatment strategies. These efforts are ongoing.

Program Management

While DOE has had a groundwater monitoring and management effort for years, some studies have raised concerns about DOE's management of the program. DOE first took steps to establish a comprehensive and integrated groundwater and vadose zone program in response to a 1998 GAO report.[9] In a 2001 review of DOE's groundwater science and technology efforts, the National Academy of Sciences expressed concern about management of DOE's integrated program. The Academy reported that responsibility for the groundwater program was distributed among two DOE offices and eight site projects. It reported that DOE had superimposed its integration program over a collection of preexisting, highly complex projects, which left unclear who had authority for making final cleanup decisions. The Academy also reported that it was unclear which project had responsibility for achieving results from technology development efforts. Although DOE had reorganized the program by 2002, various program elements continue to be fragmented among two DOE site operations offices (the Richland Operations Office and the Office of River

[9]U.S. General Accounting Office, *Nuclear Waste: Understanding of Waste Migration at Hanford is Inadequate for Key Decisions* GAO/RCED-98-80 (Washington, DC: March 13, 1998).

Protection) and four site contractors. The DOE Inspector General also raised concern about management of the groundwater effort at Hanford. He noted in a 2004 review of the groundwater program that actions DOE planned to take, such as installing surface barriers on the ground to prevent water infiltration, may be premature. Since a final end state for the groundwater has not been agreed to between DOE and the regulators, these expensive barriers may be inconsistent with final remedies. However, DOE officials said that the proposed surface barriers are needed to protect the groundwater from further degradation and the barriers will be installed in consultation with site regulators. Because of these issues, the potential for inefficiencies still exists in DOE's efforts to protect the Columbia River.

We provided a draft of this report to DOE's Office of Environmental Management, the Richland Operations Office, and the Office of River Protection. We obtained views on the report's contents from the Deputy Manager of the Richland Operations Office and other officials from each of these offices who were knowledgeable about DOE's efforts to protect the Columbia River. DOE generally agreed with our report's findings. However, DOE did not fully agree with the information we cited from the Inspector General's 2004 report that installing surface barriers to prevent water infiltration may be premature since final cleanup standards have not been established. We modified our report to more fully explain DOE's strategy for using surface barriers. DOE also offered technical comments on the draft report, which we incorporated as appropriate.

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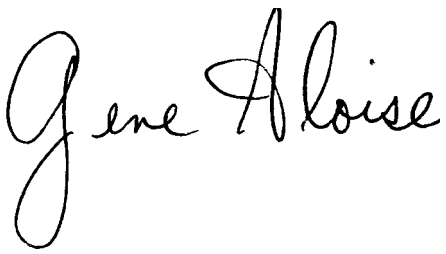
As agreed with your offices, we will make copies of this report available to others upon request. This report will also be available at no charge on GAO's Web site at http://www.gao.gov.

If you or your staff has any questions about this report, please contact me at (202) 512-3841 or aloisee@gao.gov. Contact points for our Offices of Congressional Relations and Public Affairs may be found on the last page of this report. Major contributors to this report include Chris Abraham, Nancy Kintner-Meyer, Jeff Larson, Tom Perry, Stan Stenersen, and Bill Swick.



Gene Aloise
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Enclosure

Briefing Slides

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Department of Energy: Potential for Columbia River Contamination from the Hanford Site

GAO Preliminary Information

Briefing for
Subcommittee on Energy and Water Development,
House Committee on Appropriations

September 21, 2005

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Introduction

- Beginning in the 1990s, DOE has been working to clean up the Hanford site including addressing impacts to the Columbia River. DOE plans to complete the cleanup by about 2035.
- To address migration of contaminants, DOE established a groundwater management program at Hanford in 1997. DOE's fiscal year 2005 budget for groundwater remediation and protection is about $100 million.
- Hanford cleanup is governed primarily by two environmental laws: (1) the Comprehensive Environmental Response, Compensation, and Liability Act of 1980, as amended (CERCLA), and (2) the Resource Conservation and Recovery Act of 1976, as amended (RCRA).
- Cleanup milestones and requirements are laid out in the Hanford Federal Facility Agreement and Consent Order (known as the Tri-Party Agreement), signed by DOE and its regulators, the U.S. Environmental Protection Agency, and the Washington State Department of Ecology.

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Objectives

We:

1. Examined the past, current and future sources of contaminants to the Columbia River, and the status of the contaminant plumes that threaten the river.
2. Determined what DOE's planned approach is to prevent contamination from reaching the Columbia River and whether DOE is adhering to its plan.
3. Provided preliminary observations about DOE's efforts to prevent contamination of the Columbia River.

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Scope and Methodology

To address these objectives we:

- Reviewed key documents, including Hanford's Groundwater Management Plan (2003) and Hanford Site Groundwater Strategy (2004); and various technical, budget, and cost related reports.
- Toured groundwater protection projects at the Hanford site.
- Discussed river contamination issues with key DOE and contractor officials at Hanford, and with state and federal regulators.
- Reviewed DOE Inspector General reports (2004 and 2005) and a National Academy of Sciences study (2001) on Hanford groundwater protection. We did not assess the scientific content of these reports.
- Based on our general knowledge and discussions with DOE and regulators, we determined the data were of sufficient reliability for this briefing.
- We performed our work in accordance with generally accepted government auditing standards.

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Objective 1: Sources of Contamination from the Hanford Site that Threaten the Columbia River

- **Past Sources--**Contamination from past Hanford practices that has reached or is currently migrating to the river is primarily from:
  - Direct discharges to the river from reactor operations (about 110 million curies of mostly short-lived radionuclides)
  - Air emissions drifting into the river (about 20 million curies from 1944 to 1972; the portion that went to the river is unknown)
  - Intentional liquid disposal to the ground (about 450 billion gallons)
  - Waste tank and pipeline leaks into the soil (between 500,000 to 1 million gallons containing about 1,000,000 curies)
  - Limited contamination from solid waste disposed on site (more than 710,000 cubic meters)
- Key contaminants now in the groundwater from past operations include:
  - Chemical contaminants: carbon tetrachloride, chromium, nitrate, and trichloroethene.
  - Radionuclide contaminants: iodine-129, strontium-90, technetium-99, tritium, and uranium.

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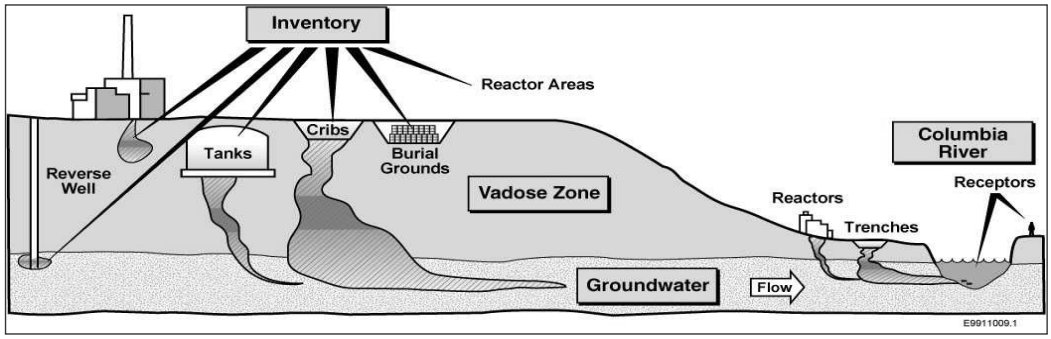
Objective 1: Sources of Contamination from the Hanford Site that Threaten the Columbia River

- These past activities resulted in extensive chemical and radioactive contamination of the site's groundwater and the soil above the groundwater, known as the vadose zone.
- Mobility of these and other contaminants in Hanford soils varies. For example, nitrate, tritium, and technetium-99 are highly mobile while uranium and strontium-90 are less mobile. Others, such as cesium and plutonium, are generally not mobile.
- Past sources of contamination:



Source: DOE

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Objective 1: Sources of Contamination from the Hanford Site that Threaten the Columbia River

- **Current Sources--**Current cleanup efforts at Hanford could contribute to some additional contamination eventually reaching the river:
  - Waste retrieval from old single-shell tanks may cause unplanned releases or leaks into the soil (DOE has developed technologies for use in these tanks to reduce the amount of liquid used for retrieval); and
  - While disposal of untreated liquid waste to the soil is no longer occurring at Hanford, some operating treatment facilities have permits to discharge waste water which contains some contaminants including tritium.
- Any large water deposit to the ground, such as from a broken water line, can drive the existing contaminants in the soil toward the groundwater.

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Objective 1: Sources of Contamination from the Hanford Site that Threaten the Columbia River

- **Potential Future Sources--**Once site cleanup is complete, DOE plans to leave radioactive and hazardous waste permanently on the site in disposal facilities. Some contaminants may eventually leach out of the facilities and begin migrating to the groundwater.
- Other potential sources of future contamination include all other locations where waste or contamination remains on the site, including buildings, closed tanks, and contamination already in the vadose zone and groundwater.
- DOE is currently developing an overall analysis using computer modeling to estimate the effects of contaminant migration in future years.

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Objective 1: Sources of Contamination from the Hanford Site that Threaten the Columbia River

- **Status of plumes--**Hanford site contaminant plumes from past practices are still substantial with
  - Contamination in 80 square miles of groundwater at or above federal drinking water standards;
  - 10 of the 49 miles of river shore on the site leaching contaminants into the river from plumes that are above federal drinking water standards; and
  - A uranium plume with readings as high as three times federal drinking water standards is leaching into the river within about four miles of the City of Richland water intake. Because of the high river volume and low leach rates, no uranium above background levels is detectable at the water intake.
- Plumes vary in size and location.

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Objective 1: Sources of Contamination from the Hanford Site that Threaten the Columbia River

- The impacts of contamination on the river ecosystem are not yet fully understood. Routine monitoring of water quality and aquatic life is performed. Findings from 2003 include:
  - Strontium-90, chromium and technetium-99 have been detected in river shellfish near the point that the contamination enters the river.
  - Strontium-90 is found in the groundwater near the river and key salmon nesting areas at up to 900 times drinking water standards.
  - Chromium is entering the river at more than 2 times drinking water standards.
  - According to DOE's river monitoring studies, because of the volume of water in the river, the contamination seeping into the river from the groundwater is generally barely detectable after entering the river and the water meets federal drinking water standards near Richland.

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Objective 2: DOE's Planned Approach

- DOE's cleanup agreement with regulators outlines many activities to address contamination moving towards or reaching the Columbia River.
  - For surface contamination, DOE has projects underway, such as stabilizing waste, cleaning up facilities, and exhuming and treating buried waste. These are funded separately.
  - Regarding below-surface contamination in the site's vadose zone and groundwater, DOE has interim actions underway, but, in many cases, final remediation actions needed to comply with RCRA and CERCLA are still being determined. DOE must provide its remediation plan to regulators by 2008.
- According to DOE's Groundwater Project Manager, to address contaminants in the vadose zone and groundwater that threaten the river, DOE's current priorities are
  - first, address threats near the river;
  - then minimize contamination threats that are farther from the river; and
  - monitor levels of contamination in the groundwater and river throughout the cleanup effort.

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Objective 2: DOE's Planned Approach

- **Addressing threats near the river** involves two main efforts:
  - **Soil and waste removal**
    - Removal of waste and contaminated soil from past operations near the river, including contaminated trenches, pits, ponds and spill areas near old reactors and other facilities.
    - Since 1996, DOE has removed 6 million tons of soil and debris from waste sites, burial grounds, and buildings and disposed of the material in a lined trench in the site's central area.
    - DOE recently signed a new contract to complete cleanup of the river shoreline and near river areas by 2015.
    - Status: As of August 2005, DOE had remediated 354 sites.

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Objective 2: DOE's Planned Approach

- **Addressing threats near the river**
  - **Groundwater treatment and barriers**
    - Four out of 5 groundwater pump and treat systems that DOE is operating are intended to address near-river threats of chromium and strontium-90.
    - DOE also installed a below-surface chemical barrier to convert chromium to a less harmful and less mobile form.
    - Status: These efforts have shown mixed results:
      - The chromium pump-and-treat systems have removed more than 1,000 pounds since 1996 while the strontium pump-and-treat system has not been effective, removing less than 2 curies of strontium-90.
      - The chemical barrier has not been fully effective in keeping chromium from the river.

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Objective 2: DOE's Planned Approach

- **Minimizing contamination threats that are farther from the river** involves four main efforts:
  - **Characterization of the vadose zone and groundwater to help understand the risks**
    - DOE is investigating numerous old liquid waste sites and the tank farms to determine the extent and nature of contamination and how contaminants of concern are moving through the vadose zone.
    - DOE is drilling wells and sampling others to investigate quality of groundwater and migration of contaminants.
    - Once characterization is complete, DOE will prepare a report proposing appropriate remedies, due to the regulators by December 2008. Upon regulatory approval, DOE plans to implement the remedies.
    - Status: DOE has a number of characterization efforts underway; however it is too early to tell if this effort is on track to allow DOE to meet its December 2008 report deadline.

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Objective 2: DOE's Planned Approach

- **Minimizing contamination threats that are farther from the river**
  - **Remediation of contaminated sites located farther from the river**
    - DOE is working with regulators to take actions, such as installing surface barriers to prevent water from infiltrating the soil, to address certain high risk sites in Hanford's central area.
    - For most waste sites farther from the river, DOE is currently studying the nature and extent of contaminant migration by monitoring, such as through groundwater wells.
    - DOE's proposed remediation plan for these sites is not due to regulators until December 2008.
    - DOE has undertaken some efforts to address contamination in some waste sites in the central area, for example actions to contain a uranium and technetium plume have been successful in meeting remedial action objectives.
    - Status: Although DOE has a number of studies underway to monitor these sites, it is too early to tell whether the department will meet its December 2008 milestone to propose remedies.

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Objective 2: DOE's Planned Approach

- **Minimizing contamination threats that are farther from the river**
  - **Decommissioning unneeded wells**
    - Old, unused wells located in or near waste sites can allow rain and snow melt or other liquid to flush contaminants down into the vadose zone and groundwater.
    - Hanford site currently contains over 7,000 wells but less than half are in use. Some of the unused wells are in areas of high contamination, such as tank farms or cribs.
    - State regulations require unused wells to be decommissioned, but no schedule is prescribed.
    - Status: From fiscal years 2003 to 2005, DOE decommissioned 257 wells.

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Objective 2: DOE's Planned Approach

- **Minimizing contamination threats that are farther from the river**
  - **Reduce water intrusion**
    - The main goal is to repair leaking water and pipe lines and surface drainage in order to reduce discharge of water to the ground above contaminated areas.
    - The Tri-Party Agreement has no requirement that DOE must perform these maintenance and repairs.
    - In 2001-02, DOE modified drainage controls, such as installing soil and rock berms, to reduce surface water drainage in single-shell tank farms and eliminated 6 leaking water lines.
    - Status: From 2003 to 2005, DOE refurbished about 26,000 linear feet of water line.

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Objective 2: DOE's Planned Approach

- **Monitoring groundwater and the river to detect and assess threats** involves three efforts:
  - Monitoring groundwater contamination levels to detect new or increasing contamination.
    - Monitoring efforts have detected emerging plumes containing high levels of technetium-99 and/or tritium in the groundwater from certain waste sites.
  - Conducting studies to detect radionuclide and chemical contamination in river life and river sediments that could impact human health and the environment.
  - Using results of monitoring studies to determine appropriate remedial actions and treatment strategies.
  - Status: These efforts are ongoing activities. DOE produces various reports as required.

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Objective 3: Preliminary Observations about DOE's Efforts to Protect the River

- **Observation 1: Performance of certain remedial actions is generally not satisfactory.**
  - **Groundwater pump-and-treat systems**
    - Since 1995, DOE has operated 5 pump-and-treat systems to remove strontium-90, chromium, carbon tetrachloride, or uranium from the groundwater at a cost of about $8 million in 2004.
    - In its 2004 report, the DOE Inspector General concluded that the system to remove strontium-90 was ineffective and that the other systems have shown mixed results.
    - A DOE Hanford project manager told us the pump-and-treat system to remove strontium-90 is largely ineffective but the remaining systems are meeting remedial objectives.
    - DOE and the regulators have agreed to continue to operate the strontium-90 pump-and-treat system so some treatment is in place.

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Objective 3: Preliminary Observations about DOE's Efforts to Protect the River

- **Observation 1: Performance of certain remedial actions is generally not satisfactory.**
  - **Chromium barrier near the Columbia River**:
    - The barrier consists of an approximately 750-yard series of wells where DOE injected a chemical into the groundwater that reacts with the chromium to change it to a less hazardous and less mobile form.
    - However, in 2004, based on groundwater readings, DOE reported that the barrier was not fully effective, and that the hazardous form of chromium was detected beyond the barrier.
    - DOE is currently evaluating alternative approaches to contain the chromium or fix the barrier.

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Objective 3: Preliminary Observations about DOE's Efforts to Protect the River

- **Observation 1: Performance of certain remedial actions is generally not satisfactory.**
  - **Treatment of uranium plume near the city of Richland**
    - A large groundwater plume from past fuel fabrication activities is entering the river about 4 miles above city drinking water intakes.
    - The original treatment plan was to allow "natural attenuation" of the contamination.
    - However, the plume has not dissipated over the 10-year period.
    - DOE is investigating the plume and ways to mitigate the problem but no treatment decision is expected before 2006.

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Objective 3: Preliminary Observations about DOE's Efforts to Protect the River

- **Observation 2: Different technologies may be needed to address remediation challenges.**
  - Technology used in several of DOE's current remedies is not performing satisfactorily.
  - A 2001 study by the National Academy of Sciences criticized DOE's technology development effort and identified several improvements needed in DOE's research effort.
  - Site regulators have raised a concern about the lack of new technologies to solve contamination issues.
  - DOE is doing some limited technology testing and development but the DOE groundwater project manager said that under the current funding constraints, other program activities are higher priority.

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Objective 3: Preliminary Observations about DOE's Efforts to Protect the River

- **Observation 3: Changing organizational structure and management of groundwater and vadose zone cleanup program raises concerns.**
  - In response to a 1998 GAO report, DOE established a comprehensive integrated groundwater and vadose zone program.
  - In a 2001 report, the National Academy of Sciences expressed concern that DOE's integrated program was not satisfactory, and that the groundwater program was operating in an unstable organizational environment, with responsibility for program activities distributed among 2 DOE offices and 8 site projects.
  - Although DOE reorganized the program by 2002, various program elements continue to be fragmented among two DOE site operations offices (Richland Operations Office and the Office of River Protection) and four site contractors. Because funding and various activities are scattered among several projects, the potential still exists for duplication, gaps, and inefficiencies.

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