Employing Interim Water Management Barriers at Waste Disposal Area – 9255

Daniel Sullivan, U. S. Department of Energy, West Valley Demonstration Project;
David Garber, Environmental Chemical Corporation;
Scott Chase, Cynthia Dayton, KK Gupta, Emil Selent, West Valley Environmental Services;
10282 Rock Springs Road, West Valley, NY 14171-9799

ABSTRACT

The West Valley Demonstration Project Act (the Act) of 1980 authorized the U.S. Department of Energy (DOE) to lead a high-level radioactive waste management demonstration project at the site of the former spent fuel reprocessing plant in West Valley, New York. The site is owned by the State of New York, through the New York State Energy Research and Development Authority (NYSERDA). West Valley Environmental Services LLC (WVES) and its predecessor company, West Valley Nuclear Services Company (WVNSCO), have been the prime contractors at the site since the beginning of the Project.

One of the primary missions of the Act – demonstrating solidification techniques which can be used for preparing high-level liquid waste for disposal – was completed in 2002. Since that time, wide-scale decontamination and dismantlement activities to prepare for Project completion were begun and continue through present-day operations.

Current site activities are focused on preparing and shipping Project wastes off-site for disposal, reducing the site's footprint by removing unneeded facilities, and managing the site in a safe configuration while a Draft Site Decommissioning Environmental Impact Statement is being prepared to evaluate alternatives for site closure and/or long-term stewardship. Remaining site facilities include the former nuclear fuel reprocessing facility building, an associated underground waste tank farm, and a 7-acre area that contains an inactive radioactive waste landfill. Major objectives for safe management of those facilities include protecting employees, the public, and the environment while reducing management costs and risks associated with those facilities.

In 2007, DOE began preparations to install water control barriers to prevent clean ground and surface water from coming in contact with buried waste in the inactive Nuclear Regulatory Commission- licensed Disposal Area (NDA). Field work was initiated and completed in 2008. This paper discusses the history of the NDA, the rationale and construction experience in installing these barriers, and the expected results.

INTRODUCTION

The Nuclear Regulatory Commission – Licensed Disposal Area (NDA) is a shallow seven-acre landfill area that was used to dispose fuel reprocessing-related wastes (1966-1982) and low-activity West Valley Demonstration Project wastes (1982-1986). It was licensed in 1963 by the NRC predecessor agency the Atomic Energy Commission. Its location is approximately 366 meters (1200 feet) southwest of the Main Plant Process Building (MPPB) on a portion of the West Valley Demonstration Project (WVDP) site that is referred to as the South Plateau. A five-acre area in the shape of a rectangle approximately 113 meters (370 feet) wide by 183 meters (600 feet) was involved with actual waste disposal activities. The NDA has been maintained in an inactive state since 1986.

The NDA is bordered by two small streams: Erdman Brook and Frank's Creek. The streams are part of the Cattaraugus Creek watershed, which feeds into Lake Erie. The proximity of waste to the surface and the high levels of radioactivity associated with NDA waste made it necessary to periodically rework the earthen cover to ensure the minimum 1.2 meters (4 feet) of cover is in place and to prevent the formation of surface fissures. The general area also required upkeep to encourage surface water runoff as opposed to penetration.

While DOE and NYSERDA are preparing a joint Site Decommissioning Environmental Impact Statement that will evaluate site management and closure options for the NDA and other site facilities, DOE is managing all facilities – including the disposal area – in a manner that is protective of public and environmental health and safety. Since decisions on the permanent disposition of the disposal area have not been decided, any actions taken now to manage the NDA must be interim and cannot preclude future remediation options for the disposal area.

NDA Hydrology, Geology, Hydrogeology, and Climatology

The WVDP site is located in a wide valley that contains Lavery till left behind by advancing and retreating glacial activity. The NDA area is overlain with a layer of weathered Lavery till that ranges from 1 to 4.5 meters (3 to 15 feet) deep, which is underlain by an unweathered layer of Lavery till that is 23 to 26 meters (75 to 85 feet) deep. The soil consists of mostly gray or cream-colored clay that is very plastic when wet and very cloddy when dry. The uppermost weathered layer of Lavery till contains fractures that are capable of conducting groundwater in lateral and downward directions at approximately 1.3 meters/yr. (4.3 ft/year). In contrast, the sand and gravel soil of the North Plateau of the site where the MPPB is located transmits water laterally at a rate of about 18 meters/year (59 feet/year). Unweathered Lavery till has a very low permeability rate, so water in the unweathered portions of the NDA tends to move very slowly, at less than (10 cm) 3 inches per year.

Groundwater levels in the South Plateau area range from a 1 meter (3 feet) below the surface to about 4.6 meters (15 feet) below the surface. The unweathered till is subject to lateral groundwater movement as a result of localized infiltration from streams and precipitation. Water movement through the unweathered till, however, tends to be downward and at a much slower rate due to the low permeability of the clay soils. The local climate is humid, with normal annual precipitation rates at about 1 meter (40 inches) per year. Water infiltration and control is an ongoing management consideration for all sub-surface structures at the site.

Waste Disposal Activities

Waste disposal activities in the NDA occurred during two distinct time periods: the Nuclear Fuel Services, Inc. (NFS) era and the WVDP era. Direct burial was conducted in pits, trenches, and special holes ranging from 4.6 to 30.5 meters (15 to 100 feet) in depth. Waste disposal records were generated and maintained. Disposal records contain actual data on radioactive constituents, however, chemical constituent data, which was not required, was compiled based on historic knowledge of the waste streams disposed in the NDA.

The radioactivity and waste volumes vary depending upon the era of waste disposal. Specifically, 10,194 m^3 (360,000 ft^3) of waste was buried in the NDA, with approximately 45 percent of the total volume being generated during the NFS-era and the remaining 55 percent being disposed during the WVDP-era. Conversely, the 298,000 curies (January 2000 basis) of radioactivity associated with the waste disposed in the NDA are nearly all from the NFS era: more than 99.5 percent.

NFS era waste: During the nuclear fuel reprocessing phase of the site, wastes generated as a result of fuel reprocessing were disposed in the NDA. Among the wastes were tanks containing as much as 87,000 liters (23,000 gallons) of treated spent solvent mixed with absorbent material, leached nuclear fuel hulls, and equipment and debris removed from the MPPB.

WVDP era waste: DOE began disposing Project waste in the NDA in 1982 and continued that practice until 1986, when DOE and the Coalition on West Valley Nuclear Wastes reached agreement to halt on-site waste disposal pending a record of decision on long-term site decommissioning. The disposal area has been maintained in an inactive state since then.

Past Interim Measures

In late 1983, radioactive solvent was detected during routine sampling of a groundwater well near the NDA. An evaluation of potential sources was conducted, and based upon historical NFS disposal records, the presence of solvent, dissolved organic material and radioactive contamination, the source was believed to be two special holes containing eight tanks of treated solvent.

In 1986, the Project exhumed the two holes and recovered the eight solvent tanks. As a result of the exhumation, 1624 liters (429 gallons) of solvent, 227 m^3 (8,000 ft^3) of contaminated soil, 25 m^3 (880 ft^3) of absorbent material, and 20.4 m^3 (720 ft^3) of size-reduced tank waste were generated. Approximately 568,000 liters (150,000 gallons) of water was also collected during the excavation project.
[1. Blickwedehl, R. R., et.al. West Valley Demonstration Project, Implementation of the Kerosene Mitigation Plan, DOE/NE/44139-38, May 1987]

In an effort to collect any residual solvent, an interceptor trench was installed on the two down-gradient sides of the NDA to capture any solvent that might be migrating out of the NDA. A liquid pretreament facility (LPS) was installed at the NDA to pretreat recovered liquid. During a normal precipitation year, approximately 400,000 gallons of runoff water is collected through the interceptor system. Since installation of LPS in 1991, the liquids collected have been below the action level of 15 ppm for Total Organic Content (TOC) and pretreatment of wastewater for removal of organic constituents has not been required prior to treatment of the liquid in the WVDP's Low-level Waste Treatment Facility (LLWTF).

Liquid collected through the interceptor trench has been transferred to the WVDP's wastewater lagoon system under the Project's State Pollutant Discharge Elimination System (SPDES) permit.

SDA Cap and Wall Experiences

A 15-acre radioactive waste landfill is located adjacent to the NDA on New York State-owned property. The New York State-licensed Disposal Area (SDA), was operated by NFS as a commercial low-level radioactive disposal area from 1963-1975. The topography and soil conditions are very similar to those at the NDA.

NFS buried approximately 680,000 m3 (2.4 million ft^3) of radioactive waste in the SDA in 14 shallow trenches, approximately 6 meters (20 feet) deep, by 6-9 meters (20-30 feet) wide. The trenches ranged in length from 137-198 meters (450 to 650 feet). From its early existence, the disposal area experienced water infiltration and retention problems. Due to the low permeability of the SDA's Lavery till, water that entered the disposal trenches through fissures in the cap tended to gather and spill over, much like a bathtub that was overfilled. The SDA was closed in 1975 when leachate levels in two of the trenches rose above the height of original grade. The liquid contained radionuclides mobilized from contacting buried waste. Historical management of the SDA has included groundwater level monitoring and as-needed pumping and wastewater treatment to prevent unplanned releases.

The New York State Energy Research and Development Authority (NYSERDA) assumed responsibility for the SDA in 1983 after the NFS lease for the West Valley site expired. NYSERDA's early management strategies for maintaining the integrity of the earthen cap included earthwork maintenance to reduce or eliminate percolation through fissures in the surface.

Due to recurring water management problems with the SDA, a number of water management initiatives were investigated, including installation of a pilot vegetation project over one trench. In late 1990 and early 1991, heavy rainfall and excessive snowmelt contributed to a dramatic rise in leachate levels in Trenches 13 and 14, the two trenches that had previously overflowed. The corresponding increases supported the presence of a hydraulic connection between the two trenches through a suspected sand and gravel lens. Further study of the trench levels, precipitation amounts, and groundwater levels did not conclusively support a single source of water infiltration into the trenches, therefore a decision was made to install both lateral and horizontal barriers to prevent water infiltration from either direction. In 1992, NYSERDA installed a 276-meter long, 9-10-meter deep slurry wall upgradient of trench 14. A geomembrane cap was installed over the two trenches in 1992. [2. Sonntag, T.L., et.al., Infiltration Controls at the Shutdown Low-Level Radioactive Waste Disposal Area at West Valley, NY, New York State Energy Research and Development Authority, March 1997.]

Post-construction results included an immediate stabilization of the leachate levels, followed by a gradual reduction in levels by approximately 2-4 cm/year. Based on the effectiveness of these barriers for trenches 13 and 14, NYSERDA eventually covered the entire 15-acre SDA. Similar results have been realized in the remaining SDA trenches. Leachate levels in trench 14 have been reduced by approximately 2 ft. since the installation of the wall and cap. [3. Ecology & Environment, Inc., Annual Statistical Assessment of SDA Water Elevations - Data through 2007, February 2008.]

Rationale for Cap and Wall

Preventative water infiltration measures were identified as a best management practice for near-term management of the NDA. Based on the results achieved with the slurry wall and cap at the SDA, in 2007 DOE identified installation of a slurry wall and cap as priority work at the NDA. The wall and cap were installed in 2008 as interim measures under the RCRA Order on Consent.

Design and Engineering

A detailed engineering evaluation was conducted at the onset of planning for the slurry wall and cap to determine whether the Liquid Pretreatment System (LPS) should remain in the structure located on the NDA. Since the TOC in effluent draining from the NDA from 2004-2007 averaged 7 ppm with a standard deviation of 4 ppm, against a specified action level of 15 ppm, the system was being maintained in an unused condition with effluent collected from NDA runoff being treated and discharged through the site’s Lagoon system, however, future need for pretreatment of NDA effluent could not be ruled out. If the interim water infiltration measures are as effective as anticipated, concentrations of contaminants could rise in parallel with decreased dilution.

Based on cap design engineering studies, cost analyses, and available alternatives for relocating, eliminating, or replacing the LPS, a justified case was made to leave the existing system in place and perform an evaluation of its longer-term disposition after verification of the effectiveness of the interim measures and potential need for liquid pretreatment is made. Design of the cap incorporated the possibility of future removal of the LPS.

Design requirements for the cap included incorporating a drainage plan for the three area retention basins and outfalls to collect and drain the runoff from the surface of the NDA. Post-construction design features include a series of shallow swales leading from the mound of the cap to three detention basins located near the creek side outfalls. The detention basins are drained by 30 cm (12 inch) discharge pipe outfalls to control runoff from a 30-year, 24-hour rain event.

The surface of the NDA was surveyed by aerial survey to determine topography and estimate the amount of backfill needed to effect proper drainage of the covered area. Preliminary estimates were 16,000 m^3 (21,000 yds^3) of backfill were needed prior to placement of the geomembrane cover with backfill depth estimates ranging from 15 cm to 2.4 meters (0.5 ft to 8 ft.) Two layers of backfill were specified: a layer of Type B soil (with maximum aggregate size of 15 cm (6 inches) and a top 30 cm (12 inch) deep layer of Type A soil, with a maximum aggregate size of 2.5 cm (1 inch). Actual fill amounts were determined by ground surveys during construction.

Pre-construction activities included the removal of several culverts under and along the roadways bordering the NDA that interfered with wall and cap installation. A general construction exclusion area was established with strict controls put in place to limit access to necessary personnel only.
The first major field activity was to perform 22 soil borings along the proposed location of the slurry wall to evaluate the soil for possible contamination migration and to delineate the transition from weathered to unweathered till. This operation ensured the wall was installed in non-contaminated soil and at an adequate depth into the unweathered till.

Stormwater pollution prevention plans (SWPPP) included a series of barriers to control runoff during construction, with special attention given to control any release of bentonite clay that might occur during slurry wall installation.

Construction was planned to commence as soon as weather permitted in the spring of 2008, with planned completion during the normal construction season. The slurry wall and cap specifications and installation experiences are discussed in detail in later sections.

Construction Readiness Activities

A drilling subcontractor with prior experience at the WVDP conducted soil boring investigations in late 2007 which were used to locate the slurry wall. The two-week sampling evolution included immediate on-site radiological surveys of each sample.

Pangea Inc. was selected as a mentor-protégé contractor for the installation of the NDA interim measures. The company mobilized on-site in April 2008. All Pangea employees completed site-specific training requirements to allow them access to the site and clearance to perform the work at the NDA.

The entire area was cleared of brush during the preconstruction phase. Affected roadway culverts, a concrete pad from a previously removed structure and a partially buried retaining wall were also removed prior to the start of slurry wall installation activities. All materials were surveyed for radiological contamination at the time of excavation. Contaminated waste such as culvert piping and spoils unsuitable for embankment fill were packaged and shipped to an off-site disposal facility. An eligible 108,000 kg (119 tons) of clean concrete was recycled, resulting in a cost-avoidance of $7300 over the cost of disposal.

Work areas were established to set up a portable slurry mixing plant and stage packaged bentonite clay for slurry mixing. Three excess soil piles on the site were designated as fill for the cap area. One soil pile required sorting to remove organic debris and oversized aggregate.

Storm water controls were established in accordance with the project’s storm water pollution prevention plan. Key components include a construction perimeter silt fence backed with straw bales in areas of extreme slope, earthen dikes to direct anticipated runoff in a controlled path, and water control check dams to slow water and confine any silt associated with the construction.

Figure 1. Excavation for the slurry wall.

Slurry Wall Installation

A working platform was established to prepare for excavation of the slurry wall and excavation for the slurry wall began in mid-June 2008. The 4.3 meter (14 foot) wide earthen platform enabled the excavator to safely straddle the slurry wall trench during excavation. The slurry wall construction was performed by excavating soil, filling the excavation with bentonite slurry, mixing the excavated soil with benotonite and water, and backfilling the trench with the soil bentonite mix. The bentonite slurry was displaced and maintained in the excavation for trench stability.

The slurry wall was excavated in a continuous line, with the excavator gradually reaching the depth of 5.5 meters (18 feet) through a series of simultaneous digging and backfilling evolutions. This method of installation was selected to provide a uniform, continuous and homogenous slurry wall that is free of joints with a permeability rate of 10-7 cm/sec.

June 2008 precipitation totaled 10.4 cm (4.11 inches) at the WVDP site, approximately 8% above the norm of 9.7 cm (3.8 inches). July 2008 was exceptionally wet, with 17.2 cm (6.79 inches) of rainfall, more than double the normal amount of 8 cm (3.14 inches). One four-day period accounted for nearly 8.9 cm (3.5 inches) of the total rainfall received during the month of July. Adding to difficulty of controlling runoff in the NDA area is the slow-drainage properties of the clay-laden NDA soil. On a number of occasions, heavy rainfall amounts damaged the working platform and resulted in significant water ponding issues on flat surface areas. Runoff was effectively controlled during these events, however, the stormwater control barriers required near constant maintenance during much of the slurry wall installation, with particular attention given to controlling runoff that contained bentonite. Despite unusually heavy rainfall events, WVES' planning and the effectiveness and ongoing attention of its stormwater pollution prevention measures were commended by the New York State Department of Environmental Conservation (NYSDEC). The project will be featured by NSYDEC as an example of effective stormwater pollution control.

Excavation and backfilling for the slurry wall was expected to take a few weeks to accomplish, however, weather impacted the schedule for wall installation. Construction of the 290 meter (950 feet) long slurry wall was completed on July 28 approximately three weeks later than planned.

Monitoring wells were added to the NDA area in upgradient and downgradient positions relative to the slurry wall to provide groundwater data for assessing the performance of the slurry wall.

Cap Preparation and Placement

Preparation of the surface of the NDA for installation of the cap included vegetation removal, addition of Type A and Type B soils, installation and modifications to piezometers and monitoring wells heads where needed, application of geotextile cushion material to provide a barrier between the soil and geomembrane cap (XR-5™ manufactured by Seaman Corp), and geomembrane application and welding.

Geomembrane was fabricated by Lange Containment of Denver, CO. Lange fabricated the 29 panels in August 2008. The panels were constructed from 3-mil thick XR-5™ ethylene polymer alloy (envaloy). The panels were irregular in length and configuration due to existing the features and contours of the NDA, necessitating a number-matched delivery and installation pattern to ensure proper placement of each panel. The first panels began arriving at the WVDP during the first week of September 2008.

In parallel with panel fabrication, soil preparation was ongoing at the site. In addition to the existing on-site surplus soil piles of 11,500 m^3 (15,000 yds^3) of available dirt, 198 m^3 (7000 yds^3) were brought in by 500 ten-wheel dumptruck loads from a nearby New York State highway project. In addition to screening to remove aggregate that exceeded maximum size, the soil was sampled to verify it met requirements for moisture content, plasticity, organic content, and compaction.

Three detention basins were constructed along the north side of the NDA to collect and manage runoff from the covered NDA. The basins were designed for adequate peak runoff from a 30-year, 24-hour precipitation event of 4.2 inches of rain. The basins were lined with a minimum of 15 cm (6 inches) of clay.

Geomembrane placement began September 22 and was completed November 8, 2008. The work was generally routine and progressed according to the plan, however, exceptionally wet weather impacted the installation schedule and resulted in excessive amounts of runoff from the NDA during cap installation. While runoff was managed in accordance with all stormwater pollution prevention requirements, additional resources were required to address runoff issues.

Through September, the WVDP site was subjected to multiple heavy rainfall events, resulting in a thorough saturation of the weathered till and a full recharge of groundwater. The low permeability of the NDA soil resulted in high soil moisture content that impacted proof rolling activities. Depending upon post-rainfall weather conditions, up to several days were required to obtain sufficient drying to enable heavy equipment access to the NDA surface. Consequently, multiple re-work evolutions of the surface were required prior to panel placement and the overall completion schedule was impacted by weather-related delays.

Figure 2. Stormwater pollution prevention barriers -- repairs and maintenance in progress after a heavy rainfall event.

As the surface area became fully saturated, a groundwater seep was observed near perimeter of the Liquid Pretreatment System (LPS) building. Monitoring of the seep volume indicated a trend toward increasing volumes of water following precipitation events. Analysis determined the water to be mildly radioactively contaminated, presumably due to existing sub-surface contaminants. Based on an investigation of the potential sources, the seep was determined to be accumulated groundwater associated with the unusual amounts of rainfall and reconfiguration of drainage pathways from the area, particularly around the LPS perimeter. To collect and manage seep effluent, a 1.5 meter by 1.5 meter (5 feet by 5 feet) dry well was installed at its source. Water collected was directed to the site's LLWTF. Approximately 53,000 liters (14,000 gallons) of water were collected from the seep; none of it exceeded criteria for acceptance in the LLWTS.

Figure 3. Panel installation in progress.

The total construction cost for the slurry wall and cap installation was approximately $5 million. The project completion costs exceeded initial estimates, which is largely attributed to weather-related delays and higher than expected geomembrane procurement costs due to increases in the cost of materials.

Expected Results

Based on NYSERDA's operating experience with the SDA and the demonstrated effectiveness of the water control barriers in place at the state-owned disposal area, it is expected that the slurry wall and cap will greatly reduce or eliminate water infiltration into the NDA. Due to the moderately high level of saturation in the till and the slow drainage properties of the clay soil at the point of cap installation, it is expected that the area will experience a prolonged period of de-watering. It is expected that the slurry wall and cap will eliminate re-charging of that saturation and effluent volumes are expected to decrease once dewatering of the soil is complete.