# Lessons Learned Concerning the Onsite Disposal Facility at the Fernald Preserve, Harrison, Ohio - 16176

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## ABSTRACT

An onsite disposal facility (OSDF) was constructed at the Fernald Preserve, Ohio, for the disposal of contaminated soil and debris generated during a Comprehensive Environmental Response, Compensation, and Liability Act site cleanup. Completed in October of 2006, the 30 ha facility contains 2.26 million $m^3$ of waste materials, has a maximum height of approximately 19.8 m, and consists of eight individual cells. The dimensions of cells 1–7 are approximately 213 m × 122 m each, or 26,000 $m^2$ (2.60 ha). The dimensions of cell 8 (the last cell constructed) are larger than those of the other cells (approximately 3.8 ha).

Each cell was constructed with a leachate collection system (LCS) that collected rainwater and storm-water runoff during waste placement and prevented it from entering the underlying environment. Other engineered features include a multilayer composite liner system, a leak detection system (LDS) positioned beneath the primary liner, and a multilayer composite cover that was placed over each cell following the completion of waste-placement activities. The LCS and LDS layers are designed to convey (by gravity) any leachate/fluid that enters the system through pipes to the west side of the facility and into tanks located in valve houses. From there, leachate can be sampled and conveyed to treatment. Groundwater is monitored beneath each cell via monitoring wells.

In November 2006, the US DOE Office of Legacy Management (LM) assumed responsibility for the long-term care and maintenance of the OSDF. LM has nine years of monitoring and maintenance experience with the Fernald OSDF. Monitoring data is reported each year in the Fernald Annual Site Environmental Report. The data collected and inspections conducted indicate that the facility is operating as designed.

The past nine years has provided LM with the opportunity to evaluate how well many of the design and as-built features of the facility have functioned over time as they pertain to environmental monitoring, valve-house operation and maintenance, and leachate transmission.

Lessons learned concerning the long-term care and maintenance of the OSDF at the Fernald Preserve are presented. The main lessons learned include the following: How bivariate plots can be used to address environmental monitoring challenges created by installing an engineered disposal facility in a location where contamination is above the background level but below cleanup standards. How valve-house design decisions can help to alleviate long-term monitoring challenges.

How scale buildup can lead to leachate transmission issues. Some additional minor lessons learned are also presented.

## INTRODUCTION

The Fernald Preserve occupies the site of the former U.S. Department of Energy (DOE) Feed Material Production Center (FMPC). The FMPC was part of the DOE nuclear weapons complex. In 1951, the U.S. Atomic Energy Commission, a predecessor agency of DOE, began building the FMPC. From 1952 to 1989, the FMPC fulfilled its mission of producing purified and machined uranium metal products for use by other government facilities involved in the production of nuclear weapons.

The Fernald Preserve, now managed by DOE's Office of Legacy Management (LM), occupies 425 ha (1,050 acres), approximately 29 km (18 miles) northwest of Cincinnati, Ohio (Figure 1). The preserve overlies the Great Miami Aquifer (GMA), which is designated a Sole Source Aquifer by the U.S. Environmental Protection Agency.

At the time that operations ended, the site environmental legacy included 14 million kilograms (31 million pounds) of nuclear metals, approximately 199,000 $m^3$ (260,000 cubic yards) of low-level radioactive solid waste, 0.9 million metric tons (t) of waste pit sludge, 1.9 million $m^3$ (2.5 million cubic yards) of soils that were impacted by low-level radioactive waste (LLRW) and Resource Conservation Recovery Act (RCRA) hazardous constituents, building debris, non-radiological solid waste, and contaminated groundwater.

In 1991 uranium production formally ended, and the site's mission changed to environmental remediation and restoration under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). Cleanup involved the decommissioning and demolition of buildings and excavation of soils impacted by LLRW and RCRA hazardous constituents at concentrations above cleanup criteria. Wastes that satisfied regulatory-agency-approved Onsite Disposal Facility (OSDF) waste acceptance criteria were placed in an OSDF. The OSDF contains approximately 2.26 million $m^3$ of such material. Materials deposited in the OSDF consist of about 85% soil and soil-like materials excavated as part of the remediation and about 15% building demolition debris, structural members, mass concrete, decommissioned equipment, lime sludge, coal fly ash, municipal solid waste, asbestos waste, and small quantities of other materials.

With the exception of contamination that remained in the Great Miami Aquifer, physical completion of the CERCLA remediation was declared on October 29, 2006, and the site was officially transferred to LM for long-term care and maintenance.


Fig. 1. Fernald Site Location Map

## OSDF FACILITY DESCRIPTION

The OSDF is located in the northeast area of the Fernald Preserve (Figure 1). It is situated upon the “best available geology” at the preserve, which includes near surface deposits of low-permeability clay rich glacial till overlying sand and gravel of the regional unconfined aquifer. The facility takes advantage of the protective hydrologic features of the glacial till to help protect the underlying sole source regional aquifer (Figure 2). The footprint of the actual disposal facility is approximately 30 ha (75 acres). A perimeter security fence that surrounds the facility defines a footprint of approximately 39 ha (98 acres).

The facility was constructed in phases, and consists of eight individual cells. Cell 1, the northernmost cell, was constructed first and completed in December 2001. Cell 8, the southernmost cell, was constructed last and completed in October 2006. Cells 1 – 7 are approximately 213 m × 122 m (700 feet × 400 feet), or 26,000 $m^2$ (2.6 ha) (280,000 square feet [6.4 acres]). The dimensions of Cell 8 are larger than those of the other cells; approximately 3.8 ha (9.4 acres), Figure 1.

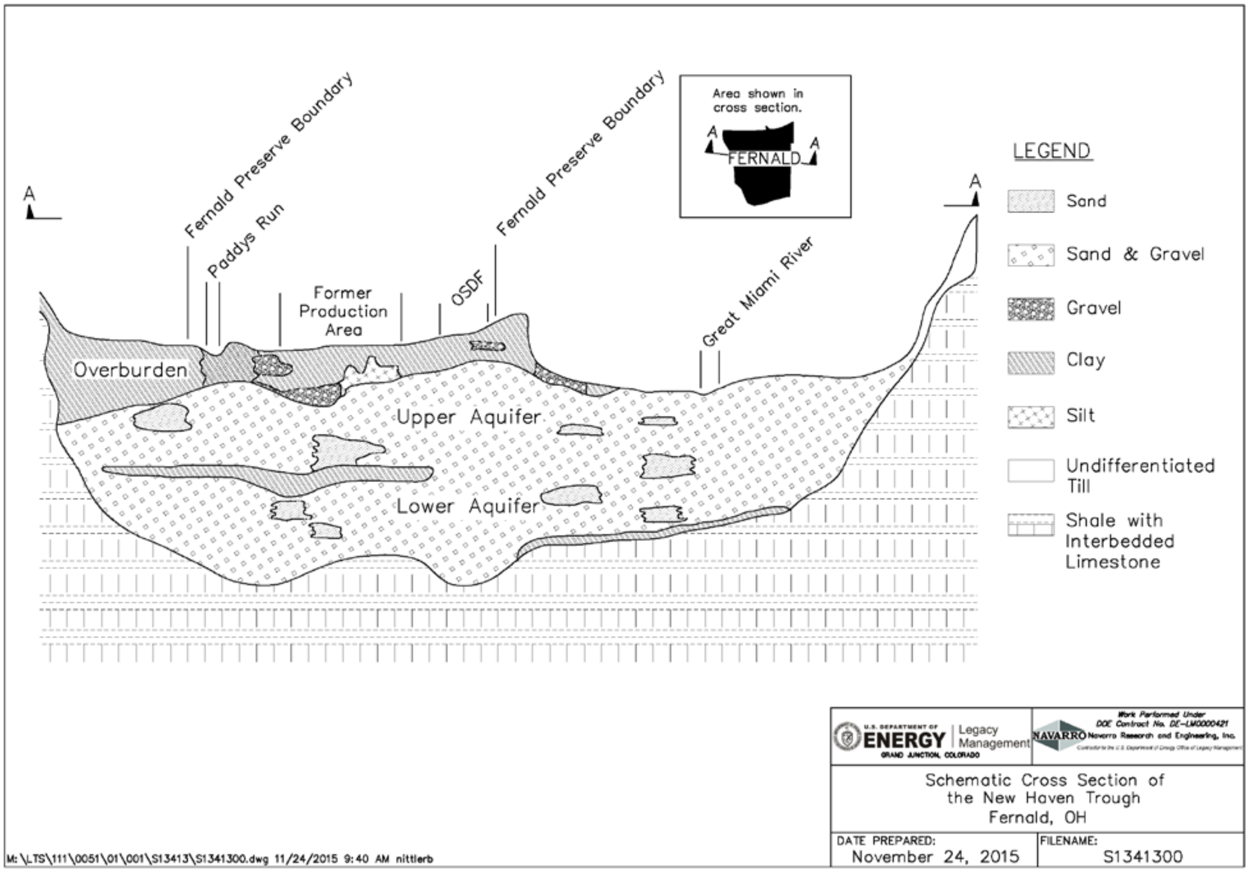


Fig. 2. Cross Section of Regional Aquifer at Fernald Site

The OSDF is essentially an above-ground facility. The bottom of each cell is graded in a herringbone pattern at a 2% slope to drain leachate by gravity to the west side of each cell and into a valve house. The grading was designed to follow preconstruction natural grades in the area. The maximum excavation depth was 4.57 m (15 ft.) at Cell 1, but the average excavation depth for the facility is only about half a meter.

Each individual cell has a multilayer composite cover system, a leachate collection system (LCS), a leak detection system (LDS), a multilayer composite liner system, and a valve house. Figure 3 is a cross section of a typical waste cell. The multilayer composite cover system is nearly 3 m thick. The cover system serves to keep water, plant roots, and burrowing animals from getting down to the encapsulated waste. The LCS is installed in a gravel layer beneath the waste to collect rainwater that came into the contact with the waste during cell construction and additional moisture that is draining from the waste following capping of each cell. The LDS is located beneath the LCS and the primary geosynthetic liner system. It provides a mechanism for collecting and monitoring leakage through the primary geosynthetic liner system prior to any releases from the facility to the surrounding environment.

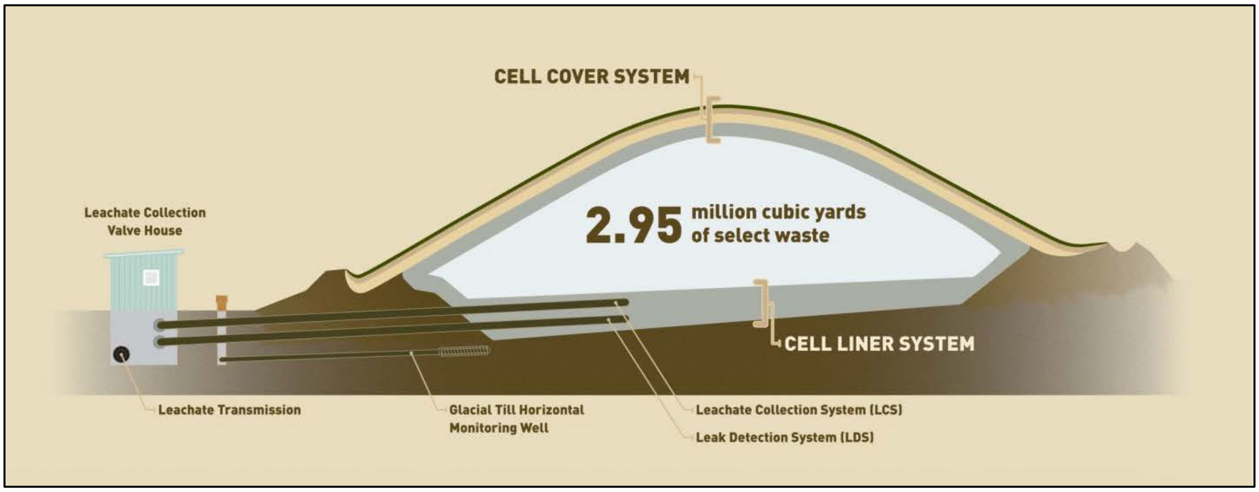


Fig. 3. Cross Section of a Disposal Cell

Both the LCS and the LDS drainage systems gravity drain to the west and extend beyond the synthetic liner systems into valve houses, where leachate becomes accessible for monitoring. The eight individual cells were designed with intercell berms so that the LCS and LDS for a cell capture only the liquids produced from that cell. The multilayer composite liner system located beneath the LDS is approximately 2 m (6 feet) thick.

Both the LCS and LDS exit the cell liner through a liner penetration box located on the west side of the cell. Each cell is monitored below the liner penetration box with a horizontal till well (HTW) that represents the first monitoring point for a release from the cell to the surrounding environment. HTWs provide monitoring of the perched groundwater quality beneath the liner penetration box; the most likely location for a leak to occur. The GMA is monitored using both an upgradient and downgradient monitoring well for each cell.

The OSDF performance period is divided into three operating time frames: (1) initial period, (2) intermediate period, and (3) final period. The initial period is defined as from closure to the end of the 30-year post-closure monitoring period (2006 to 2036).

The intermediate period will begin in 2036 and run for at least 200 years (2236) and up to 1,000 years (3036) to the extent reasonably achievable. It is expected that during this period that the geomembrane components of the liner and final cover system will remain functional. The LCS and LDS (as well as the cover system) will be maintained as necessary.

The final period will occur sometime between 200 and 1000 years after final closure of the facility in 2006. During this period, natural components of the liner and final cover will be functional. It is anticipated that at some point of time in the future, the high-density polyethylene (HDPE) geomembrane and other geosynthetic components on the liner and cover systems will begin to degrade and progressively lose functionality. Responsibility for maintenance and stewardship for the OSDF rests in perpetuity with the U.S. government.

In 2015, the facility began the ninth year of the 30-year Initial Post-Closure Period. As reported in the 2014 Fernald Annual Site Environmental Report, the leachate volume and water-quality data collected from and surrounding the facility indicates that the facility is operating as designed. LCS and LDS drainage volumes continue to diminish with time. There was not enough water in the LDS of Cells 1, 2, 3, 4, and 5 during 2014 to even collect a water sample. Liner efficiencies were greater than 99% for all cells in 2014. The chemical character of water in the facility (LCS and LDS) does not appear to be mixing, indicating that they are not in communication. Physical inspection of the cell cap reveals no visual signs that the integrity of the OSDF cover system has been compromised.

## LESSONS LEARNED

Nine years of long-term care and maintenance of the OSDF has brought to light a few lessons to share. The lessons pertain to (1) environmental monitoring, (2) LCS/LDS and valve-house operation and maintenance, and (3) leachate transmission.

### Environmental Monitoring

Three lessons learned are discussed below for environmental monitoring.

1. Bivariate plots can be utilized to present alternate source determinations in situations where “dirty” facilities are installed within a “dirty” background.
2. More cells increase long-term monitoring costs
3. Inert material should be used to backfill drainage pipe installations used for monitoring

<u>Bivariate plots can be utilized to present alternate source determinations in situations where dirty facilities are installed within a dirty background.</u>

Installing a “dirty” facility within a “dirty” background complicates the leak detection monitoring effort. By design, the OSDF Final Design Calculation Package [1] defines an action leakage rate of 200 gallons per acre per day (gpad) for the LDS. The action leakage rate is the maximum design flow rate that the LDS can remove without the fluid head on the bottom liner of the facility exceeding 1 ft.at the liner penetration box (40 CFR 264.302). Stated in another way, it is the flow rate that corresponds to a hydraulic head within the facility capable of driving fluid through a liner breach.  To be conservative, DOE has defined an initial response leakage rate that is 1/10 the action leakage rate (20 gpad). Should the flow in the LDS ever reach a rate of 20 gpad, DOE will begin the process of determining why flow is increasing so that actions can be taken long before the action leakage rate is ever reached. Therefore, the potential for leakage from the OSDF can be monitored by monitoring the rate of flow out of the LDS.

Although the OSDF is an engineered disposal facility (with a designed action leakage rate) and not just a sanitary landfill, Ohio Solid Waste Disposal Facility Leak Detection Monitoring Rules written for RCRA landfills (Ohio Administrative Code 3745-27-10) are an applicable or relevant and appropriate requirement for the OSDF Leak Detection Monitoring Program. The rules state that water-quality monitoring results must be used to demonstrate that a facility is not leaking. This monitoring task is challenging when the facility is installed in a location where contamination is above background level but below cleanup standards, as is the case for the OSDF at Fernald.

In the immediate vicinity of the Fernald OSDF, contaminant concentrations in the surrounding environment are present above background levels in surface and subsurface soil, the perched groundwater in the glacial till, and the underlying GMA. The nature and extent of contamination in these media were documented in the OU5 Remedial Investigation Report [2]. Additional characterization of the perched groundwater in the glacial till in the OSDF footprint is documented in the OSDF Pre-Design Report [3]. Final remediation levels (FRLs) for soil were established in the OU5 Record of Decision [4], and residual contamination below the soil FRLs interferes with the interpretation of water-quality data.

Contaminant concentrations in surface and subsurface soil within the OSDF footprint exceeded the soil FRLs, but certification reports [5–8] show that contaminant levels are now below FRLs. For example, the background value for uranium is 3.7 mg/kg [9], the FRL is 82 mg/kg [4], and the mean values for the 17 certification units that correspond to the locations of the HTWs range from 5.96 to 57.2 mg/kg (Table 1).

DOE has been monitoring selected constituents in the HTWs, and some of the constituent concentration trends have been increasing. Because residual contamination below the FRLs is present in the area of the HTWs, and installation of the facility changed recharge/infiltration conditions in the area, it is not unexpected that contaminant concentrations in perched groundwater might increase.

The OU5 leaching coefficients for contaminated soil [10] can be used to calculate the range of expected groundwater uranium concentrations in below-FRL soil (Table 1), and uranium values in the HTWs [11] fall near or below the lower level of this range. The maximum detected uranium concentration in perched groundwater (0.021 mg/L) prior to OSDF construction [3] is lower than the maximum HTW value detected (0.059 mg/L in Cell 3). However, this is expected, as the soil was disturbed during construction, and particle surfaces exposed to the atmosphere during construction may leach more readily than less-reactive surfaces in undisturbed soil. On the basis of the $K_l$ value of 185 in Table 1, the uranium concentration in the Cell 3 HTW could reach a maximum value near 0.2 mg/L without uranium contribution from the OSDF.

TABLE 1. Mean uranium value[a] for certification units at or near the horizontal till wells, expected groundwater uranium concentrations based on the reported range for uranium leach coefficients ($K_l$) in low-leachability soil[b], maximum HTW concentration[c], and observed perched-water concentration prior to OSDF construction[d].

| **Certification Unit** | **Uranium (mg/kg)** | **Cell** | **Uranium (mg/L)** | | | |
|---|---|---|---|---|---|---|
| | | | $K_l$ = 185 | $K_l$ = 2700 | HTW-max | Pre-const |
| P19 | 38.1 | 1 | 0.206 | 0.014 | 0.019 | 0.020 |
| P18 | 38.9 | 1, 2, and 3 | 0.210 | 0.014 | 0.059 | 0.010 |
| P18-11 | 18.6 | 3 | 0.101 | 0.007 | 0.059 | 0.003 |
| P17-33 | 11.7 | 3 and 4 | 0.063 | 0.004 | 0.059 | 0.013 |
| P17-31 | 25 | 4 | 0.135 | 0.009 | 0.008 | 0.013 |
| A1P2-S2SP-01 | 24.3 | 5 | 0.131 | 0.009 | 0.021 | 0.005 |
| A1P2-S2SP-02 | 32.5 | 5 | 0.176 | 0.012 | 0.021 | 0.005 |
| A1P2-S2SB-04 | 10.9 | 6 | 0.059 | 0.004 | 0.024 | 0.007 |
| A1P2-S2NI-02 | 21.5 | 6 | 0.116 | 0.008 | 0.024 | 0.007 |
| A1P2-S2SB-02 | 6.64 | 6 | 0.036 | 0.002 | 0.024 | 0.007 |
| A1P2-S2NI-07 | 8.64 | 6 and 7 | 0.047 | 0.003 | 0.024 | 0.007 |
| A1P2-S2SB-01 | 5.96 | 7 | 0.032 | 0.002 | 0.012 | 0.021 |
| A1P2-S2SP-04 | 17.7 | 7 | 0.096 | 0.007 | 0.012 | 0.021 |
| A1P2-S2NI-08 | 57.2 | 7 and 8 | 0.309 | 0.021 | 0.012 | 0.021 |
| A1P4-C1 | 28.8 | 8 | 0.156 | 0.011 | 0.007 | 0.019 |
| A1P4-C2 | 14.7 | 8 | 0.079 | 0.005 | 0.007 | 0.019 |
| A1P4-C3 | 16.6 | 8 | 0.090 | 0.006 | 0.007 | 0.019 |

[a]Data obtained from certification reports [5–8].
[b]Leach coefficients obtained from Table 2.2 of the OU5 $K_l$ study [10].
[c]HTW maximum concentrations for Cells 1-7 taken from 2014 Site Environmental Report [11].
[d]Perched groundwater results taken from OSDF preconstruction study [3].

Without the understanding of pre-existing conditions, upward trends in contaminant concentrations in the environment surrounding a facility could be interpreted as being the result of the facility leaking, when in reality, they are the result of changing chemical conditions outside of the facility. At Fernald, bivariate plots are used to provide an “alternate source determination” for concentration increases observed beneath the facility.

Figure 4 is an example of a bivariate plot for Cell 4. Sodium and uranium were selected for the plot because this combination provides a good distinction between the LCS, LDS, and HTW monitoring horizons. This combination was discovered during an evaluation of aqueous ions in the monitoring systems of the onsite disposal facility [12]. The bivariate plot provides a visual representation of the concentration signatures for uranium–sodium in each monitoring horizon for Cell 4.

Distinct clustering of data points for the LCS, LDS, and HTW samples indicates that the fluid chemistry in those different monitoring horizons is distinct and not mixing. Over time, should a leak occur, the water chemistries for the separate monitoring horizons would equilibrate and occupy the same space on the bivariate plot.

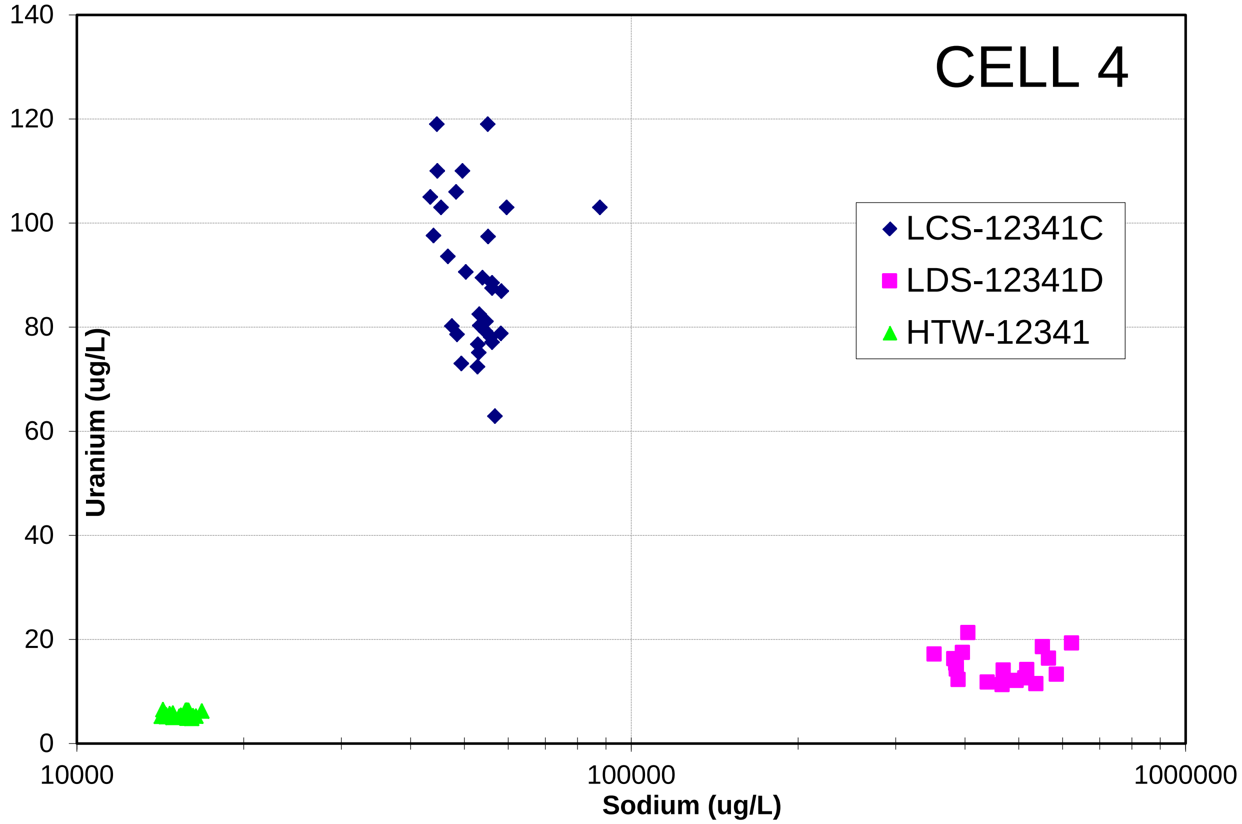


Fig. 4. Sodium-Uranium Bivariate Plot for Cell 4

Bivariate plots prepared for the OSDF (and reported each year in the Fernald Site Environmental Report) support that chemical signatures for the different monitoring horizons are separate and distinct, indicating that mixing between the horizons is not occurring; therefore, upward concentration trends measured beneath the cells in HTW and/or GMA wells seen in some constituents are attributed to fluctuating ambient concentrations beneath the cell, rather than poor liner performance.

<u>More cells increase long-term monitoring costs.</u>

To minimize long-term monitoring costs, it would be better to have a facility with just one cell rather than multiple cells. Each cell within a facility essentially requires its own leak detection monitoring program. The disposal facility at Fernald has eight individual cells, each with a leachate collection system, leak detection system, a horizontal till well, and at least two other groundwater monitoring wells (for the GMA). This amounts to a minimum of five monitoring points for each cell. Multiply that by 8 cells and the program has 40 long-term monitoring locations. A disposal facility with fewer cells would be cheaper to monitor in the long term due to the overall reduction in the number of locations to be monitored.

Use inert material to backfill drainage pipe installations used for monitoring.
Rather than limestone or dolomite gravel, inert quartz gravel should be used to backfill any pipe beds, especially those installed for environmental sampling. Limestone or dolomite gravel may be lower in cost initially when compared to quartz gravel during the construction phase, but the use of inert quartz is preferred for long-term monitoring efforts.

At the Fernald site, the HTW, LDS, and LCS installations were backfilled with limestone or dolomite. The soluble limestone and dolomite affects the chemistry of the fluid in the perforated piping. The piping in the OSDF facility and the storage tanks in the valve houses have also experienced a buildup of calcareous scale from the gravel used to fill the pipe trenches. The scale has partially clogged the perforations in the collection pipes (as evidenced by the periodic camera surveys completed in the pipes), and coats the inside of the tanks used to collect fluid from the LCS and LDS. This scale also coats the instrumentation installed within the tanks – driving the need for additional maintenance (see the Leachate Transmission Section below). The use of inert quartz would have prevented some if not all of the chemistry and scale issues.

**LCS/LDS and Valve-House Operation and Maintenance**

Two lessons are discussed below for LCS/LDS valve-house operation and maintenance.

1. Expect foul-smelling odors to vent from the cells into the leachate tanks.
2. Design the valve houses to address the long-term monitoring mission.

Expect foul-smelling odors to vent from the cells into the leachate tanks.
Foul-smelling odors should be expected to vent from the cells into the leachate tanks located in the valve houses. At Fernald, this was not an initial consideration for the design of the valve houses. Exhaust fans needed to be installed post-closure to vent odors from the leachate collection tanks.

Testing of the atmosphere in the tanks by a certified industrial hygienist revealed high readings for lower exposure limit and low oxygen concentrations in some of the eight valve houses. The source of the abnormal readings was the LCS tanks that are connected to the waste within the disposal cells via the LCS drain pipe. The strong odors and abnormal readings appeared to be caused by “sewer gas,” which is a mixture of gases that are heavier than air and, therefore, unlikely to rise through the tank to vent to the atmosphere out of the top of the valve house without supplemental ventilation.

Design the valve houses to address the long-term monitoring mission.
Leachate valve houses should be designed so that they are not confined spaces, by using steps, and exhaust fans. Fans installed on the valve house to vent odors

should be installed with timers on the building exhaust fans so that they can operate regularly to clear the air in the valve houses, but use less energy than if operated continuously.

Steps should be designed with maintenance and monitoring in mind. Maintenance and monitoring personnel will need to carry equipment up and down the steps. Care should be taken in the selection of sampling tanks. The tanks installed at Fernald have feet that are part of the tank. When filled with fluid the water cannot be emptied out of the feet resulting in compromised samples. The tanks installed at Fernald and have a limited size opening on top in which to access the interior of the tanks. The limited size opening makes it difficult to clean the inside of the tanks.

Care should be taken in selecting which type of valve to use. Large gate valves (like the ones used at Fernald) are nearly impossible to open and close. Sampling spigots in the valve houses should be designed with durability in mind. Plastic spigots used at Fernald are not sturdy and can easily break.

Long-term flow projections should be considered when designing tanks and sampling points. Leachate flow at Fernald has decreased dramatically since the facility was capped. In 2006, before the final cell was capped, 28.8 million liters of leachate were collected. In 2007, after the entire facility was capped, 1,295,569 liters of leachate were collected. In 2014, the volume was down to 525,979 liters. The large tanks installed to handle earlier flow volumes are oversized for the volumes now being encountered. Grab samples from the large tanks are becoming harder to obtain as the flow decreases.

### Leachate Transmission

At Fernald, scale from the pipe-bedding material has deposited on the instruments, pumps, and collection tanks. An example of the scale buildup problem occurs with the water-level instruments that must be cleaned several times per year to keep them operating accurately. The scale also affects valve operations, which could possibly be counteracted by designing Teflon internals in the valves to reduce lime scale. The change in chemical composition of the water as well as the resulting scale may cause additional issues determining end-state treatment options for the leachate after the current onsite treatment is no longer needed. Operation of equipment for leachate transmission and treatment should be automated as much as possible.

Leachate is often corrosive and has corroded through metal pipes in several places inside the valve houses at Fernald. A design utilizing HDPE pipe for the entire system would alleviate this problem. Any design should include two different flow meters for high flow and low flow because flow meters can only be accurate in a particular range.

## CONCLUSIONS

In November 2006, the US DOE Office of Legacy Management assumed responsibility for the long-term care and maintenance of the OSDF at the Fernald Preserve. LM has 9 years of monitoring and maintenance experience with the Fernald site OSDF, and monitoring data indicate that the OSDF is operating as designed to isolate waste from the environment.

Experience with OSDF long-term care and maintenance has brought to light several lessons learned, including, but not limited to the following. Alternate source determinations (supported by bivariate plots) are used at Fernald to help explain why upward concentration trends measured beneath cells (in the horizontal till wells and/or GMA wells) for some constituents are attributed to fluctuating ambient concentrations beneath each cell and are not related to cell performance. Foul-smelling odors should be expected to vent from the cells into the leachate tanks. Foul-smelling odors did develop in the valve house of the Fernald OSDF, and venting of the valve houses was, therefore, installed post-closure. Potential scale buildup, due to the use of certain pipe-bedding materials, was not properly considered at Fernald when limestone and dolomite were used to backfill piping installations in monitoring horizons. The use of inert quartz might have prevented or lessened this scale buildup.

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