Groundwater Treatment at the Fernald Preserve: Status and Path Forward for the Water Treatment Facility - 12320

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ABSTRACT

Operating a water treatment facility at the Fernald Preserve in Cincinnati, Ohio—to support groundwater remediation and other wastewater treatment needs—has become increasingly unnecessary. The Fernald Preserve became a U.S. Department of Energy Office of Legacy Management (LM) site in November 2006, once most of the Comprehensive Environmental Response, Compensation, and Liability Act environmental remediation and site restoration had been completed. Groundwater remediation is anticipated to continue beyond 2020.

A portion of the wastewater treatment facility that operated during the CERCLA cleanup continued to operate after the site was transferred to LM, to support the remaining groundwater remediation effort. The treatment facility handles the site's remaining water treatment needs (for groundwater, storm water, and wastewater) as necessary, to ensure that uranium discharge limits specified in the Operable Unit 5 Record of Decision [1] are met.

As anticipated, the need to treat groundwater to meet uranium discharge limits has greatly diminished over the last several years. Data indicate that the groundwater treatment facility is no longer needed to support the ongoing aquifer remediation effort.

SITE BACKGROUND

The Fernald Preserve is located approximately 28.9 kilometers northwest of downtown Cincinnati, Ohio (Figure 1). Scattered residences and several villages, including Fernald, New Baltimore, New Haven, Ross, and Shandon, are near the site. The Fernald Preserve overlies the Great Miami Aquifer (GMA), which the U.S. Environmental Protection Agency (EPA) has designated a sole-source aquifer.

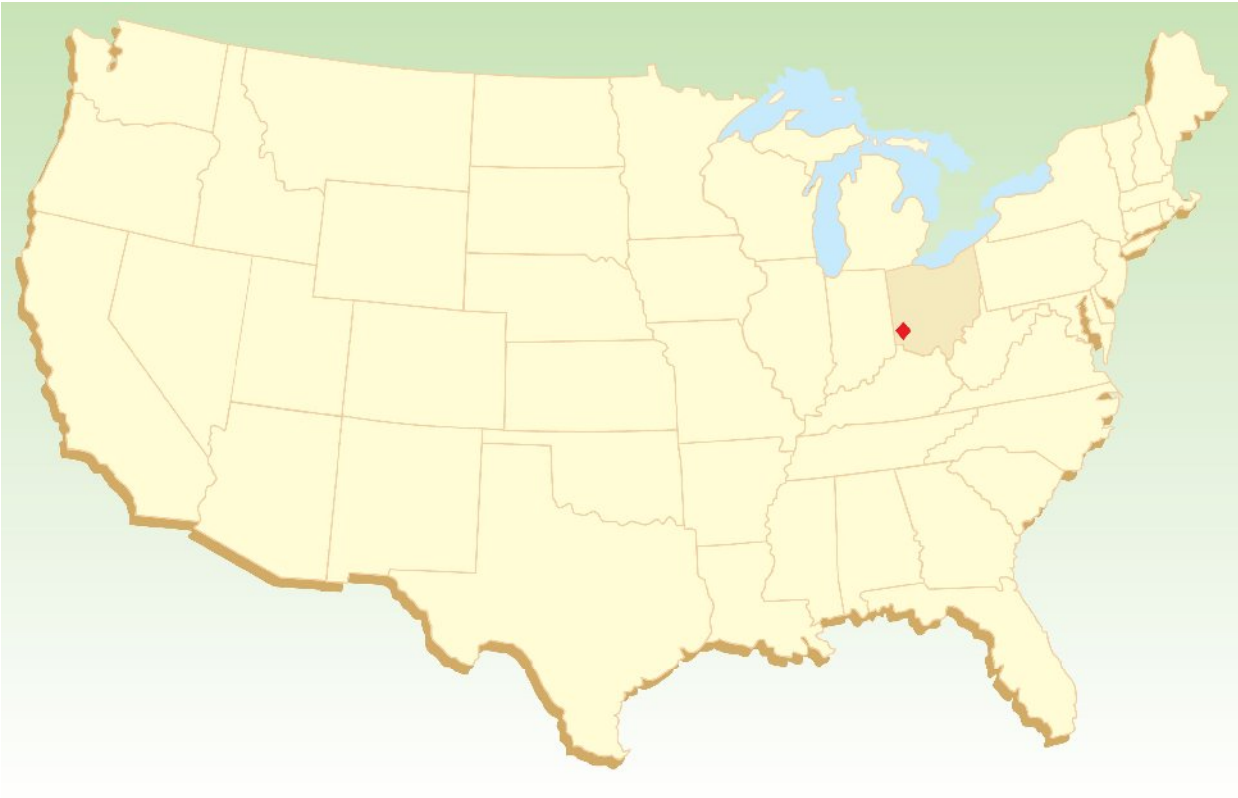

Figure 1. Location of the Fernald Preserve

The site dates back to 1951, when the U.S. Atomic Energy Commission, a predecessor agency of the U.S. Department of Energy (DOE), began building the Feed Materials Production Center on a 4.2 billion square meter tract of land outside the small farming community of Fernald. The mission was to produce “feed materials” in the form of purified uranium compounds and metal for use by other government facilities involved in the production of nuclear weapons for national defense. More than 227 million kilograms of uranium metal products were produced at the Feed Materials Production Center from 1952 through 1989. Production operations caused releases to the surrounding environment, which contaminated soil, surface water, sediment, and groundwater on and around the site.

In 1991, the mission of the site officially changed from uranium production to environmental cleanup under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). With the exception of the GMA, physical completion of the CERCLA remediation was declared on October 29, 2006, and the site was officially transferred to LM.

In 2007, the site name changed to the Fernald Preserve to reflect the completion of the cleanup (with the exception of groundwater), the successful transition of the site to LM, and the site’s new mission: to be an asset to the community as an undeveloped park with an emphasis on wildlife.

A pump-and-treat restoration of a groundwater contamination plume covering approximately 748,643,940 square meters in the GMA continues at the Fernald Preserve. Twenty-three extraction wells are operating at a combined target pumping rate of 18,073 liters per minute. Groundwater modeling predictions indicate that pump-and-treat operations will continue until approximately 2023. Certifying cleanup of the aquifer and removing the remediation infrastructure will likely require an additional 3 years.

Through August 2011, 118.5 billion liters of groundwater have been extracted from the GMA, 38 billion liters of water have been treated, and 4,815 kilograms of uranium have been removed from the aquifer.

WATER TREATMENT OPERATIONS

The water treatment facility (called the Converted Advanced Wastewater Treatment facility [CAWWT]) became fully operational in its current configuration in 2005 (Figure 2). The CAWWT handles water treatment needs at the Fernald Preserve, including treating groundwater, leachate from the On-Site Disposal Facility (OSDF), storm water, and wastewater from well field operations and groundwater monitoring activities. It also serves as an operations-and-maintenance (O&M) hub for aquifer restoration activities. It has a design capacity of 6,813 lpm and operates using three 2,271-lpm treatment trains. Two of the trains treat only groundwater, and one of the trains can treat groundwater, storm water, process wastewater, and leachate from the OSDF.

Figure 2. The CAWWT at the Fernald Preserve

Regulatory discharge limits for uranium to the Great Miami River are the primary driver to treat the water. The discharge limits (as defined in the Operable Unit 5 Record of Decision [OU-5 ROD]) [1] are as follows:

- 30 parts per billion (ppb) monthly average
- 272 kilograms per year uranium mass

The OU-5 ROD calls for groundwater treatment to continue until both discharge limits can be met without treatment. When treatment of groundwater is no longer required to meet the discharge limits, the water treatment facility is to be placed in a standby configuration until DOE and EPA determine, jointly, that the groundwater treatment facility is no longer needed. If the decision is made to remove the facility, impacted facility debris and associated impacted soil will be disposed of off site.

Guidelines for determining when the CAWWT might be shut down were provided in the *Fernald Groundwater Certification Plan* [2]. The guidelines state that groundwater will be treated to help meet uranium discharge limits specified in the OU-5 ROD until discharge limits can be achieved by blending untreated water alone. Eliminating groundwater treatment will not be pursued (1) at the expense of compromising mass removal, or (2) if significant deviation from desired aggressive pumping rates is required. Any decision to operate by blending alone is to be made only after careful assessment regarding the need to treat the high startup concentrations that might be experienced during pulsed pumping operations.

The site's current status with respect to achieving groundwater treatment commitments from the OU-5 ROD [1] and *Fernald Groundwater Certification Plan* [2] has been evaluated. As discussed below, results indicate that:

- Discharge limits can be achieved by blending untreated water alone.
- Predicted uranium mass removal from the aquifer can be maintained without treatment.
- Groundwater extraction rates specified in the aquifer remedy design documents can be maintained without treatment.
- Future well field operational changes can be managed without treatment.
- Other anticipated or potential treatment streams can be addressed without treatment if uranium is the only consideration.

CURRENT STATUS OF WATER TREATMENT NEEDS

Discharge Limits Can Be Achieved by Blending Untreated Water Alone

The CAWWT has been successfully operated, as necessary, to ensure that the uranium concentration and mass in the site's treated effluent to the Great Miami River comply with uranium discharge limits specified in the OU-5 ROD [1]. The regulatory discharge limits have been the drivers for how much the CAWWT has been operated. Water is treated as necessary to meet the discharge limits.

The uranium concentration of groundwater pumped from the GMA is decreasing over time. As predicted, and as shown in Figure 3, the need to treat groundwater to meet regulatory discharge limits has also diminished over time. Figure 3 shows the percentage of total groundwater pumped that was treated to ensure that the monthly average uranium discharge limit was not exceeded. During the last 5 months of 2010, less than 1 percent of the water pumped was treated, and the CAWWT has been maintained in a ready-to-operate standby mode for most of the last 2 years. Based on concentration data dating back to 2010, the groundwater treatment capacity that the CAWWT provides is no longer needed.

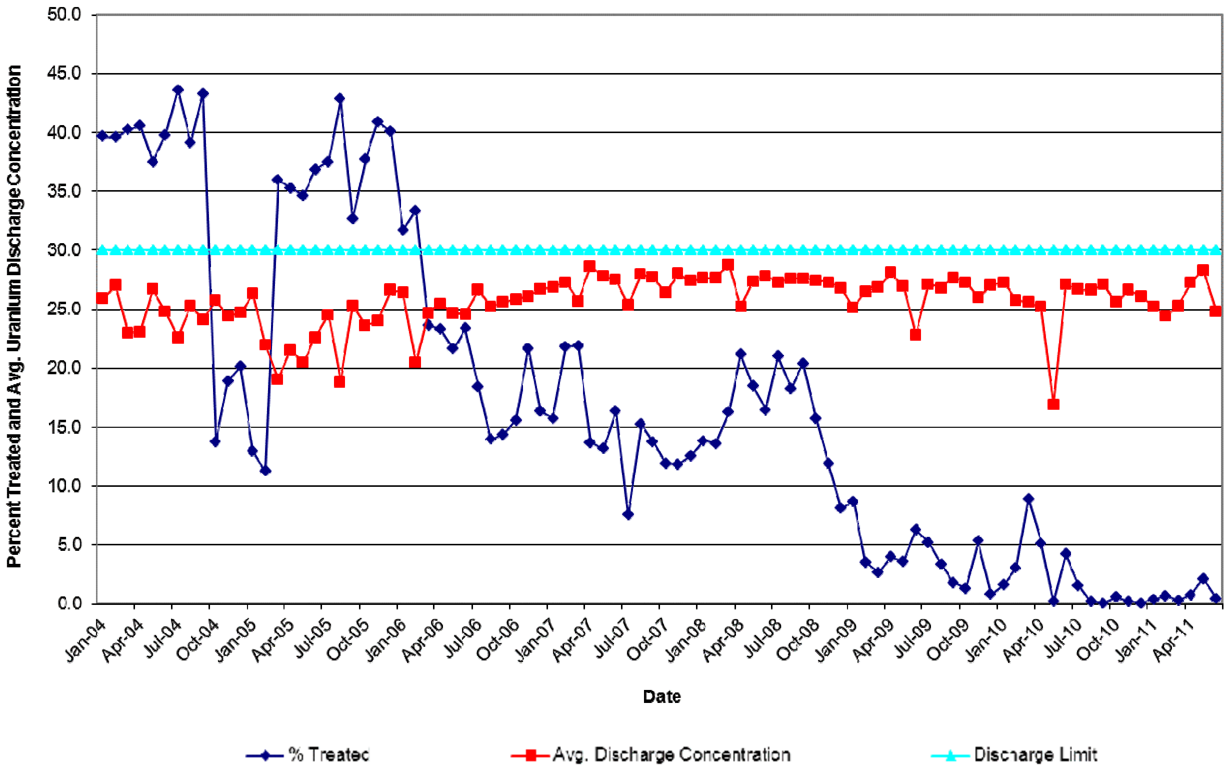

Figure 3. Percent treated and average monthly uranium discharge, concentration vs. time, January 2004 through June 2011.

Based on kilograms of uranium discharged to the Great Miami River each year, water treatment to meet the 272 kilogram-a-year limit is also no longer needed. Table I. provides a summary of actual 2009 and 2010 uranium discharge data as well as estimates of what the discharge data would have been without any treatment at the CAWWT. Following is a detailed description of the information provided in the table:

Column 1 indicates the respective month and designates annual totals where applicable.

Column 2 shows the actual monthly average uranium concentrations as derived from daily flow-weighted composite samples collected at the site effluent discharge point. This number includes well field flows that bypassed the CAWWT as well as all flow through the CAWWT. *Note that in all months, the concentration was well below the 30 ug/L limit.*

Column 3 shows the actual kilograms of uranium discharged as derived from daily flow-weighted uranium concentration data and daily flow totals as measured at the site's effluent discharge monitoring point. *Note that in both years, the total kilograms discharged were less than the 272-kilogram annual limit.*

Column 4 provides the estimated monthly average uranium concentration assuming none of the water discharged had been treated. This number was derived by substituting uranium concentrations from days before or after each treatment run (whichever was higher) rather than the actual measured concentration number for the days when treatment occurred (as were used for the calculation of the numbers in Column 2). *Note that the monthly average concentrations assuming no treatment were less than the limit for all months except April 2009.*

Column 5 provides the estimated kilograms of uranium that would have been discharged if none of the water had been treated, using the estimated concentrations shown in Column 4 and actual flow totals as measured at the site's final discharge monitoring point. *Note that under this scenario, the 272-kilogram limit would have been exceeded without treatment in 2009 but would have been met without treatment in 2010.*

Column 6 provides another estimate of the kilograms of uranium that would have been discharged if none of the water had been treated, this time using the calculated kilograms of uranium deposited on the ion-exchange resin in the CAWWT treatment vessels and the uranium in the groundwater that bypassed treatment. The number of kilograms deposited on the resin was derived from ion-exchange tank influent and effluent uranium concentrations and treatment flows. The kilograms deposited on the resin were added to the actual discharge kilograms in Column 3 to come up with the monthly totals in this column. *Note that under this scenario, the 272-kilogram limit would have been exceeded without treatment in 2009 but would have been met without treatment in 2010.*

Table I. Summary of 2009 and 2010 Uranium Discharges

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6
Month	**Actual Concen-tration (µg/L)**	**Actual Discharge to GMR (Kilograms)**	**Estimated Concentra-tion (µg/l) without Treatment**	**Estimated Discharge to GMR (Kilograms) without Treatment, using Estimated Concentrations**	**Estimated Discharge to GMR (Kilograms) without Treatment, using Calculated Kilograms Deposited on Resin**
January 2009	25.1	23.22	28.9	26.70	26.05
February 2009	26.5	21.44	28.7	23.18	22.75
March 2009	26.9	24.71	28.5	26.25	25.55
April 2009	28.1	24.97	30.0	26.61	26.31
May 2009	26.9	18.91	29.1	20.47	20.05
June 2009	22.8	7.67	25.4	8.54	8.47
July 2009	27.1	23.13	29.4	25.10	25.11
August 2009	26.8	25.03	27.9	26.13	26.41
September 2009	27.7	24.92	28.2	25.38	25.19
October 2009	27.3	26.04	27.6	26.29	26.45
November 2009	26.0	22.65	27.9	24.28	23.94
December 2009	27.0	23.17	27.3	23.49	23.41
2009 Totals		**265.87**		**282.42**	**279.70**
January 2010	27.3	26.67	27.3	26.67	27.21
February 2010	25.8	21.74	27.1	22.87	22.75
March 2010	25.6	21.10	27.8	22.95	23.98
April 2010	25.2	19.40	26.6	20.46	20.96
May 2010	16.9	2.89	16.9	2.89	2.91
June 2010	27.1	21.70	28.6	22.95	22.77
July 2010	26.7	24.60	27.1	24.98	24.91
August 2010	26.6	25.12	26.8	25.30	25.17
September 2010	27.1	24.12	27.1	24.12	24.12
October 2010	25.6	23.00	26.1	23.46	23.12
November 2010	26.6	21.28	26.6	21.28	21.33
December 2010	26.1	24.71	26.1	24.71	24.73
2010 Totals		**256.34**		**262.63**	**263.96**

GMR = Great Miami River

Predicted Uranium Mass Removal from the Aquifer Can Be Maintained Without Treatment

The annual predicted uranium mass to be removed from the aquifer through 2024 is provided in Table II. Table II also shows the planned and actual weight of uranium extracted from the GMA as a result of remedial pumping for 2007 through 2010, and the planned annual weight to be removed for the predicted life of the aquifer remedy. The planned annual weight to be removed (Columns 2 and 3) was derived from two methods:

1. The figures in Column 2 were derived from regression analysis of individual extraction well uranium concentration data and design target pumping rates.

2. The figures in Column 3 were derived from groundwater modeling performed in support of the *Waste Storage Area Phase II Design Report* [3].

The planned amount derived from both methods is less than the 272-kilogram annual uranium discharge limit from 2009 forward.

Table II. Kilograms of Uranium Removed from the Aquifer.

Column 1	**Column 2**	**Column 3**	**Column 4**	**Column 5**
Year	**Annual Uranium to be Extracted from GMA (Kilograms) Based on Concentration Data (Through Prior Year)**	**Annual Uranium to be Extracted from GMA (Kilograms) Based on Model**	**Annual Uranium Extracted from GMA (Kilograms)**	**Percent of Design Target Pumping Rate Achieved**
2007	345	420	296	97
2008	290	316	307	99
2009	260	266	266	105
2010	233	231	250	102
2011	215	204		
2012	188	183		
2013	166	166		
2014	146	152		
2015	120	139		
2016	119	125		
2017	106	112		
2018	95	102		
2019	85	94		
2020	76	88		
2021	69	82		
2022	62	77		
2023	56	72		
2024	51	68		

Column 4 shows the actual kilograms of uranium removed from the aquifer by remedial pumping for 2007 through 2010. This number was calculated using well-specific uranium concentrations (derived from monthly samples) and flows. Column 5 shows the well field performance for the past 4 years compared to the design target performance established in the *Waste Storage Area Phase II Design Report* [3]. Since 2007, the well field performance has been very close to or has exceeded the design target pumping rate.

Planned and actual amounts of uranium removed in 2008, 2009, and 2010 are all in fairly close agreement with the actual amount of uranium removed. However, the actual amount of uranium removed from the aquifer in 2010 was still approximately 22 kilograms less than the 272-kilogram uranium discharge limit. Predictions of how much uranium would be removed in future years via the two methods are far less than the 272-kilogram annual limit. Based on the information provided in Table II, the predicted amount of uranium to be removed from the aquifer can be maintained without groundwater treatment.

Pumping Rates Specified in the Aquifer Remedy Design Documents Can Be Maintained without Treatment

The target groundwater pumping rate specified by the aquifer remedy design is 18,073 lpm, as noted in the *Waste Storage Area Phase II Design Report* [3] and in the *Fernald Groundwater Certification Plan* [2]. Figure 4 shows how the actual groundwater remedial pumping volume has compared to the design target volume on an annual basis since remedial pumping began in 1993. The percentage of the target achieved has varied considerably over the years, and it is notable that since site closure in 2006, the groundwater remedial pumping performance has been excellent. That excellent performance since 2006 is attributed to the refinement of the site's well field performance monitoring and maintenance program [4]. It is anticipated that the refined program will be maintained for the life of the remedial pumping action. Therefore, it can be expected (barring continued decline in aquifer water levels) that the pumping rates will continue to be such that the design target pumping rate and volume can be maintained over the life of the groundwater remedy.

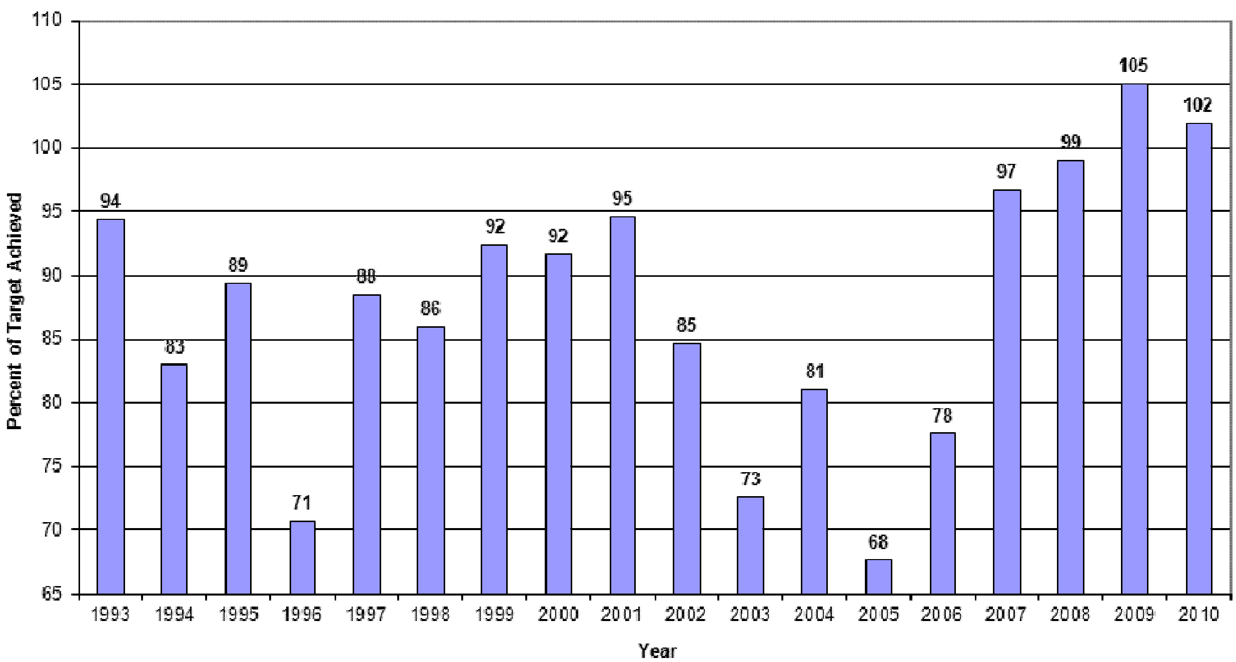

Figure 4. Percentage of target achieved, billions of liters pumped (actual versus target), 1993 through August 2010.

Future Well Field Operational Changes Can Be Managed without Treatment

It is anticipated that some well-specific uranium concentrations from future pulse pumping operations may be above the 30 ppb monthly average uranium discharge limit; however, these occurrences will probably be in isolated wells and not in the entire well field. The basis for this statement is information derived from month-long annual well field shutdowns that have occurred since 2007. The information from the annual shutdowns indicates that while there is an increase in some extraction well uranium concentrations when pumping is restarted, the increase is not large or long-lived. Any concentration increase from pulse pumping is expected to be similar to what has been seen after the annual shutdowns. Due to this similarity, and given the additional uranium mass being removed from the aquifer by the ongoing pump-and-treat operation, it is very likely that future “rebound” uranium concentrations after pulse pumping can be managed without treatment.

OTHER ANTICIPATED OR POTENTIAL TREATMENT STREAMS

Six other sources for water are currently treated through the CAWWT:

1. Water used to backwash the multimedia filters and ion-exchange vessels within the CAWWT.
2. Storm water draining from the south side of the CAWWT.
3. Leachate from the OSDF.
4. Process wastewater from well field maintenance activities.
5. Process water from the laboratory the CAWWT contains.
6. Purge water and decontamination water from groundwater sampling equipment.

All of these sources combined are very minor compared to the former groundwater treatment needs. Treatment streams 1 and 2 will no longer be generated when the CAWWT is dismantled. Treatment streams 3 through 6 are discussed below.

Leachate from the OSDF

The uranium concentration within the composite leachate stream from all eight cells averaged 83 ppb when checked in the spring and summer of 2011. As shown in Table III, the predicted leachate volume for 2011 is approximately 570,490 liters and is projected to decrease to 14,269 liters in 2028. Volumes shown in Table III were predicted using actual monthly leachate volumes from 2007 to 2010 and regression analysis to estimate volumes for 2011 to 2028. The predicted leachate volume for 2011 is approximately 1/15,200 of the volume of groundwater scheduled to be pumped. This volume could be blended with the groundwater stream without compromising site uranium discharge limits; however, a leachate treatment exemption would need to be approved prior to implementing this. Once groundwater pumping stops, (scheduled for 2023) this minor stream may require treatment for uranium removal.

All of the leachate is collected and stored in a 15,140-liter tank at the existing lift station located at the southwest corner of the OSDF. The leachate collected at the lift station is conveyed to the CAWWT for treatment via an underground, pressurized pipe system.

Table III. Historical and Predicted Leachate Volume

Year	Actual (2007–2010) and Predicted (2011–2028) Liters of Leachate
2007	1,295,428
2008	968,930
2009	756,455
2010	559,132
2011	570,490
2012	500,036
2013	441,036
2014	390,283
2015	345,745
2016	306,063
2017	270,279
2018	237,698
2019	207,793
2020	17,403
2021	154,470
2022	130,473
2023	107,960
2024	86,756
2025	66,714
2026	47,721
2027	27,865
2028	14,269

Process Wastewater from Well Field Maintenance Activities

This stream consists of spent treatment solutions (rehab water) pumped from the extraction wells after the pumps or well screen/filter pack is cleaned. The treatment solution is a blend of hydrochloric and glycolic acids mixed with water. It is placed in the pump or well and then agitated until it is spent (neutralized or nearly neutralized). It is then pumped out of the well and into one of two tanks (each of which can hold 3,785 liters). Then it is transported to the CAWWT Backwash Basin, where solids are settled, and neutralized as necessary before it undergoes treatment for uranium removal. Uranium concentrations in this stream are less than 200 ppb, and the anticipated annual volume is approximately 1,021,950 liters. A small amount of treatment capacity will need to be maintained to address this treatment stream.

Process Water from the Laboratory the CAWWT Contains

This flow is estimated to be 7,570 liters per month (90,840 liters per year) with a low uranium concentration of less than 30 ppb. Therefore, it will not require treatment for uranium removal.

Purge Water and Decontamination Water from Groundwater Sampling Equipment

Most of the monitoring wells are micro-purged, so this volume is very small, on the order of 3,785 liters per year. Based on the current sampling frequency (quarterly), the pre-sampling purge water from the OSDF horizontal till wells is estimated to be 128,690 liters per year. The sampling frequency will probably be reduced in the future, and this water (along with the micropurge water) can likely be disposed of without treatment. The decontamination of sampling equipment generates an insignificant volume of water for treatment—less than 3,785 liters per year.

PATH FORWARD FOR WATER TREATMENT

Although the groundwater treatment facility is no longer needed to support the ongoing aquifer remediation effort, a reduced water treatment capacity is needed to address the anticipated or potential wastewater treatment streams discussed above.

Over the past year, DOE worked with EPA and the Ohio Environmental Protection Agency to decide on a path forward that will adjust groundwater treatment capacity to better fit current and potential water treatment needs.

Several alternatives were considered in order to decide whether to continue to operate and maintain the CAWWT, or to go with an alternate facility. These alternatives included:

- Removing the CAWWT altogether and building a new, smaller water treatment facility and O&M hub.
- Mothballing unneeded process equipment in the CAWWT and continuing to use the CAWWT building as an O&M hub, and building a new, smaller water treatment facility.
- Removing unneeded process equipment from the CAWWT and continuing to use the CAWWT building as an O&M hub, and building a new, smaller water treatment facility.

Costs for the deactivation and decommissioning (D&D) of the CAWWT are substantial (estimated at approximately $4.7 million). The D&D of the CAWWT at this time will also require that a smaller replacement system be designed and constructed to serve the site wastewater treatment needs, not only through the remainder of the aquifer restoration project, but also after the aquifer has been remediated, when only leachate from the OSDF remains to be treated. Any replacement system constructed to meet current wastewater treatment needs would be oversized when the groundwater remedy is completed and would add infrastructure to the site, which would have to be removed later.

Based on cost analysis of the alternatives noted above, continued operation of the CAWWT at a reduced treatment capacity is the most cost-effective approach. No new infrastructure is required, substantial D&D costs are postponed, familiarity with the existing system is maintained, and stakeholder concerns are addressed. In discussions with EPA and the Ohio Environmental Protection Agency, a reduced treatment capacity of 1,893 to 2,271 lpm was targeted. This rate would require that only one of the three existing treatment trains be maintained.

Maintaining one treatment train will also allow DOE to address an important stakeholder and regulator concern: having the flexibility to respond to groundwater treatment needs that may arise in the future. These needs may come about due to implementing groundwater remediation options (other than the currently approved remedy), which may result in rebounding uranium concentrations in the pumped groundwater, thereby necessitating additional treatment. As discussed earlier, it is anticipated that any future rebounding uranium concentration could be managed without treatment. Having the capability to treat between 1,893 and 2,271 lpm, if needed, provides the added assurance that stakeholders and regulators were seeking.

Maintaining the CAWWT also provides for a needed O&M hub for aquifer restoration activities without having to incur any additional construction costs for a new facility.

DOE, EPA, and the Ohio Environmental Protection Agency have reached an understanding that DOE intends to move forward with the D&D of the unused portion of the CAWWT. This will likely be accomplished over the next couple of years, depending on funding constraints.

REFERENCES

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