Appendix B

Supplemental Surface Water and Effluent Information

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Abbreviations

DOE	U.S. Department of Energy
FFCA	Federal Facility Compliance Agreement
FRL	final remediation level
GMA	Great Miami Aquifer
IEMP	Integrated Environmental Monitoring Plan
LMICP	*Comprehensive Legacy Management and Institutional Controls Plan*
NPDES	National Pollutant Discharge Elimination System
Ohio EPA	Ohio Environmental Protection Agency
OU5 ROD	Operable Unit 5 Record of Decision

Measurement Abbreviations

cfs	cubic feet per second
mg/L	milligrams per liter
µg/L	micrograms per liter
pCi/L	picocuries per liter

B.1.0 Surface Water and Effluent

This appendix presents additional surface water and effluent data in support of Section 4.0 of this *Fernald Preserve 2023 Site Environmental Report* and provides an evaluation of the final remediation level (FRL) exceedances for surface water and effluent at the Fernald Preserve, Ohio, Site, including an assessment of potential cross-media impacts to the groundwater exposure pathway. Surface water data are available through the U.S. Department of Energy (DOE) Office of Legacy Management's Geospatial Environmental Mapping System (GEMS) database at https://gems.lm.doe.gov/#.

Surface water and effluent samples are collected as required by the Integrated Environmental Monitoring Plan (IEMP), which is Attachment D of the *Comprehensive Legacy Management and Institutional Controls Plan* (LMICP) (DOE 2023a). Figure B-1 shows all IEMP surface water monitoring locations. The following information is discussed in this appendix:

- Surveillance monitoring (Section B.1.1)
- Federal Facility Compliance Agreement (FFCA)/*Final Record of Decision for Remedial Actions at Operable Unit 5* (OU5 ROD) (DOE 1996) compliance (Section B.1.2)
- Controlled and uncontrolled areas (Section B.1.3)
- Surface water monitoring reductions (Section B.1.4)

Routine National Pollutant Discharge Elimination System (NPDES) permit sampling is not discussed in this appendix because it is discussed in detail in Section 4.0, "Surface Water and Effluent Pathway," of this 2023 Site Environmental Report.

B.1.1 Surveillance Monitoring

Surveillance monitoring is the comparison of surface water and effluent analytical results to the surface water FRLs to determine the effects of remediation activities on the surface water exposure pathway. Surveillance monitoring also includes an assessment of the effects surface water may have on the groundwater pathway (referred to as cross-media impacts).

All 2023 data were compared to surface water FRLs. Concentration versus time plots are presented in Figures B-2 through B-11. Samples collected at the Parshall Flume (PF 4001) are used in the surveillance evaluation because this is the last point effluent is sampled before discharge to the Great Miami River.

Water discharged to the Great Miami River is required to be below the FRLs at the point where discharged water is completely mixed with water in the Great Miami River (i.e., outside the mixing zone). In cases where the Parshall Flume data are already below the FRLs, no further action is taken. When the Parshall Flume data are above the FRLs the following calculation is applied to determine each constituent's concentration at this point in the Great Miami River. No samples collected at PF 4001 exceeded the surface water FRLs in 2023.

$$C_{PF\,4001} = \frac{[Q_{10}][C_{GMR}] + [Q_{PF}][C_{PF}]}{[Q_{10}] + [Q_{PF}]}$$

where:

C_{PF4001} = Flow-weighted average concentration outside the mixing zone in the Great Miami River, picocuries per liter (pCi/L), micrograms per liter (µg/L), or milligrams per liter (mg/L)

Q_{10} = 7-day, 10-year low flow, 280.56 cubic feet per second (cfs)

C_{GMR} = Background concentration in the Great Miami River from Table 11 in Attachment D of the LMICP, measured in pCi/L, µg/L, or mg/L; (zero was used when no background concentration was available)

Q_{PF} = Daily flow at PF 4001, cfs

C_{PF} = Daily concentration at PF 4001, pCi/L, µg/L, or mg/L

Note Flow conditions at the Hamilton Dam gauge are periodically reviewed to determine whether there is a lower flow than the 7-day, 10-year low flow of 280.56 cfs. The low flow of 280.56 cfs went into effect during the NPDES permit renewal process using information provided in the NPDES permit fact sheet finalized in 2022 (Ohio EPA 2022). The lowest daily flow measured at the Hamilton Dam gauge (if lower than 280.58 cfs) is used in the equation to see whether an exceedance could potentially occur. The lowest daily flow recorded during 2023 was 536 cfs, which occurred on October 11, 2023.

B.1.1.1 Evaluation of Constituents Above FRLs for 2023

As shown in Table B-1, there were 13 exceedances of the total uranium surface water FRL in 2023, which is applicable outside the mixing zone of the Great Miami River. Figures B-2 through B-7 are plots of the total uranium concentration versus time for all surface water sampling locations sampled in 2023. The 13 total uranium surface water FRL exceedances (530 µg/L) occurred at sampling location SWD-09. Figure B-2 is a plot of the total uranium concentration versus time for sampling location SWD-09. Concentrations display a cycle of high to low each year. The historical high was 2,087 µg/L, measured in December 2016. The highest total uranium concentration in 2023, 1,142 µg/L, was at this location. The overall statistical trends (Mann-Kendall) with a 95% confidence interval at SWD-09 is "Down."

As discussed in Section 4.0 of this Site Environmental Report, surface water monitoring currently conducted in a small swale area west of the former waste pits continues to show elevated but slowly diminishing uranium concentrations. After a limited maintenance activity was completed in fall 2007, DOE committed to continued monitoring of the swale area. Two monitoring points (SWD-05 and SWD-09) were added to the surface water program to fulfill this monitoring commitment. Through 2023, these two locations were sampled weekly, when water is present.

Location SWD-05 has been sampled 306 times and location SWD-09 has been sampled 512 times between January 2007 and December 2023. As shown in Table B-1, 297 of the

512 samples collected at SWD-09 (58%) have exceeded the total uranium surface water FRL which is applicable outside the mixing zone in the Great Miami River. As discussed in Appendix A, Attachment A.2, the swale is isolated from surface drainage features, so water entering the swale either evaporates or infiltrates into the ground. If the surface water with elevated total uranium concentration infiltrates into the aquifer beneath the swale, it is quickly captured by nearby extraction well 33347 and poses no threat to human health or the environment. Additional information concerning this area is provided in Appendix A, Attachment A.2, Section A.2.1.1.4, and this document Section B.1.5.

B.1.1.2 Evaluation of Cross-Media Impacts for 2023

One of the objectives of the IEMP surveillance monitoring program is to provide an ongoing assessment of the potential for cross-media impacts from surface water to the underlying Great Miami Aquifer (GMA). To conduct this assessment, sampling locations were selected to evaluate contaminant concentrations in surface water just upstream from those areas where site drainages have eroded through the protective glacial overburden (e.g., the storm sewer outfall ditch, Pilot Plant Drainage Ditch, and certain reaches of Paddys Run). In areas where the glacial overburden is absent, a direct pathway exists for contaminants to reach the aquifer. Key sampling locations associated with these areas of direct infiltration are SWD-04, SWD-05, SWD-08, and STRM 4005 (Figures B-3 through B-6 and Figures B-8 through B-11).

Because it is the primary contaminant at the site, total uranium is used as an indicator to evaluate the impact of surface water on the GMA. A conservative assumption is used in this assessment, which considers the total uranium concentration (and all other constituent concentrations) in the surface water to be at the same concentration when the water reaches the GMA through infiltration. However, the more likely scenario is that the total uranium concentration (and all other constituent concentrations) would decrease through dilution and adsorption to sediment particles as the water infiltrates through the ground and mixes with the groundwater in the GMA. The groundwater total uranium FRL of 30 µg/L is used in this cross-media impact assessment.

The results of the cross-media impact assessment for 2023 indicate that two (SWD-04 and SWD-05) of the four surface water locations evaluated had results that exceeded the total uranium groundwater FRL of 30 µg/L. The impact SWD-04 has on the aquifer is similar to SWD-09's impact discussed in Section B.1.1.1. All locations are within capture of the groundwater remediation system. Sampling at these locations will continue, and results of these samples will continue to provide an assessment of the cross-media impacts.

B.1.2 FFCA/OU5 ROD Compliance

The OU5 ROD and subsequent *Explanation of Significant Differences for Operable Unit 5* (DOE 2001) stipulate compliance with a monthly flow-weighted average total uranium concentration discharge limit of 30 µg/L at the Great Miami River via PF 4001. In addition to the concentration limitation, the OU5 ROD stipulated that the total mass discharged during a year not exceed 600 pounds.

During 2023, the total uranium concentrations were monitored daily at PF 4001 to demonstrate compliance with these limitations. The Fernald Preserve was in compliance with the total mass limitation, as uranium discharges totaled 259 pounds, which is below the 600-pound limit.

The Fernald Preserve was in compliance with the monthly flow-weighted concentration limit every month in 2023, as identified in Figure B-12.

B.1.3 Controlled and Uncontrolled Stormwater Runoff Areas

In 2023, there were no previously uncontrolled areas that were added to the Fernald Preserve controlled storm water system (Figure B-13). At the conclusion of remediation in October 2006, control of storm water runoff was no longer required. The only storm water collected for treatment is that which falls on the controlled pad of the Converted Advanced Wastewater Treatment facility.

B.1.4 Surface Water Monitoring Reductions

As stated in the *Fifth CERCLA Five-Year Review Report for the Fernald Preserve* (DOE 2021), based on an initial review of the surface water results, it may be appropriate to stop monitoring several locations where FRLs have not been exceeded during the 5-year period. This review, which was to also take into account cross-media impact issues, was discussed in the 2021 Site Environmental Report (DOE 2022). Additional surface water monitoring program reductions were documented in the 2015 and 2017 Site Environmental Reports (DOE 2016 and DOE 2018, respectively). The 2021 assessment was completed due to the number of years of data that had been collected without FRL exceedances at many locations. Concentration versus time graphs were reviewed for the 2021 Site Environmental Report for each location and evaluated against the following criteria:

- The surface water location has never had a surface water FRL exceedance
- The cross-media impact surface water location has never had a groundwater FRL exceedance
- It has been at least 10 years since the surface water (all locations) or groundwater (cross-media impact locations) FRL exceedance has occurred.

Table B-2 of the 2022 Site Environmental Report (DOE 2023) provided a list of surface water locations that met these criteria and proposed reducing sampling at the locations. With approval from the U.S. Environmental Protection Agency and Ohio Environmental Protection Agency (Ohio EPA), DOE documented these changes to the IEMP surface water monitoring program in the 2023 LMICP (DOE 2023b). 2022 was the last year these locations were monitored and reported.

Additional assessment of the surface water program was presented in the 2022 Site Environmental Report (DOE 2023b) related to sampling frequency at SWD-05 and SWD-09. Based on the number of years of data collected at SWD-05 and SWD-09, DOE proposed reducing the frequency of sampling at these locations from weekly to semiannual to align with the sampling of the remaining surface water locations. After discussions with the regulators, sampling of SWD-09 was reduced to quarterly and SWD-05 was reduced to semiannually. This change was implemented in 2024 with approval of the 2024 LMICP variances.

B.1.5 Surface Water West of Waste Pit 3

In response to an Ohio EPA comment on the 2022 Site Environmental Report (DOE 2023b), DOE committed to providing additional discussion on the uranium concentrations measured on SWD-09, which is west of Waste Pit 3. The impacted area is a series of small puddles due west of the center of Waste Pit 3, which generally drain south to a depression near the production-era former cement pond. Surface water in the area west of Waste Pit 3 was first sampled in late 2006 in support of sitewide surface water sampling to support the site's residual risk assessment. Ohio EPA collected a sample on November 22, 2006, which produced a total uranium result of approximately 714 µg/L. Subsequent sampling and analysis by DOE showed that most concentrations were between 650 and 880 µg/L, exceeding the surface water FRL of 530 µg/L that was identified in the Operable Unit 5 Record of Decision (OU5 ROD) (DOE 1996) as being applicable to the Great Miami River outside the mixing zone. The impacted area at peak water retention is approximately 0.5 acre as the area is typically dry for several months of the year which coincides with increased evaporation that occurs in late summer and early fall. Uranium concentrations indicate that the highest concentrations are at the northern end of the swale and dimmish to the south. There is no direct outlet of this drainage swale to Paddys Run. The soils in the area are generally poorly draining based on the 1993 site wetland delineation.

Based on the *Sitewide Excavation Plan* (DOE 1998), the area is in soil certification Area 6. The *Sitewide Excavation Plan* requires that each area of the site undergoes predesign, excavation, and precertification activities, including real-time instrumentation and physical sampling and analysis. Based on the results of the precertification activities, the area is either further remediated and precertified a second time or can be certified. The certification process is extensive sampling and analysis, statistical analysis of the data, and assessment of the certification criteria. The *Certification Report for Area 6 Waste Pits 1, 2, and 3, the Burn Pit, the Clearwell, and the Areas West and North of the Waste Pits* (DOE 2006), which documents the precertification and certification process of the area indicates that the subject area did not require further remediation prior to certification. The area underwent a rigorous soil certification process and all the certification samples from the impacted area were well below the soil certification FRL. Consistent with the *Sitewide Excavation Plan*, DOE determined that the area met certification criteria. The area would be certified clean when the EPA and Ohio EPA concurred that the certification criteria had been met; however, because of the elevated total uranium concentrations in the puddles west of Waste Pit 3, the regulators withheld approval of the certification report.

In late 2006, DOE initiated a leachability study of the impacted area which tested total uranium of the soil matrix as well as the uranium that has leached into the aqueous phase to produce a leachability constant similar to what was done in the *Operable Unit 5 Feasibility Study* (DOE 1994, Appendix F) and documented in the *Operable Unit 5 K_l Sampling and Analysis Results Report* (DOE 1995). Preliminary results of the total uranium in the soil demonstrated that residual uranium soil concentrations are consistent with the results from the certification efforts in the area (DOE 2007c). The results of the leachability study (DOE 2007c; DOE 2007d) indicated that:

> *"…the residual surface uranium in this area (approximately 30-foot by 30-foot) is the source of the elevated uranium in the surface water. The K_l values demonstrate that the uranium chemistry in this area is about four times more leachable in water than the*

majority of the Fernald site, however, the uranium in this area is about 5 times less leachable than the areas in the former production area that were considered 'high-leach' areas. The area underwent a rigorous certification effort to show that the soil FRL of 82 mg/kg was attained in this area and the total uranium results determined on the four soil samples collected for this leachability study corroborated this certification process. However, this study demonstrated that certified soil samples with uranium concentrations as low as 48 mg/kg can produce water concentrations that are above one of the surface water FRLs. The area immediate to the west where a 6" excavation was conducted shows very low residual uranium concentrations (i.e., near background range in soil). Based on this information, there is unlikely to be any other unknown source of uranium contamination in the area."

It should be noted that the OU5 ROD (DOE 1996) specifically applies the surface water FRL to the Great Miami River mixing zone, which is offsite. Two sections from the ROD that illustrate this point are as follows:

(1) ROD Section 9.2, "Remedial Action Objectives and Clean-Up Levels," states:

"*The remedial action objectives include eliminating or reducing to acceptable levels the potential for human or ecological receptors to come into contact with contaminated environmental media and prevention of off-property migration of contaminants in excess of the contaminant-specific FRLs.*"

(2) ROD Section 10.0, "Statutory Determinations," specifically Section 10.1.4, "Surface Water," states:

"*Surface water resources of the site (Paddys Run and the Great Miami River) will not require direct remediation as a consequence of the selected remedy. Paddys Run is a pathway for contaminant migration and the Great Miami River a receiving body for treated water discharges from the FEMP's water treatment operations. Final remediation levels are established for surface water to delineate protective requirements for the discharge of treated storm water, groundwater, and remediation wastewater to the Great Miami River and to control runoff to Paddys Run. These final remediation levels are protective of surface water receptors (represented by recreational users of the river and consumers of meat and milk products derived from cattle that directly consume surface water) at a cumulative incremental life cancer risk of between 1 X 10^{-4} and a hazardous index of less than 1."*

Based on the ROD language, it is clear the intent from a protectiveness standpoint is that contaminant concentrations within Great Miami River are of concern for protection of surface water receptors. Additionally, it should be noted that based on the site's institutional controls, the fact that the area is onsite and public access is restricted, there are no recreational users of surface water and cattle grazing is prohibited. Because the area is within capture of the groundwater remediation system, and site institutional controls restrict public access to the area, there is a negligible risk to the public from the total uranium concentrations in the ponded water or the groundwater in this area. Therefore, a direct comparison between these surface water locations and the surface water FRL of 530 µg/L identified in the OU5 ROD is not appropriate.

Because the regulators and stakeholders expressed concern about the area, DOE committed (DOE 2007a) to a maintenance activity to remove the top 6 inches of soil of the certified area suspected of being the source of the higher leachability uranium and to continue monitoring the surface water. The area was graded to reduce or eliminate future ponding, treated with lime (to further reduce leachability), and vegetated (DOE 2007b). Following the maintenance activity and DOE's action to continue monitoring the surface water in the area, EPA and Ohio EPA approved the area's certification report (*Certification Report for Area 6 Waste Pits 1, 2, and 3, the Burn Pit, the Clearwell, and the Areas West and North of the Waste Pits* [DOE 2006]) in late 2007 (EPA 2007; Ohio EPA 2007).

To monitor the area, DOE established weekly surface water monitoring at two locations in late 2007: SWD-09, the area of the highest locations which diminished southward and SWD-05 (south of SWD-09, near the former cement pond).

As reported in the 2015 Site Environmental Report, groundwater modeling was conducted in 2014 to determine the potential impact to model-predicted cleanup times if uranium-contaminated groundwater is infiltrating into the aquifer from the swale. A model worst-case scenario was based on the highest total uranium concentration measured in ponded water within the swale and high modeled infiltration rates. The uranium concentration of the infiltrating water was modeled at a concentration of 1,900 parts per billion (highest total uranium concentration measured in surface water in the swale as of 2014). In addition, the conservative groundwater modeling scenario took no credit for uranium attenuation in glacial till or alluvium. Modeled infiltration of water into the subsurface was increased from 6 inches per year (modeled infiltration rate in areas where glacial overburden is present) to 50 inches per year (modeled infiltration rate used in select areas of the model known to be near areas of aquifer recharge). Modeling these extreme conservative conditions of high uranium concentration and high infiltration had no impact to model-predicted cleanup times in the aquifer.

The highest total uranium concentrations at SWD-09 are generally measured in the winter, a time when soil generally becomes re-saturated after drying out in the summer and fall due to the higher evaporation and evapotranspiration rates occurring at that time of year. The concentration may reflect the first flush phenomenon where the recently re-saturated soil is yielding a higher concentration to the puddle at SWD-09. The Mann-Kendall trend for all of the data for both locations indicate the overall dataset is trending down. DOE will continue to monitor the locations to understand any changes to the area and to assist in verifying cross-media impacts.

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Table B-1. Summary Statistics and Trend Analysis for Constituents with 2023 Results Above Surface Water FRLs

Location[a]	Constituent	Number of Samples[b,c,d]	Number of Samples Above FRL[b,c,d]	Number of Samples Above FRL for 2023[c,d]	FRL[e] (µg/L)	Maximum FRL Exceedance 2023 (µg/L)	Minimum[b,c,d,f,g] (µg/L)	Maximum[b,c,d,f,g] (µg/L)	Average[b,c,d,f,g] (µg/L)	Standard Deviation[b,c,d,f,g] (µg/L)	Trend[b,c,d,f,g] (µg/L)
SWD-09	Uranium	512	297	13	530	1142	3.40	2,087	637	370	Down

[a] Refer to Figure B-1.
[b] Based on samples collected from January 3, 2007, through December 31, 2023.
[c] If more than one sample is collected per surface water location per day (e.g., duplicate, grab, composite), then only one sample is counted for the number of samples,
and the sample with the maximum concentration is used for determining the summary statistics (minimum, maximum, average, and standard deviation), the Mann-Kendall test for trend with a 95% confidence interval, and in determining FRL exceedances.
[d] Rejected data qualified with laboratory qualifiers R or Z were not included in the count, the summary statistics, or Mann-Kendall test for trend.
[e] FRL = final remediation level. From OU5 ROD, Table 9−5.
[f] For results where the concentrations are below the detection limit, the results used in the summary statistics and Mann-Kendall test for trend are each set at half the
method detection limit.
[g] If the number of samples is greater than or equal to four, then all of the summary statistics and the Mann-Kendall test for trend are reported. If the total number of samples is equal to three, then the minimum, maximum, and average are reported. If the total number of samples is equal to two, then the minimum and maximum are
reported. If the total number of samples is equal to one, then the data point is reported as the minimum.

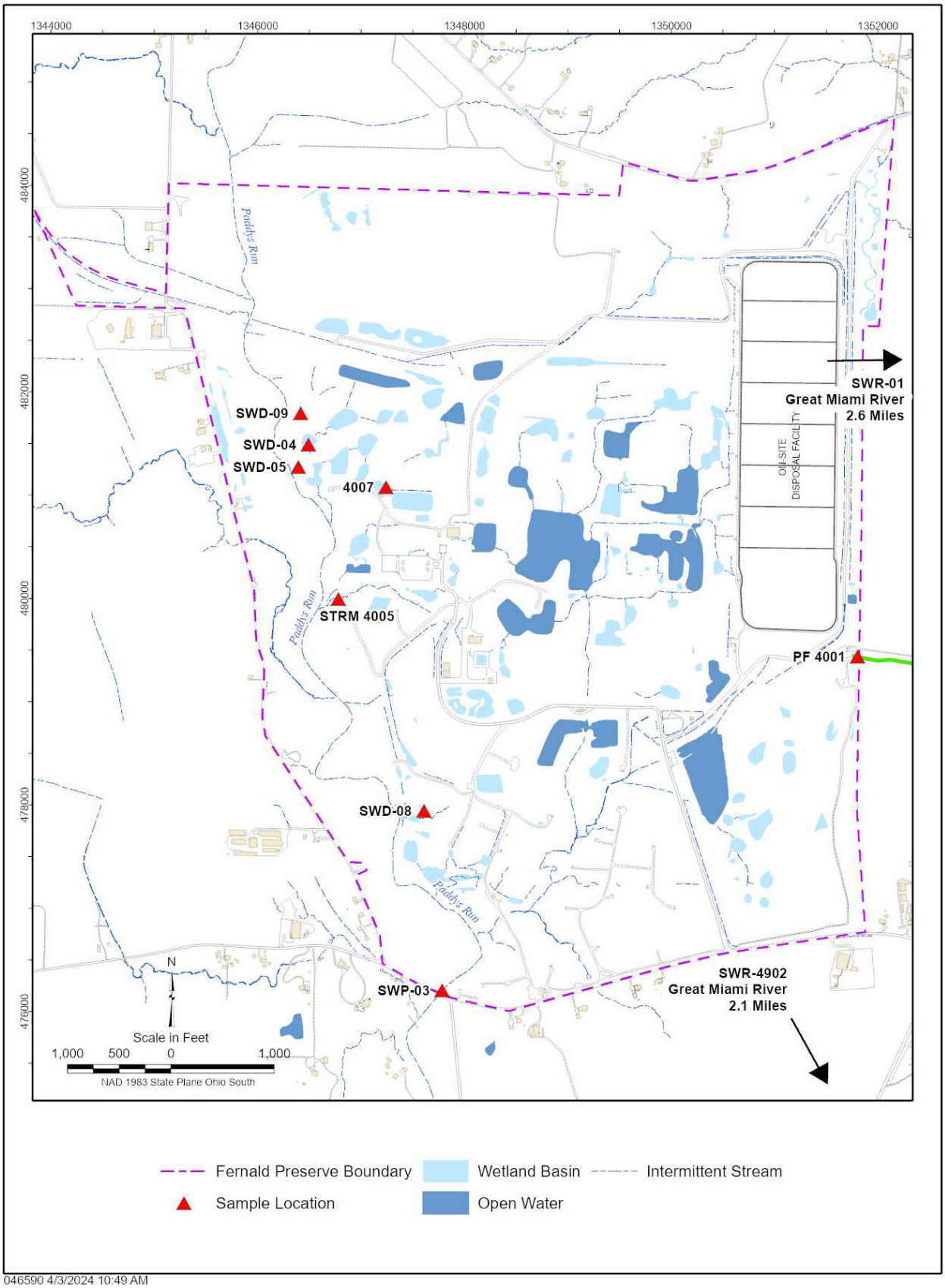

Figure B-1. IEMP/NPDES Surface Water and Effluent Sample Locations

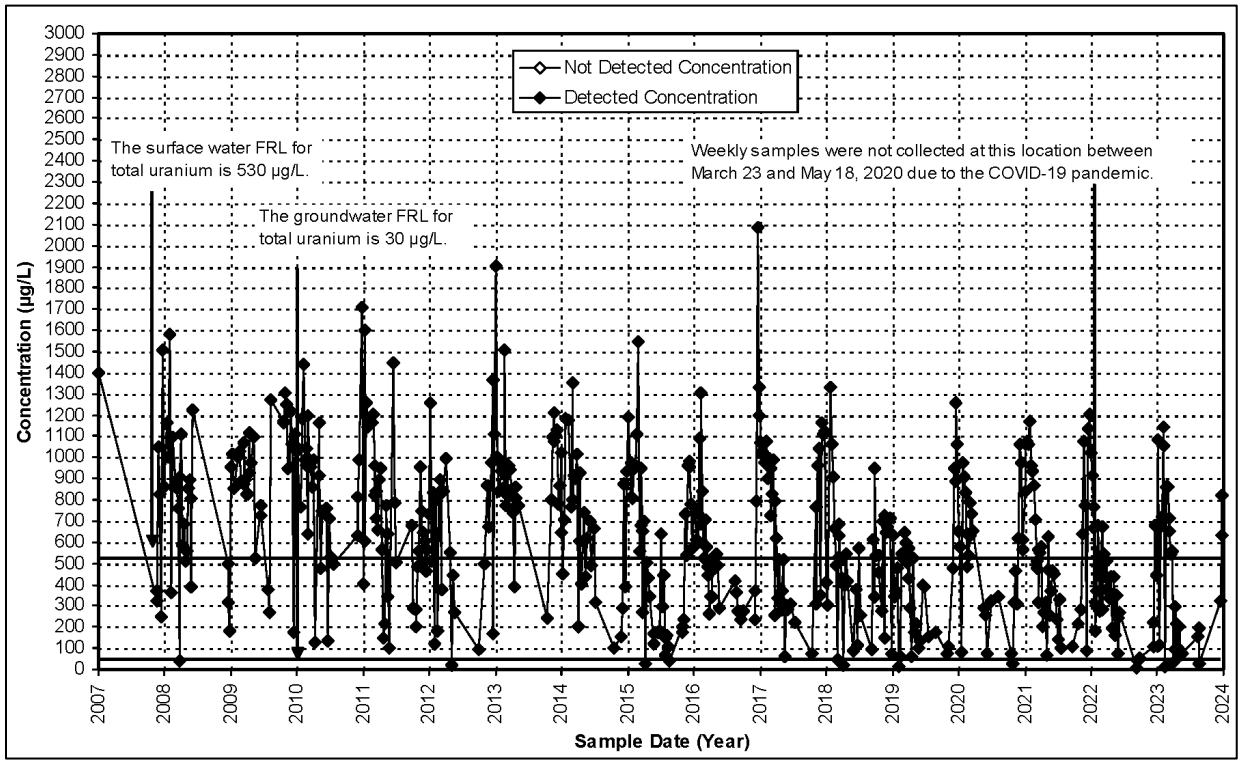

Figure B-2. Total Uranium Concentration Versus Time Plot for Location SWD-09 (Former Waste Storage Area)

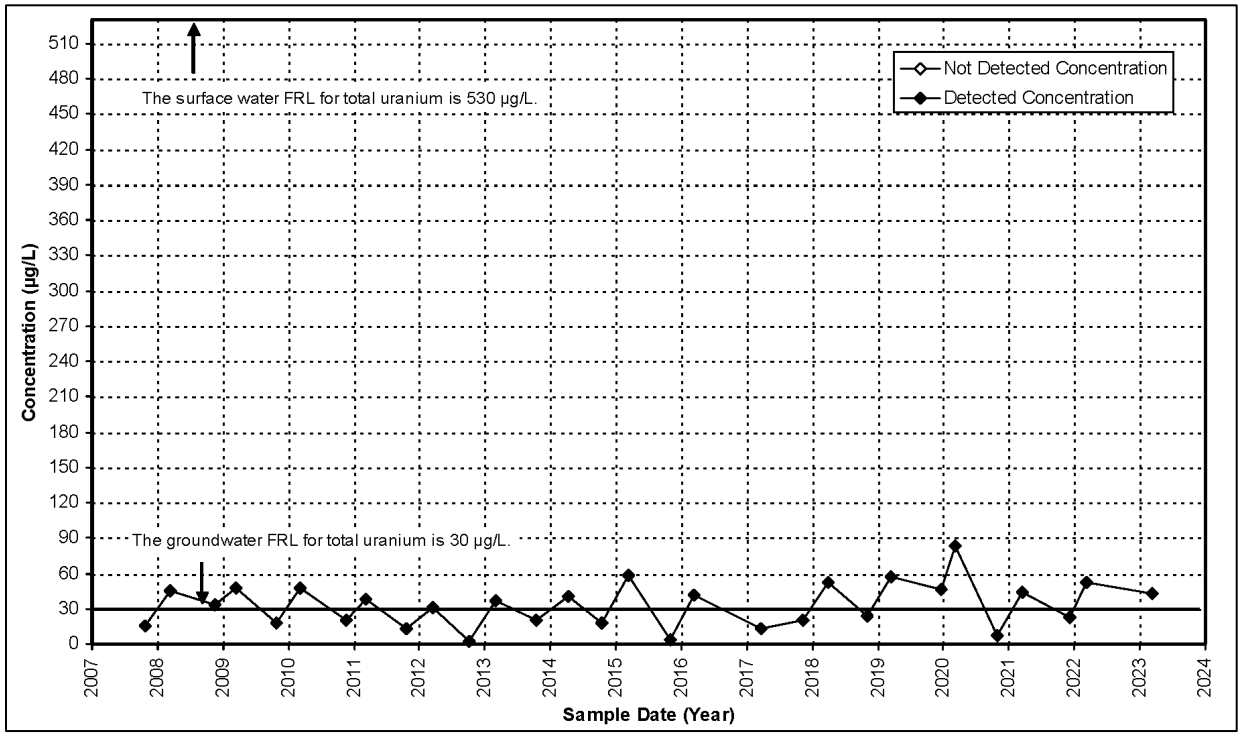

Figure B-3. Total Uranium Concentration Versus Time Plot for Location SWD-04 (Former Waste Pit 3) for Cross-Media Impact Evaluation

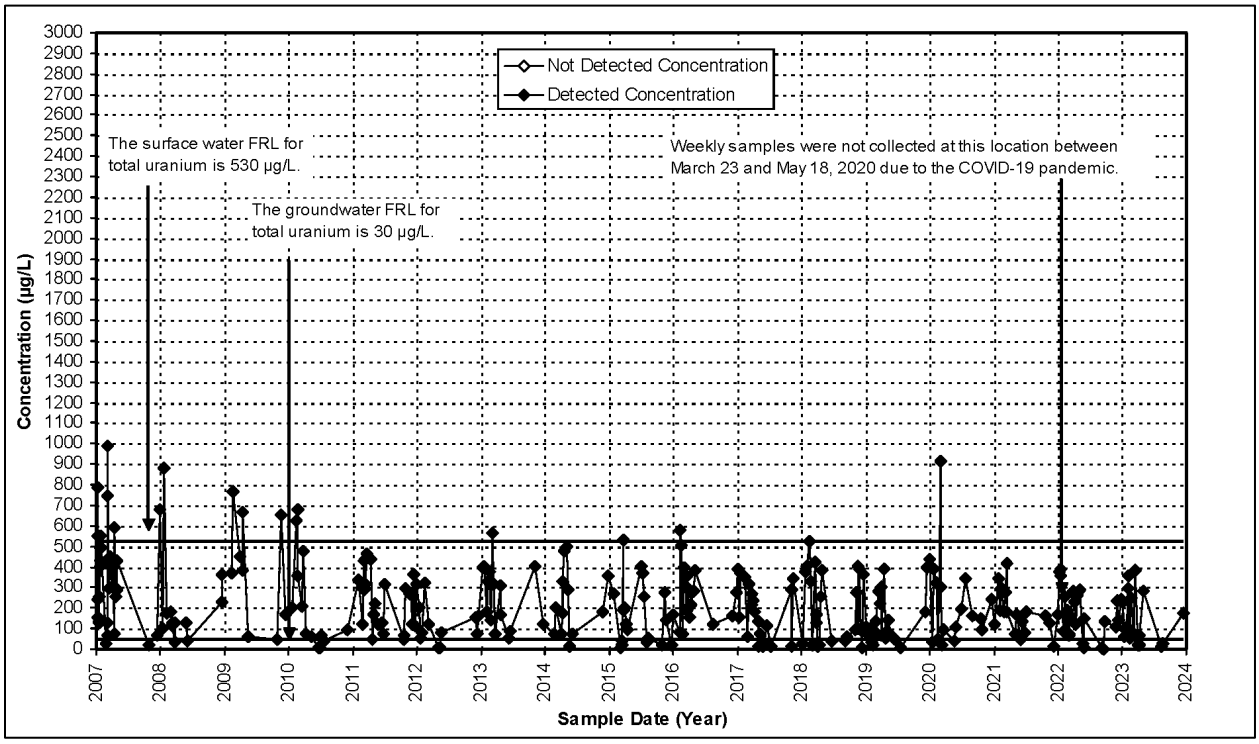

Figure B-4. Total Uranium Concentration Versus Time Plot for Location SWD-05 (Former Waste Storage Area) for Cross-Media Impact Evaluation

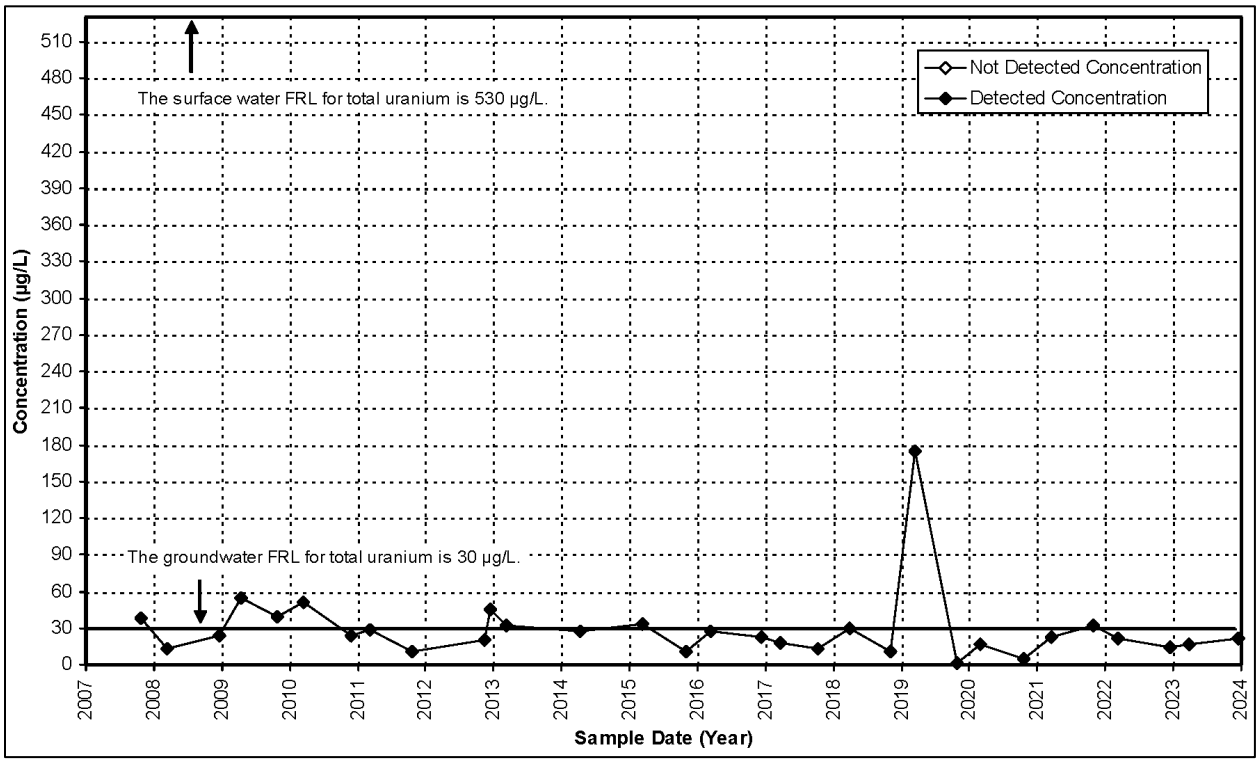

Figure B-5. Total Uranium Concentration Versus Time Plot for Location SWD-08 (Former Southern Waste Units) for Cross-Media Impact Evaluation

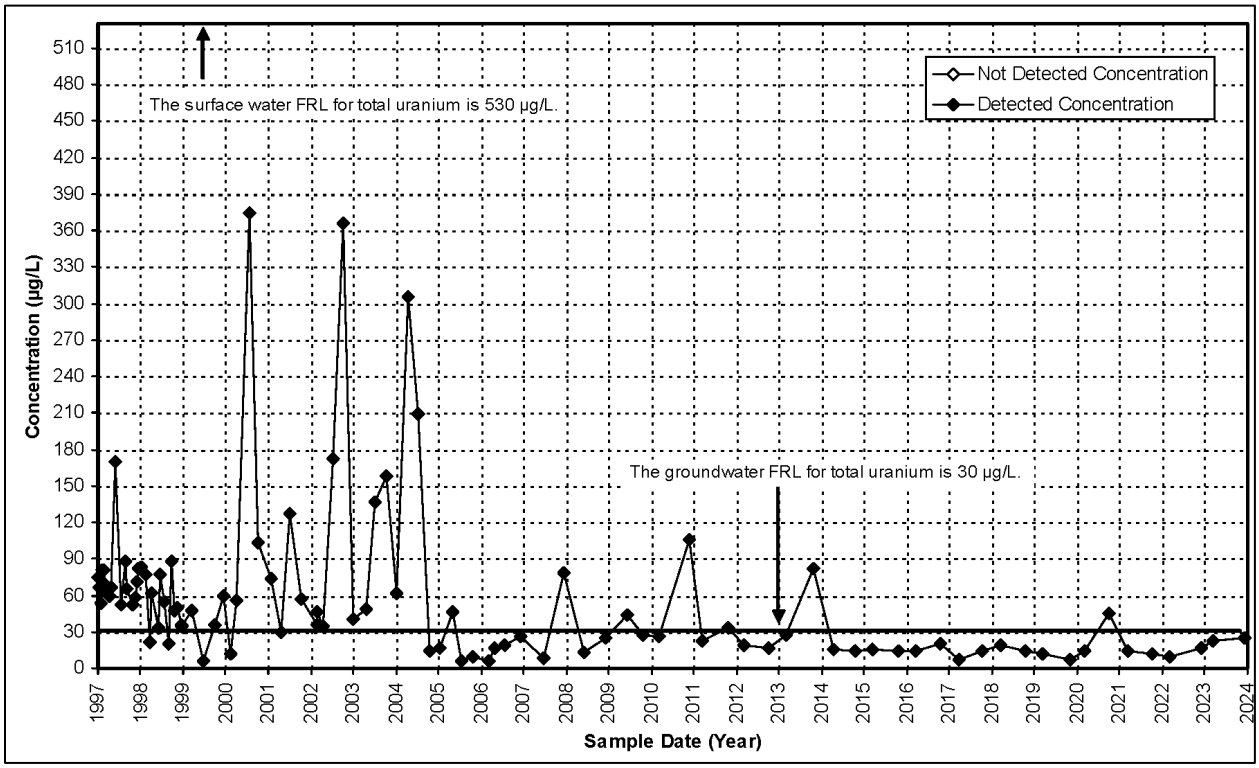

Figure B-6. Total Uranium Concentration Versus Time Plot for Location STRM 4005 (Drainage to Paddys Run) for Cross-Media Impact Evaluation

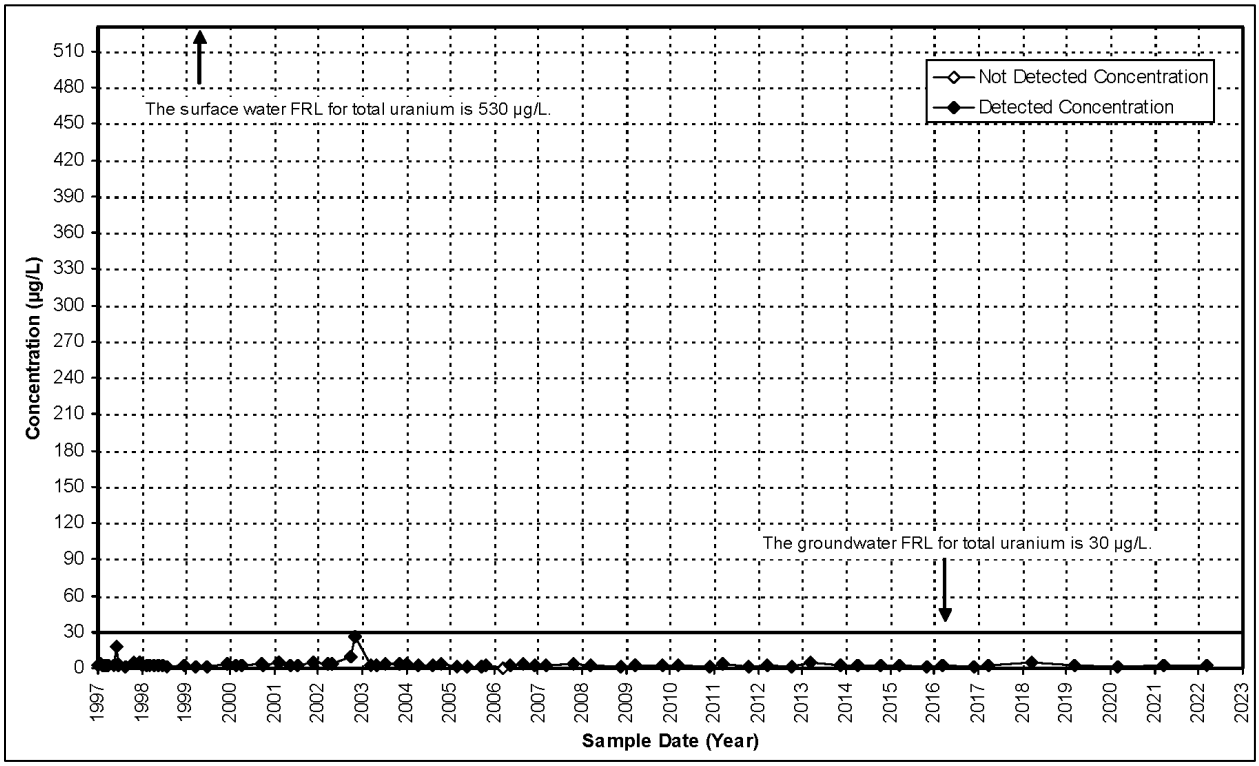

Figure B-7. Total Uranium Concentration Versus Time Plot for Location SWP-03 (Paddys Run at Downstream Property Boundary)

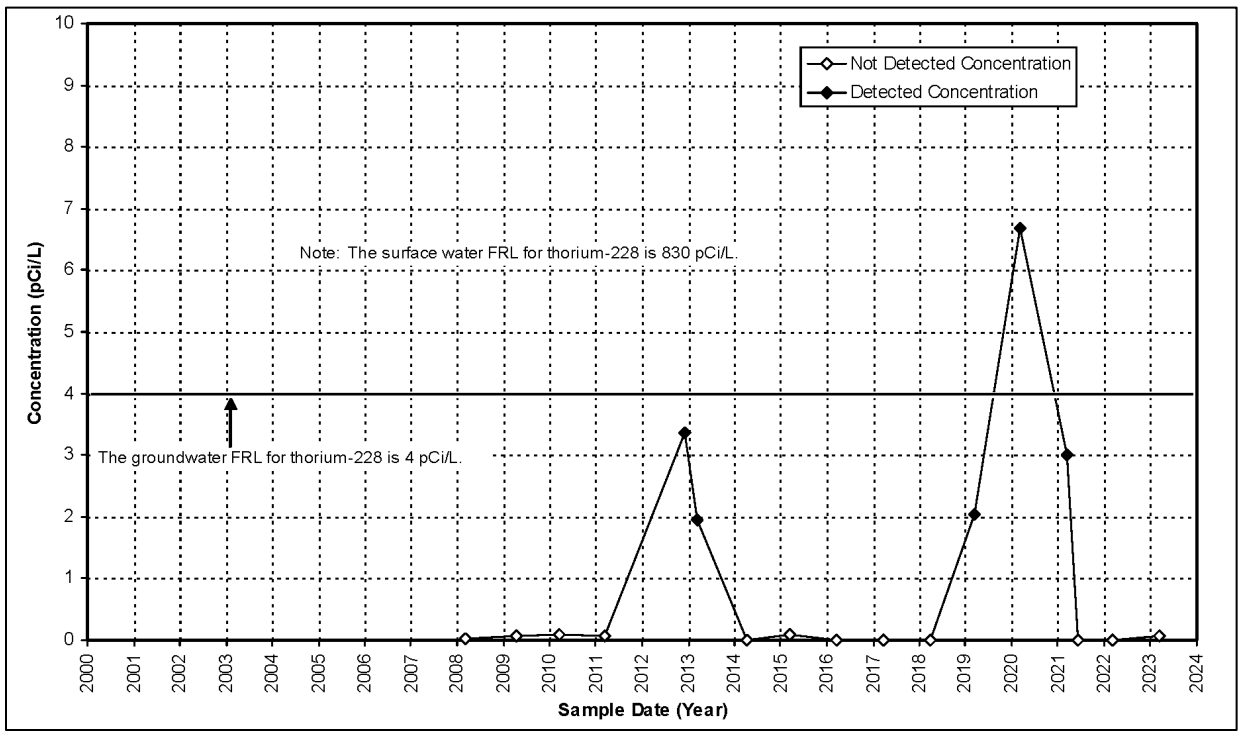

Figure B-8. Thorium-228 Concentration Versus Time Plot for Location SWD-05 (Former Waste Storage Area) for Cross-Media Impact Evaluation

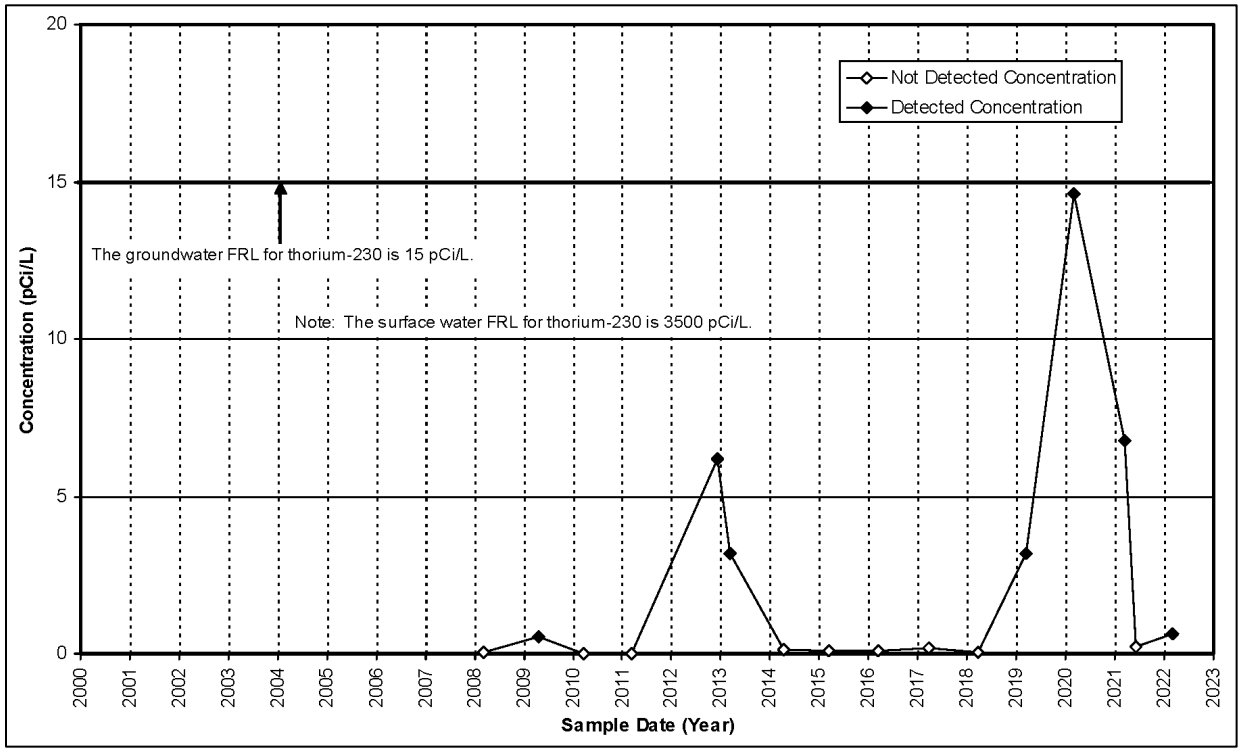

Figure B-9. Thorium-230 Concentration Versus Time Plot for Location SWD-05 (Former Waste Storage Area) for Cross-Media Impact Evaluation

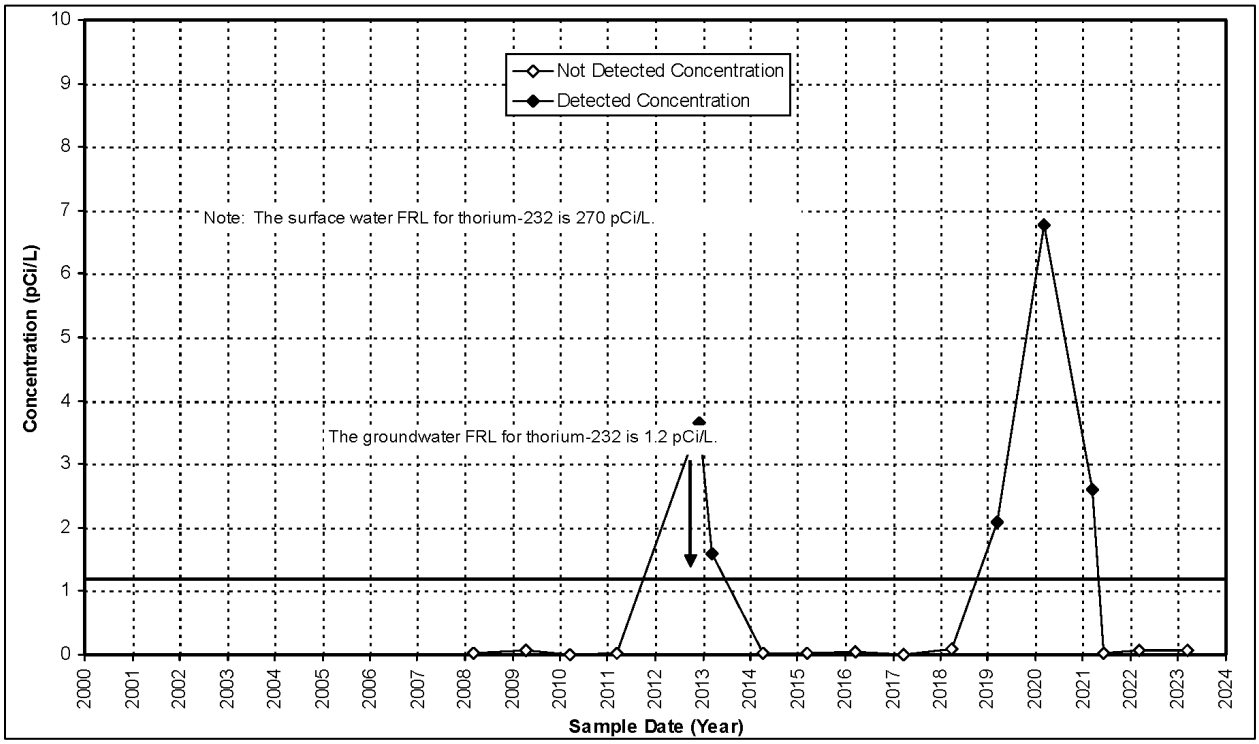

Figure B-10. Thorium-232 Concentration Versus Time Plot for Location SWD-05 (Former Waste Storage Area) for Cross-Media Impact Evaluation

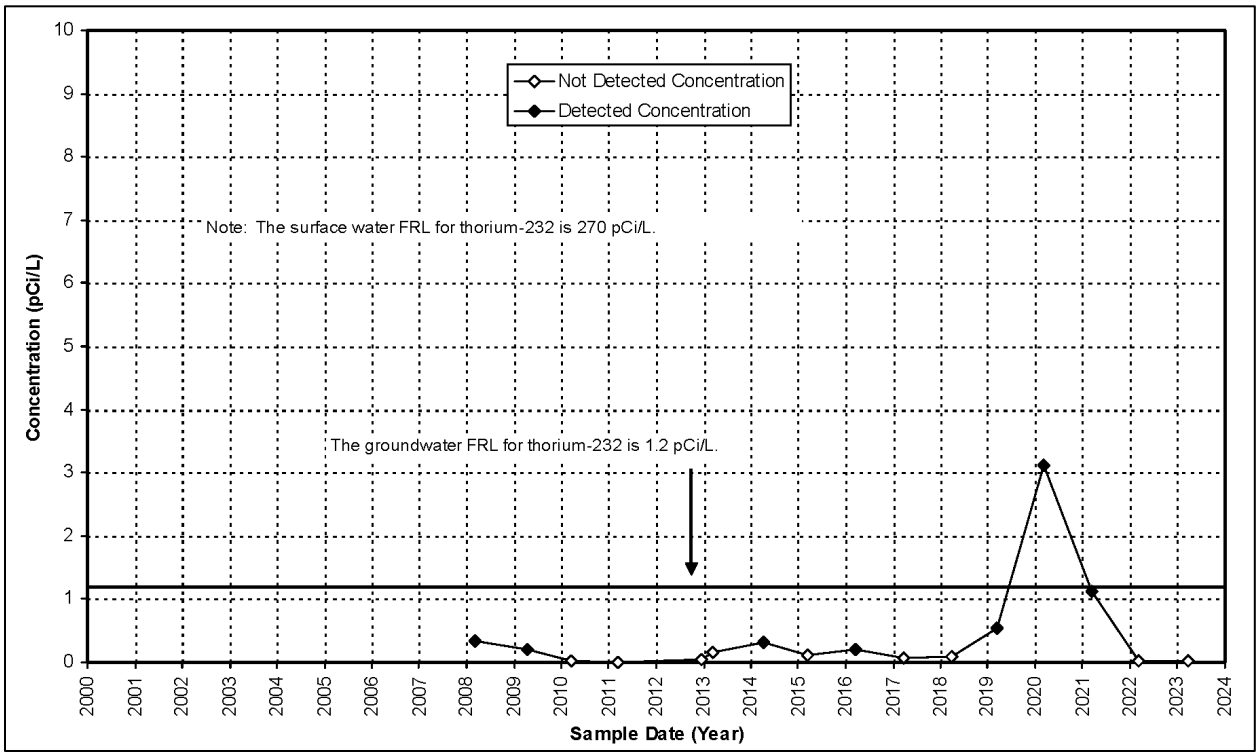

Figure B-11. Thorium-232 Concentration Versus Time Plot for Location SWD-08 (Former Southern Waste Units) for Cross-Media Impact Evaluation

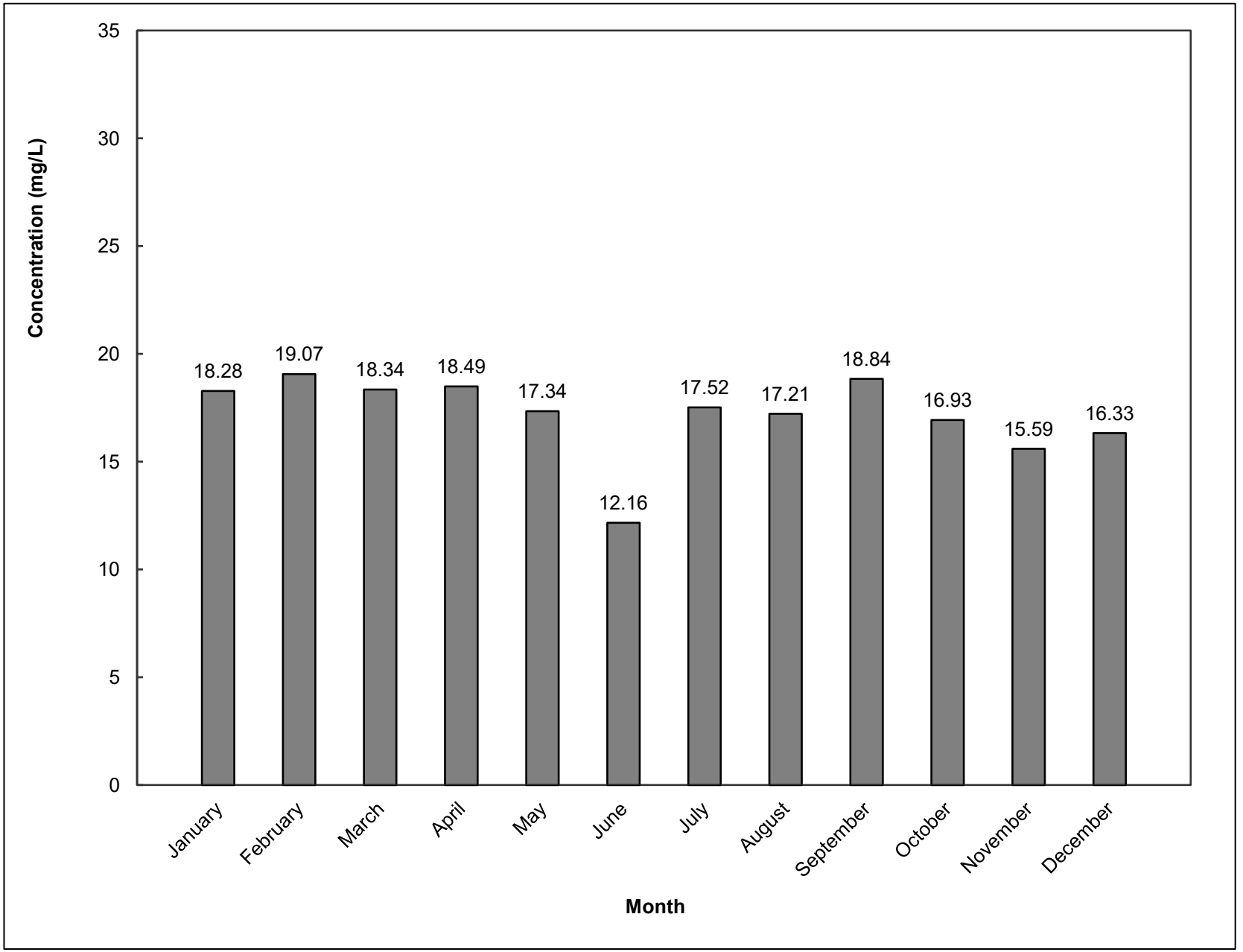

Figure B-12. 2023 Monthly Average Total Uranium Concentration in Water Discharged from PF 4001 to the Great Miami River

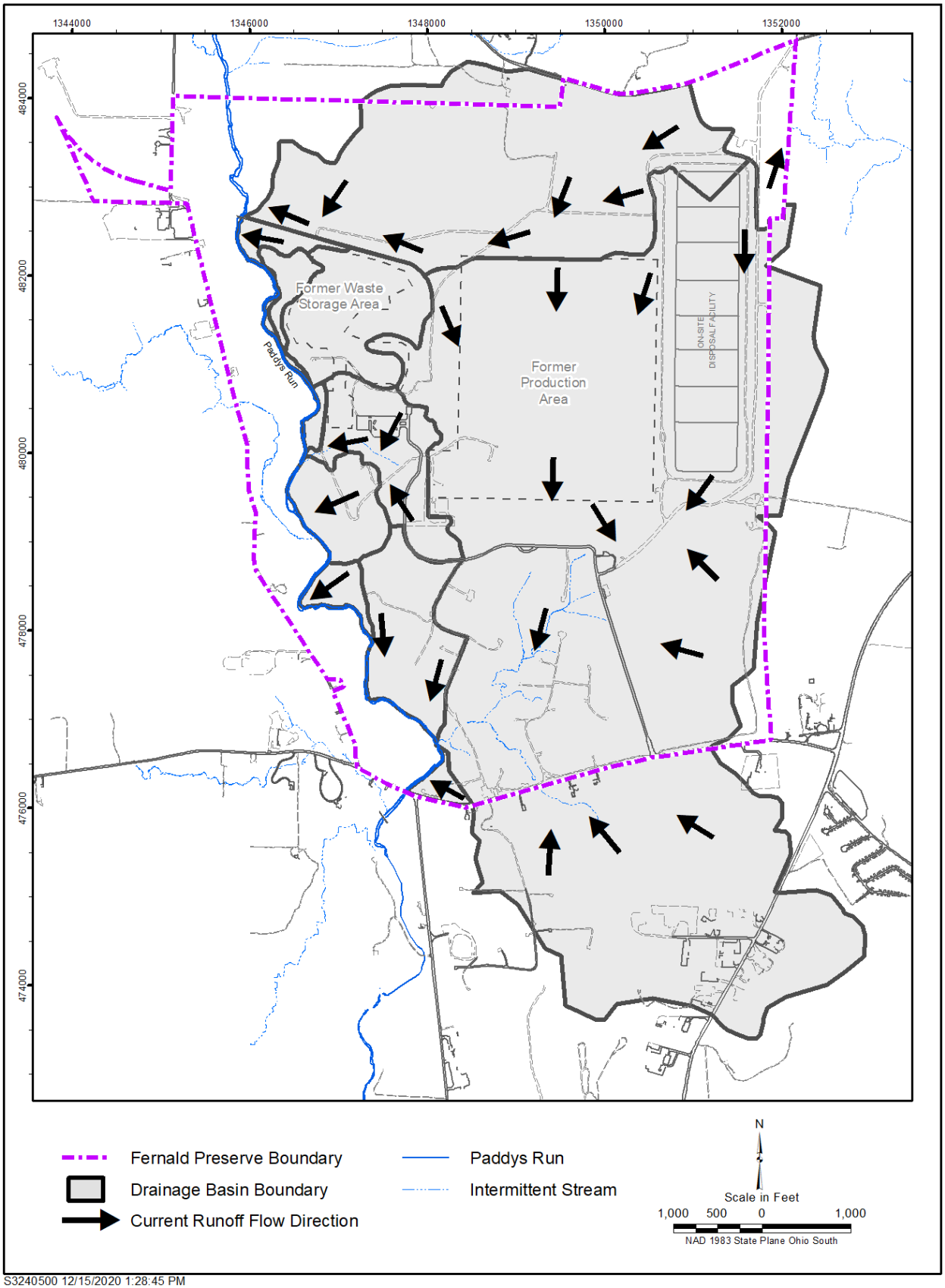

Figure B-13. Current Surface Water Basins and Runoff Flow Direction