Oregon Hanford Cleanup Board

Position Paper on Capping Waste Sites located on the Hanford Nuclear Site

JULY 2005

Oregon Hanford Cleanup Board

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Cover photo: Waste trench at the Hanford Site

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Capping waste sites on the Hanford Nuclear Site

Summary

For more than 40 years, the federal government produced plutonium at the Hanford Nuclear Site in southeastern Washington state for America's nuclear weapons program. The plutonium production process created huge amounts of radioactive and chemically hazardous wastes. Since plutonium production ended at Hanford in 1988, a massive cleanup program has been underway at the site.

More than 1,900 waste sites have been identified at Hanford, ranging from small areas of surface contamination to 177 underground storage tanks holding more than 50 million gallons of highly radioactive waste. Billions of gallons of liquid waste were dumped into hundreds of disposal trenches and waste sites, heavily contaminating the soil column and the groundwater. Solid waste, contaminated with various radioactive materials and chemicals, was buried in hundreds of different landfills. In addition, hundreds of contaminated buildings remain on site, including reactors, chemical processing facilities, and laboratories.

In recent years, millions of tons of contaminated soil and other waste has been dug up from many of the burial grounds and liquid waste disposal trenches. Many sites have been successfully cleaned up, especially those in areas near the Columbia River. For many of the remaining sites, however, the U.S. Department of Energy (DOE), which owns Hanford, is considering leaving waste in place, and permanently "disposing" of that waste by putting a cover, or "cap," on top. The cap is intended to keep water from percolating through the waste, which could spread contaminants through the environment. There are also other conditions in which contaminants could spread, as discussed later.

The Oregon Hanford Cleanup Board was established to consider and advocate cleanup policies that protect Oregon's interests – including the Columbia River – from the hazards posed by Hanford. The Board devoted a significant portion of its March 2005 meeting to the topic of caps. This report contains the Board's findings and provides recommendations for DOE and its regulators in considering when a cap might be a necessary and acceptable means of waste disposal, and when it may not.

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CAPPING WASTE SITES ON THE HANFORD NUCLEAR SITE

Introduction

The Hanford Site is, arguably, the most contaminated site in the United States. In 1944, when Hanford workers began producing plutonium, they also began disposing of radioactive and chemical waste to the soil, the groundwater, and the Columbia River. Many of these actions were consistent with industrial practices at the time, which generally called for solid waste to be buried and liquid waste disposed to the ground. What separates Hanford from all other contaminated sites is both the sheer volume of waste and the nature of the contaminants. The nation's environmental laws now require these waste sites to be cleaned up.

An estimated 444 billion gallons of contaminated liquids were dumped into Hanford soils. Some disposal trenches were a mile long. This enormous volume of liquid waste caused the groundwater beneath the site to rise tens of feet above historic levels, changing both the direction and speed with which the groundwater moved. There was extensive contamination of the surface, the vadose zone (the area between the surface and groundwater) and the groundwater.

A liquid waste disposal trench (the Z-shaped trench) near Hanford's N reactor.

In addition, 67 of the 177 underground waste storage tanks at Hanford are known or suspected to have leaked, releasing about one million gallons of highly radioactive and chemical waste to the soil. The leaked tank waste, containing an estimated one million curies of radioactivity, has reached the groundwater.

Solid wastes were buried in hundreds of burial grounds and some 500 contaminated buildings are scattered across the site.

Contaminants include a wide range of radioactive materials, such as uranium, plutonium, strontium, cesium, technetium and iodine, among many others. The contaminants also include various chemicals, such as chromium, carbon tetrachloride, lead, cadmium, mercury, beryllium, acids and nitrates. Many of these contaminants move rapidly through the soil. Others bind readily to soil and are fairly immobile. Some of the radioactive contaminants will be hazardous for thousands or millions of years. Many of the chemicals will remain dangerous forever.

Records are incomplete as to what wastes were dumped in specific burial grounds. Since Hanford workers began to poke into waste sites and burial trenches as part of the cleanup process, there have been numerous surprises.

- In April 1998, excavation of a burial ground in Hanford's 300 Area was halted when drums were uncovered that contained pyrophoric uranium metal shavings in mineral oil. Pyrophoric metals can catch fire spontaneously when exposed to air. Several of the drums had corroded through and leaked their protective oil to the ground. Hanford workers had no idea that these barrels existed. Ultimately, 1,184 drums were removed from the burial ground.

- In January 2000, high concentrations of tritium, 400 times above drinking water standards, were found in a monitoring well next to the 618-11 burial ground near the south end of the site. Hanford officials said they had no indication there was anything in that burial ground that could have caused the high readings of tritium.

- Highly radioactive irradiated pieces of nuclear fuel have been found in burial sites near the B and C reactors.

- Twenty-two pieces of irradiated depleted uranium fuel were found buried adjacent to another burial ground, with no record they were there.

- In 2005, Hanford workers found a locked safe buried in Hanford's 300 Area, with containers of plutonium residue inside.

In the Board's opinion, these examples demonstrate that without substantial additional work to characterize the burial grounds and disposal trenches, it is not possible to accurately assess the risks of leaving waste in place.

The Time has Come for Critical Cleanup Decisions

Significant progress has been made since cleanup began at Hanford, although considerable work remains. We have reached the point in cleanup where decisions made during the next few years, especially those regarding the use of caps and leaving waste in place, will define the quality of the remaining cleanup.

In September 2004, DOE contractor Fluor Hanford delivered a proposed plan for closure of Hanford's Central Plateau. The plan covers Hanford's underground tank farms, five canyon facilities, 884 waste sites and 955 structures. The plan advocates leaving contaminated materials and soils in place, unless removal and disposal are judged to be more cost effective. Under this plan, almost all of the waste in Hanford's burial trenches would remain in place and be capped. Hanford's tank farms would all be capped. Hundreds of miles of contaminated underground pipelines, many containing high-level nuclear waste, would be left in place. The plan advocated capping a huge area covering more than 1,700 acres (more than twice the size of New York's Central Park) and requiring more than 41 million cubic yards of cover material.

While Flour Hanford's closure plan is not a DOE proposal, it represents a significant step advocating widespread use of capping. Board staff at the Oregon Department of Energy felt compelled to submit written comments to DOE, challenging the basic premises offered in the Fluor proposal:

> "…the draft plan:
>
> 1) Reverses the (U.S. Environmental Protection Agency) guidance and bias for action to a bias for leaving waste in place with insufficient characterization or monitoring.
>
> 2) Ignores the evidence that water moves laterally in Hanford vadose zone soils. DOE has relied extensively on numerical models which presume that water and waste move uniformly downward through the soil. Caps and covers are then presumed to be effective (and hopefully less costly) remedies based on reducing the rate at which water moves downward through the caps and then through the wastes. The evidence at Hanford suggests that these assumptions are flawed.
>
> 3) Ignores the natural resource injury and damages as factors that need to be weighed in the decisions, and
>
> 4) Ignores the record of poor performance of caps and covers in the near term nationally, while presuming these will be effective remedies for the extremely long term."
>
> *(letter from Ken Niles of the Oregon Department of Energy to Larry Romine of the U.S. Department of Energy, December 21, 2004)*

Capping is already an integral part of DOE's strategy for disposal of some wastes at Hanford. Much of the contaminated soil and other wastes that has been removed from areas along the Columbia River has been placed in a lined, engineered disposal facility, called the Environmental Restoration Disposal Facility (ERDF). A new disposal facility, called the Integrated Disposal Facility (IDF), is also being planned. As portions of ERDF and then IDF are filled, those areas will be covered with dirt and other fill material. Eventually, a cap will be installed over both ERDF and IDF.

The Board acknowledges that for some waste sites at Hanford, such as ERDF and IDF, caps will be a necessary component of the final solution. This is acceptable because these waste sites are engineered as disposal sites and will contain a known and quantifiable inventory. There are also plans to monitor the cap performance following closure of each facility.

There will likely be some other waste sites for which capping – for a variety of reasons – could be an acceptable method of waste disposal. The Board has strong concerns with establishing capping as the default approach. Unless a burial ground or waste site can offer similar protection as an engineered disposal site, then the waste should be retrieved, treated, if necessary, and disposed into one of the engineered disposal sites or sent offsite to an appropriate waste repository. Depending on the type of waste, treatment may include thermal treatment to destroy certain chemicals, the addition of cement or another substance to immobilize the waste, or encapsulation – again with the intent of immobilizing the waste.

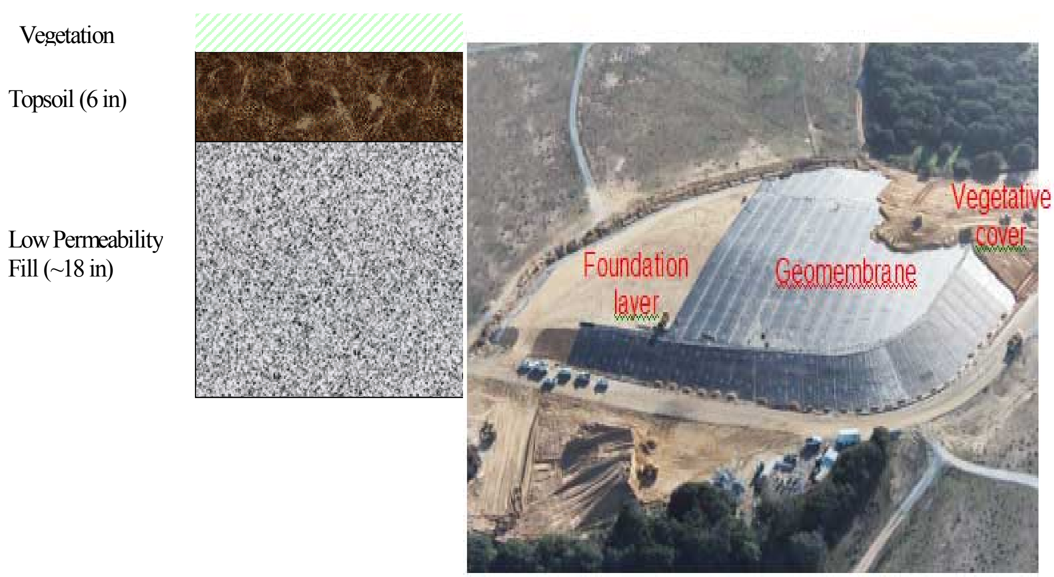
The Basics of Caps

Caps are covers placed over landfills and other waste areas, and are intended to isolate the waste. They are designed to prevent (or control) movement of water into or through waste, and to prevent access to buried waste by plants (roots) and animals. Caps may consist of only a soil cover. They may be composed of a series of engineered layers made up of soils (gravel, sand, silt, clay), geotextiles (such as synthetic fabrics), geo-membranes (such as polyvinyl chloride), and soil amendments or additions (*e.g.*, Portland cement, growth retardants).

Traditional caps use an impervious material (such as clay, plastic, or asphalt) to divert water and prevent burrowing animals and plant roots from reaching the waste.

Simple caps are commonly used at municipal and hazardous waste landfills. A federal cleanup law, the Resource Conservation and Recovery Act (RCRA), has specific requirements for caps and barriers for both municipal and hazardous waste landfills.

A RCRA cap over a municipal landfill (commonly known as a subtitle "D" barrier) may include six inches of topsoil and 18 inches of clay or another less permeable material. It is expected to have a life of about 30 years.



Subtitle "D" Barrier

A RCRA barrier over a hazardous waste landfill (known as a subtitle "C" barrier) would have many different layers of cover soil, a "protection" layer, a "drainage" layer, and other barrier layers. It may be as much as seven feet thick. It is also designed to have a life of about 30 years.

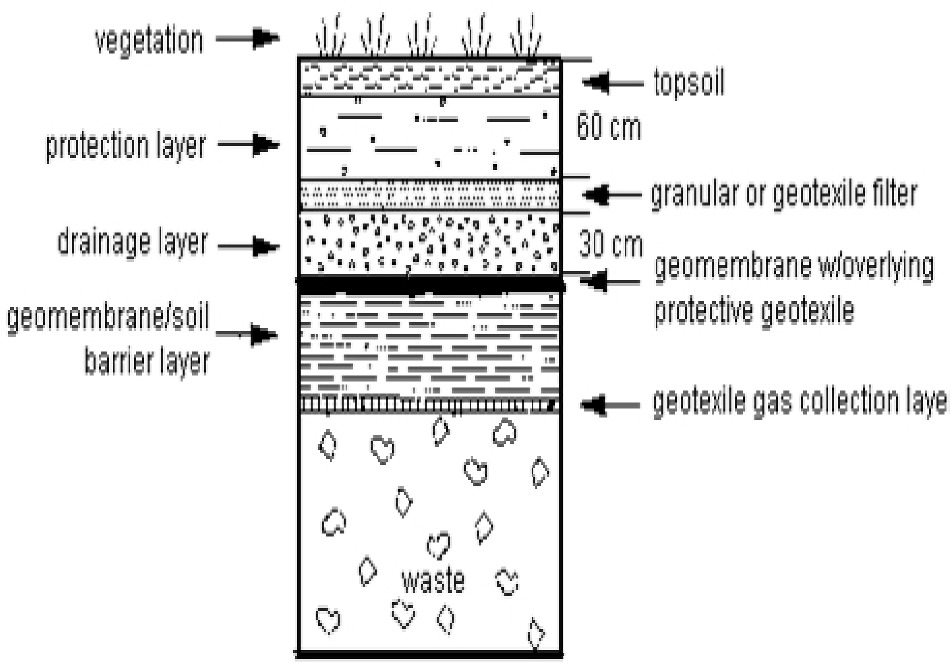


Diagram of Subtitle "C" Barrier

Several years ago, it was recognized that a RCRA subtitle C barrier may not be adequate for long-term isolation of some wastes at Hanford, so a new prototype barrier was designed. The "Hanford Prototype Barrier" is about 15 feet thick and is composed of many different layers of material. Its design life was intended to be about 1,000 years.

A different type of barrier – called an evapotranspiration (ET) barrier – is now also being considered for use at Hanford. Rather than repelling water, the ET barrier relies on natural processes to prevent water contact with contaminants. The ET barrier is designed to store rainwater and other precipitation, and then slowly release it into the atmosphere. The design depends on the natural processes of evaporation (from soil) and transpiration (by plants) to dry the soil and prevent percolation through the waste.

Unlike many other types of barriers, which can have multiple engineered layers, ET barriers are a simplified version of a RCRA subtitle D cap. They consist of a soil layer deep enough to retain the largest expected input of rainwater and snow melt. Native grasses and shrubs are then planted on top of the barrier to take up this stored water and evaporate it back to the air.

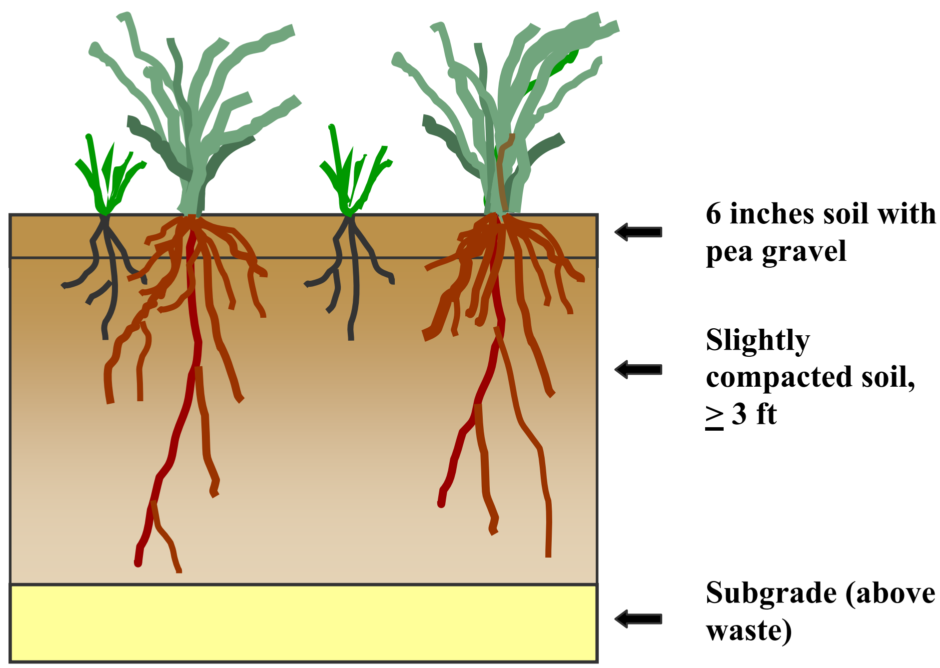


Diagram of ET barrier

The presumed advantages of an ET barrier are that they are relatively simple and inexpensive to build and maintain and are considered somewhat "self healing," which means that in the event of movement due to settling or a seismic event, soils could move freely and reseal resulting cracks. Similar stress on a RCRA subtitle C or D cap could result in a permanent break of a clay or asphalt layer or a tear in the geofabric or geotextile. ET barriers are also regarded as being especially effective in arid climates, where low annual precipitation inputs are much lower than potential transpiration by vegetation on the cap. ET caps also have limitations, which are discussed later.

Guidance from CERCLA

Several principles and requirements govern waste site cleanup. First and foremost are the governing laws. In some cases, these may dictate the cleanup. In most cases, they provide the framework for deciding what solutions are acceptable, or most often for what criteria must be weighed by the decision-makers in reaching a decision.

The cleanup at Hanford needs to comply with federal requirements under the Comprehensive Environmental Response Compensation and Liability Act (CERCLA), also know as Superfund, and with state requirements under both RCRA and Washington's Model Toxic Control Act. CERCLA and the state laws clearly identify removal and treatment as the preferred alternative for waste disposal.

Under CERCLA, when determining what options to use in cleaning up a particular site, the responsible party is required to consider the following nine criteria, which are categorized into three groups:

- Threshold Criteria (if a cleanup option fails either of these criteria, then it must be rejected)
  - Overall protection of human health and the environment
  - Compliance with ARARs (applicable or relevant and appropriate requirements)

- Balancing Factors (equally weighted factors that are used to compare major trade-offs between alternatives)
  - Long-term effectiveness and permanence
  - Reduction of toxicity, mobility, or volume through treatment
  - Short term effectiveness
  - Implementability
  - Cost

- Modifying Criteria (can be considered initially, but usually are only considered following the receipt of public comments on a proposed cleanup plan. Modifying criteria are equally as important as balancing factors)
  - State acceptance
  - Community acceptance

In deciding whether waste at Hanford should be left in place or removed, several of the CERCLA criteria are directly relevant: long-term effectiveness and permanence; reduction of toxicity, mobility, or volume through treatment; cost; and community acceptance.

Long-term effectiveness and permanence

Long-term effectiveness is first and foremost based on taking actions that prevent the future release of contaminants to the environment.

Generally, long-term expectations are based on computer models, which have a high degree of uncertainty. The uncertainties include the inventory of waste (its quantity and its constituents), its mobility, what portion of the inventory is moving and what processes are controlling that movement, how quickly and in what direction(s) movement is occurring, and the long-term performance of the cap. In other words, assumptions must be made for each one of these factors and a numerical model is developed to calculate what may happen over time, based on that set of assumptions.

Much of the waste will be hazardous for thousands or millions of years. Containing the wastes for that length of time is challenging, at best. Neither caps nor engineered barrier systems are expected to last more than several hundred years without failure, and many of the wastes at Hanford will remain dangerous well beyond that time period.

Reduction of toxicity, mobility, or volume through treatment

A cap is an attempt to keep the waste in place but the nature of the waste beneath the cap is not changed. Capping a waste site therefore does not change the waste's toxicity. Neither does it change the waste volume or mobility of the waste. Once containment is lost or the containment has failed, a level of risk returns. This is why capping or covering a waste site is considered a temporary, or interim, clean-up action.

Cost

For some waste sites at Hanford, it is cheaper to excavate the waste and move it to an engineered disposal site, rather than cap the waste site. But for many waste sites at Hanford, the opposite could be true. The short-term costs of constructing a cap might be cheaper than excavating certain waste sites.

While cost is just one of five balancing factors to be considered in clean-up, experience has demonstrated that cost resonates strongly with DOE and often overrides other factors. However, the Board recognizes that often the life-cycle costs of actions such as capping are not fully considered.

The costs of maintaining a cap and monitoring its performance, and of maintaining institutional controls necessary to keep the cap effective for as long as the risk remains, must also be considered as part of the costs. In addition, leaving waste in place results in long-term environmental injury and lost services that are compensable under the Natural Resource Damage Assessment (NRDA) provisions of CERCLA. For areas that are capped, cost analyses must include the full costs of NRDA injury assessment and of damages. Given the manner in which the federal budget is prepared and considered, future anticipated costs are given no consideration, yet to fairly judge the true costs of an option, those long-term costs must be reflected.

Community acceptance

Money spent excavating a waste site has longer-lasting societal value than money spent installing caps or barriers. That's because a capped site is lost to most future uses and is not thought of as beneficial to the surrounding region.

Hanford Reach of the Columbia River

National Environmental Policy Act

CERCLA, RCRA and all of the nation's environmental laws are guided by the overarching goals set forth in the National Environmental Policy Act (NEPA). NEPA Section 101 sets out those goals:

> *(b) In order to carry out the policy set forth in this Act, it is the continuing responsibility of the Federal Government to use all practicable means, consistent with other essential considerations of national policy, to improve and coordinate Federal plans, functions, programs, and resources to the end that the Nation may--*
>
> *1. fulfill the responsibilities of each generation as trustee of the environment for succeeding generations;*
>
> *2. assure for all Americans safe, healthful, productive, and aesthetically and culturally pleasing surroundings;*
>
> *3. attain the widest range of beneficial uses of the environment without degradation, risk to health or safety, or other undesirable and unintended consequences;*
>
> *4. preserve important historic, cultural, and natural aspects of our national heritage, and maintain, wherever possible, an environment which supports diversity, and variety of individual choice;*
>
> *5. achieve a balance between population and resource use which will permit high standards of living and a wide sharing of life's amenities; and*
>
> *6. enhance the quality of renewable resources and approach the maximum attainable recycling of depletable resources.*

Evaluation of the nine CERCLA criteria must be assessed with these goals in mind.

Reliability of Caps

To be effective, a cap must remain intact and must effectively isolate wastes for as long as they remain hazardous. During that period of time, the cap's integrity must be verified by a regular monitoring program. Institutional controls to prevent public access to the area – signs, fences, deed restrictions – must also be imposed and maintained to prevent disturbance of the cap and underlying wastes.

An institutional control

The long-term reliability of a cap, compared to the life of wastes at Hanford, is, at best, speculative. As noted above, some radioactive and chemical wastes at Hanford will remain hazardous for a period far exceeding the expected lifetime of any cap. The designed lifetime of RCRA "C" and "D" caps is only thirty years. Although the Hanford prototype barrier has a design life of 1,000 years, it likely will not be used much, if at all, and some waste sites will present serious hazards far beyond that 1,000 year period. As such, one should expect that any engineered cap used for disposal of chemical or radioactive wastes at Hanford will eventually fail.

The long-term reliability of ET caps is largely unknown; the oldest of such caps in use on landfills in the U.S. is only about a decade. The concept of an ET cap as a self-maintaining entity is appealing, but several factors potentially threaten the long-term integrity of an ET cap.

- If the storage capacity of soils in the cap is exceeded by any combination of events (water pooling to a small area of the cap, record precipitation, an extreme rain on snow event, climate change leading to a long-term trend of wetter climate, etc.), cap failure could result and excess water could flow through the cap into underlying waste.

- Fire is a common occurrence at Hanford most summers. Fire likely would destroy plant cover on the cap, severely reducing the transpiration capacity until the recovery of a mature plant layer. This greatly increases the amount of water moving through the cap until the plant community recovers.

- Plants killed off by a wildfire may be replaced by shallow-rooted annual grasses, a shift that would permanently reduce the ability of vegetation to transpire water from subsoils.

- For an ET cap to function effectively, roots must extend near the bottom of the soil layer so they can draw water from the soil and remove it by transpiration. Roots are likely to eventually extend below the bottom of the soil layer and penetrate into wastes, creating a mechanism for wastes to be transported to the surface. Root channels and animal burrows also create preferential flow paths for water to the base of the soil layer, where it can flow into wastes.

Hanford has a history of badgers, ants, fruit flies, snakes, rabbits and other animals and insects intruding into waste sites and mobilizing the wastes into the environment. Hanford also has a history replete with intrusions by plants of all sorts, mobilizing radioactive and hazardous materials into the environment.

Assumptions about the effectiveness of caps fail to acknowledge that water often moves laterally in Hanford's subsurface. A cap is intended to keep water from percolating downward into a waste site. However, water moving laterally beneath the surface could also invade a waste site and mobilize the contaminants. Work at Hanford has indicated that there is considerable lateral flow of water in the subsurface, which may reduce or even negate the short-term effectiveness of a cap.

An example of water moving laterally on the Hanford site

Board Concerns and Recommendations

From the Board's perspective, capping a waste site is an acknowledgement of failure in cleanup. A cap means that a particular area – for whatever reason – will not be cleaned up and the land will be unusable. This is not a good legacy to leave for future generations. This also creates a liability in terms of natural resource injury. Future mitigation actions will likely be necessary to compensate for these and other injuries.

As mentioned earlier, the Board recognizes there will be some circumstances where leaving waste in place beneath a cap or some other engineered barrier system will likely be as protective of people and the environment as retrieving the waste and moving it to a lined disposal facility. There will likely be some other cases – especially where the contaminants are very deep in the soil – where retrieval is not technically practical now or the costs would be prohibitive. In these cases, a cap may help prevent further spread of the contamination.

Considering that many contaminants at Hanford will remain dangerous for hundreds or thousands of years, the Board is concerned about the ability of a cap to isolate the waste for that period of time. The Board is also concerned that many waste sites at Hanford are inadequately characterized to fully and properly understand the risks resulting from leaving waste in place beneath a cap.

For these reasons, the Board strongly opposes establishing any cleanup plans at Hanford that designate capping as the default position. Instead, each waste site must be approached with the goal of waste retrieval. The Board believes this position is consistent with federal and state environmental regulations. The Board recognizes there are many complex variables to consider, and that decisions will need to be made on a site-by-site basis.

The Board asks that DOE and its regulators adopt the following guidelines when assessing the viability of using a cap at any particular waste site:

- The likely risk of leaving waste in place cannot be accurately predicted without sufficient understanding of what contaminants are in a particular waste site, in what quantities, and how combinations of these contaminants affect natural resources. Therefore, no site should be proposed for capping until waste has been sufficiently characterized to understand the risks imposed by leaving the waste in place.

- When comparing costs of treatment and capping, there must be a full accounting of all costs associated with capping, including monitoring, site maintenance, institutional controls, NRDA injury assessment, and NRDA damages.

- If the contaminants in a particular waste site are hazardous for only a short period of time and they will lose their toxicity in a few years to, at most, a few decades, then the waste site might be a candidate for capping. However, if the movement of water through soils around the site is not fully understood and controlled, the site is not a candidate for capping.

- Conversely, if contaminants in a particular waste site are long-lived – and/or are somewhat mobile – that waste site is probably a bad candidate for capping. In these instances, capping should be considered only if removal is technically infeasible or if costs are prohibitive.

- The consequence of cap failure or failure of a waste site to retain the contaminants must be considered. Waste sites near the Columbia River would generally have a greater consequence of failure than waste sites in Hanford's Central Plateau, where groundwater travel time to the river is expected to be much longer, and there could be more of an opportunity to take further action to keep contaminants from the river.

The Board is committed to working with DOE and its regulators to reach our common goal of a successful cleanup of the Hanford Site. We appreciate DOE's willingness to participate in a dialogue with the Board and other stakeholders about strategies for determining the best methods to close waste sites.

For more information, see http://egov.oregon.gov/ENERGY/NUCSAF/HCB/hwboard.shtml, or contact the Nuclear Safety Division of the Oregon Department of Energy, 625 Marion St. NE, Salem, OR 97301, 800-221-8035 (toll free in Oregon) or 503-378-4040 (in Salem or outside Oregon).