Interim Barrier in Hanford's TY Farm to Protect Groundwater at the Hanford Site, Washington, USA – 11295

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ABSTRACT

An innovative interim surface barrier was constructed as a demonstration project at the Hanford Site's TY Tank Farm. The purpose of the demonstration barrier is to stop rainwater and snowmelt from entering the soils within the tank farm and driving contamination from past leaks and spills toward the ground water. The interim barrier was constructed using a modified asphalt material with very low permeability developed by MatCon®. Approximately 2,400 cubic yards of fill material were added to the tank farm to create a sloped surface that will gravity drain precipitation to collection points where it will be routed through buried drain lines to an evapotranspiration basin adjacent to the farm. The evapotranspiration basin is a lined basin with a network of perforated drain lines covered with soil and planted with native grasses. The evapotranspiration concept was selected because it prevents the runoff from percolating into the soil column and also avoids potential monitoring and maintenance issues associated with standing water in a traditional evaporation pond. Because of issues associated with using standard excavation and earth moving equipment in the farm a number of alternate construction approaches were utilized to perform excavations and prepare the site for the modified asphalt.

BACKGROUND

The TY Tank Farm Interim Barrier Project was conducted to meet a proposed Hanford Federal Facility Agreement and Consent Order (HFFACO) milestone. The proposed milestone M-045-92 subpart b, has since become final with the signing of Consent Decree No. 08-5085-FVS [1]. Milestone M-045-92 Subpart b requires, among other things, that a final design and monitoring plan for an interim barrier at TY Tank Farm be submitted for approval by the Washington State Department of Ecology (Ecology) by March 31, 2010, and that construction of the barrier be completed by September 30, 2010.

The TY Tank Farm barrier was installed to minimize the migration of residual contamination of the soil around the six, single-shell (SST) in TY Tank Farm. The TY Tank Farm is located on the Hanford Site in southeastern Washington State. These tanks have been used to store hazardous radioactive waste and some are assumed to have leaked in the past.

Selection of TY Farm Barrier Application

The TY Tank Farm was chosen for the application of an interim barrier based on a number of factors. TY Tank Farm was constructed between 1951 and 1952 and began receiving waste in 1953. Five of the six tanks in TY Farm are classified as assumed to have leaked during their operational period [2]. A ranking of potential barrier locations based on calculated reduction in peak Technicium-99 (^{99}Tc) groundwater impact with and without an interim barrier, identified the TY Tank Farm as a useful location for an interim barrier [3].

In addition, TY Tank Farm was classified as "controlled, clean, and stable." The controlled clean and stable process included steps to reduce worker exposure to hazards [4], and applied at TY Tank Farm resulted in a relatively clean level gravel surface within the farm. This clean, level, gravel surface allowed the emplacement of an interim barrier with a minimum of leveling of the farm, as well as with a minimum of radiological hazards to contend with during construction.

Fig. 1. Aerial photograph of TY barrier before barrier.

The benefits of interim surface barriers on the Hanford Site tank farms have been evaluated [5]. Based on numerical modeling, soils beneath the barrier are expected to continue draining with decreasing soil moisture content. The interim barriers are expected to reduce the impacts from existing vadose zone contamination by delaying the time of arrival of the peak concentration and reducing the peak concentration in the ground water.

Barrier Alternative and Runoff Selection Process

To select the material and configuration to be used to construct the TY Tank Farm barrier and the methodology to dispose of collected water, an inter-agency, multi-step selection process was used. The first step in the process was to identify potential barrier configurations and materials. Two key sets of information on potential interim surface barriers came from a literature review;

and from experience gained from the design and installation of the T Tank Farm Interim Surface Barrier.

Literature Review

A number of interim surface barrier evaluations have been completed that identified and evaluated potential materials and configurations for application in the tank farms. In a 1988/1989 review of the SSTs at Hanford, the U.S. General Accounting Office recommended that the U.S. Department of Energy (DOE), "Develop specific plans to replace the gravel surfaces at the tank farms with a less permeable material and promptly replace the gravel surfaces if ongoing studies indicate that these surfaces could promote the movement of (leaked) waste toward the groundwater." The U.S. General Accounting Office report also expressed concerns about water pooling at surface low points during the onsite investigation.

Interim surface barriers were evaluated in 1992 as part of an effort to identify and evaluate alternatives to cover all 149 SSTs [6]. Four concepts were developed and evaluated for potential application. These included:

- Placement of a fine-textured top soil to absorb and retain precipitation for subsequent evaporation.
- Above-grade roofed structures.
- Low permeability surface materials.
- Placement of low-permeability membrane liner below-grade materials to cause lateral migration.

A low permeability surface material, polymer modified asphalt, was identified as the preferred alternative due to low permeability and cost considerations. The engineering study concluded that implementation of these four approaches to cover all the SSTs ranged from $40 million to $158 million.

An innovative treatment remediation demonstration forum was held in Richland, Washington in May 1999 to discuss techniques for reducing and monitoring infiltration at the SST farms. The DOE, Hanford Site contractors, and various vendors from throughout the United States and Canada attended. Pacific Northwest National Laboratory summarized this conference in a two volume report, "Reducing Water Infiltration Around Hanford Tanks" (Molton, 1999). This effort is referred to as TECHCON 1999. Four technical sessions were conducted to discuss:

1. Moisture monitoring and characterization
2. Structures or buildings to cover the waste management areas (WMA)
3. Surface modifications or covers
4. Near-surface modifications (barriers and permeability reduction techniques).

The forum concluded that existing commercial capabilities could be employed to reduce and monitor infiltration in the WMAs, but that no one technology was appropriate for all seven WMAs [7].

The tank farm RCRA Corrective Action program was initiated in 2001. Initial efforts were taken as interim actions to reduce the migration of subsurface contamination. Actions have been taken to cut and cap aging water lines in and around the farms, construct berms to control surface water run-on/run-off, and put caps on all drywells. Subsequent to these "good housekeeping" actions, potential corrective measures have been identified and evaluated.

The evaluation of interim surface barriers was revisited in 2001 as a part of the RCRA Corrective Action Program [7]. This report summarizes previous long-term and interim barrier concepts. The report recommended that an engineering study be performed to determine the costs and impacts of placing a surface barrier. The report also recommends a demonstration of an interim surface barrier, thus providing information on actual construction costs, operations and maintenance costs, effectiveness, barrier life-span, and risk reduction.

In 2007, the National Research Council published the Assessment of the Performance of Engineered Waste Containment Barriers (NAP 2007). While this report does not specifically address interim barrier applications, it does address the performance of barrier system components such as geomembranes, asphalt, and clay materials.

T Tank Farm Experience

The first interim barrier was installed at T Tank Farm, north of TY Tank Farm, in 2007 and 2008. The T Tank Farm interim surface barrier consists of a sloped polyurea surface barrier, storm water conveyance system, and infiltration pond located outside of the T Tank Farm. The T Tank Farm barrier was constructed of 250-mil thick polyurea coating hand-sprayed on to a geotextile substrate. The geotextile substrate was anchored to the underlying sloped backfill. The T Tank Farm Interim Surface Barrier Project conducted a value engineering study at project completion. This value engineering study is documented in RPP-39785, *Surface Barrier Project Value Engineering Workshop* [8], and was used as the starting point for the TY Tank Farm barrier design.

The material selection process used to evaluate and select the barrier material used for the T Tank Farm barrier demonstration, is documented in Section 9 of RPP-33431, *Design Analysis for T-Farm Interim Surface Barrier (TISB)* [9]. The report documents the evaluation, ranking, and scoring of seven interim barrier concepts/materials for application at the T farm. The polyurea material was selected as the preferred barrier material for T Tank Farm.

Interim Surface Barrier Alternatives

Based on the above, 13 tank farm interim surface barrier alternatives were identified:

- Spray-on polyurea
- Spray-on polyurea with gravel
- Metal-roofed structure
- Fabric-roofed structure
- Geomembrane
- Geomembrane/geotextile combination with gravel
- Geosynthetic clay liner
- Spray-on polymer
- Evaporative barrier with soil

- Evaporative barrier with gravel
- Modified asphalt
- Specialty concrete
- Evapo-transpiration barrier.

Barrier Alternative Down Selection Process

A series of meetings and discussions were held among personnel from Washington River Protection Solutions LLC, DOE, and Ecology, to evaluate and choose alternatives to be used for the TY Tank Farm project. The technical and performance requirements for the TY Tank Farm barrier to be met were listed in RPP-SPEC-38937, *TY Farm Interim Surface Barrier Subsystem Specification* [10]. These requirements include:

- Dome loading limits
- Designed for the environmental conditions present at the tank farms (i.e., wind, sun, temperature)
- Barrier monitoring
- Flexibility and expansion
- Cover the ground surface to minimize infiltration of precipitation
- Control barrier surface water runoff
- Minimum design life of 25 years with minimum maintenance.

Several non-technical requirements for the barrier were also considered in the analysis of alternatives. The non-technical requirements of concern included:

- Personnel safety
- Estimated cost for installing the barrier
- Estimated cost of maintaining the barrier over the design life
- Allow routine surveillance (personnel and vehicle access) to support tank farm operations
- Physically interface with existing tank farm features
- Decontamination/decommissioning
- Support future retrievals
- Availability of product information for the evaluation
- Existing tank farm requirements.

The alternatives were evaluated and ranked using a scoring system designed to provide the highest score to the best balance among the evaluation criteria. The scoring process estimates option performance in the following functional areas:

- Cost
- Design
- Construction
- Operations
- Future Implications.

Based on this scoring process, the modified asphalt (MatCon®) option was chosen as the preferred material for the TY Tank Farm barrier application. The spray on polyurea material used for the T Tank Farm barrier did not score well during the TY Tank Farm barrier material evaluation process because installation of the polyurea barrier took much longer to construct than originally planned and the polyurea material tends to attract radon which is an inconvenience for radiological control.

Runoff Alternatives

In addition to selecting a potential material/concept for an interim surface barrier, a related decision was the selection of an alternative for managing and disposing of the rainwater and snowmelt shed by the barrier. Through brainstorming and material review five runoff alternatives were identified for consideration:

- Infiltration pond near the tank farm
- Evaporation pond or evaporative system near the tank farm
- Storm water discharge system/engineered infiltration system
- Storage and evaporation
- Storage, collection, and removal to an existing water treatment facility.

Based on an evaluation of the runoff alternatives, the storage and evaporation option consisting of a lined evaporation basin configured as an evapotranspiration system was selected for the TY Tank Farm barrier application. The evapotranspiration alternative provided a number of advantages over other methods. The primary advantages of the evapotranspiration basin are that it eliminates discharges to the subsurface soil in the area surrounding the tank farm and requires minimal monitoring and maintenance.

Water balance calculations along with empirical data were used to size the evapotranspiration basin. The Hydrologic Evaluation of Landfill Performance, Version 3 (HELP3) model was used to evaluate the water balance for the evaporative basin. Additionally, water balance data from the Field Lysimter Test Facility (FLTF) was reviewed for evaluating the effectiveness of an evapotranspiration system. Long-term water balance data from the FLTF indicate that a silt-loam cover system overlaying a coarse gravel layer acting as a capillary break can limit deep drainage to near-zero amounts in a semi-arid setting (Fayer and Gee, 2004). Test data over a number of years showed that for a silt loam thickness of 3.3 ft, with or without plants did not lead to drainage from the silt loam layer under ambient precipitation conditions or enhanced (3X normal) precipitation. Observations were also made that it was difficult to maintain a non-vegetated surface (e.g., due to a fire or disturbance) and that vegetation would quickly re-establish after a few months and certainly within a year.

Interim Barrier Monitoring

Both the T and TY Tank Farm barriers have monitoring systems installed to measure the moisture content in the subsurface. While there are no specific monitoring requirements for an interim barrier, negotiations with Ecology resulted in the need for submittal and approval of a monitoring plan for the demonstration project.

Since the decision to design and construct an interim barrier in the tank farm to mitigate the potential impact from vadose zone contamination represents a considerable commitment of resources, a best management practice approach was taken in establishing monitoring requirements. The TY Tank Farm interim barrier is considered a demonstration project and monitoring requirements should provide a means to compare the performance of the TY Tank Farm barrier to the T Tank Farm barrier. Monitoring requirements identified for the TY Tank Farm barrier include:

- Periodic collection and assessment of data to verify the integrity of the barrier and provide confidence that the barrier is functioning as designed to minimize the infiltration of precipitation.
- Collection and assessment of data to compare the performance of different barrier materials of construction.

To meet these requirements, two nested instrument arrays were installed at the TY Tank Farm barrier. One instrument array was placed within the barrier footprint and one instrument array was located outside of the barrier footprint to provide background data. Each instrument array consists of three shallow wells (<50 ft deep) that include the following:

- Vertical access tube for neutron-moisture logging
- EnviroSMART capacitance probe
- Heat dissipation unit(s) (HDU) for measuring soil matric potential.

This system provides the ability to quantify the drying effect of the barrier by monitoring the change in soil moisture beneath the barrier as compared to the soil moisture from a location near the barrier.

Vadose zone response will be monitored by examining systematic changes of subsurface conditions over time as represented by time-history trends at the monitoring locations. The trends in subsurface conditions beneath the interim surface barrier will be used to verify the reduction in soil moisture beneath the barrier, monitor barrier performance, and provide data to support comparisons between the materials of construction used for the T Tank Farm barrier and the TY Tank Farm barrier.

A clear vadose zone response indicator is a near-surface instrument response after precipitation or snow melt events. Adequate barrier performance should result in no observable increases in moisture content, drainage, or soil-water pressure (less negative) immediately after precipitation or snow-melt events. Such instrument responses would indicate percolating water and general barrier failure, provided the instruments are functioning.

A secondary component of barrier performance is the potential advective movement and buildup of water vapor immediately beneath the low-permeable barrier. Condensation of the water vapor would result in increased soil-water content immediately below the barrier. The seasonal water movement that might observed by the capacitance probe monitoring, will most likely be attributed to thermally induced vapor and liquid flow as described above, and it is expected that this fluctuation will persist for the life of the barrier. The magnitude of the water content changes and the depth of penetration depend on the soil type and initial water content of the soil, but for typical Hanford conditions, it should not extend deeper than a few 10s of cm into the subsurface.

Regulatory Approval

It should be noted that the barrier selection and runoff alternatives process resulted in recommendations. Final acceptability of the recommended alternatives was established through regulatory review and approval of the TY Tank Farm barrier design, which involved a public review process.

The footprint of the barrier was selected based on an iterative review with the DOE and Ecology. A number of footprint combinations were considered to cover the areas of contamination as interpreted from the resistivity based characterization results (red and green areas in Fig. 2) and the sample analyses from direct push locations (red x's in Fig. 2). Based on consideration of all available characterization data a decision was made to cover the entire tank farm plus a smaller area to the south of the tank farm that showed elevated levels of Tc-99 during soil sampling and analysis.

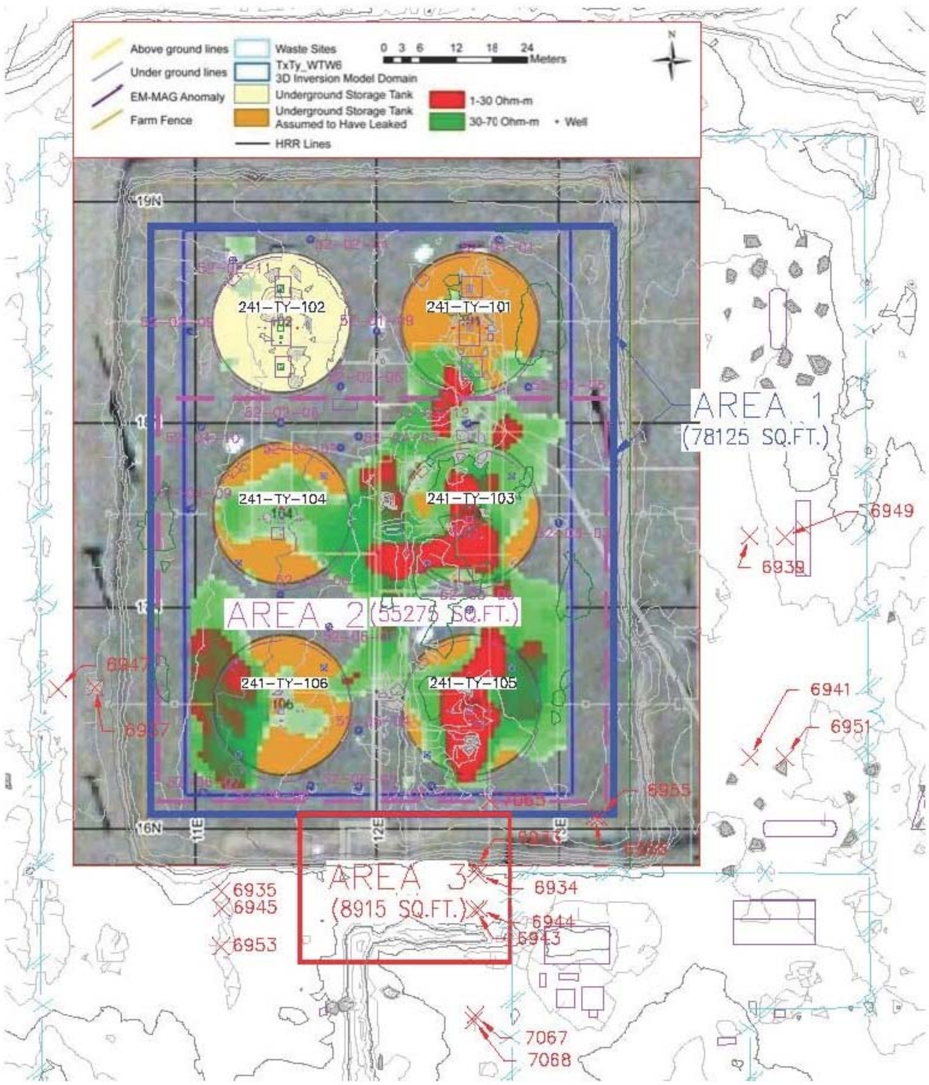

Fig. 2. Interim barrier footprint selection.

CONSTRUCTION

Construction of Monitoring Nests

Construction of the TY Tank Farm barrier commenced with the emplacement of the monitoring system as described in RPP-PLAN-36705, *241-TY Tank Farm Interim Surface Barrier Monitoring Plan* [11]. The monitoring system, consisting of two monitoring nests, was installed using direct push technology. Direct push is particularly applicable to work within the tank farms as it does not produce drill cuttings which would require disposal. The installation of the monitoring system used the procedures previously developed for installation of the similar monitoring nests at the T Tank Farm barrier. To simplify installation, the same personnel were used in construction of the monitoring nests.

Construction of Barrier and Basin

Construction of the barrier and basin occurred next with focus on either the basin or barrier being dictated by available resources and the sequencing of activities to simplify the construction process. The evapotranspiration basin is located outside the tank farm and was therefore fairly straightforward. There were radiological complications associated with excavation in a radiation buffer area. The excavation portion of the construction was closely monitored by the Radiological Controls organization and no radioactive contamination was identified. Therefore, at the completion of excavation work, radiological work controls were reexamined and modified. Although work was still closely monitored by the Radiological Controls organization, work restrictions were lowered to allow refilling of the basin to proceed in an expeditious manner. Radiological work controls were still in place to ensure the safety of workers and the environment, but were lessened from the requirements in place during excavation.

Construction of the barrier occurred within the tank farm boundary. Construction inside a tank farm offers a number of challenges and more conservative work controls were mandated. Because standard machine excavation is not allowed within the tank farms, excavation necessary to install the subgrade for placement of asphalt and trenching for installation of drainage piping were planned for hand excavation. Early in the project, it was recognized that ways to expedite excavation were needed. Therefore, a regulated-filter vacuum truck known as the “Guzzler,” was employed for both trenching and general removal of material where needed. After the crew became familiar with the guzzler, excavation speed was greatly increased, while maintaining safety.

Barrier Excavation

Although standard excavation equipment could not be used for excavation, the project team worked with personnel from Safety, Radiological Control, and the Facility organizations to reach agreement on its use for soil movement within the tank farm. Standard excavation equipment was used to redistribute already excavated material and distribute fill brought in from offsite. Spotters were used around the equipment to ensure tank farm equipment was not damaged and that personnel were safe. The use of equipment for this purpose greatly increased construction efficiency, without compromising safety or the quality of the finished product.

Asphalt Installation

Asphalt placement was through the use of standard commercial asphalt equipment. This allowed for rapid completion of the barrier which is a significant advantage over other materials that require significant amount of handwork or time to install. Again, spotters were used to ensure there was no damage to tank farm equipment, and to ensure personnel safety.

Fig. 7. Photograph of asphalting.

CONCLUSION

The TY Tank Farm barrier and associated basin were designed and constructed in a safe, cost effective manner. The project team worked with the customer, regulatory staff, vendors, and tank farm personnel to find ways to expedite construction within the tank farm, while ensuring the safety of workers and the environment.

Fig. 8. Photograph of final barrier.

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