Independent Technical Review Report: Savannah River Site

Review of Disposal Practices at the Savannah River Site

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1. INTRODUCTION

Disposal operations have been conducted at the Savannah River Site (SRS) for more than 50 yr. The active disposal areas are located in the E Area (Fig. 1), which is near the center of SRS. Wastes that are being managed include low level radioactive wastes (LLRW), transuranic waste (TRU waste), hazardous wastes as defined by the Resource Conservation and Recovery Act (RCRA), wastes controlled under the Toxic Substances Control Act (TSCA), and mixed wastes (containing both hazardous and radioactive constituents). Legacy wastes and newly generated wastes are being managed. However, only LLRW is disposed at SRS.

LLRW disposed at SRS is generated by 17 different on-site programs. Except for wastes associated with naval reactors, all of the wastes disposed at SRS are from the 17 on-site programs. Approximately, 19,000 m^3 of LLRW has been disposed annually at SRS between 2002 and 2007, and 11,000 m^3 of disposal is projected for 2008. Wastes are disposed in unlined slit trenches (Fig. 2a, and cover photograph), unlined engineered trenches (Fig. 2b), low activity waste vaults (Fig. 3), and intermediate level vaults (Fig. 4) in the E-Area. Some of the LLRWs are grouted in place to provide isolation. All of the wastes ultimately will be covered with a cap that includes a hydraulic barrier intended to limit the amount of precipitation entering the waste.

DOE requested that an Independent Technical Review (ITR) team provide input on three lines of inquiry related to the disposal operations at SRS. The ITR team, which was comprised of Craig H. Benson, PhD, PE (University of Washington; Seattle, WA), William H. Albright, PhD (Desert Research Institute; Reno, NV), David P. Ray, PE (US Army Corps of Engineers; Omaha, NE), and John Smegal (Legin Group; Washington, DC), has expertise in waste containment, civil engineering, geotechnical engineering, and project management. All waste disposal operations were reviewed as part of the activities conducted during this study. However, wastes buried in trenches are the primary focus of this report.

The ITR team was requested to address the following lines of inquiry (LOI):

1. Do any issues exist with the disposal facility design, operations, and management that could impact its ability to meet performance objectives? Are there potential issues in the program that could lead to problems similar to those identified at Hanford’s ERDF? If yes, have preventive and mitigative measures been taken to remedy the situation?

2. Are there cost-effective lessons learned from reviews of other DOE disposal operations that may improve the reliability and effectiveness of operations and management of SRS disposal facilities?

3. Are there good practices at SRS landfills that may benefit other EM sites?

These LOI were addressed by conducting a site visit on 24 June 2008, reviewing documents provided by DOE personnel from SRS, and based on the experience of the ITR team. Findings of the ITR team for each of the LOI are described in the following sections.

2. LINE OF INQUIRY NO. 1

Do any issues exist with the disposal facility design, operations, and management that could impact its ability to meet performance objectives? Are there potential issues in the program that could lead to problems similar to those identified at Hanford's ERDF? If yes, have preventive and mitigative measures been taken to remedy the situation?

The ITR team found no immediate concerns with operations at SRS that could precipitate problems similar to those found at ERDF. Waste disposal operations at the site are being conducted in a manner consistent with the performance assessment (PA), and good relationships exist with the regulatory agency. The operating contractor is engaged with technical issues that may affect the disposal operation and is tackling future issues using accepted methods in engineering practice.

SRS has adopted a strategy of controlled release of contaminants from the slit trenches and the engineered trenches in the E-Area. Liners and leachate collection systems are not employed to collect leachate for treatment, and a final cover relying on a mineral barrier is proposed. This approach recognizes that some contaminants will be mobilized, but seeks to control the release rate such that threshold concentrations in the surrounding environment are not exceeded. This performance-based approach to waste containment is fundamentally different from systems designed to provide near total containment and places considerable emphasis on a comprehensive understanding of the interactions between the waste, the engineered system, the relevant environmental factors, and mechanisms of transport.

The ITR team recognizes that this performance-based approach has important merits, but is concerned about the use of unlined trenches (slit trenches and engineered trenches) for LLRW disposal in humid climates with shallow ground water. The ITR team recognizes that the PA addresses the impact of these trenches on ground water, and that a vadose zone monitoring system is in place to monitor the concentration of radionuclides between the base of the facility and the ground water table. In addition, the ITR team recognizes that IAEA, NRC, and DOE regulations do not require or recommend the use of liners. However, limited data are available on fluxes from the trenches, and fluxes are difficult to predict accurately using models. Moreover, assessments generally do not account explicitly for bias in fluxes, including assessments made with stochastic models. Thus, the ITR team recommends that future trenches be instrumented to obtain large-scale measurements of volumetric and mass fluxes (e.g., using pan lysimeters). These measurements would be compared to fluxes assumed or computed in the PA to ensure that the PA is accurate or conservative, as suggested in DOE Order 435.1 (Part 4b of Section P).

The ITR team also recommends that SRS consider conducting inverse analyses using data from plumes associated with un-lined legacy disposal units. A range of probable fluxes could be obtained from inverse analyses, and this range could be compared to the fluxes assumed in the PA. These measured and inverted fluxes could also be compared to fluxes anticipated for the low activity waste vaults and the intermediate level vaults after they are filled with grout and buried.

Instrumentation for monitoring fluxes could be installed in each new trench. Alternatively, a single prototype trench of each type (slit trench and engineered trench) could be constructed and instrumented to provide surrogate data. Prototype trenches would be filled with simulated waste that is representative of the wastes at SRS. Either approach would be suitable to characterize the flux from these facilities.

Long-term settlement issues are also a concern for the slit trenches, which are long and deep relative to their width. Differential settlement at the edges of narrow disposal trenches have been problematic at Department of Defense sites, imposing unwanted stress on barrier layers in covers and disrupting surface runoff due to the washboard surface caused by settlement. This problem is exacerbated when waste placement does not include compaction, which is the practice at SRS. Deep dynamic compaction, which is planned prior to installation of the final cover, will help alleviate some of these problems. Nevertheless, the potential for differential settlement at the trench boundaries should be evaluated via field testing and analysis, and a plan for compaction during waste placement should be considered. The impact of metal containers on the effectiveness of dynamic compaction should also be evaluated, as compaction may be impeded by containers that are only partially corroded.

SRS has been and continues to conduct research that will be applied to address the settlement issues towards the end of the institution control period. Topics to be addressed include field-scale evaluation of dynamic compaction and static surcharging, technology development needed for implementation of production-scale dynamic compaction and static surcharging, field-scale evaluation of the impacts of subsidence on various cover materials, and evaluation of methods to repair covers that may be damaged by settlement. These applied research efforts should be effective in identifying the significance of settlement problems and practical methods to address settlement issues.

The ITR team was interested in studies demonstrating that the grouts used for in-situ isolation of contaminated materials (i.e., CIG isolation) are compatible with the surrounding soils and have a non-shrink formulation. Shrinkage or degradation of the grout over time might result in greater contact between contaminated materials and water percolating through the profile, resulting in higher than anticipated releases of radionuclides. Given the important role of the grout, a definitive scientific assessment of the long-term integrity of the grout is needed.

There is also concern regarding the percolation rates assumed in the PA for final closure. The final cover relies on a geosynthetic clay liner (GCL) to control percolation rates, and recent studies have shown that the hydraulic conductivity of GCLs can increase orders of magnitude within a few years of service (Melchior 2002, Meer and Benson 2007). In humid climates, percolation rates exceeding 200 mm/yr can be expected for GCLs (Benson et al. 2007). Similar behavior can be anticipated when thick clay barriers are used instead of covers relying on GCLs (Albright et al. 2006). Thus, percolation into the waste most likely will be higher than anticipated in the PA if an earthen cover is deployed. Polymeric barriers (e.g., geomembranes) or periodic replacement of the cover may be necessary to achieve the percolation rate assumed in the PA.

The ITR team recommends that SRS revisit the percolation rates assumed in the PA, and consider different barrier systems for the final cover if necessary. The ITR team also recommends an investigation into long-term changes in material properties and hydrologic performance of earthen barrier layers being considered for use in the final cover. Such an effort could be included in a larger investigation of final cover performance.

3. LINE OF INQUIRY NO. 2

Are there cost-effective lessons learned from reviews of other DOE disposal operations that may improve the reliability and effectiveness of operations and management of SRS landfills?

An important lesson learned from all of the DOE disposal facilities reviewed by the ITR team is the effect of waste placement operations and settlement on the long-term stability of the final cover. The use of dynamic compaction at SRS will reduce the impacts of heterogeneities induced by waste placement. In addition, the temporary geomembranes used at the surface during the institutional control period will minimize the hydrologic importance of differential settlements during the institution control period. However, the impact of dynamic compaction on the magnitude and variability of differential settlement is not well known, particularly for periods on the order of 1000 yr. The ITR encourages SRS to evaluate the effectiveness of dynamic compaction in controlling very long-term settlements, the differential settlements that are likely to occur over the 1000-yr period, and how these settlements may impact the hydrological effectiveness of the final cover.

Field testing is being conducted at some of the DOE sites to ensure that the performance anticipated in a PA is being realized at field scale. For example, Hanford is conducting long-term settlement tests to evaluate whether the compaction methods used at ERDF to stiffen the waste will provide stable long-term support for the final cover without excessive settlement. Similarly, NTS is conducting long-term testing to validate that the final cover design they have selected provides adequate hydrological control.

At SRS, the ITR team recommends that field testing be conducted to assess the adequacy of dynamic compaction in stiffening the waste, the potential for long-term settlements and how they impact the proposed final cover, the hydrological performance of the final cover, and the flux of liquid from the base of the unlined trenches with and without final cover. These field tests would be useful in validating assumptions made in the PA, and provide DOE with confidence regarding the long-term performance of the waste containment strategies. These tests could be conducted in prototype trenches constructed using the same methods as the trenches containing LLRW, but with non-contaminated materials used as 'simulated' waste in lieu of actual LLRW. The simulated waste would need to be as representative as practical. For example, partially and fully corroded boxes would need to be included to simulate the condition of the waste at the end of the institutional control period.

4. LINE OF INQUIRY NO. 3

Are there good practices at SRS landfills that may benefit other EM sites?

SRS has adopted a long-term stabilization strategy for managing waste settlement that includes delaying placement of the final cover until the end of the institutional control period, during which the majority of the settlement is likely to occur. A temporary geomembrane cover will be employed at the surface during the institutional period to minimize infiltration. This cover will be inspected regularly and replaced as needed. The ITR team believes that these are excellent practices that could be followed throughout the DOE complex. By allowing waste to settle during the institutional control period, the potential for damage to the final cover due to settlement will be much lower at SRS that at other sites in the DOE complex. The flexible geomembrane cover deployed during the institutional control period should limit infiltration effectively, and can be readily inspected and replaced as necessary without excessive cost.

The Waste Information Tracking System (WITS) developed at SRS appears to be a particularly useful tool for tracking and management of LLRW disposed on-site. In addition to waste shipping and tracking functions, WITS has several innovative features that could potentially be employed at other sites across the DOE complex. In particular, WITS performs automatic waste loading/radionuclide limit checks on up to eight limit domains ranging from total activity in a location or a unit to total activity on a shipment, including per waste volume or waste weight.

SRS has found WITS to be useful to ensure limits are not exceeded when wastes are placed, and also in the re-location and subsequent replacement of waste. These limit recalculations, based on relocated inventories, can be scheduled to run at various user-determined intervals. The site also provides extensive training on WITS to all generators located on-site.

SRS has also instituted a Groundwater Modeling Consistency Team to ensure consistency between modeling efforts throughout the site. This practice will reduce ambiguity and increase confidence in modeling predictions at SRS. A complex-wide effort on modeling consistency could be formulated based on the approach being used at SRS.

5. RECOMMENDATIONS

The following recommendations are made by the ITR team:

- Trenches (actual or prototype) should be instrumented to obtain large-scale measurements of volumetric and mass fluxes (e.g., using pan lysimeters). Fluxes should also be estimated by conducting inverse modeling using data from plumes associated with legacy disposal units. These measured and inverted fluxes should be compared to fluxes assumed or computed in the PA to ensure that the PA is accurate or conservative.

- Field testing should be considered to assess the adequacy of dynamic compaction in stiffening the waste, the potential for long-term settlements and how they impact the proposed final cover, the hydrological performance of the final cover, and the flux of liquid from the base of the unlined trenches with and without final cover. These tests could be conducted in prototype trenches constructed using the same methods as the trenches containing LLRW, but with non-contaminated materials used as 'simulated' waste in lieu of actual LLRW. Findings from these tests can be used to validate assumptions made in the PA.

- Field testing should be considered to determine the effectiveness of dynamic compaction in controlling very long-term total and differential settlements. These tests could be conducted using prototype trenches with synthetic waste representative of conditions anticipated at the end of the institution control period.

- SRS's long-term stabilization strategy for managing waste settlement, including the use of temporary geomembrane covers, should be considered for disposal facilities at other locations in the DOE complex.

- SRS's Waste Information tracking System (WITS) is a useful tool for tracking and management of LLRW disposed on-site. DOE should consider developing tools like WITS for general use in the DOE complex.

- A complex-wide program based on SRS's Groundwater Modeling Consistency Team is recommended. Such a program would reduce ambiguity and increase confidence in modeling predictions made for DOE sites.

These recommendations should be considered in the context of SRS's Radioactive Waste Management Basis and Disposal Authorization Statement and the associated conditions imposed by the Low-Level Waste Disposal Facility Federal Review Group. If necessary, an Unreviewed Disposal Question Evaluation might be conducted or a recommendation could be addressed through appropriate PA Maintenance Plan activities.

6. ACKNOWLEDGEMENT

This technical review was supported by Mark Gilbertson (DOE-HQ), Dinesh Gupta (DOE-HQ), and Howard Pope (DOE-SRS). The ITR thanks those individuals with DOE who provided information and input during the review. The photograph on the cover is from a PowerPoint presentation made by Luke Reid of SRS.

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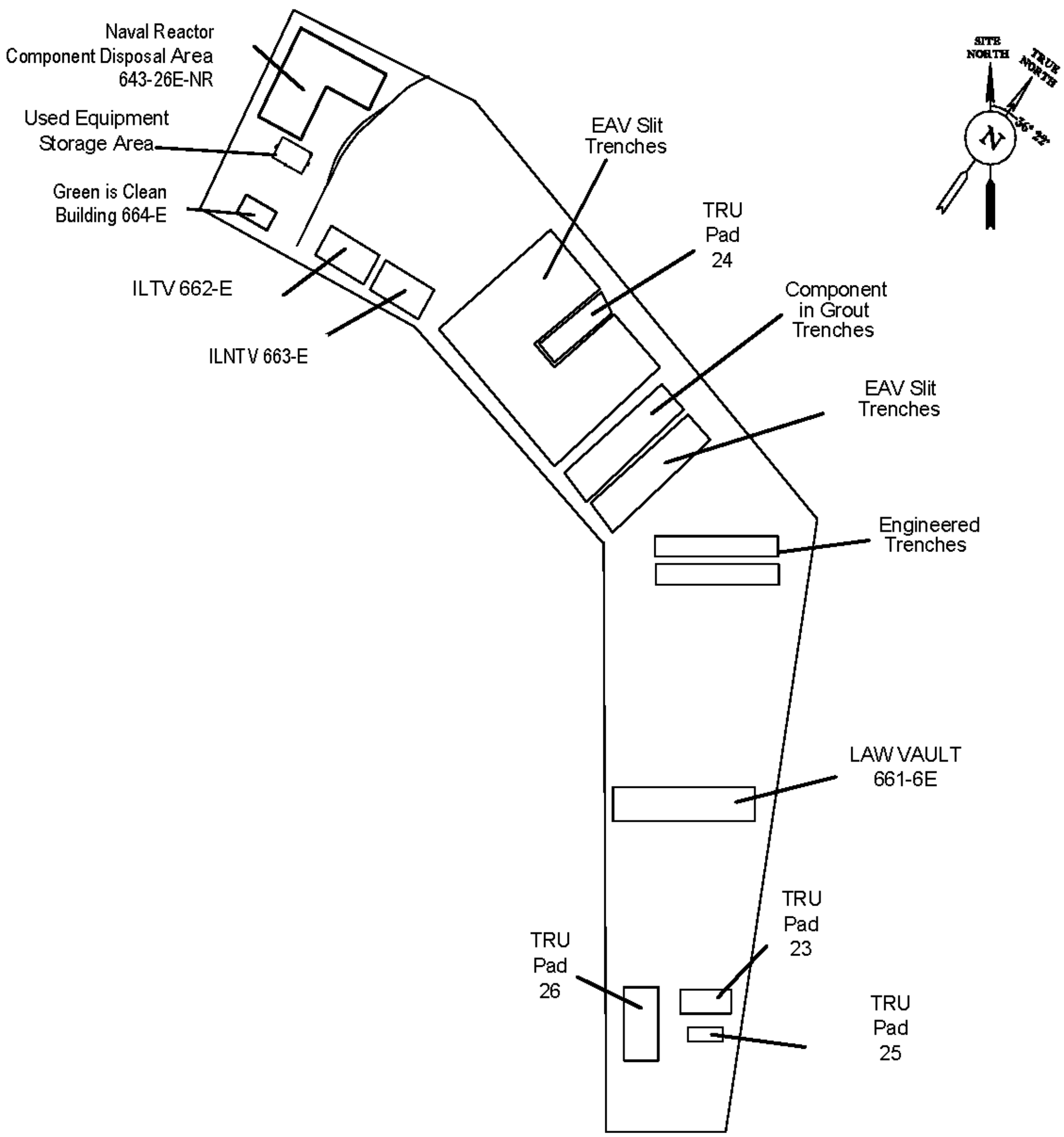

Fig. 1. Schematic of E-Area used for waste disposal at SRS (from SRS 2008).

Fig. 2. Crane placing container in slit trench (a) and aerial view of engineered trench (b) at SRS. Photos courtesy of PowerPoint presentation by Shawn Reed during ITR site visit.

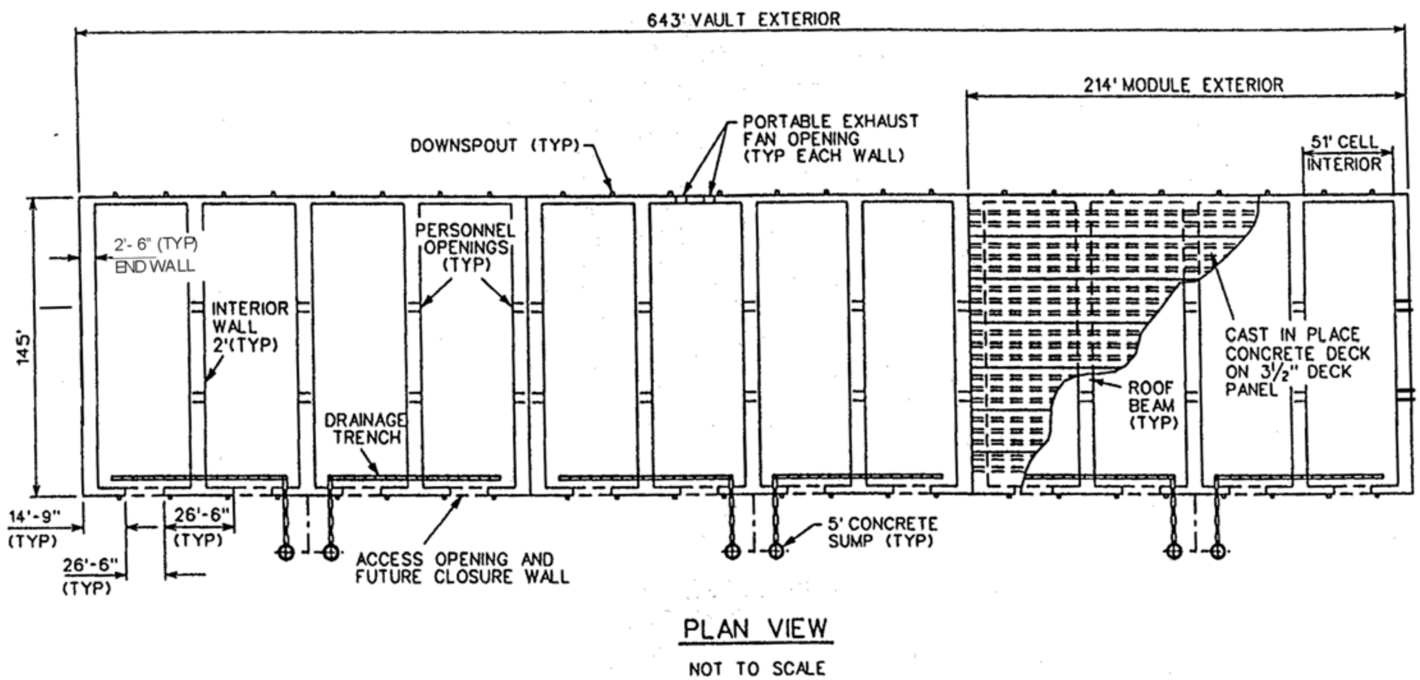

Fig. 3. Schematic of low activity waste vaults at SRS (from SRS 2008).

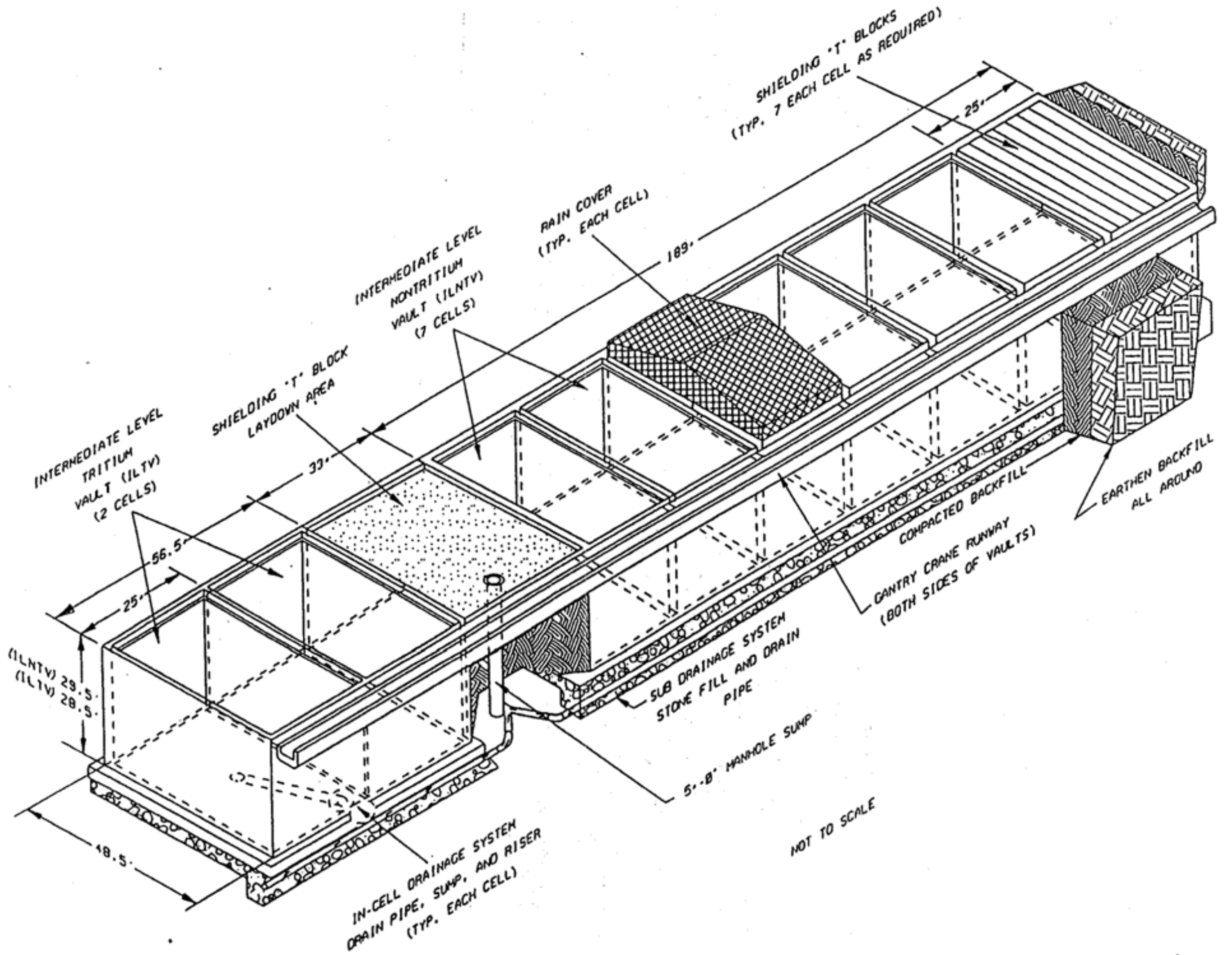

Fig. 4. Schematic of intermediate level waste vaults at SRS (from SRS 2008).