7.3 Other Vadose Zone Activities

D. G. Horton and S. P. Reidel

This section summarizes the activities and results of several technical studies done at the Hanford Site during 2002 to better understand the vadose zone sediment, hydrology, and contamination. These studies were designed to develop new, innovative methods for cleanup and monitoring at the Hanford Site. The studies included the application of various geophysical methods to vadose zone monitoring, infiltration studies at a monitored prototype surface barrier site, and laboratory studies of immobilization of chromium, technetium-99, and uranium.

7.3.1 Correlation of Strontium-90 Concentration and Gamma Log Response

R. G. McCain and C. Koizumi

Anomalous gamma-ray radioactivity detected in the subsurface during routine borehole geophysical logging at a region northeast of tank B-110 in the 200-East Area suggests a zone of subsurface strontium-90 contamination. However, there was no other evidence for any gamma-emitting radionuclide contaminants in the area (GJO-99-113-TAR, GJO-HAN-28). One possible source for the anomalous gamma-ray activity is a special type of radiation called bremsstrahlung radiation, which results when beta particles (positively charged electrons emitted from the nucleus of an atom) from strontium-90/yttrium-90 strike the steel casing of a well or borehole.

Borehole 299-E33-46 was drilled during 2001 to investigate Waste Management Area B-BX-BY and to collect samples for laboratory analysis to investigate subsurface contamination. Analyses from the samples showed high concentrations of strontium-90 that appeared to correlate with anomalous zones of gamma-ray activity, thus making the borehole a good place to test for bremsstrahlung radiation.

During 2002, a technique called spectral shape factor analysis was used to test this concept. Spectral shape factor analysis compares the shape of energy peaks produced by gamma-ray producing radionuclides to the shape produced by the background measurements recorded for the same interval in the borehole. Using this technique, the energy peak for strontium-90 will have a specific shape due to bremsstrahlung radiation. The results of this test showed that there appears to be a spectral shape factor correlation between laboratory-measured strontium-90 concentrations and the gamma-ray count rate. This suggests that bremsstrahlung radiation may be the source of anomalous gamma-ray radioactivity observed in that borehole. The results of this investigation may lead to a method for quantitative measurement of strontium-90 in the subsurface.

7.3.2 Test of Hanford Site 1,000-Year Surface Barrier Design

G. W. Gee, A. L. Ward, and C. D. Wittreich

DOE has been investigating technologies that can be used to develop surface barriers at the Hanford Site (RHO-CD-1142; Wing and Gee 1994; Ward and Gee 2000; BHI-01551; Link et al. 1995). A prototype surface barrier was constructed in 1994 that was designated to be used at waste sites in arid climates for at least 1,000 years. A report was issued in 1999 (PNNL-13116) on the first 4 years of data monitoring. This section updates that report with information that was collected through 2002.

Because a barrier must last for at least 1,000 years without maintenance, natural construction materials (e.g., fine soil, sand, gravel, cobble, basalt riprap) and asphalt were selected for its design. Most of these are available in large quantities on the Hanford Site. The barrier consists of a fine-soil layer overlying other layers of coarser materials, such as sands, gravels, and basalt riprap (Figure 7.3.1). Asphalt provides an impermeable layer at the base of the barrier. Natural vegetation was then established on the surface of the barrier.

The primary purpose of a surface barrier is to prevent water from passing through it. Infiltrating water (usually as precipitation) is the main driving force that will move waste downward to the groundwater. Therefore, it is important to know the water balance; that is, how much precipitation is diverted away and out of the soil cover by asphalt, how much water gets past the asphalt layer, how much water is surface runoff, how much water is stored in the soil, and how much water is lost by evapotranspiration. Evapotranspiration is the only component not directly measured at the Hanford Site prototype barrier, but it can be calculated from the other variables just mentioned.

In order to determine the water balance, the north half of the prototype barrier was irrigated from November 1994 through October 1997 with water equivalent to three times the long-term average annual precipitation. Water-balance monitoring of the surface barrier was carried out using rain gages to measure irrigation and precipitation, neutron probes for soil water content (water storage), and pan or basin-type lysimeters for drainage collection. Piping carried the drainage water from collection zones to basins where it was monitored.

Monitoring results from September 1994 through September 2002 indicated that evapotranspiration was the most important process for water removal. All irrigation water and natural precipitation plus all plant-available stored soil water were removed by evapotranspiration over the years the barrier was monitored. There was no monitoring at the barrier between September 1998 and May 2000; however, so no data are available for that time period.

The results suggest that extreme winter precipitation, the prime cause of recharge and drainage of the vadose zone at the Hanford Site, is stored in the surface barrier until spring when it is removed from the soil by evapotranspiration. This supports the case for designing a surface barrier with sufficient capacity to store water so that even under extreme conditions, the surface barrier will still perform adequately.

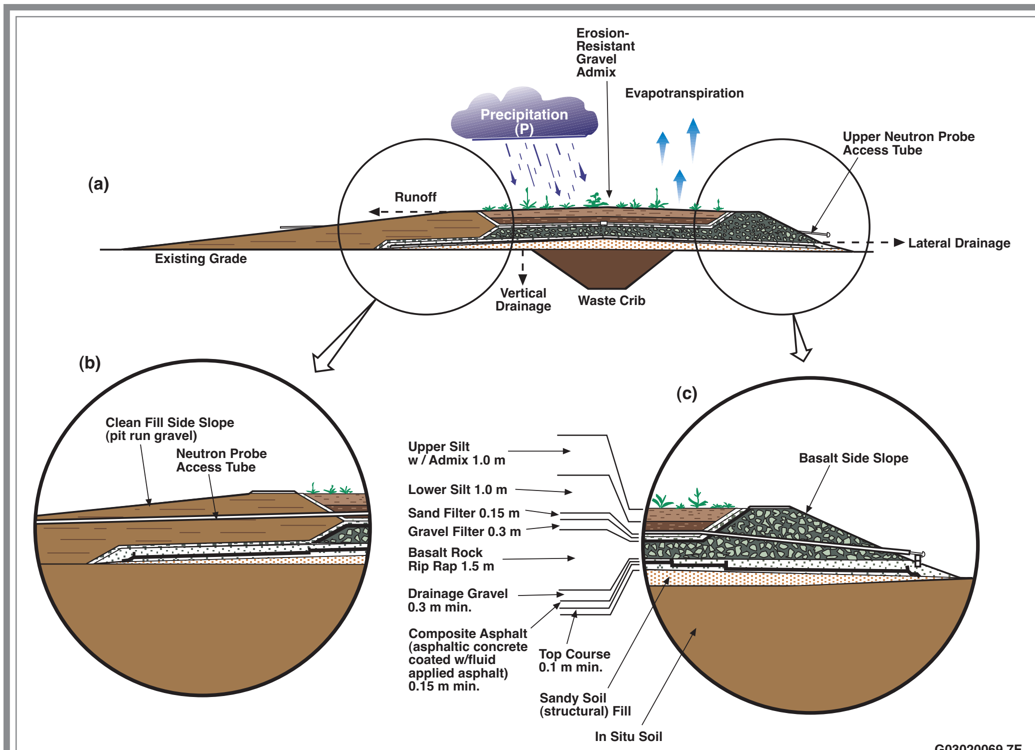

Figure 7.3.1. Cross Section of the Hanford Site Prototype Barrier Showing (a) Interactive Water Balance Processes, (b) Gravel Side Slope, and (c) Basalt Riprap Side Slope

The ability of the barrier to remove water and limit drainage demonstrates the benefits of having vegetation on the surface. Evapotranspiration for the irrigated part was nearly double that for the non-irrigated part, suggesting that vegetation is capable of adjusting to differing amounts of water. This indicates that the combination of vegetation and soil storage capacity is more than sufficient to remove all applied water under the test conditions. Neutron logging confirmed that no water got under the asphalt pad.

The rapid establishment of the natural vegetation cover on the surface was thought to have at least three positive benefits to the performance of the surface barrier. First, the vegetation was the main process responsible for removing water from the surface soil. Second, the surface was stabilized against water erosion and runoff. Third, it helped control wind erosion. After a plant community established itself during November 1994, there were no measurable soil losses by wind erosion from the surface of the prototype barrier.

Eight years of testing provided important but limited information for long-term barrier-performance estimates. Because only a finite amount of time was available to test a barrier that was intended to function for a considerably longer period of time, the testing program was designed to stress the prototype so that barrier performance could be determined within a reasonable period of time. To date, the results are very encouraging and support the premise that a barrier can be subjected to extreme stresses, for example, 1,000-year storms, and still perform successfully. It is desirable to continue to monitor the performance of the prototype barrier for an extended period because the succession of vegetation types, the full development of root profiles, and the natural colonization of the barrier surface by burrowing animals will occur over a longer time period.

Test results obtained to date show that in the Hanford Site's arid climate, a well-designed barrier limits drainage to near-zero amounts. Data collected under extreme conditions (excess precipitation) provides confidence that the surface barrier has the capability to meet performance objectives for its 1,000-year design life.

7.3.3 Use of Electromagnetic Induction and Ground-Penetrating Radar to Monitor Sediment-Water Storage in a Prototype Surface Barrier

A. L. Ward, W. P. Clement, and G. W. Gee

A barrier-development program was started at the Hanford Site during 1985 to develop, test, and evaluate the effectiveness of various surface barrier designs (Section 7.3.2). However, the lack of cost-effective technologies for long-term monitoring and the difficulty in projecting barrier performance from the short term to the long term were major challenges to barrier deployment. For this reason, two non-invasive geophysical techniques, electromagnetic induction and ground-penetrating radar, were investigated as techniques for measuring sediment-water content and storage in a surface barrier. The objective this study was to investigate how electromagnetic induction and ground-penetrating radar responded to spatial and temporal variations in soil-water storage in a surface barrier. The study was conducted during 2002 on the prototype surface barrier discussed in Section 7.3.2.

Electromagnetic induction measures the electrical conductivity of the ground; that is, it is a measure of the amount of electrical current that can move through the sediment. Water or moisture in sediment may dissolve substances that can make it easier for electric current to pass through the sediment, thus providing a method to determine the location of water or moisture and the amount present. This technique is effective as far as 6 meters (20 feet) below the ground surface. This study used two surveys that were designed to penetrate 0.75 and 1.5 meters (2.5 and 5 feet). The data from these two surveys were compared to neutron probe measurements of water content as a function of depth.

The ground-penetrating radar surveys use radar to probe the subsurface. Radar waves are similar to radio waves but with slightly different properties. Radar waves generated at the surface are reflected back by materials in the subsurface. Water or soil moisture can reduce the amount of signal reflected back or the velocity of the reflection providing a method for determining the location of sediment-water and the amount present. Metallic objects at and below the surface can negatively affect the results of both techniques because metals conduct electricity and are good reflectors of radar waves.

Electromagnetic induction conductivity maps suggest that irrigation on the north end of the barrier between November 1994 and September 1997 might have caused an increase in conductivity (moisture) from the initial condition during 1994. An analysis of the data shows a linear relationship for water stored in the sediment that was measured by a neutron probe and apparent electrical conductivity. The small size of the data set may limit the use of this relationship for predicting sediment-water storage from electrical conductivity measurements; however, it does suggest that the method may hold promise for field-scale monitoring of water storage. The mobility of these instruments, the speed with which measurements can be made, and the ability to do this with aerial electromagnetic induction surveys in mapping large areas makes this method an attractive option for monitoring large field-scale surface barriers.

Ground-penetrating radar surveys showed slower velocities (more moisture) for surveys during January and March 2001 than for surveys during May and October 2001. These velocity differences reflected differences in water content in the upper layer of the barrier, with the highest water content occurring in the winter and spring, and the lowest in the summer and fall. Similar differences were seen also in the electromagnetic induction measurements. As with the electromagnetic induction measurements, the data set for ground-penetrating radar is quite limited. Nevertheless, the data show a linear relationship between ground-penetrating radar measurements and neutron probe measurements.

In summary, these investigations showed relationships between results from electromagnetic induction and ground-penetrating radar surveys and the spatial and temporal variations of sediment-water storage in the surface barrier. Electromagnetic measurements showed some anomalous values due to metallic components in the Hanford surface barrier, but the data could be used to develop reasonable relationships between water content, water storage, and electrical conductivity. Ground-penetrating radar also showed considerable promise for high-resolution mapping of sediment-water content and storage distributions in surface barriers. Changes in the ground-penetrating radar response correlated well with changes in soil moisture over time.

Non-invasive geophysical techniques offer significant advantages over traditional monitoring methods including high speed data acquisition, lower costs, high sampling resolution, and integration of multiple spatial scales. Furthermore, the non-intrusive nature minimizes damage to barrier integrity from instrument installation or degradation. The potential for the airborne deployment of electromagnetic induction and ground-penetrating radar make these methods attractive for monitoring large field-scale barriers. The improved understanding of the non-linear dependence of large-scale processes on local-scale water content that can be gained from these data is an important step toward the use of remote sensing for monitoring barrier performance.

7.3.4 Evaluation of Electrical Leak-Detection Methods

D. B. Barnett, M. D. Sweeney, M. D. Johnson, and G. W. Gee

The Hanford Federal Facility Agreement and Consent Order (Tri-Party Agreement; Ecology et al. 1998) requires removal of waste from single-shell tanks and other miscellaneous underground tanks for storage in the double-shell tank system. CH2M HILL Hanford Group, Inc. is demonstrating several retrieval methods to dislodge, mobilize, and remove the waste from the tanks. During retrieval operations, conditions beneath and in the single-shell tanks may be monitored as an additional precaution to protect the vadose zone beneath the tanks.

From mid-July through early November 2002, Pacific Northwest National Laboratory and CH2M HILL Hanford Group, Inc. evaluated two electrical geophysical methods at the 105-A mock tank facility in the 200-East Area of the Hanford Site. These two geophysical methods were designed to detect leaks beneath buried tanks. The techniques tested were electrical resistivity tomography designed by Lawrence Livermore National Laboratory and a high-resolution steel-casing resistivity technique designed by HydroGEOPHYSICS, Inc. The two techniques were initially tested during 2001 and were selected for further evaluation during an appraisal/elimination process completed during January 2002 (PNNL-13818). The possible leak events that were tested involved a series of blind, leak/no leak events and continuous monitoring. Only preliminary results are presented here; detailed analysis of the collected data is still in progress.

Preliminary results indicate that the methods performed within the expected ranges of sensitivity for leak detection. Early indications from the high-resolution steel-casing resistivity technique suggested that equipment configurations in contact with the tank (as a receiver or transmitter) appear to be very sensitive to both leak detection and estimation of the leak volume. Final results from this testing are expected to be available during 2003.

7.3.5 Tank Farm Vadose Zone Project – Corrective Measures

D. A. Myers

The Tank Farm Vadose Zone Project under CH2M HILL Hanford Group, Inc. took a series of major interim corrective measures in the 200-East and 200-West Areas during 2002. In the 200-East Area, actions were taken to protect the tank farms from surface water runoff that could flow onto a tank farm. Measures were taken to protect all single-shell tank farms from the nominal 30-year storm and from potential leaks from pressurized water lines that are within the tank farms. Of particular note was the re-working of Baltimore Avenue that runs north-south between B Tank Farm and the BX and BY Tank Farms in the 200-East Area (Figure 7.1.2). When a transfer line between B and BX Tank Farms was built during the 1970s, the construction left a berm that resulted in water ponding upstream of the transfer line and west of Baltimore Avenue. Since the transfer line was built, a total of six rapid snowmelt events have taken place that provided a potential source of recharge that could mobilize vadose zone contamination resulting in groundwater contamination. A culvert system was designed and installed during 2002 to carry the water away from this area to the north fence line of the 200-East Area. Berms were constructed to direct water runoff away from the farms.

Water lines servicing the 200-East Area single-shell tank farms were tested to ascertain their integrity; all lines passed the pressure tests. Those lines for which no future use was found were cut and capped outside the waste management area boundaries to prevent any inadvertent release of water to the tank farms.

In the 200-West Area, a water line servicing the 244-TX double-contained receiver tank was cut and capped in 2002. During 2001, tests determined this line was losing water at a rate of 0.72 liter (0.19 gallon) per minute. However, the water line was needed to flush waste from the Plutonium Finishing Plant to the SY Tank Farm so this water line was not capped until after the flush was completed.

7.3.6 Immobilization of Chromium, Technetium, and Uranium in Hanford Sediment by Gaseous Reduction

E. C. Thornton, V. L. Legore, and K. B. Olsen

Chromium, technetium-99, uranium-233, uranium-234, uranium-235, uranium-236, and uranium-238 are vadose zone contaminants at the Hanford Site that could be leached from the sediment and reach groundwater by surface-water infiltration. In situ gaseous reduction appears to be a promising technology for immobilizing these contaminants. Laboratory tests were done to determine (1) if sediment contaminated with technetium and uranium can be treated effectively by exposing it to a diluted hydrogen sulfide gas and (2) if sediment treated with hydrogen sulfide can retard the migration of chromium, technetium, and uranium in solutions infiltrating through the treated zone. Results from these tests became available during 2002.

In situ gaseous reduction can be applied in two different ways to waste in the vadose zone. The first application involves immobilization of chromium, technetium, and uranium by forming coatings on existing sediment grains or mineral precipitates that incorporate these contaminants. This stabilizes the existing contamination. The second application creates a permeable reactive barrier in vadose zone sediment by changing ferric iron to ferrous iron. This provides a way to capture contamination from possible future waste tank leaks.

7.3.6.1 Gaseous Treatment of Technetium-99 Contaminated Sediment

Sediment contaminated with technetium-99 was treated in laboratory tests to determine whether technetium can be changed from the +VII to +IV oxidation state and immobilized with hydrogen sulfide diluted with air or nitrogen. Treated and untreated sediment then were leached with water, and the rate of technetium-99 release was monitored. The test results indicate that ~50% of the technetium present in the contaminated sediment was immobilized by treatment with diluted hydrogen sulfide.

Treatment of the vadose zone with hydrogen sulfide in air could provide a way to partially stabilize technetium contamination beneath single-shell tanks in the vadose zone. The partial immobilization of technetium may result from incorporation of technetium in iron oxide as it formed or in the formation of a coating (e.g., elemental sulfur on sediment grains). These processes would retard technetium movement through the vadose zone and lower the amount reaching groundwater. Treatment of the vadose zone sediment with hydrogen sulfide diluted with air, however, would not be useful in generating a permeable reactive barrier.

Hydrogen sulfide diluted with nitrogen, however, may stabilize technetium contamination in the vadose zone and create a permeable reactive barrier. A permeable reactive barrier would result from reaction of nitrogen with the iron component present in vadose zone sediment, which then could immobilize technetium. The longevity of the barrier would be a function of the iron content and the rate the barrier would re-oxidize, which is related to water infiltration rates and the diffusion of oxygen through the vadose zone.

7.3.6.2 Gaseous Treatment of Uranium-Contaminated Sediment

Sediment contaminated with uranium was treated in laboratory tests with air and nitrogen to determine whether uranium can be chemically changed from the mobile +VI oxidation state to the immobile +IV oxidation state by treatment with diluted hydrogen sulfide. During 2002, treated and untreated sediment was then leached with water and the rate of sediment reoxidation and uranium release was monitored.

Test results indicate that the treatment of the vadose zone with hydrogen sulfide in air would probably not provide a way to stabilize uranium contamination in Hanford Site sediment. Treatment with hydrogen sulfide with nitrogen, however, may stabilize uranium contamination present in the vadose zone to some extent and create a possible permeable reactive barrier.

7.3.6.3 Evaluation of the In Situ Gaseous Reduction Permeable Reactive Barrier Concept to Immobilize Chromium, Technetium, and Uranium in the Vadose Zone

During 2002, uncontaminated sand-dominated sediment from the SX Tank Farm in the 200-West Area was used in laboratory experiments to test the potential of using an in situ reactive barrier to immobilize chromium, technetium, and uranium. The testing involved packing two columns with the uncontaminated sediment. One column was an untreated control sample and a hydrogen sulfide gas mixture was passed through the second column. Air and nitrogen gas were individually mixed with the hydrogen sulfide gas. A mixture of chromium (VI), technetium (VII), and uranium (VI) then was pumped through both columns. The concentrations of the three contaminants in the effluent from the treated column were compared to that of the untreated column to determine the degree of immobilization associated with gas treatment.

The results suggest that a permeable reactive barrier generated by a hydrogen sulfide/nitrogen gas mixture would be very effective at immobilizing chromium (VI) in the vadose zone because once chemically changed from chromium (VI) to chromium (III), chromium is not readily re-mobilized. However, the barrier would no longer be effective for immobilizing additional chromium (VI) once infiltrating water that was carrying oxygen re-oxidizes the sediment. The barrier lifetime is estimated to be hundreds to several thousands of years depending on the iron content of the sediment, barrier thickness, and transport rates of oxygen through the vadose zone.

The test results also indicate that it is possible to limit the amount of technetium (VII) that will move through the vadose zone using an in situ gaseous reduction vadose zone permeable reactive barrier. The change to technetium (IV) is reversible under natural conditions and, thus, technetium could be re-mobilized from the barrier once it is re-oxidized and returns to technetium (VII). This suggests that an in situ gaseous reduction permeable reactive barrier could be useful as a short-term measure to capture technetium (VII) that might be released during waste tank closure operations. The long-term viability of the barrier, however, is difficult to assess. It is possible that a mid- to long-term barrier useable lifetime could be achieved if the barrier is periodically recharged by treatment with additional hydrogen sulfide.

Uranium also was immobilized in both the untreated and treated laboratory tests. The mechanism responsible for the relatively low mobility of uranium (VI) is not clear. Uranium may have precipitated in the tests as a carbonate or hydroxide phase.

7.3.6.4 Evaluation of the Potential for Long-Term Chromium Reoxidation in Hydrogen-Sulfide-Treated Sediment

The length of time the immobilization treatment for contaminants will last is a critical issue. Chromium (VI) is readily changed to chromium (III) by reaction with hydrogen sulfide. It is generally regarded that the chromium (III) form is stable in the natural environment and relatively insoluble. A long-term test was conducted during 2002 to determine whether or not re-oxidation of chromium could occur.

A chromate-contaminated sediment sample from the 100-K Area was treated with diluted hydrogen sulfide gas, then leached with water and the amount of chromium (VI) in the leachate was measured. Results from the test showed that levels of chromium (VI) in the sediment dropped and suggests that the chromium will not re-oxidize to the (VI) state.

7.3.7 Water Monitoring of the Tree Shelterbelt at the 200-West Area

G. W. Gee, J. S. Carr, J. O. Goreham, and C. E. Strickland

Water entering the vadose zone from irrigating a tree shelterbelt (windbreak) in the 200-West Area of the Hanford Site (Figure 7.3.2) was monitored during the summer of 2002. Water rate and sediment-water contents were measured within the shelterbelt and at two locations just east of the shelterbelt to assess the effect of the irrigation on the vadose zone and to assist in optimizing the irrigation applications. During May 2002, sensors were placed in auger holes and connected to a computer system to gather data.

There was little rain (6 millimeters [0.24 inch]) between July and September 2002, so water applied to the soil was almost exclusively from irrigation. During the first 65 days of monitoring (June 26 through August 30, 2002), the application rate averaged 751 liters (198 gallons) per day per tree, over 13 times the design rate of 57 liters (15 gallons) per day per tree. Feedback from the monitoring data has resulted in subsequent reductions in both application and drainage rates within the tree line. Further adjustments have reduced the water application rate to 159 liters (42 gallons) per day per tree. Drainage within the tree line from irrigation has exceeded 3,100 millimeters (122 inches) of water for the 80-day monitoring period. The drainage rate was reduced by more than half, from 36 millimeters (1.4 inches) per day for the first 65 days, to 17 millimeters

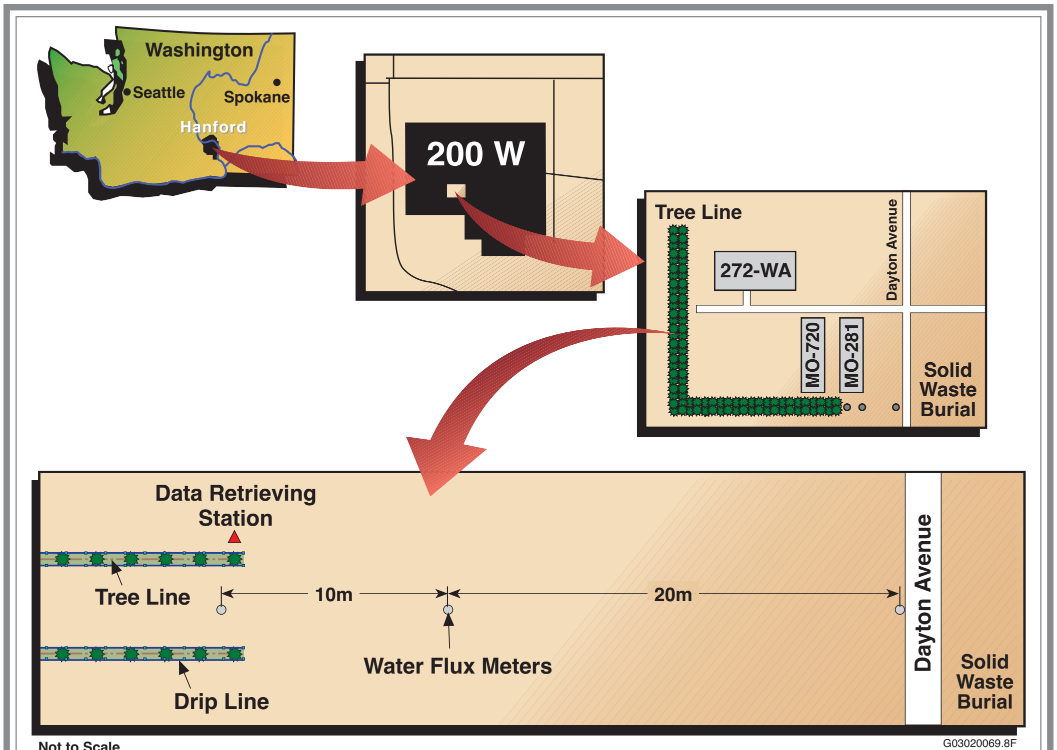

Figure 7.3.2. Location of Windbreak in the 200-West Area of the Hanford Site Showing Locations of the Tree Line, Water Drip Line, and Water Flux Meters

(0.7 inch) per day for a 7-day period ending in September 24, 2002. In spite of these improvements, the irrigation and drainage rates were still not optimized as irrigation exceeded the design rate by almost a factor of three. Monitoring of two adjacent sites found no drainage during the 80-day monitoring period. Continued monitoring within and adjacent to the tree line will provide an evaluation of the overall efficiency of the irrigation system and help assess the effect of drainage on adjacent areas such as solid waste burial grounds.

7.3.8 Soil-Gas Investigation at the 618-10 Burial Ground

K. B. Olsen, P. E. Dresel, and R. E. Peterson

During 1999, groundwater samples taken from the 618-11 burial ground in the 300 Area contained 1.86 million pCi/L (68,889 Bq/L) of tritium. The 618-10 burial ground (originally named the 300 North Solid Waste Burial Ground) received similar waste, but the extent of groundwater contamination was unknown there. Soil-gas investigations were undertaken at the 618-10 burial ground to determine if tritium levels in groundwater at this location were also elevated. These results became available during 2002.

The 618-10 burial ground was used between 1954 and 1963 and received a wide variety of solid, dry, radioactive waste. However, there is no evidence for significant quantities of liquid waste being placed in the burial ground, although small amounts of various liquid waste may have been included with the solid materials. In addition, several range fires occurred at the burial ground during which significant quantities of water may have been applied to the ground surface for fire suppression.

The use of helium-3/helium-4 ratios in soil gas to successfully detect and delineate tritium contamination at the 618-11 burial ground is described in PNNL-13675. The method is based on the decay of tritium to helium-3, which is a stable, inert isotope. When waste containing tritium comes in contact with sediment moisture, tritium can be incorporated with the sediment moisture, which then may migrate away from the tritium source. The tritiated sediment-moisture mixes with infiltrating moisture from precipitation (e.g., rainfall, snowmelt), or moisture from human activities (e.g., dust control, irrigation, fire suppression), and migrates downward to subsequently enter groundwater. Concurrent with tritium's release to the vadose zone, its daughter isotope, helium-3, begins to build up in the vadose zone and/or the underlying groundwater at the rate of tritium decay. The helium-3 then diffuses away from its source and migrates toward the surface. Helium-3, thus, acts as a non-reactive tracer for tritium.

A soil-gas investigation for helium isotopes and volatile organic compounds was conducted around the perimeter of 618-10 burial ground during September 2002 to determine if a tritium plume originated from the burial ground and to assist in choosing locations for two new groundwater monitoring wells. Sampling points were installed and soil-gas samples were collected and analyzed for helium isotopes and volatile organic compounds.

Fourteen sampling locations were chosen for the survey near the burial ground and in adjacent areas downgradient of the burial ground. One location upgradient of the burial ground was included to provide background levels of the targeted parameters for the soil-gas samples. Six soil-gas locations were selected for the sampling of volatile organic compounds.

The result of the analyses identified numerous hydrocarbon compounds and several chlorinated hydrocarbon compounds in all six of the soil-gas samples, but they appeared to represent problems with sampling methods. Because soil-gas analyses showed only low levels of volatile chlorinated compounds, they are probably not of concern for routine monitoring in groundwater. The result of the soil-gas analysis for volatile chlorinated compounds failed to provide compelling evidence to recommend locations for two additional groundwater monitoring wells in the vicinity of the 618-10 burial ground.

Soil-gas samples were collected and analyzed for helium isotopes following procedures established during investigations at the 618-11 burial ground (PNNL-13675). The helium-3/helium-4 ratios did not indicate high levels of tritium along the perimeter of the 618-10 burial ground. By comparison, helium-3/helium-4 ratios observed in soil gas near the 618-11 burial ground were much higher near the suspected buried sources and over the tritium groundwater plume that extends downgradient from that burial ground.

There appears to be little contribution of volatile organic compounds to the soil gas at the 618-10 burial ground based on the volatile chlorinated organic compounds results on the soil-gas samples. It was not possible to determine whether there were hydrocarbon compounds present in the soil gas because of the pervasiveness of contamination from the sample tubing.

7.3.9 Standardized Stratigraphic Nomenclature

S. P. Reidel

One of the main goals of the Groundwater Protection Program is the integration of vadose zone and groundwater activities. Historically, the stratigraphy of the vadose zone sediment at the Hanford Site has been described by several nomenclature schemes such that there has been little consistency in naming and correlating the vadose zone sediment. The numerous site-specific nomenclatures developed over the years at Hanford resulted in confusion and made it difficult to compare the stratigraphy encountered across the Hanford Site. During 2002, the Groundwater Protection Program oversaw the publication of a standardized stratigraphic nomenclature for post-Ringold Formation deposits. The standardized nomenclature (Figure 7.3.3) was needed to support and integrate hydrogeologic characterization and performance assessment modeling at the Hanford Site. The new standardized nomenclature represents a consensus that was reached by Hanford Site geologists during 2002.

<table>
<tr><th></th><th>Informal, Local, Hanford Site Nomenclature</th><th colspan="2">DOE/RL-2002-39</th></tr>
<tr><td rowspan="6">Hanford formation</td><td>Touchet Beds (previously formalized)</td><td colspan="2">Interbedded sand-and silt-dominated facies association (ISSD)</td></tr>
<tr><td>H1a Upper sandy sequence</td><td colspan="2">Stratigraphically highest sand-dominated facies association (SD)</td></tr>
<tr><td>H1 Upper gravel sequence</td><td colspan="2">Stratigraphically highest gravel-dominated facies association (GD)</td></tr>
<tr><td>H2 Sandy sequence</td><td colspan="2">Sand-dominated facies association (SD)</td></tr>
<tr><td>H3 Lower gravel sequence</td><td colspan="2">Stratigraphically lowest gravel-dominated facies association (GD)</td></tr>
<tr><td>H4 Lowest sand sequence</td><td colspan="2">Stratigraphically lowest sand-dominated facies association (SD)</td></tr>
<tr><td></td><td>Pre-Missoula gravels</td><td rowspan="3">Cold Creek unit</td><td>Mainstream alluvium facies</td></tr>
<tr><td></td><td>Early “Palouse” soil/silt</td><td>Fluvial overbank and/or eolian facies</td></tr>
<tr><td></td><td>Plio-Pleistocene unit</td><td>Side-stream facies</td></tr>
<tr><td></td><td>Ringold Formation</td><td colspan="2">Ringold Formation</td></tr>
<tr><td></td><td>Columbia River Basalt Group</td><td colspan="2">Columbia River Basalt Group</td></tr>
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ecs03002

Figure 7.3.3. New Hanford Site Stratigraphic Nomenclature and Comparison to Previous Hanford Nomenclature. Four initialisms commonly used for units of the Hanford formation are shown next to descriptive names in bold.