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APR 04 2011

Ms. Jennifer Tufts
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U.S. Environmental Protection Agency, Region 4
61 Forsyth Street
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PPPO-02-1074146-11

Mr. Edward Winner, FFA Manager
Kentucky Department for Environmental Protection
Division of Waste Management
200 Fair Oaks Lane, 2nd Floor
Frankfort, Kentucky 40601

Dear Ms. Tufts and Mr. Winner:

REMOVAL ACTION REPORT FOR CONTAMINATED SEDIMENT ASSOCIATED WITH THE SURFACE WATER OPERABLE UNIT (ON-SITE) AT THE PADUCAH GASEOUS DIFFUSION PLANT, PADUCAH, KENTUCKY (DOE/LX/07-0357&D2)

Enclosed is the Removal Action Report for the Surface Water Operable Unit (SWOU) Removal Action at the Paducah Gaseous Diffusion Plant. This secondary document satisfies the requirement for a Removal Action Completion Report, as identified in the *Removal Action Work Plan for Contaminated Sediment Associated with the Surface Water Operable Unit (On-Site) at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-0221&D2/R1 (RAWP). The U.S. Department of Energy (DOE) acknowledges Kentucky Department for Environmental Protection's comment in their letter dated February 17, 2011, recognizing that DOE completed the SWOU hotspot removal in accordance with the RAWP. As discussed during the April 14, 2010, Federal Facility Agreement (FFA) Managers meeting, the contents of this report satisfy Section X.A of the FFA.

If you have any questions or require additional information, please contact me at (270) 441-6825.

Sincerely,

Reinhard Knerr
Paducah Site Lead
Portsmouth/Paducah Project Office

Enclosures:
1. *Removal Action Report for Contaminated Sediment Associated with the Surface Water Operable Unit (On-Site) at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky,* DOE/LX/07-0357&D2 Clean Version
2. *Removal Action Report for Contaminated Sediment Associated with the Surface Water Operable Unit (On-Site) at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky,* DOE/LX/07-0357&D2 Redline Version
3. EPA Comment Response Summary
4. KDEP Comment Response summary
5. Kentucky Radiation Health Branch Comment Response

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REMOVAL ACTION REPORT FOR CONTAMINATED SEDIMENT ASSOCIATED WITH THE SURFACE WATER OPERABLE UNIT (ON-SITE) AT THE PADUCAH GASEOUS DIFFUSION PLANT, PADUCAH, KENTUCKY

Description of the Removal Action Implemented

As documented in the approved *Removal Notification for the Surface Water Operable Unit Removal Action Unit (On-Site) at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-0011; the *Engineering Evaluation/Cost Analysis for Contaminated Sediment Associated with the Surface Water Operable Unit Removal Action Unit (On-Site) at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-0012; and the subsequent *Action Memorandum for Contaminated Sediment Associated with the Surface Water Operable Unit (On-Site) at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-0119&D2/R1, a non-time-critical removal action for the Surface Water Operable Unit (SWOU) (On-Site) was warranted. The specific areas or defined units called exposure units[1] (EUs) are located within the Paducah Gaseous Diffusion Plant (PGDP) at PGDP Outfalls 001, 008, 010, 011, and 015 and their associated internal ditches and specific areas or EUs located within the North-South Diversion Ditch (NSDD) Sections 3 and 5 that contained contaminated soils and sediments. Each EU is further subdivided into remediation units[2] (RUs) and the RUs are further divided into survey units[3] (SUs).

In support of this report, the following appendices are included.

- Appendix A Figures (e.g., Excavation Locations)
- Appendix B Data Tables
- Appendix C Residual Risk Evaluation
- Appendix D Clean Fill Vendor Certification
- Appendix E Photographs

As documented in the Engineering Evaluation/Cost Analysis, direct contact with sediment was the exposure pathway of concern at the site, and, as a result, removal of contaminated sediment was the primary focus of the removal action. A complete listing of the contaminants of concern (COCs) can be found in Appendix C, Residual Risk Evaluation, Table C.1, of this report. In addition to removal of sediment contaminated with COCs, areas from which total excess lifetime cancer risk (ELCR) exceeded a target of 1E-05 also were removed.

The Removal Action Objectives (RAOs) for this removal action are consistent with the overall RAOs for the SWOU and meet the intent of the Section X, Removal Actions, of the Federal Facility Agreement (FFA). The RAOs for this action are as follows:

[1] An EU is defined as approximately 0.5 acres.
[2] An RU is defined as approximately 1,225 ft^2 ($100m^2$).
[3] An SU is defined as approximately one-fourth of a RU or 269 ft^2 ($25m^2$).

- Ensure direct contact risk at the on-site ditches for the current industrial worker falls within the U.S. Environmental Protection Agency (EPA) risk range.

- Ensure direct contact risk at the NSDD for both the current industrial worker and recreational user falls within the EPA risk range.

Completion of this removal action reduces the risk to current and future workers, excavation workers, and recreators from direct contact by removing known sources of contamination. Appendix C provides the residual risk analysis for the complete listing of COCs, as found in Table C.1.

Summaries of Results

Under this action, identified hot spots were removed and verification of cleanup was conducted.

As documented in the RAWP, Appendix F, F.3. Field Sampling Plan, surrogate COCs were used during the removal action surveys. This decision is supported by *Co-Contamination Study for the Removal of Contaminated Soil and Sediment Associated with the Surface Water On-Site.* This study indicates that the surrogate use of the chemicals and action levels listed in Table 1 during the evaluation of postexcavation samples provides an acceptably low-level of failure during the evaluation of verification samples. (Failure is defined as the chance that postexcavation samples will contain COCs at concentrations that exceed cleanup levels.)

Table 1. Surrogate COCs

On-Site Ditches	
Total PCB	10 mg/kg
Cesium-137	5 pCi/g
Uranium-238	65 pCi/g
Uranium	150 mg/kg
NSDD	
Total PCB	10 mg/kg
Thorium-230	100 pCi/g
Uranium	150 mg/kg

Once all the surrogate COC concentrations were less than or equal to the action levels in postexcavation samples, excavation was deemed complete and cleanup level samples were obtained for verification that the cleanup level for all COCs have been achieved.

Each outfall (001, 008, 010, 011, and 015, and its associated internal ditches and areas within PGDP) and the NSDD are discussed here. Figures showing the site locations are included in Appendix A. The following discussion refers to many units and subunits within each outfall and/or ditch, and the enclosed figures (Appendix A) can be used in conjunction with the text to aid in understanding the discussion.

Outfall 001

At Outfall 001, EU 15, containing 10 RUs over an area of approximately 1,240 yd^2, was to be excavated. Prior to conducting work at this location, additional preexcavation samples similar to those specified in the removal action work plan (RAWP) were collected to confirm the presence of contamination within the 10 RUs of Outfall 001and, as a result, four of the 10 RUs (RUs 02, 08, 09, and 10) were not

excavated. This methodology was discussed and agreed upon with the regulators during an FFA Managers Meeting on June 17, 2010.

Uranium was the surrogate COC at Outfall 001, EU 15, Area 2 [at Area 1, polychlorinated biphenyl (PCB) was the surrogate COC] and during the planning process, the extent of contamination in Area 2 had been established based on just two total uranium results, one elevated and one not elevated (642 mg/kg and 8 mg/kg, as compared to a cleanup criteria of 227 mg/kg). In an effort to define more clearly the horizontal extent of contamination at Area 2, sampling was undertaken in this area utilizing the postexcavation sampling protocol specified in the RAWP. The results of this sampling effort indicated that contamination above the total uranium action limit of 150 mg/kg was limited to the northern half of RU 03 and RUs 04–07. Verification sample results for uranium confirmed that RUs 02 and 08–10, as well as the southern half of RU 03, are not impacted above the cleanup level of 227 mg/kg total uranium. Additionally, sample results indicated that in all RUs within Area 2, all COCs, except uranium and uranium-238 (U-238), were below their respective cleanup levels. Figure A.3 found in Appendix A shows the results of this sampling effort, and Appendix B includes the data results in Tables B.1.1 and B.1.2. Sample locations are shown in Figure C1.1 found in Appendix C.

In light of the foregoing, a revised approach to Outfall 001, Area 2, was proposed and agreed to at the June 17, 2010, FFA Managers Meeting. Excavation would be limited to those RUs that were impacted above the action limit of 150 mg/kg for total uranium. This included the northern half of RU 03 and RUs 04, 05, 06, and 07. The southern half of RU 03 and RUs 02, 08, 09, and 10 were not excavated because the data show that these areas are not impacted above the action limits or the cleanup levels.

At the five RUs addressed under this action, one RU, RU 6, was excavated to 2 ft. The remaining RUs were excavated to 3 ft at some SUs and 4 ft at other SUs (see Figure A.4). The walkover survey results and the field screening results indicate that all RUs were remediated to below their respective action levels (65 pCi/g for U-238, 5 pCi/g for Cs-137, 150 mg/kg for total uranium, and 10 mg/kg for PCBs), and verification sample results indicate that the cleanup levels have been achieved. Additionally, two field screen samples collected from the surface at the southern half of RU 03 (the portion not excavated) indicate that the surrogate COC concentrations are below the action levels. Figure A.4, found in Appendix A, shows the final excavation limits, and the data results are included in Appendix B, Tables B.1.1 and B.1.2. Photographs of the excavation area before, during, and after the removal action are shown in Figures E.1 through E.6 in Appendix E.

At Outfall 001, 926 yd^3 of soils were removed; 501 yd^3 were disposed of at Energy*Solutions* in Clive, Utah; and 425 yd^3 were disposed of at the C-746-U Landfill.

Outfall 008

At Outfall 008, EU 11, containing two RUs, over an area of approximately 200 yd^2, was excavated. Soils were removed to a depth of 2 ft at this location.

At the two RUs excavated under this action, the walkover survey results and the field screening results indicate that all RUs were remediated to below their respective action limits, and verification sample results indicate that the cleanup levels have been achieved. Figure A.5, found in Appendix A, shows the final excavation limits, and Appendix B includes the data results in Tables B.2.1 and B.2.2. Sample locations are shown in Figure C1.2 found in Appendix C.

At Outfall 008, 244 yd^3 of soils were removed and disposed of at Energy*Solutions* in Clive, Utah.

No problems were encountered at Outfall 008, and no deviations from the Work Plan were required during performance of the work.

Outfall 010

At Outfall 010, EU 1, containing four RUs over an area of approximately 400 yd^2, was excavated. Soils were removed to a depth of 2.5 ft at three of the RUs, and 2 ft at one RU.

A French drain was encountered at the south end of the outfall (along Tennessee Avenue) at a depth of 2 ft-6 inches. As a result, work at Outfall 010 was suspended until repair/replacement could be arranged. Repair/replacement was considered necessary to ensure the continued stability of Tennessee Avenue. When work resumed at the site in June 2010, the decision was made to remove an additional 6 inches from the three RUs that had been remediated in January and to resample each. The French drain also was removed at this time (to native soils or 2 ft-6 inches below ground surface).

The walkover survey results and the field screening results indicate that all RUs were remediated to below respective action limits, and verification sample results indicate that the cleanup levels[6] had been achieved. Twelve samples also were collected beneath the French drain (one every 10 ft). One sample exceeded 10 ppm PCB (as indicated by field analyses), resulting in an additional 6 inches of excavation, subsequently followed by a sample that was below 10 ppm PCB (as indicated by field analyses). The additional excavation was from one clean sample to the next clean sample, encompassing the one area that exceeded the PCB thresholds of 10 ppm. One verification sample also was collected beneath the former French drain. These results likewise show that this area was remediated to below action limit and cleanup levels[6] for the site. Figure A.6, found in Appendix A, shows the final excavation limits, and the data results are included in Appendix B, Tables B.3.1 and B.3.2. Sample locations are shown in Figure C1.3 found in Appendix C. Photographs of the excavation area before, during, and after the removal action are shown in Figures E.7 through E.9 in Appendix E.

At Outfall 010, 642 yd^3 of soils were removed and disposed of at Energy*Solutions* in Clive, Utah.

Outfall 011

At Outfall 011, one EU containing 14 RUs, over an area of approximately 1,500 yd^2, was excavated. Initially, soil/sediment was removed to 2 ft below grade. During Activity 1 (i.e., field screening) sampling, the walkover surveys indicated that consistently elevated levels of uranium were present at 2 ft below grade. A decision was made to excavate all 14 RUs identified within Outfall 011 an additional ft to 3 ft below grade before conducting additional Activity 1 sampling.

After excavation to 3 ft, 13 of the 14 RUs had achieved the site cleanup goals. One SU, within RU 01, at the northwest corner of Outfall 011, did not. Excavation of an additional ft, to a depth of 4 ft, was performed within this SU. While field screen results at the 4-ft depth indicated that uranium levels continued to exceed the action limits, the verification sample results show that the RU had achieved cleanup goals. Walkover survey results at RU 01 indicated that contamination extended further to the west than the defined limits of excavation (i.e., beyond the bounds of RU 01). Excavation of this area was postponed until such time as a path forward was determined. Once a plan was developed to address the contamination outside the boundary of RU 01, excavation on the west side of Outfall 011 resumed on June 9, 2010. At this time, an area approximately 450 ft^2 was excavated to a depth of 4 ft. yielding an additional 76 yd^3 of soils for disposal. Additional field screens and verification samples were collected, the results indicate that action limit and cleanup goals[7] were achieved in this area outside the boundary of RU 01, west of RU 01.

Figure A.7, found in Appendix A, shows the final excavation limits, and the data results are included in Appendix B, Tables B.4.1 and B.4.2. Sample locations are shown in Figure C1.4 found in Appendix C. Photographs of the excavation area before, during, and after the removal action are shown in Figures E.10 through E.12 in Appendix E.

In Outfall 011, 3,900 yd^3 of soil, sediment, and debris were removed. Of this, 457 yd^3 was disposed of at Energy*Solutions* in Clive, Utah; and 3,443 yd^3 was disposed of at the C-746-U Landfill.

Outfall 015

At Outfall 015, five EUs containing 67 RUs, over an area of approximately 8,800 yd^2, were excavated. At the majority of the RUs, soil/sediment was removed to a depth of 2 ft. Some RUs were excavated to 3–4 ft. Specifically, RU 03 in EU 03 was excavated an additional 1 ft due to elevated cesium at the 2-ft depth; RU 12 in EU 02 was excavated an additional 1 ft due to elevated uranium (total and U-238); and RUs 14–18 (inclusive) in EU 07 were excavated an additional 2 ft due to elevated uranium in the field screen samples. Additionally, some SUs were excavated an additional 1 ft based on walkover survey results.

Upon completion of excavation, the X-ray fluorescence (XRF) and PCB field screening results indicate that the all RUs were remediated to below respective action limits of 150 mg/kg uranium and 10 mg/kg total PCB, with the exception of one SU at EU 07, RU 17, which had an XRF result for uranium of 349 mg/kg at 4 ft (the verification result for uranium for this RU indicated 2.4 mg/kg uranium).

Walkover surveys were not performed at EU 03, RUs 09–14, because the banks were considered unstable and not safe for workers.

No problems were encountered and no deviations were required from the RAWP for EU 04 and EU 08. EU 04 was excavated for total ELCR and EU 8 was excavated for PCB contamination.

Verification sample results indicate that the cleanup levels had been achieved at all RUs at Outfall 015. Figure A.8, found Appendix A, shows the final excavation limits, and the data results are included in Appendix B, Tables B.5.1 and B.5.2. Sample locations are shown in Figures C1.5 through C1.9 found in Appendix C. Photographs of the excavation area before, during, and after the removal action are shown in Figures E.13 through E.28 in Appendix E.

Yellow/green-stained soils and gravel were encountered on the south wall of the excavation at Outfall 015, EU 07, RU 16. After the excavation was backfilled, the seam was delineated on August 31, 2010, by using direct push technology. Cores from 11 locations at depths of approximately 10 ft each, south of the excavated area, were collected. The cores were surveyed, radiologically and visually, and only one of the 11 cores (closest to the previously exposed seam) identified the yellow/green stained soils with radiological readings above instrument background (seam was present in the 2–4 ft level below ground surface). The area investigated was less than 500 ft^2 and resulted in identifying the seam approximately 8 ft by 3 ft by 1 ft adjacent to the previously exposed excavation at Outfall 015, EU 07, RU 16. Removal of these soils took place on September 14/15, 2010, and resulted in an additional 34 yd^3 of soil that was disposed of at Energy*Solutions* facility in Clive, Utah. XRF and PCB samples were collected below the excavation and resulted in less than 150 mg/kg uranium and less than 10 ppm PCBs.

At Outfall 015, 10,009 yd^3 of soil, sediment, and debris was removed. Of this, a total of 4,983 yd^3 was disposed of at Energy*Solutions* in Clive, Utah; and a total of 5,026 yd^3 was disposed of at the C-746-U Landfill.

NSDD Sections 3 and 5

At NSDD, four EUs (EUs 01, 02, 03, and 08) containing 40 RUs, over an area of approximately 5,200 yd^2, was addressed. At the majority of the RUs, soil/sediment was removed to a depth of 2 ft. Two RUs (RUs 11 and 12 at EU 03), were excavated to 3 ft based on elevated gross alpha results. RU 12 was excavated an additional ft upon receipt of verification sample results that indicated Th-230 levels were present in the area above the cleanup goals. One RU (RU 12 at EU 02) was not addressed due to the presence of a high pressure gas line immediately underneath, an area approximately 1,225 ft^2. Sampling results—collected previously from areas not excavated and from areas excavated—were used in the risk evaluation for this EU. The residual risk for this EU was below the cumulative risk goal; therefore, the inability to excavate the area around the gas line did not affect the attainment of the project's RAO. Lastly, RUs that extended into Ogden Landing Road (including RUs 08, 09, and 11 in EU 03) were excavated by sloping at 1:1 from the edge of the road so as not to impair the stability of the road.

Activity 1 (i.e., field screening) uranium and PCB field screening sampling was performed at NSDD, as described in the RAWP; however, gross alpha analyses, from samples collected from the center of each SU, with the application of a conservative assumption that all gross alpha activity be considered Th-230, were substituted for the walkover surveys that were specified in the Work Plan. This modification was implemented because of the inability to reliably quantify Th-230 at the action limit of 100 pCi/g. The following is the reason Th-230 cannot be quantified reliably, as described in the Work Plan.

Typical radiological methods for detection of radionuclides in a field setting depend upon the ability to detect gamma radiation emitted from a radionuclide or its daughters. Th-230, which primarily decays by the emission of an alpha particle, does not emit gamma or X-ray radiation at a sufficient quantity or energy to facilitate its direct detection in a field setting. Alpha particles are attenuated by soil, moisture, and debris and, when coupled with their very short range, this makes them unsuitable for measurement of radioactivities in a field setting. While Th-230 does not emit reliably detectable gamma radiation, its daughter, Ra-226, has a very high energy gamma ray that is emitted at a readily usable yield. Because of the detectability of Ra-226, it is possible to use field techniques to quantify *naturally occurring* Th-230 using the Ra-226 daughter which, in nature, exists in equilibrium with the Th-230 parent (i.e., Ra-226 is used as a surrogate for Th-230 because the equilibrium is constant).

PGDP received uranium feed material that had been separated chemically and converted from its natural form. As a result of the separation and conversion process, the uranium daughters, which naturally are found to be in equilibrium, were separated and removed from the feed stream. Additionally, the processes employed at PGDP produced uranium residuals from the feed stream that generated various radionuclides in various proportions generally not found in nature. The U-234 and Th-230 daughters (including Ra-226) that ultimately will equilibrate with the parent are produced slowly and will not reach equilibrium for many thousands of years. In other words, the processes imposed upon the uranium utilized at PGDP that resulted in the generation of Th-230 disrupted the natural equilibrium between the Th-230 parent and its daughter Ra-226.

While it may be possible to quantify *naturally occurring* levels of Th-230 through the detection of gamma rays emitted by the Ra-226 daughter, in the case of NSDD, this does not provide a reliable mechanism for quantification of PGDP-derived (i.e., not naturally occurring) Th-230. Due to the separation and conversion processes, equilibrium of long-lived daughters, such as Th-230 and Ra-226, has not been achieved; therefore, any measurement of Th-230 using Ra-226 as a surrogate would bias negatively the reported activity of Th-230.

To illustrate this point, an analysis was performed to calculate the activity of Ra-226 from a Th-230 parent, assuming a 50-year in-growth period. For a Th-230 activity of 100 pCi, the Ra-226 activity after 50 years would be 2.1 pCi. This level is comparable to naturally occurring Ra-226 and is not practically achievable in a field setting as that found in the NSDD. A review of sampling data for Ra-226 in the NSDD confirms that there are no areas of detectable Ra-226 in excess of 2.2 pCi/g.

At the completion of excavation activities, the gross alpha and field screening results indicated that all RUs that were excavated were below the respective action limits, and verification sample results indicated that the cleanup levels had been achieved. Figures A.9 through A.11 show the final excavation limits and are included in Appendix A. Appendix B includes the data results in Tables B.6.1 and B.6.2. Sample locations are shown in Figures C1.10 through C1.13 found in Appendix C. Photographs of the excavation area before, during, and after the removal action are shown in Figures E.29 through E.42 in Appendix E.

From NSDD Sections 3 and 5, a total of 6,956 yd^3 of soil, sediment, and debris was removed. Of this, 5,690 yd^3 was disposed of at Energy*Solutions* in Clive, Utah; and 1,266 yd^3 was disposed of at the C-746-U Landfill.

General

Backfilling and site restoration were conducted following excavation by using a track hoe excavator and a tracked skid-steer loader for placement of the cover material. Both the tracks and the buckets of the equipment were used to compact the cover material once it was in place. Final grading was accomplished with the skid-steer loader and hand tools working to grade stakes installed by a local engineering firm. Generally, the cover material consisted of soil, as discussed in the next paragraph; however, in areas where the existing slope had been too steep to allow for placement of soil, areas were backfilled with riprap. Riprap was used for portions of Outfall 011 and NSDD Section 3 and all of NSDD Section 5.

Clean backfill that was generated as part of the construction of the Northwest Storm Water Collection Basin in 2001 was brought in for site restoration. The backfill material utilized for the SWOU Remedial Action was the same material as referenced in the Soils Operable Unit Inactive Facilities Removal Action Report D1 as submitted on August 4, 2010.

Clean riprap was used at Outfall 001, Outfall 011, and NSDD. The vendor of this product provided certification as to the uncontaminated nature of the fill. This certification is included as Appendix D. Restoration also included replacement of the French drain at Outfall 010. In addition, off-site clean fill (soil) was brought in for backfilling the seam area at Outfall 015 ditch, EU 07, RU 16, and a certification is included in Appendix D.

Refer to Appendix E for photographs showing the condition of the excavation areas following restoration. Consistent with the RAWP, inspections and site maintenance will continue to control erosion until the affected areas are stable.

Verification of Cleanup

The enclosed data tables (Appendix B) show a comparison of the ELCR-based and hazard index (HI)-based cleanup levels to the sampling results. Appendix C addresses residual risk associated with the excavated EUs.

Comparison of Cleanup Levels to Sampling Results

At Outfalls 001, 008 and 010, all sample results show that cleanup levels had been met at these locations.

One sample at Outfall 011 did not achieve the cleanup levels (OF011-01-01-V-3). This area subsequently was excavated one additional ft. Sample OF011-01-01-V-4a, collected at the 4-ft depth, at the completion of excavation, is representative of the soils remaining at RU 01. This sample indicates that the area achieved the cleanup goals for the site.

At Outfall 015, two samples, OF015-07-12-V-2 and OF015-03-03-V-2, did not achieve the cleanup levels. These areas subsequently were excavated one additional ft, and samples OF015-07-12-V-3 and OF015-03-03-V-3, collected at the 3-ft depth at the completion of excavation, are representative of the soils remaining at EU 07, RU 12 and EU 03, RU 03, respectively. These sample results indicate that the area achieved the cleanup goals for the site.

Yellow/green-stained soils and gravel were encountered on the south wall of the excavation at Outfall 015, EU 07, RU 16. XRF and PCB samples were collected below the excavation and resulted in less than 150 mg/kg uranium and less than 10 ppm PCBs.

At NSDD, only two samples did not achieve the cleanup levels (NSDD3-03-12-V-2 and NSDD3-03-12-V-3). Both of these samples were collected at RU12 at EU 03 in the NSDD (one at the 2-ft depth, the other at the 3-ft depth). This area subsequently was excavated one additional ft. Sample NSDD3-03-12-V-4, collected at the 4-ft depth at the completion of excavation, is representative of the soils remaining at RU12 at EU 03. This sample indicates that the area achieved the cleanup goals for the site.

In summary, upon completion of all excavation activities, all RUs that were addressed under this removal action were remediated to below the cleanup levels established for this action for all COCs, as specified in Table 1 of the RAWP.

Risk Evaluation

Appendix C presents the residual risk that remains at PGDP Outfalls 001, 008, 010, 011, and 015, and their associated internal ditches, and Sections 3 and 5 of the NSDD after completion of the removal action. Results of the risk evaluation indicate that the cumulative ELCR and HI for COCs from EUs with excavated hot spots and areas identified in the RAWP within PGDP Outfalls 001, 008, 010, 011, and 015, and their associated internal ditches, and Sections 3 and 5 of the NSDD achieved the RAO of a cumulative ELCR of 1E-05 and a cumulative HI of 1.0. A complete listing of the COCs can be found in Appendix C, Residual Risk Evaluation, Table C.1 of this report.

As a result, the overall RAO for this project, to reduce the direct contact risk to the current and future industrial worker and recreational user within the EPA risk range, was achieved.

Summaries of Problems Encountered

Deviations from the RAWP were minor field changes as discussed above and as summarized below.

Outfall 001

No problems were encountered during excavation of Outfall 001. As indicated previously, with concurrence of the FFA managers, RUs 02, 08, 09, and 10 in Area 2 were not excavated because the data show that these areas are not impacted above the action limits or cleanup levels.

Areas where the existing slope had been too steep to allow for placement of soil were backfilled with riprap. Clean riprap was used at Outfall 001, Outfall 011, and NSDD.

Outfall 008

No problems were encountered at Outfall 008, and no deviations from the Work Plan were required during performance of the work.

Outfall 010

A French drain was encountered at the south end of the outfall (along Tennessee Avenue) at a depth of 2 ft-6 inches. The French drain was removed to a depth of 2 ft-6 inches; samples were collected from underneath the system; and the French drain replaced with 4-inch perforated polyvinyl chloride surrounded by #9 gravel, fabric filter, and flowable fill.

Due to the length of time between beginning and completing excavation in this area, the three RUs that were excavated in January (RUs 01, 02, and 03) were excavated an additional 6 inches and resampled to ensure that any contamination that had moved between RUs was removed.

Outfall 011

Contamination extended beyond the bounds defined in the Work Plan at the west end of the outfall. The contamination was addressed by removing soils/sediments in this area and extending the horizontal limits of excavation outside the bounds of RU 01. See Figure A.12 for actual excavation limits (Appendix A).

Often there was a discrepancy between the walkover survey results for uranium and the XRF results for uranium. It has been speculated that lack of reliability of the walkover survey may be due to the walkover results being biased high, and geometry of Outfall 011 (i.e., steep sidewalls) can elevate the results from field instruments and provide false positives. In all cases where the walkover survey results and the XRF results did not agree, the XRF results were considered the valid results.

Outfall 015

Yellow/green stained soils and gravel were encountered on the south wall of the excavation at Outfall 015, EU 07, RU 16. These soils, as discussed previously, were delineated and removed. After excavation to 4 ft at Outfall 015, EU 07, RU 16, field screen sample results and the verification sample indicate that action limits and cleanup goals were achieved at this RU, as well at as the surrounding RUs.

In some cases, the walkover survey results were ambiguous. It is believed that walkover results are biased high, and geometry, such as steep banks, can elevate the results from field instruments and provide false positives. Consequently, when there was a discrepancy between the walkover survey results for uranium and the XRF results for uranium, the XRF results were considered the more accurate of the two field screening methods.

NSDD

As previously described, Activity 1 sampling at NSDD was modified such that gross alpha analyses, instead of walkover surveys, was used to determine if the action limit of 100 pCi/g for Th-230 had been met.

One RU (RU 12 at EU 02) was not addressed due to the presence of a high pressure gas line immediately underneath.

RUs that extended into Ogden Landing Road (including RUs 08, 09, and 11 in EU03) were excavated by sloping at 1:1 from the edge of the road so as not to impair the stability of the road.

General

In some instances, excavations that might have been backfilled were left open longer than anticipated, resulting in the excavations filling with water. The fact that excavations had filled with water delayed collection of field screening and verification samples and delayed overall progress of work because manpower was diverted from excavating soils to managing water in accordance with the approved Work Plan. As weather allowed, accumulated water in excavated areas was bypass-pumped downstream of the active RU, was bypass-pumped to an adjacent ditch that is not part of the project, and/or containerized as appropriate.

Actual excavation volumes exceeded planning estimates by over 50%. This is believed to be due primarily to two factors:

(1) Volume estimates were developed using areas calculated based on plan views multiplied by a depth of 2 ft. Most excavation areas associated with the removal action were not flat, but were U- or V-shaped. As such, the method of calculating the area of each ditch should have been based on cross sections, multiplying the area of the face of each surface times a depth of 2 ft.

(2) The Site Investigation collected samples at 1- and 2-ft depths; consequently, volume estimates were based on an excavation depth of 2 ft. However, at several locations, excavation proceeded to 3 and 4 ft before cleanup could be considered complete.

Due to contamination levels being at a higher percentage than forecast, more waste was generated than anticipated that could not be disposed of in the on-site C-746-U Landfill. As a result more waste and a higher percentage of all waste generated was disposed of at the off-site waste disposal facility in Clive, Utah.

Summaries of Accomplishments and/or Effectiveness of the Removal Action

The overall RAO for this project, to reduce the direct contact risk to the current and future industrial worker and recreational user within the EPA risk range, was achieved. Table 2 depicts volumes removed from each location.

Table 2. Volumes of Contaminated Sediments Dispositioned

Location	Disposition (yd^3)				
	C-746-U Landfill	**Energy*Solutions*, Clive, UT**	**Total Volume Disposed Of (yd^3)**	**Original Estimated Excavation Volume (yd^3)**	**Additional Volume Generated (%)**
Outfall 001	425	501	926	~995	-7
Outfall 008	0	244	244	~220	20
Outfall 010	0	642	642	~320	101
Outfall 011	3,443	457	3,900	~1,200	225
Outfall 015	5,026	4,983	10,009	~7,040	42
NSDD Section 3	1,266	5,287	6,553	~3,760	74
NSDD Section 5	0	403	403	~400	0
Total	10,160	12,517	22,677	13,935	63

Copies of Relevant Laboratory/Monitoring Data

Relevant laboratory/monitoring data are included as Appendix B.

Summary of Project Costs

Table 3 below depicts project costs.[4]

Table 3. Costs Associated with Project

Activity	Cost
Excavation	$14,458,980
Waste Management	$ 681,534
Off-Site Disposal	$ 3,171,849
Total	**$18,312,363**

These costs are higher than the estimate provided in the Engineering Evaluation/Cost Analysis of $7,635,816. The higher costs can be directly attributed to the deviations and project problems discussed on pages 8, 9, and 10 of this report.

[4] The accounting of expenditures is based on an estimate governed by figures known at the time the report was written.

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APPENDIX A

FIGURES

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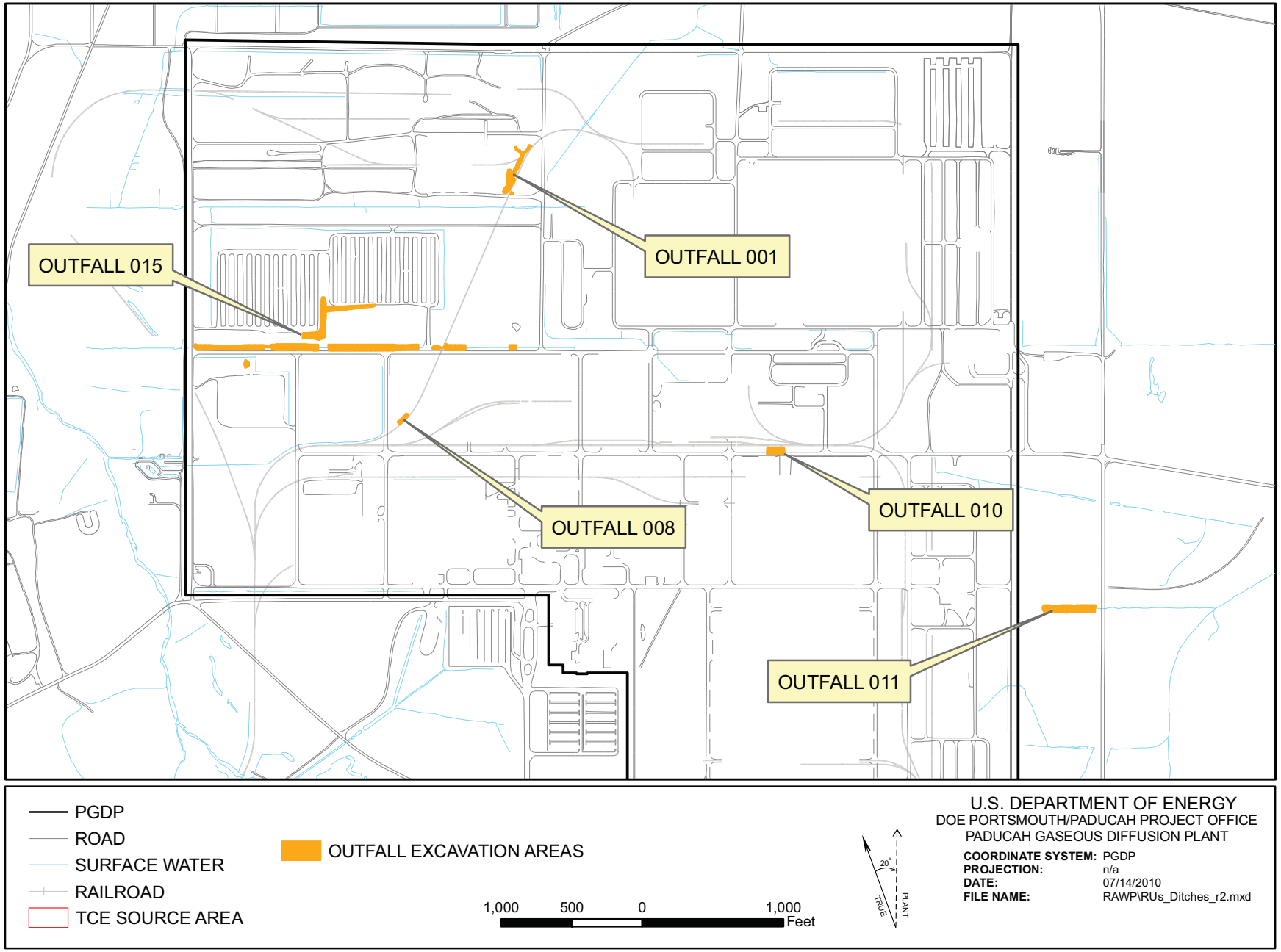

Figure A.1. Location of Outfalls for On-Site Ditches

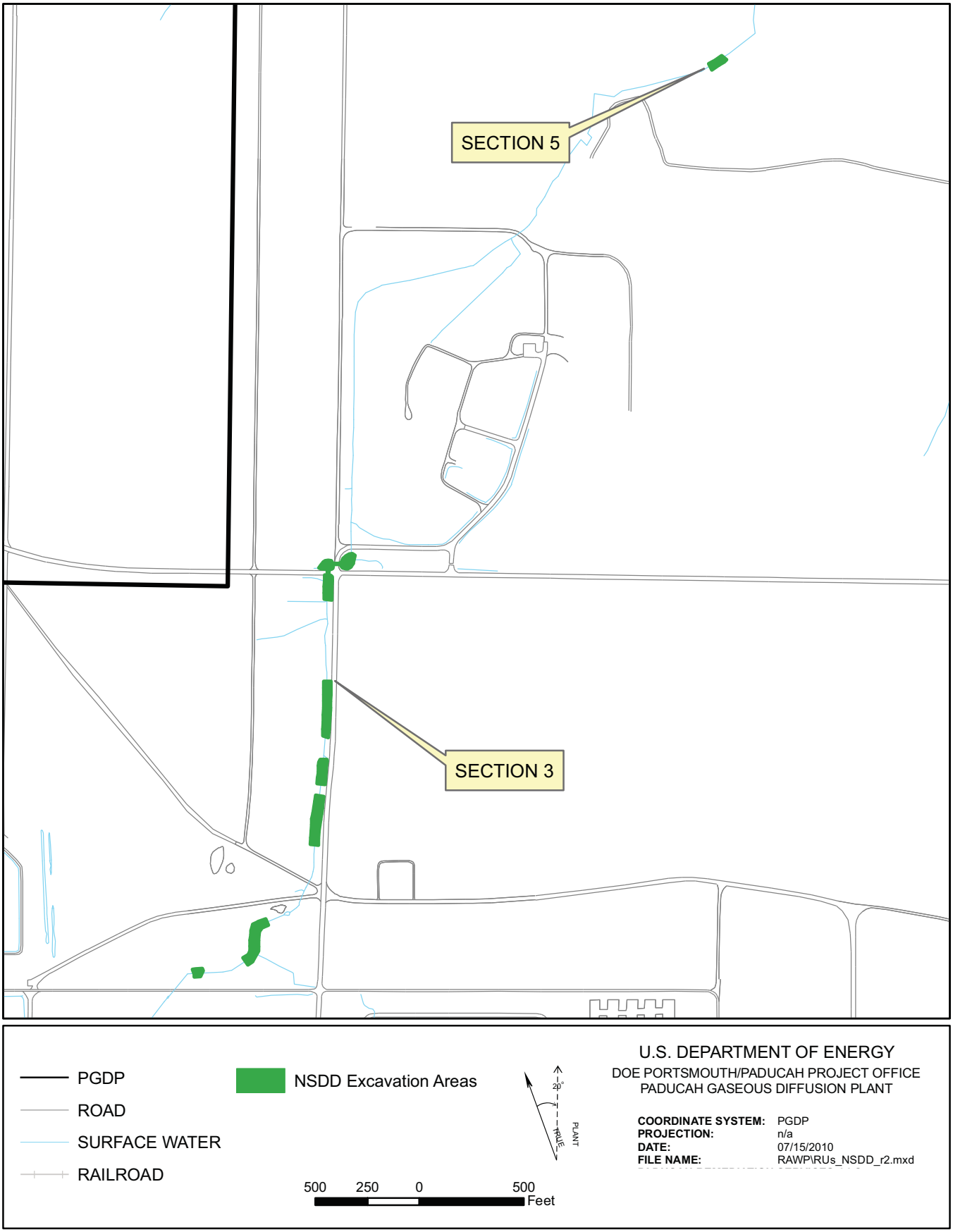

Figure A.2. Location of NSDD Sections 3 and 5

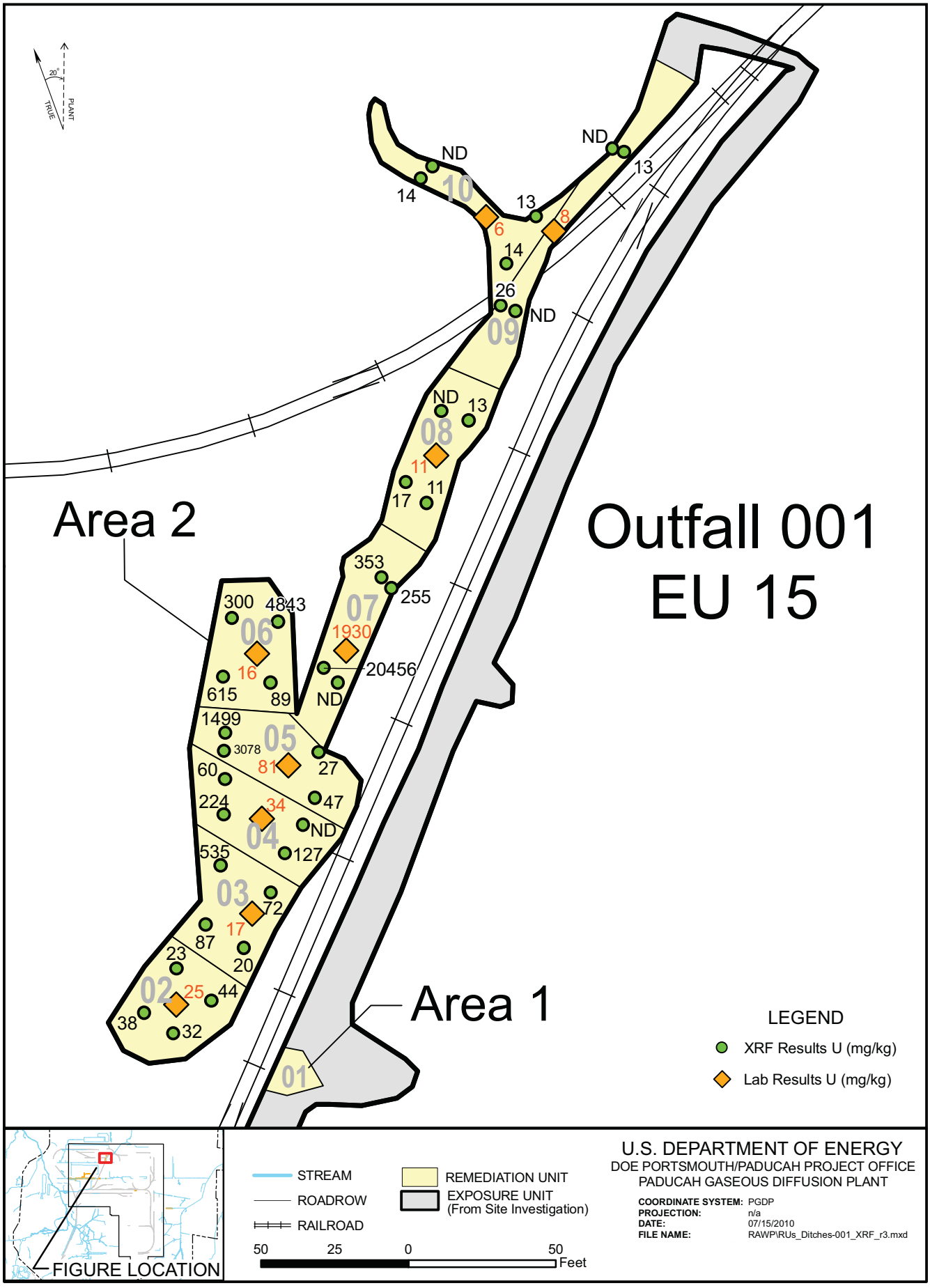

Figure A.3. Outfall 001 Preexcavation (5/18/10) Sample Results

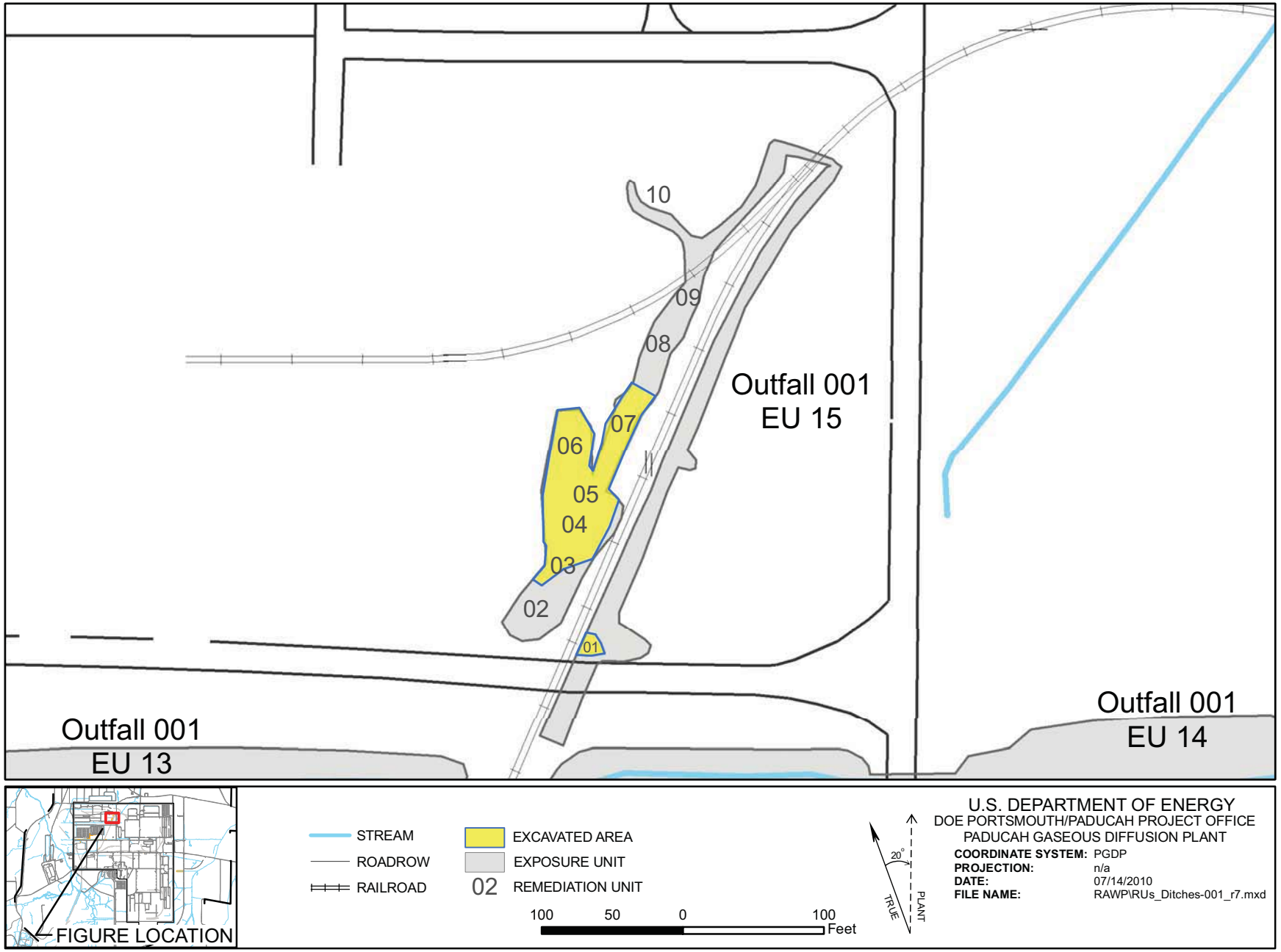

Figure A.4. Outfall 001 Actual Excavation Limits

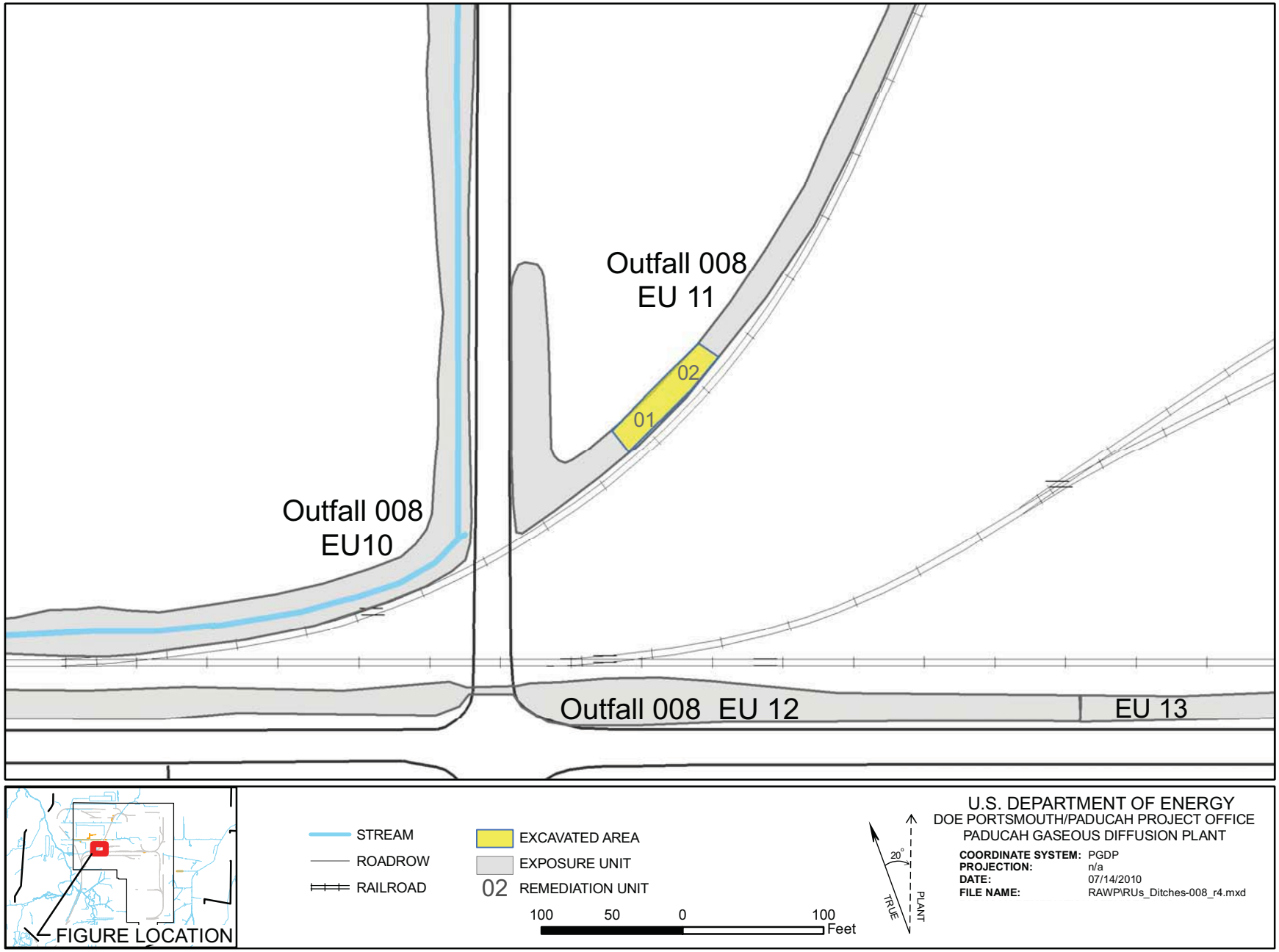

Figure A.5. Outfall 008 Actual Excavation Limits

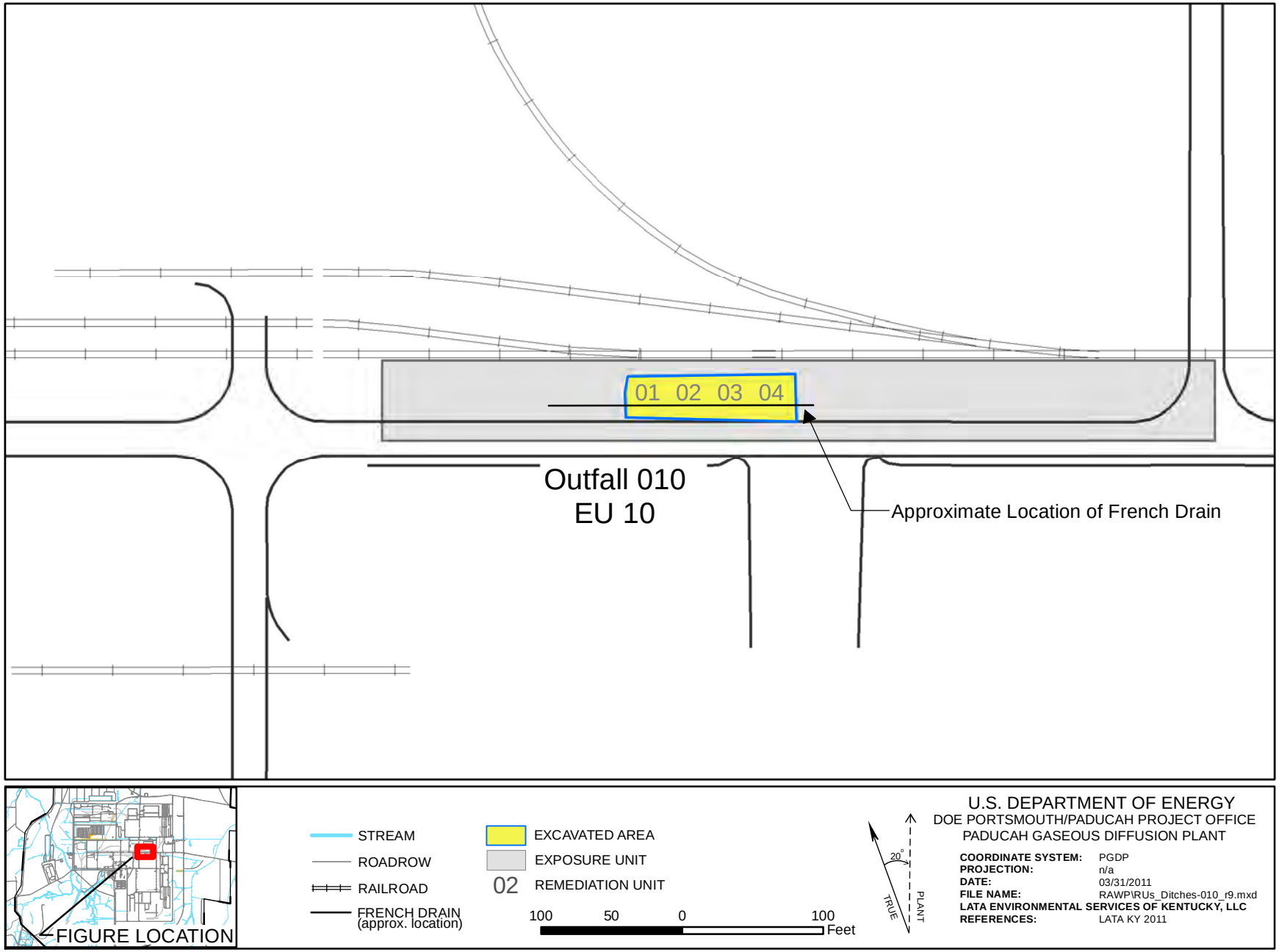

Figure A.6. Outfall 010 Actual Excavation Limits

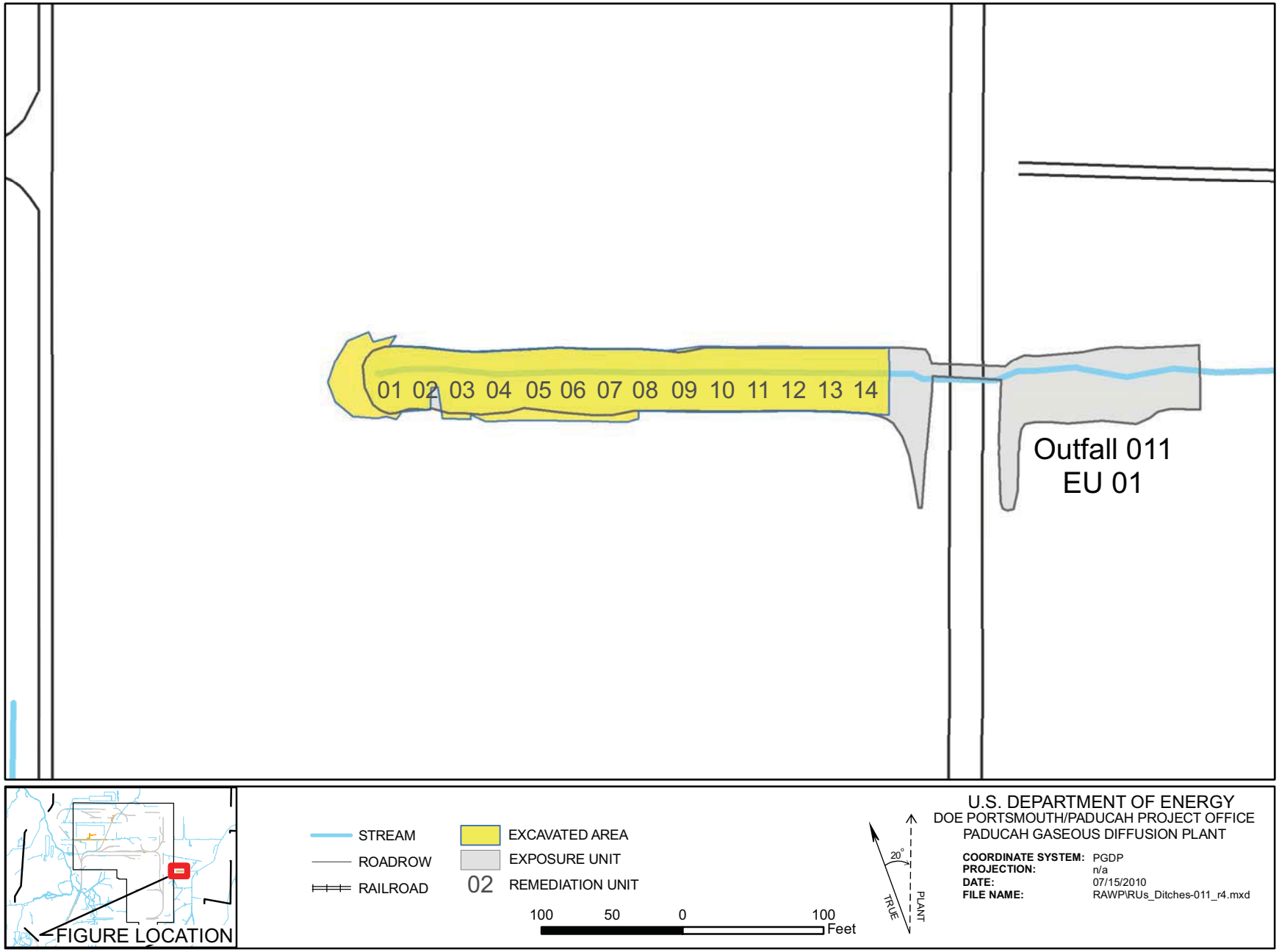

Figure A.7. Outfall 011 Actual Excavation Limits

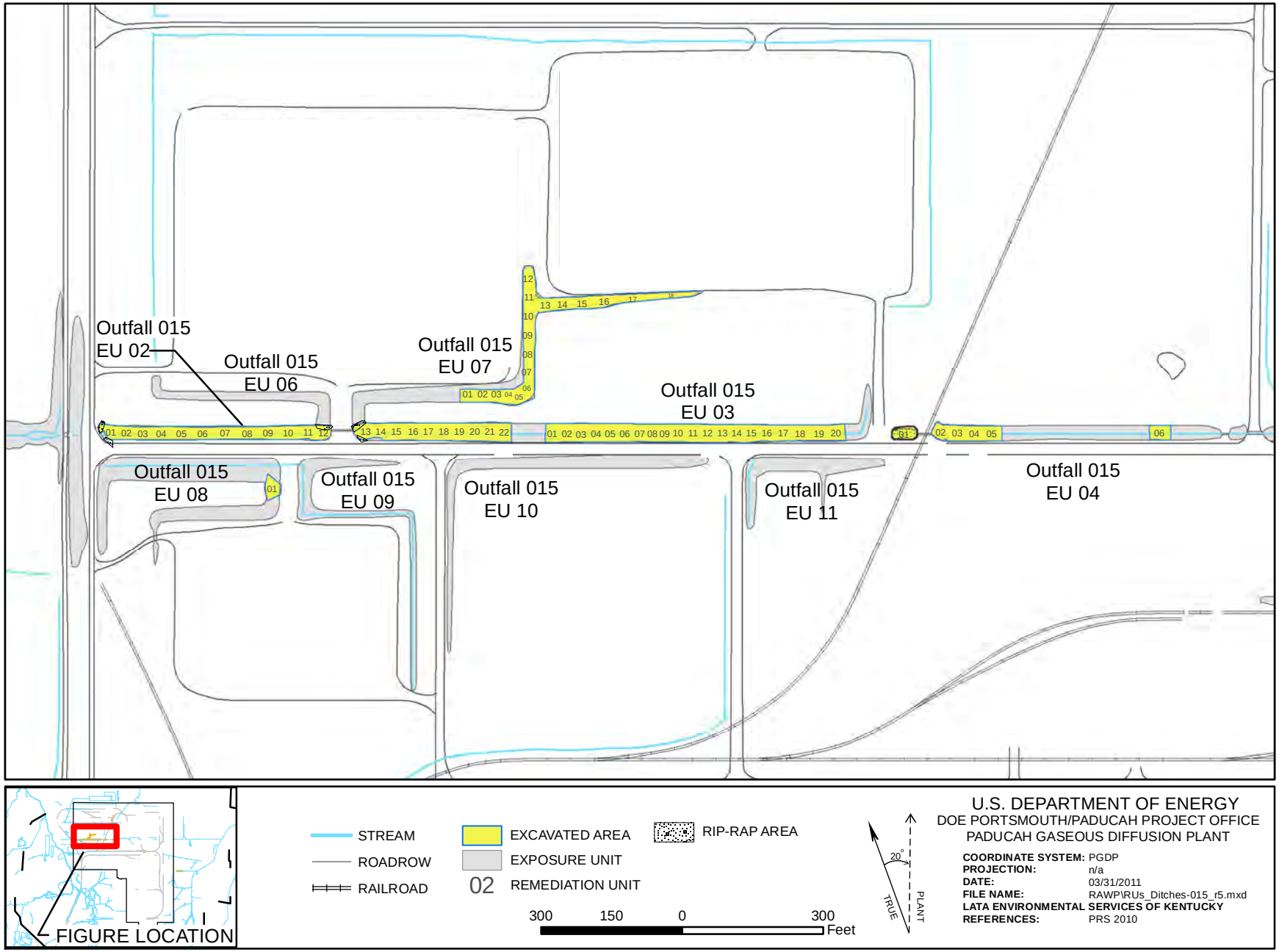

Figure A.8. Outfall 015 Actual Excavation Limits

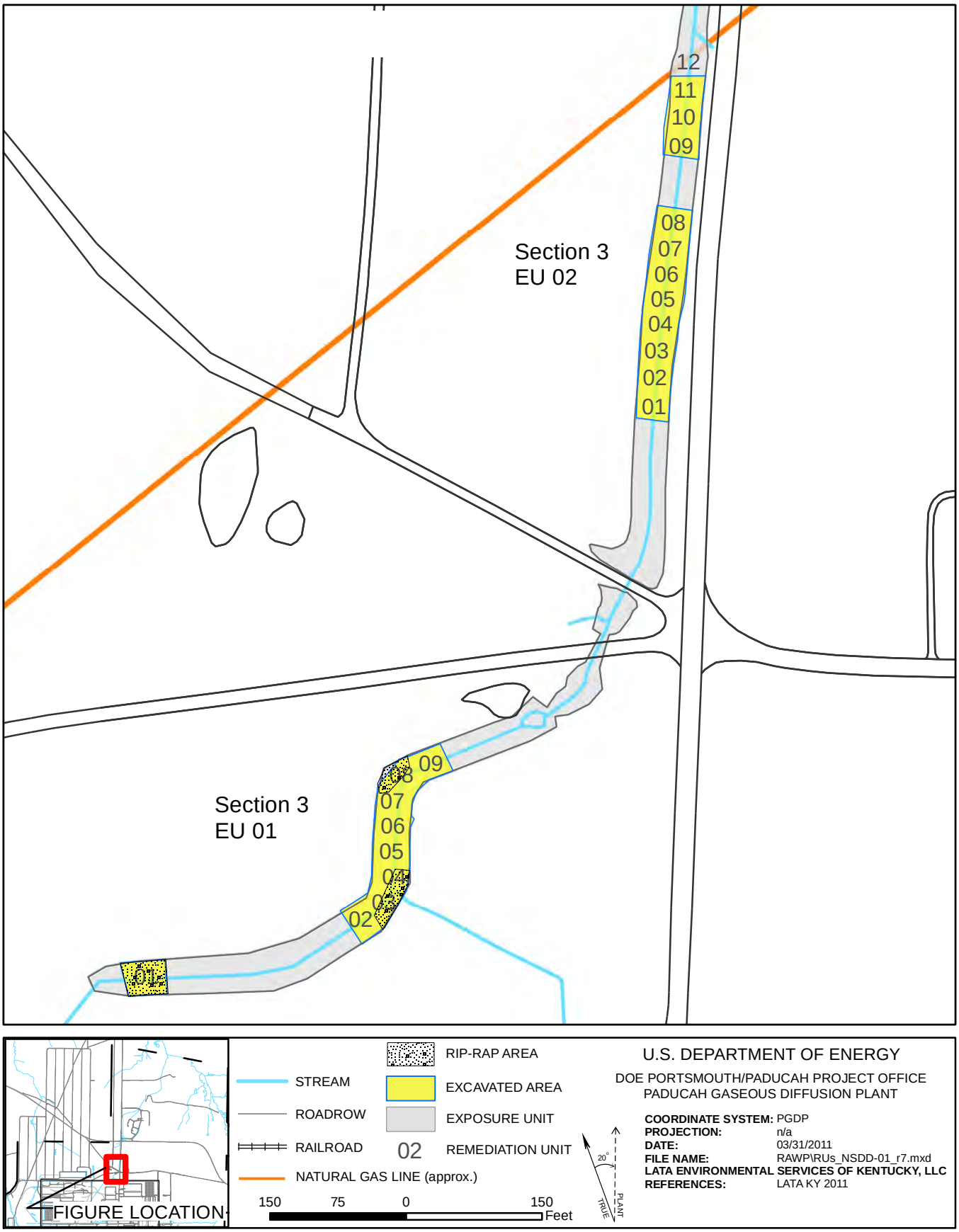

Figure A.9. NSDD Section 3 EUs 01 & 02 Actual Excavation Limits

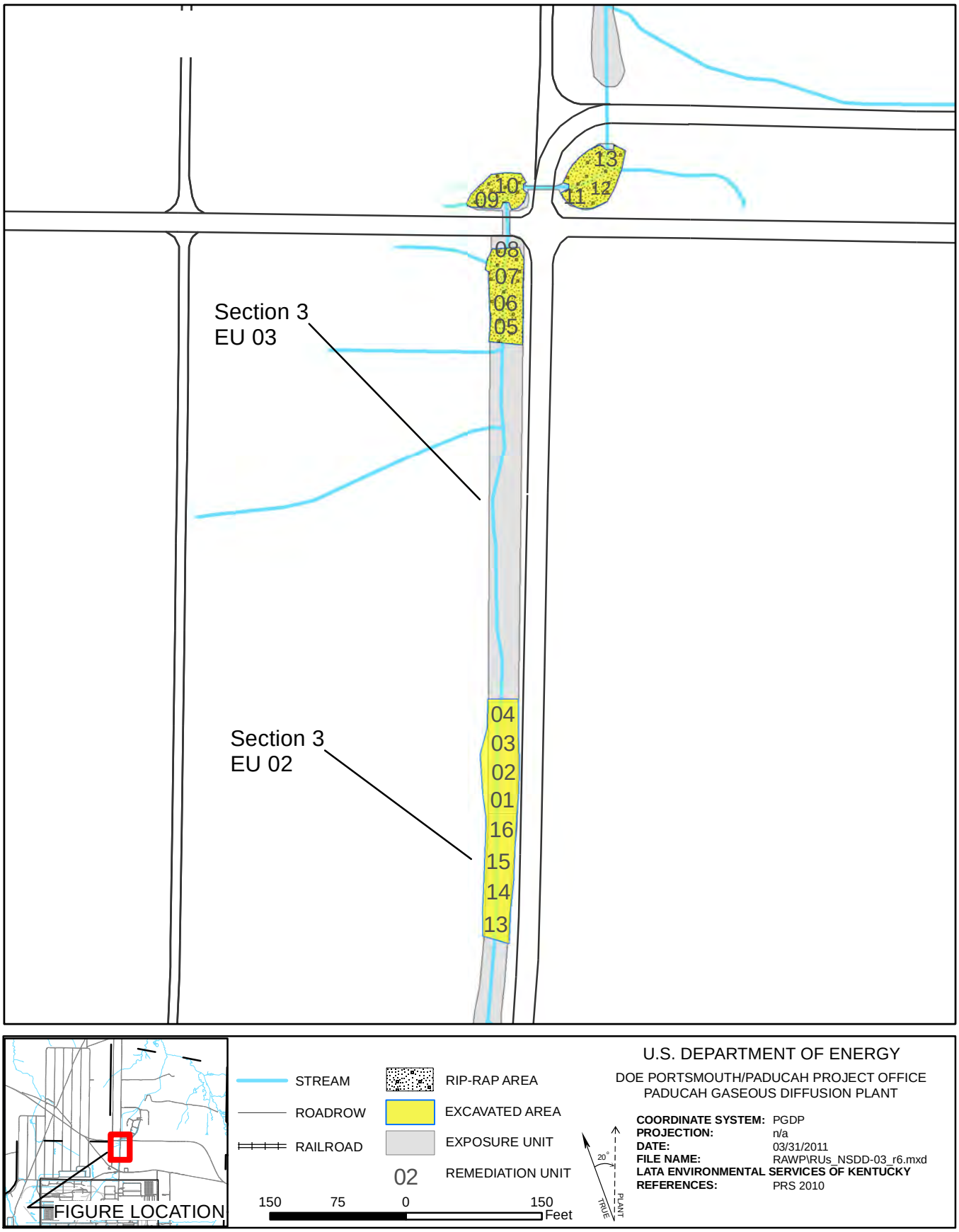

Figure A.10. NSDD Section 3 EUs 02 & 03 Actual Excavation Limits

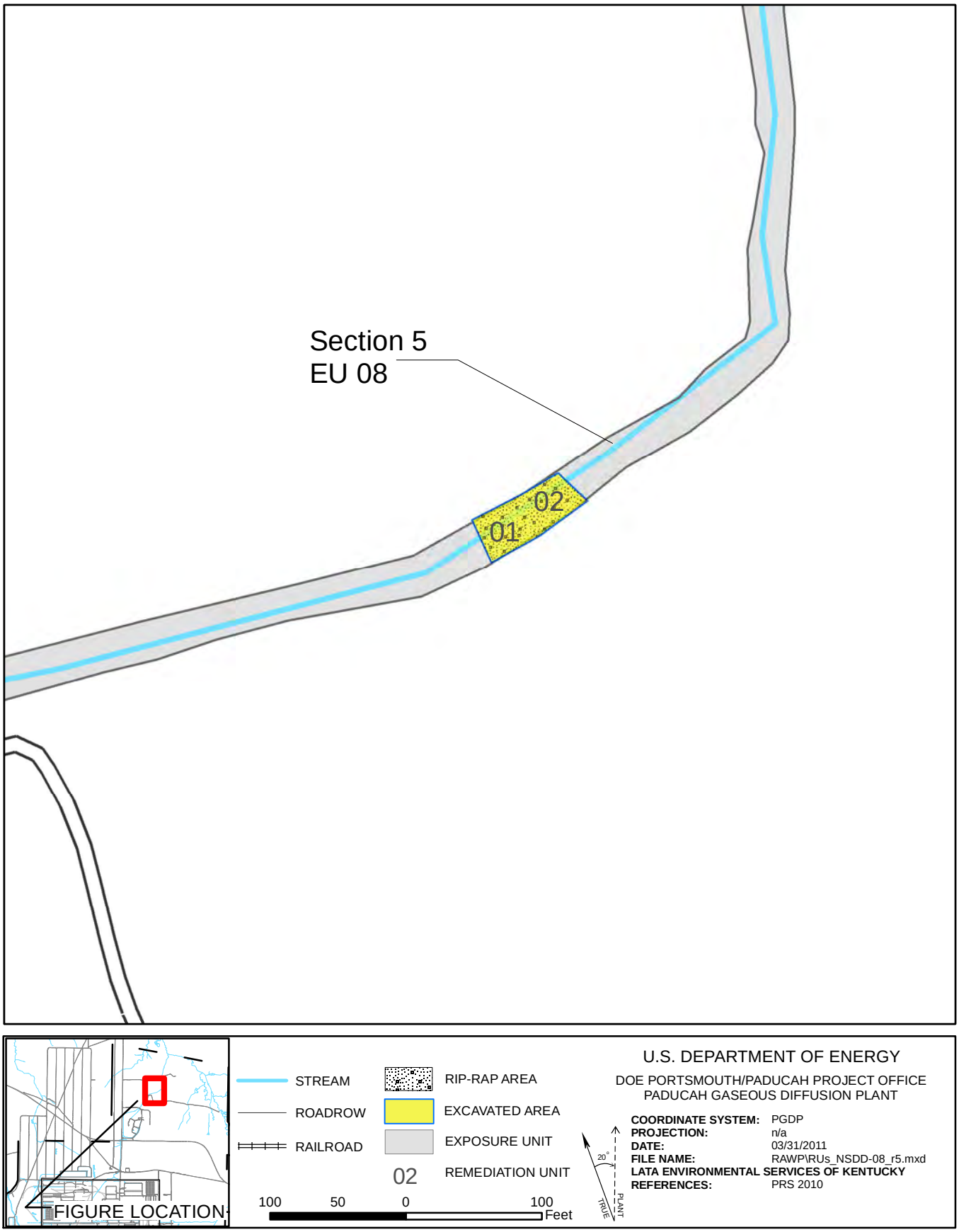

Figure A.11. NSDD Section 5 Actual Excavation Limits

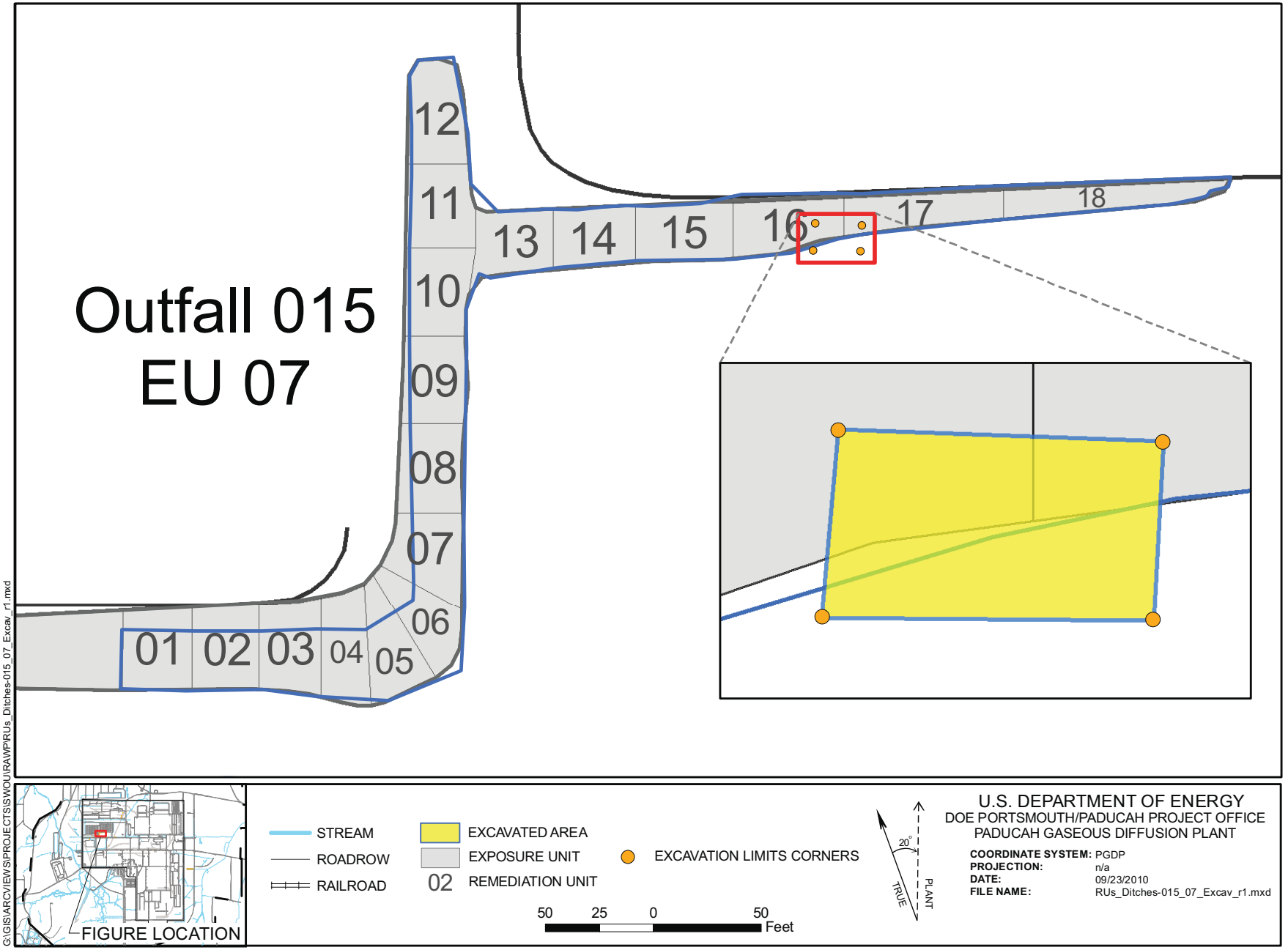

Figure A.12. Outfall 015 "Seam" Excavation

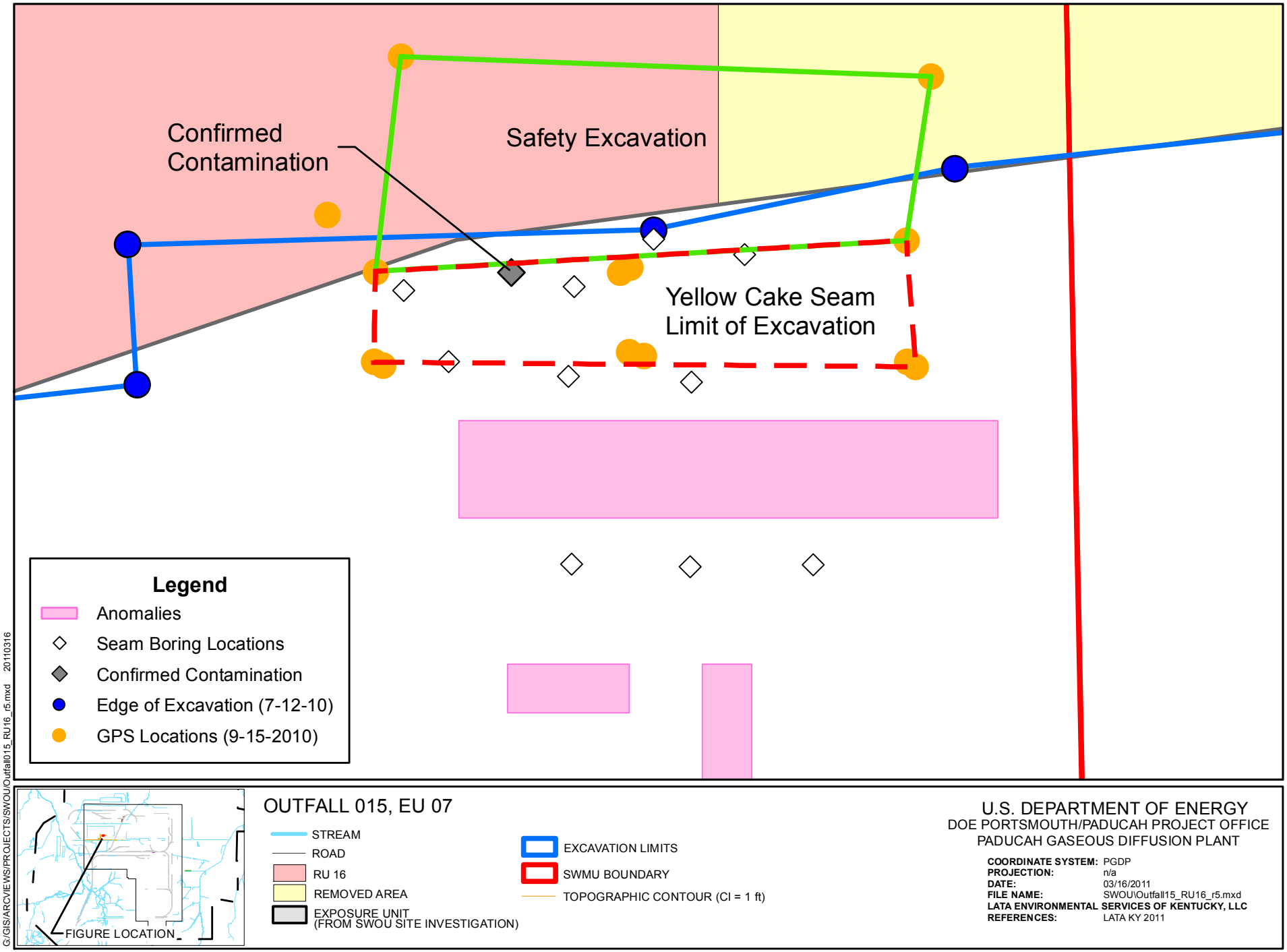

Figure A.13. Outfall 015 Surveying Points Yellow Cake Seam

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APPENDIX B

DATA TABLES

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APPENDIX B

DATA TABLES (ON CD)

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APPENDIX C

RESIDUAL RISK EVALUATION

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RESIDUAL RISK EVALUATION FOR THE SWOU REMOVAL ACTION

In accordance with the *Removal Action Work Plan for Contaminated Sediment Associated with the Surface Water Operable Unit (On-Site) at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky,* (DOE 2009) hot spots were removed. These areas were identified in the Removal Action Work Plan (RAWP) using a cumulative excess lifetime cancer risk (ELCR) of 1E-05 and a cumulative hazard index (HI) of 1.0 based upon the information presented in Appendix F, "Risk-Based Cost-Benefit Analysis," of the Engineering Evaluation/Cost Analysis. The risk evaluation calculates the cumulative residual risk and hazard for exposure units with excavated hot spots within Surface Water Operable Unit (SWOU) Removal Action for the industrial worker at all locations and for the recreational user at the North-South Diversion Ditch (NSDD). This enclosure serves to provide verification of cleanup to a cumulative excess lifetime cancer risk (ELCR) of 1E-05 and a cumulative HI of 1.0. Consistent with the results of the risk-based cost-benefit analysis, verification of cleanup is based upon comparisons between sampling results and chemical-specific ELCR-based cleanup levels. The ELCR and HI target used in deriving the cleanup levels[1] are 5E-06 and 1.0, respectively, for individual contaminants of concern (COCs) in order to ensure the cumulative values were reached. The cancer risk-based and hazardous-based cleanup levels that are used in the comparison for the SWOU On-Site Project are shown in Table C.1.

Table C.1. Cleanup Levels Based on Carcinogenic Risk and Hazard[a]

COC	Risk-Based Concentration	
Arsenic	27	mg/kg
Beryllium	50,000	mg/kg
Total PCB	16	mg/kg
Americium-241	115	pCi/g
Cesium-137	8	pCi/g
Neptunium-237	22	pCi/g
Plutonium-239/240	108	pCi/g
Technetium-99	3,825	pCi/g
Thorium-230	147	pCi/g
Thorium-232	129	pCi/g
Uranium-234	188	pCi/g
Uranium-235	30	pCi/g
Uranium-238	94	pCi/g
COC	**Hazard-Based Concentration**	
Uranium	227	mg/kg

Table C.1 is taken from the *Removal Action Work Plan for Contaminated Sediment Associated with the Surface Water Operable Unit (On-Site) at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-0221&D2/R1, December 2009.

[a]The cleanup levels for SWOU were established in the Engineering Evaluation/Cost Analysis to be protective of both recreational user and industrial worker scenarios.

Exposure units (EUs) were developed for the SWOU Site Investigation. Each EU is approximately 0.5 acres and is consistent with the area defined in the Risk Methods Document (DOE 2001) for determining risk. Each outfall and NSDD EU that required excavation is evaluated separately. For each COC, the exposure concentration was the maximum detected concentration remaining in place (i.e., concentrations from removed soil were not used) if fewer than 10 results were available for the EU. For EUs with 10 or more results available, the lesser of the maximum detected concentration and the 95% upper confidence limit (UCL) on the mean of the appropriate distribution was used as the exposure concentration (DOE 2010). The U.S. Environmental Protection Agency (EPA) software program ProUCL was used for determining the appropriate 95% UCL value. The attachment (Exposure Unit Sample

Locations, Figures C1.1 through C1.13) to this risk evaluation shows the locations of the EUs and the sample locations from which the exposure concentrations were derived.

The equation used to derive the risk estimate for each COC (i.e., chemical-specific cancer risk or hazard) is as follows:

$$\textbf{Risk} = \frac{\textbf{Exposure Concentration}}{\textbf{Cleanup Value}} \times \textbf{Target Risk Value}$$

where:

Risk = calculated chemical-specific cancer risk or hazard value.
Exposure Concentration = Maximum or 95% UCL concentration taken from Table C.2.
Cleanup Value = Risk-based or hazard-based concentration taken from Table C.1. For the recreational scenario calculations, the values are taken from Tables E.1 and E.2 of the *Engineering Evaluation/Cost Analysis for Contaminated Sediment Associated with the Surface Water Operable Unit (On-Site) at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-0012&D2, September 2008, and are shown below.

Reference Information[a]

COC	Recreational User ELCR=1E-5	
Arsenic	18.1	mg/kg
Beryllium	100,000	mg/kg
Total PCB	6.44	mg/kg
Americium-241	811	pCi/g
Cesium-137	11.9	pCi/g
Neptunium-237	37.8	pCi/g
Plutonium-239/240	2,370	pCi/g
Technetium-99	70,600	pCi/g
Thorium-230	3,020	pCi/g
Thorium-232	2,790	pCi/g
Uranium-234	4,070	pCi/g
Uranium-235	55.3	pCi/g
Uranium-238	246	pCi/g
COC	**Recreational User HI=1**	
Uranium	5,310	mg/kg

[a] Cleanup levels for the SWOU were established in the Engineering Evaluation/Cost Analysis and were established to be protective of both recreational user and industrial worker scenarios. See "Cleanup Value" information above for table reference.

Target Risk Value = Cancer risk 5E-06 or hazard (1) upon which the target cleanup value is based. For the recreational scenario calculations, the values are cancer risk 1E-05 or hazard (1), upon which the target cleanup value is based.

Results of the application of this equation are presented in Table C.3. After risk estimates for each COC were determined, a cumulative risk for each EU was calculated as follows:

$$\text{Total Risk} = \sum \text{Analyte-specific Risks}$$

Table C.2. Exposure Concentrations for SWOU EUs

EU	Arsenic (mg/kg)	Beryllium (mg/kg)	Total PCB (mg/kg)	Uranium (mg/kg)	Am-241 (pCi/g)	Cs-137 (pCi/g)	Np-237 (pCi/g)	Pu-239/240 (pCi/g)	Tc-99 (pCi/g)	Th-230 (pCi/g)	Th-232 (pCi/g)	U-234 (pCi/g)	U-235 (pCi/g)	U-238 (pCi/g)
Outfall 001														
15	5.381	0.459	10.5	16.53	0.223	0.115	0.135	0.15	16.09	1.809	0.806	3.252	0.197	5.907
Outfall 008														
11	4.91	0.491	9.22	15.9	0.0972	0.45	0.152	0.274	7.76	2.08	0.883	2.54	0.156	3.76
Outfall 010														
10	12.6	0.58	3.36	12	0.198	0.726	0.172	0.109	8.44	1.23	0.934	2.47	0.155	4.66
Outfall 011														
01	3.561	0.495	1.338	65.86	0.0752	0.0669	0.0108	0.0275	3.761	0.891	0.705	3.11	0.238	47.64
Outfall 015														
02	4.626	0.409	0.0754	22.29	0.153	1.17	0.157	0.214	4.65	8.607	0.919	3.294	0.386	6.357
03	3.724	0.391	0.08	27.14	0.128	0.646	0.12	0.392	0.816	10.31	0.922	3.792	0.271	9.092
04	10.4	1.08	0.81	36.1	0.184	11.2[a]	0.527	2.42	21.6	8.73	1.03	2.36	0.171	9.64
07	6.088	0.55	0.0813	30.5	0.129	0.125	0.0167	0.174	0.882	1.236	0.932	3.869	0.216	25.57
08	46.9[b]	0.495	0.13	55.7	0.083	0.443	0.0638	0.0434	3.31	1.43	0.989	0.588	0.0405	0.843
NSDD, Section 3														
01	4.315	0.5	0.979	35.8	0.713	0.593	0.802	2.236	40.86	26.42	0.879	9.106	0.848	13.11
02	4.213	0.504	0.729	27.38	1.633	0.774	1.898	8.277	105.3	54.99	0.938	6.194	0.389	8.533
03	4.268	0.44	0.583	45.23	1.99	1.516	1.382	9.512	306.4	101.2	0.914	6.525	0.389	8.171
NSDD, Section 5														
08	15.99	0.695	0.798	87.8	0.694	1.667	0.199	2.027	24.62	26.05	0.646	3.385	0.235	4.956

Am-241 = Americium-241 Cs-137 = Cesium-137 Np-237 = Neptunium-237 Pu-239/240 = Plutonium-239/240 Tc-99 = Technetium-99 Th-230 = Thorium-230
Th-232 = Thorium-232 U-234 = Uranium-234 (reported as Uranium-233/234) U-235 = Uranium-235 U-238 = Uranium-238

[a] The value shown is above the chemical-specific cleanup level as shown in Table C.1 because it is the maximum value for the EU and is from a historical data sample. The area from which the historical data sample was collected was not excavated because the Cs-137 value was not higher than the individual 1E-5 ELCR value defined in the Engineering Evaluation/Cost Analysis (15.2 pCi/g) (DOE 2008).

[b] The value shown is above the chemical-specific cleanup level as shown in Table C.1 because it is the maximum value for the EU and is from a historical data sample. The area from which the historical data sample was collected was not excavated because the arsenic value was not higher than the individual 1E-5 ELCR value defined in the Engineering Evaluation/Cost Analysis (54.8) (DOE 2008).

Table C.3. Risk and Hazard Estimates for SWOU EUs

EU	Arsenic	Beryllium	Total PCB	Uranium	Am-241	Cs-137	Np-237	Pu-239/240	Tc-99	Th-230	Th-232	U-234	U-235	U-238
INDUSTRIAL WORKER														
							Outfall 001							
15	9.96E-07	4.59E-11	3.28E-06	0.1	9.70E-09	7.19E-08	3.07E-08	6.94E-09	2.10E-08	6.15E-08	3.12E-08	8.65E-08	3.28E-08	3.14E-07
							Outfall 008							
11	9.09E-07	4.91E-11	2.88E-06	0.1	4.23E-09	2.81E-07	3.45E-08	1.27E-08	1.01E-08	7.07E-08	3.42E-08	6.76E-08	2.60E-08	2.00E-07
							Outfall 010							
10	2.33E-06	5.80E-11	1.05E-06	0.1	8.61E-09	4.54E-07	3.91E-08	5.05E-09	1.10E-08	4.18E-08	3.62E-08	6.57E-08	2.58E-08	2.48E-07
							Outfall 011							
01	6.59E-07	4.95E-11	4.18E-07	0.3	3.27E-09	4.18E-08	2.45E-09	1.27E-09	4.92E-09	3.03E-08	2.73E-08	8.27E-08	3.97E-08	2.53E-06
							Outfall 015							
02	8.57E-07	4.09E-11	2.36E-08	0.1	6.65E-09	7.31E-07	3.57E-08	9.91E-09	6.08E-09	2.93E-07	3.56E-08	8.76E-08	6.43E-08	3.38E-07
03	6.90E-07	3.91E-11	2.50E-08	0.1	5.57E-09	4.04E-07	2.73E-08	1.81E-08	1.07E-09	3.51E-07	3.57E-08	1.01E-07	4.52E-08	4.84E-07
04	1.93E-06	1.08E-10	2.53E-07	0.2	8.00E-09	7.00E-06	1.20E-07	1.12E-07	2.82E-08	2.97E-07	3.99E-08	6.28E-08	2.85E-08	5.13E-07
07	1.13E-06	5.52E-11	2.54E-08	0.1	5.61E-09	7.81E-08	3.80E-09	8.06E-09	1.15E-09	4.20E-08	3.61E-08	1.03E-07	3.60E-08	1.36E-06
08	8.69E-06	4.95E-11	4.06E-08	0.2	3.61E-09	2.77E-07	1.45E-08	2.01E-09	4.33E-09	4.86E-08	3.83E-08	1.56E-08	6.75E-09	4.48E-08
							NSDD, Section 3							
01	7.99E-07	5.00E-11	3.06E-07	0.2	3.10E-08	3.71E-07	1.82E-07	1.04E-07	5.34E-08	8.99E-07	3.41E-08	2.42E-07	1.41E-07	6.97E-07
02	7.80E-07	5.04E-11	2.28E-07	0.1	7.10E-08	4.84E-07	4.31E-07	3.83E-07	1.38E-07	1.87E-06	3.64E-08	1.65E-07	6.48E-08	4.54E-07
03	7.90E-07	4.40E-11	1.82E-07	0.2	8.65E-08	9.48E-07	3.14E-07	4.40E-07	4.01E-07	3.44E-06	3.54E-08	1.74E-07	6.48E-08	4.35E-07
							NSDD, Section 5							
08	2.96E-06	6.95E-11	2.49E-07	0.4	3.02E-08	1.04E-06	4.52E-08	9.38E-08	3.22E-08	8.86E-07	2.50E-08	9.00E-08	3.92E-08	2.64E-07

Table C.3. Risk and Hazard Estimates for SWOU EUs (Continued)

RECREATIONAL USER

NSDD, Section 3														
01	2.38E-06	5.00E-11	1.52E-06	<0.1	8.79E-09	4.98E-07	2.12E-07	9.43E-09	5.79E-09	8.75E-08	3.15E-09	2.24E-08	1.53E-07	5.33E-07
02	2.33E-06	5.04E-11	1.13E-06	<0.1	2.01E-08	6.50E-07	5.02E-07	3.49E-08	1.49E-08	1.82E-07	3.36E-09	1.52E-08	7.03E-08	3.47E-07
03	2.36E-06	4.40E-11	9.05E-07	<0.1	2.45E-08	1.27E-06	3.66E-07	4.01E-08	4.34E-08	3.35E-07	3.28E-09	1.60E-08	7.03E-08	3.32E-07
NSDD, Section 5														
08	8.83E-06	6.95E-11	1.24E-06	<0.1	8.56E-09	1.40E-06	5.26E-08	8.55E-09	3.49E-09	8.63E-08	2.32E-09	8.32E-09	4.25E-08	2.01E-07

Am-241 = Americium-241 Cs-137 = Cesium-137 Np-237 = Neptunium-237 Pu-239/240 = Plutonium-239/240 Tc-99 = Technetium-99 Th-230 = Thorium-230
Th-232 = Thorium-232 U-234 = Uranium-234 (reported as Uranium-233/234) U-235 = Uranium-235 U-238 = Uranium-238

The cumulative hazard and cancer risk for the EUs are listed in Table C.4.

Table C.4. Cumulative ELCR and HI for SWOU EUs

Outfall/ NSDD Section	EU	ELCR (Cancer)	HI (Hazard)
INDUSTRIAL WORKER			
Outfall 001	15	4.9E-06	0.1
Outfall 008	11	4.5E-06	0.1
Outfall 010	10	4.3E-06	0.1
Outfall 011	1	3.8E-06	0.3
Outfall 015	2	2.5E-06	0.1
	3	2.2E-06	0.1
	4	1.0E-05	0.2
	7	2.8E-06	0.1
	8	9.2E-06	0.2
Section 3	1	3.9E-06	0.2
	2	5.1E-06	0.1
	3	7.3E-06	0.2
Section 5	8	5.8E-06	0.4
RECREATIONAL USER			
Section 3	1	5.4E-06	<0.1
	2	5.3E-06	<0.1
	3	5.8E-06	<0.1
Section 5	8	1.2E-05	<0.1

UNCERTAINTIES IN CALCULATION OF CUMULATIVE RESIDUAL RISK AND HAZARDS FOR COCs

Several uncertainties should be taken into account when considering the calculation of cumulative residual risk and hazards for COCs for excavated hot spots within SWOU internal ditches and the NSDD.

One uncertainty for consideration is that the laboratory-reported results from samples collected during the SWOU Site Investigation for uranium isotopes present at or near background values may be biased low based on the extraction method the laboratory historically has used. It should be noted that this uncertainty occurs only when using SWOU Site Investigation data (not removal verification data). Estimated risk from uranium isotopes are well within acceptable ranges; thus, this uncertainty is not considered significant.

Only risk and hazard contributed by chemicals considered COCs and listed in the Table C.1 were included in the calculation, as specified in the RAWP.

Chemicals not detected at their laboratory sample quantitation limit (SQL) were used in the calculation at the full SQL value. Additionally, results detected below site background were included in the calculation. This may have resulted in an exaggerated value of cumulative risk and hazard.

Any risk or hazard associated with the removal of the French drain within Outfall 010 was not considered in this evaluation. All laboratory data associated with this removal were well below cleanup levels, so this area is not expected to have any adverse effect to the cumulative risk or hazard for Outfall 010, EU 10.

RESULTS OF CALCULATION OF CUMULATIVE RESIDUAL RISK AND HAZARDS FOR COCs FROM EXPOSURE UNITS WITH EXCAVATED HOT SPOTS WITHIN SWOU REMOVAL ACTION

The calculation of cumulative residual risk and hazard for COCs from EUs with excavated hot spots within SWOU Removal Action indicates that the removal goal of cleanup to a cumulative ELCR of 1E-05 and a cumulative HI of 1.0 was achieved.

REFERENCES

DOE 2001. *Methods for Conducting Risk Assessments and Risk Evaluations at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky Volume 1, Human Health,* DOE/OR/07-1506&D2, December.

DOE 2008. *Engineering Evaluation/Cost Analysis for Contaminated Sediment Associated with the Surface Water Operable Unit (On-Site) at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky,* DOE/LX/07-0012&D2, September.

DOE 2009. *Removal Action Work Plan for Contaminated Sediment Associated with the Surface Water Operable Unit (On-Site) at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky,* DOE/LX/07-0221&D2/R1, December.

DOE 2010. *Methods for Conducting Risk Assessments and Risk Evaluations at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky Volume 1, Human Health,* DOE/LX/07-0107&D2/V1, July.

EPA 2010. ProUCL Version 4.00.05 Technical Guide (Draft). EPA/600/R-07/041 Technical Support Center, Characterization and Monitoring Branch, Las Vegas, NV, May. (Model available at www.epa.gov/nerlesd1/tsc/software.htm)

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ATTACHMENT

EXPOSURE UNIT SAMPLE LOCATIONS

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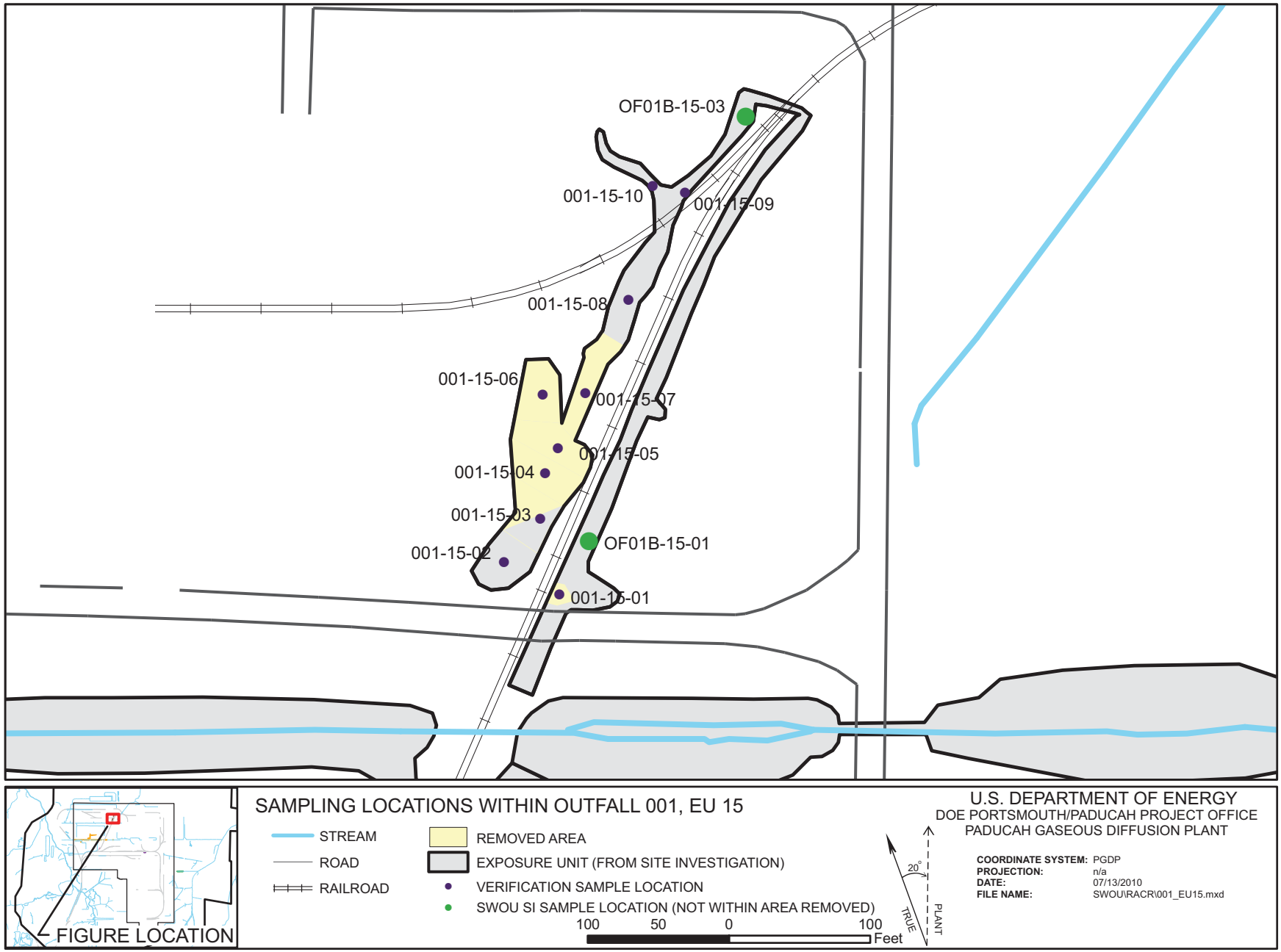

Figure C1.1. Sampling Locations within Outfall 001, EU 15

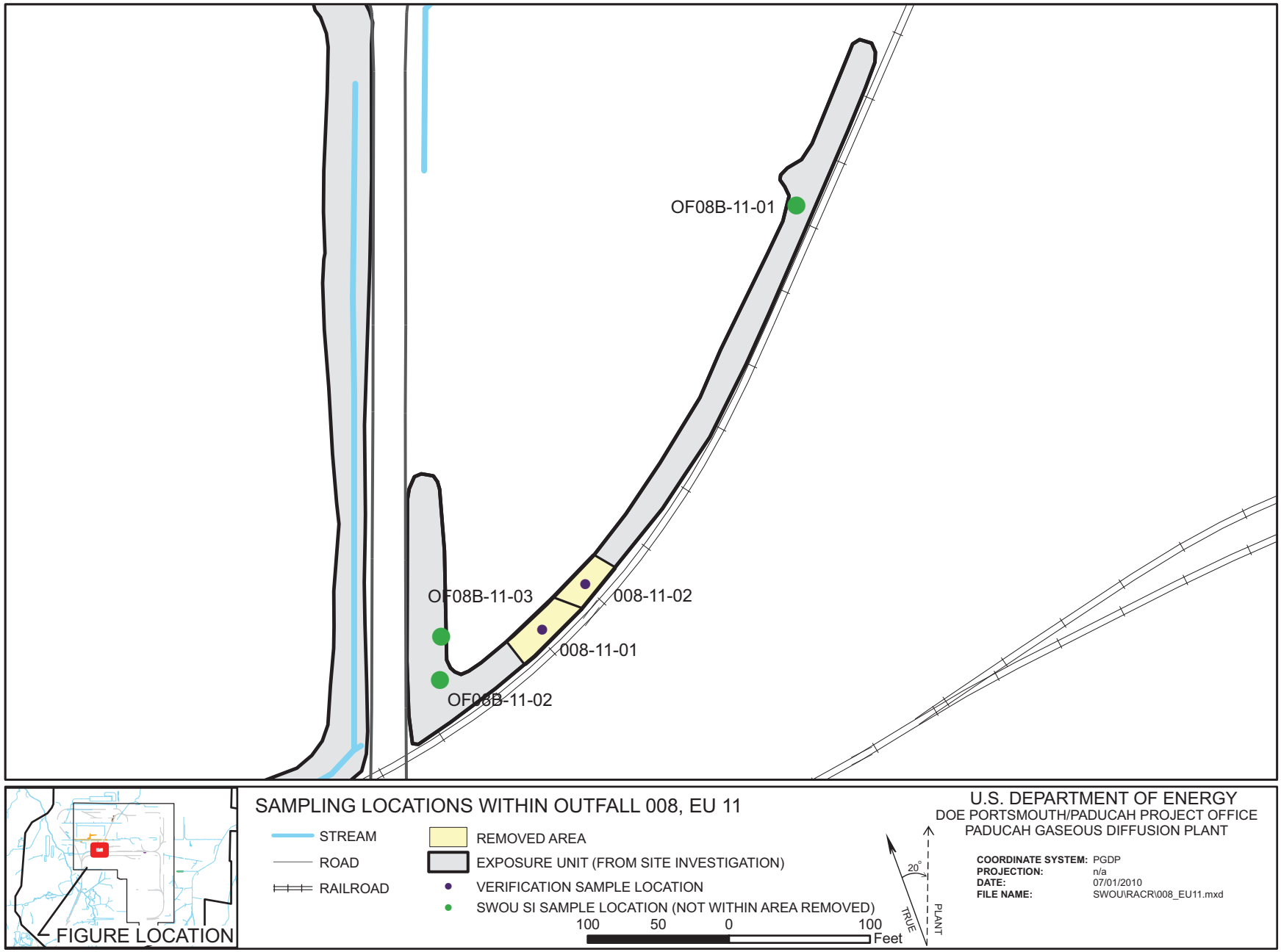

Figure C1.2. Sampling Locations within Outfall 008, EU 11

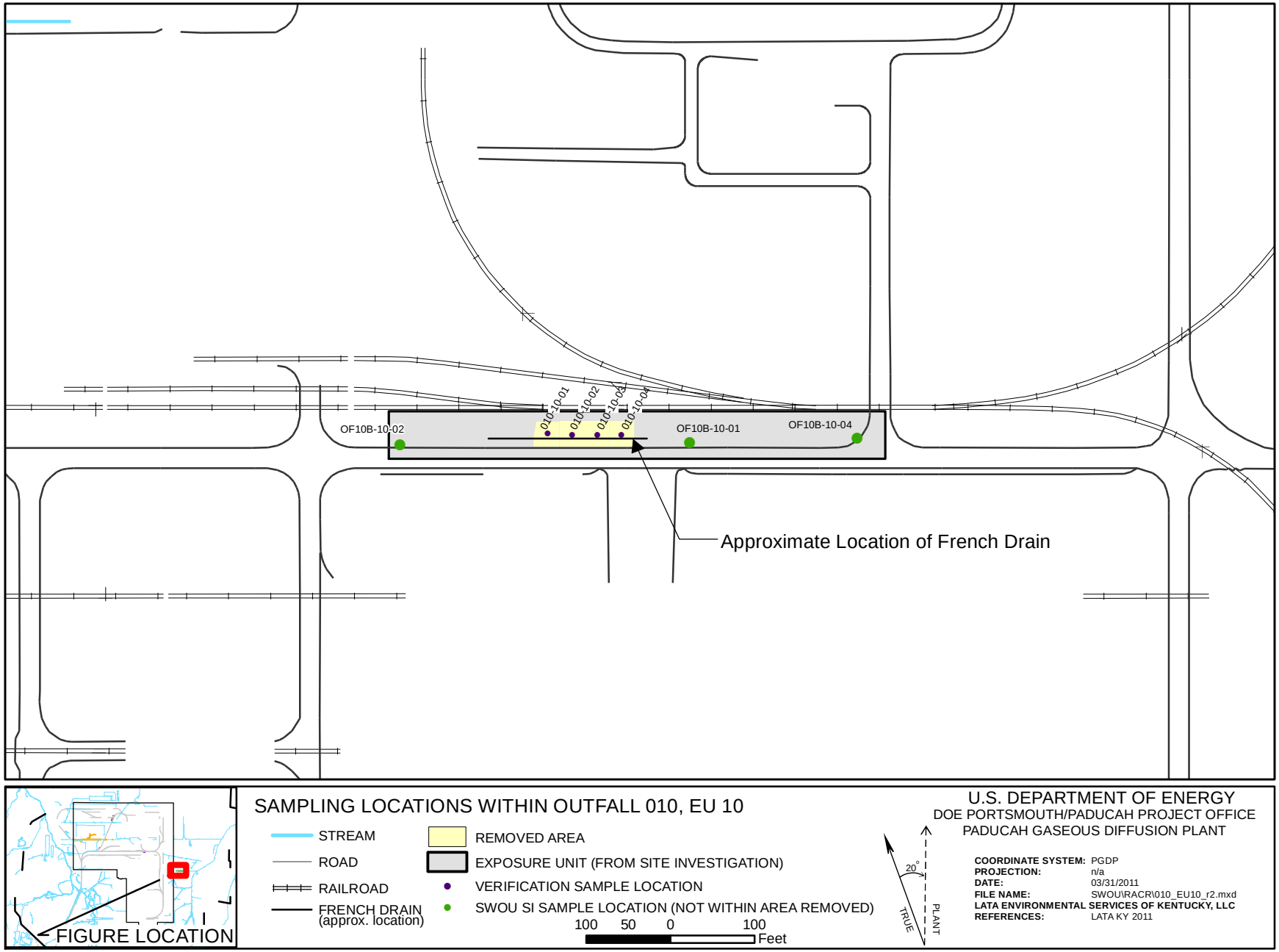

Figure C1.3. Sampling Locations Within Outfall 010, EU 10

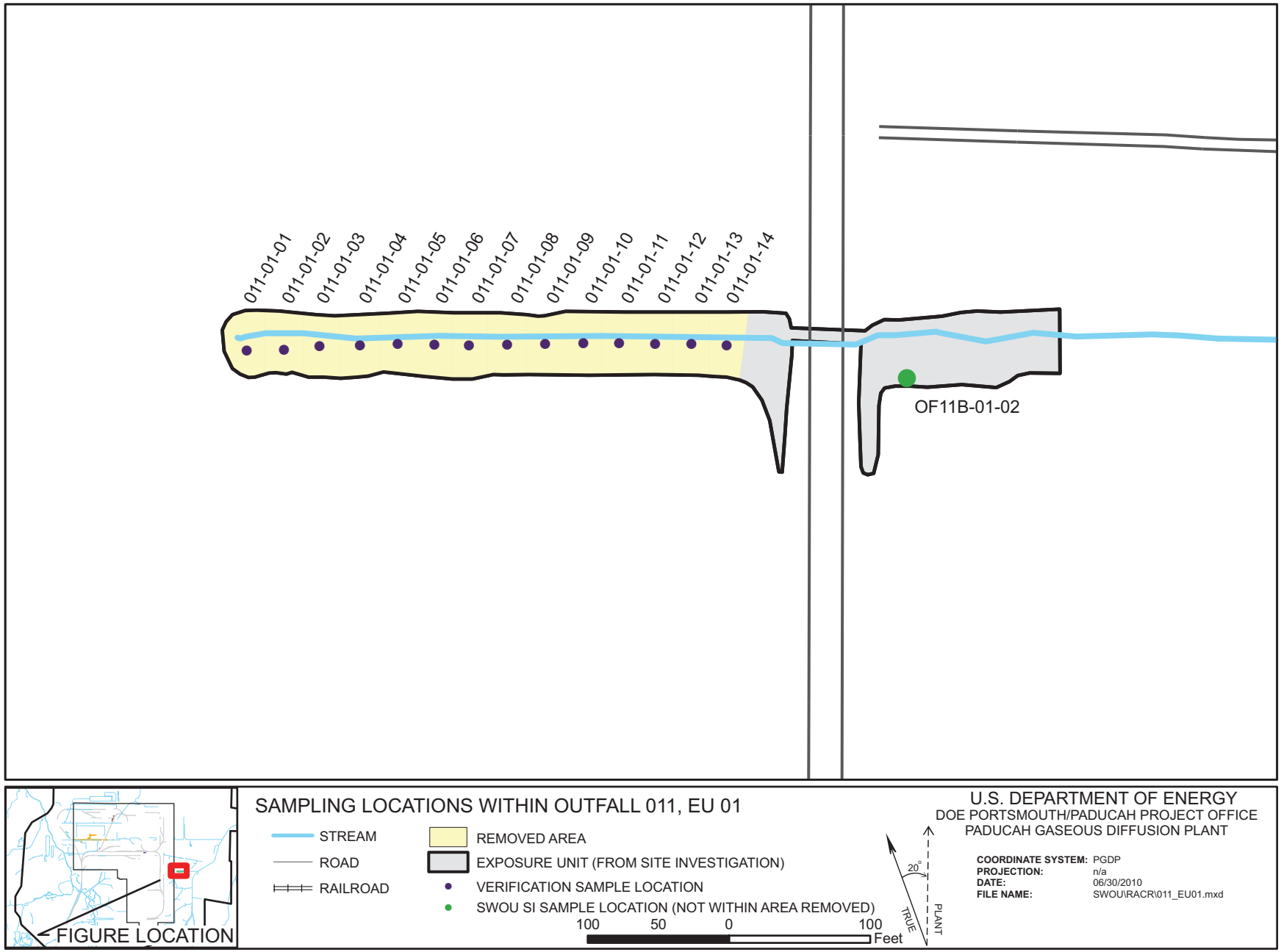

Figure C1.4. Sampling Locations within Outfall 011, EU 01

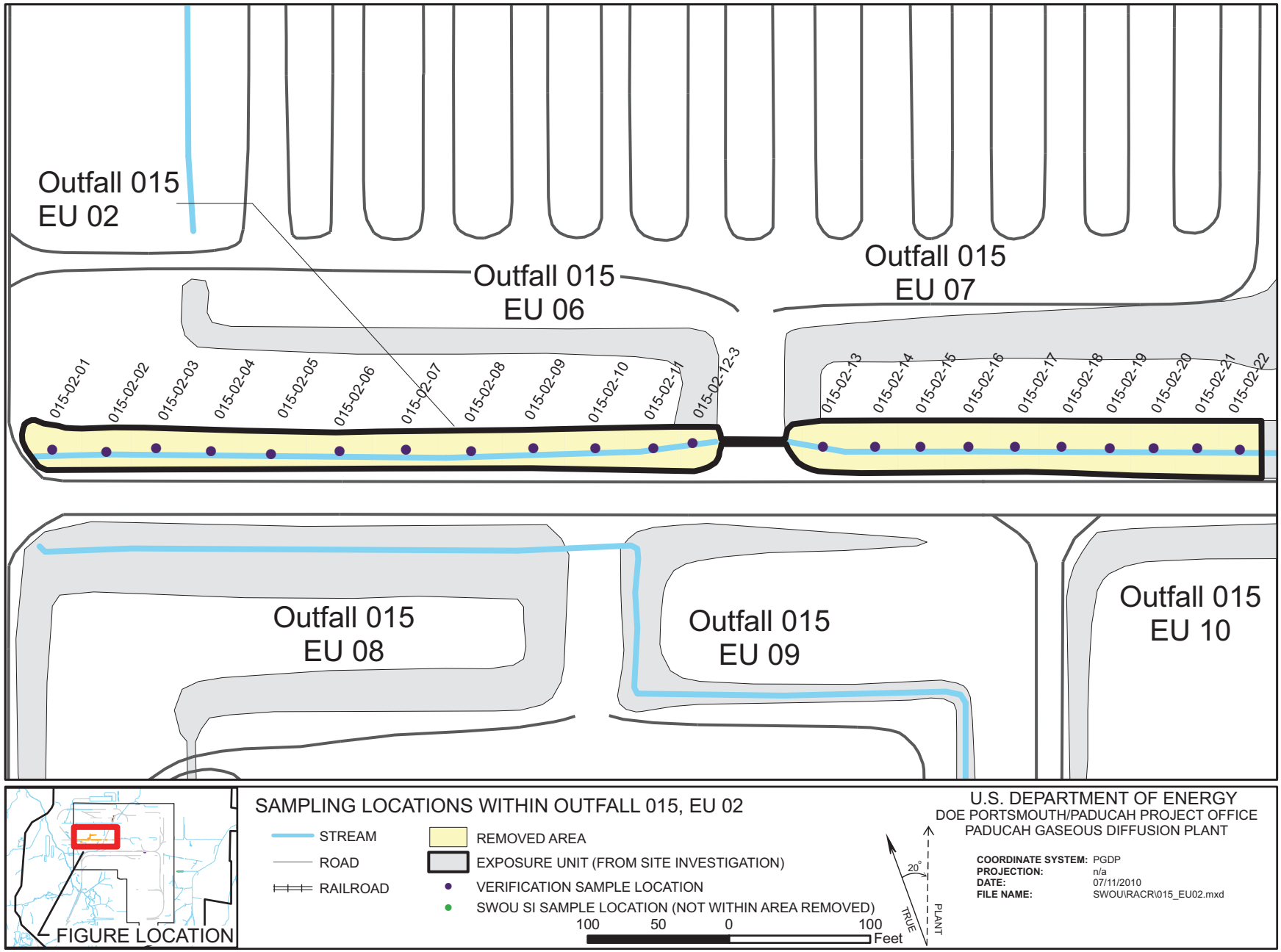

Figure C1.5. Sampling Locations within Outfall 015, EU 02

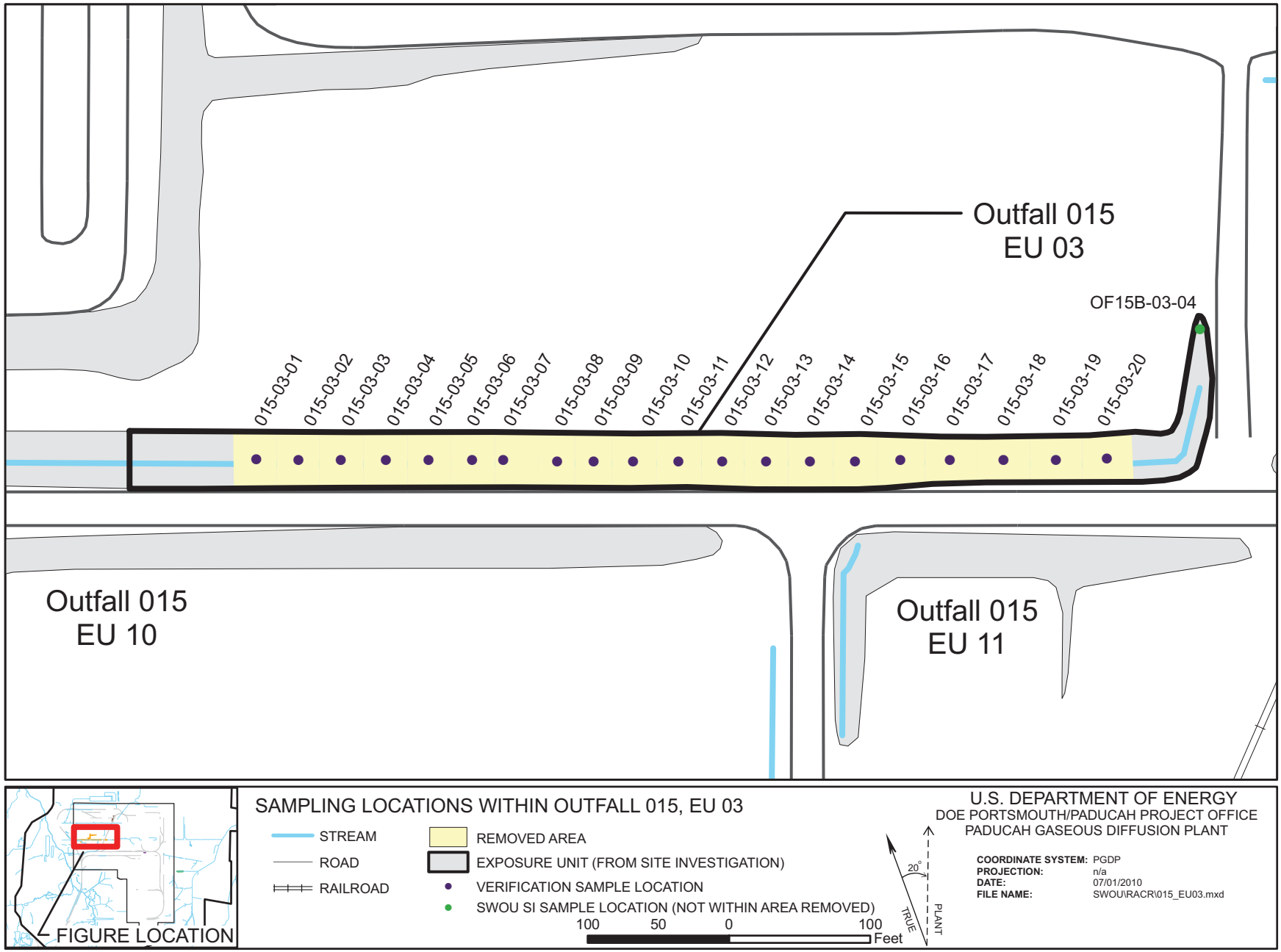

Figure C1.6. Sampling Locations within Outfall 015, EU 03

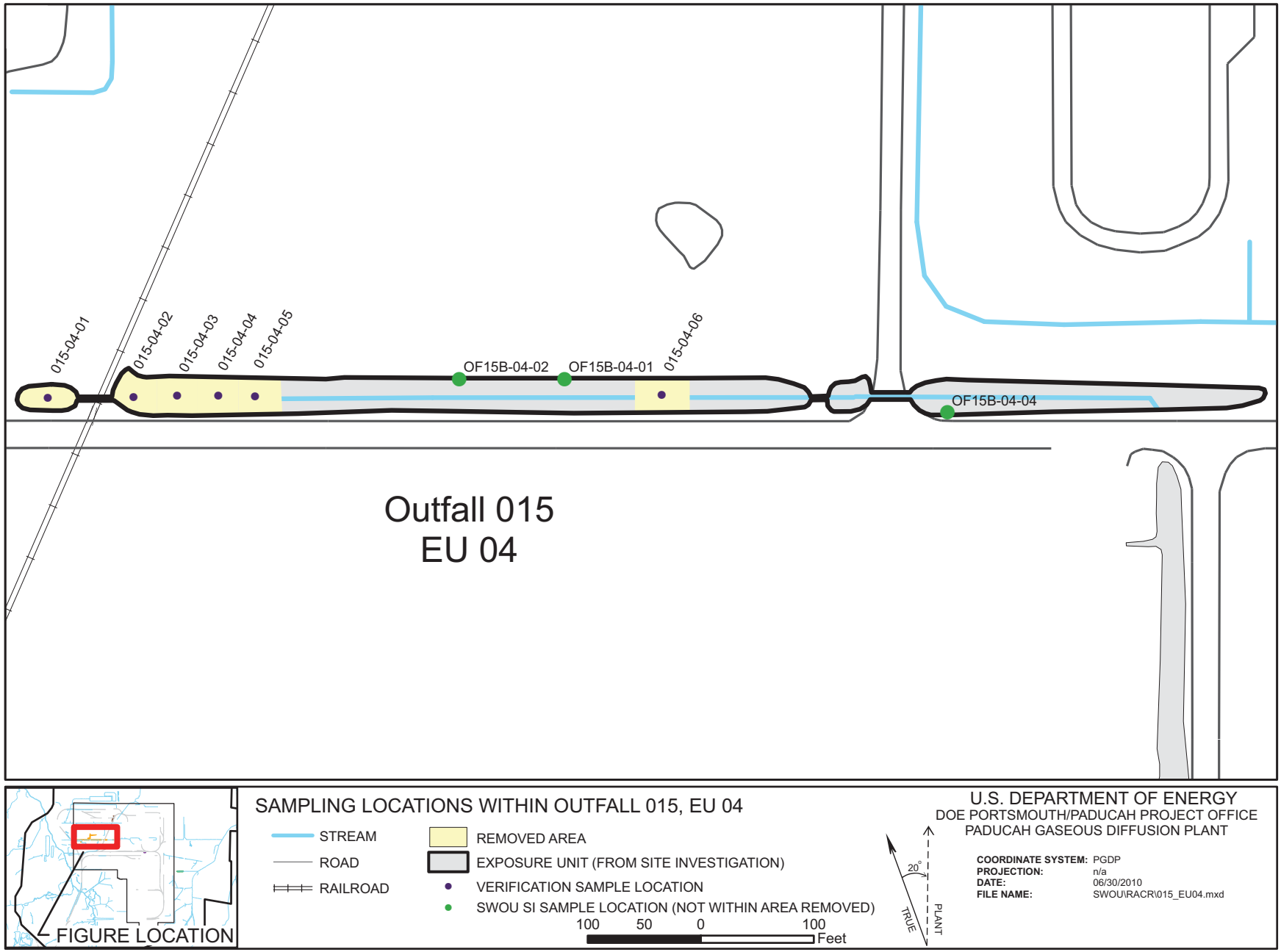

Figure C1.7. Sampling Locations within Outfall 015, EU 04

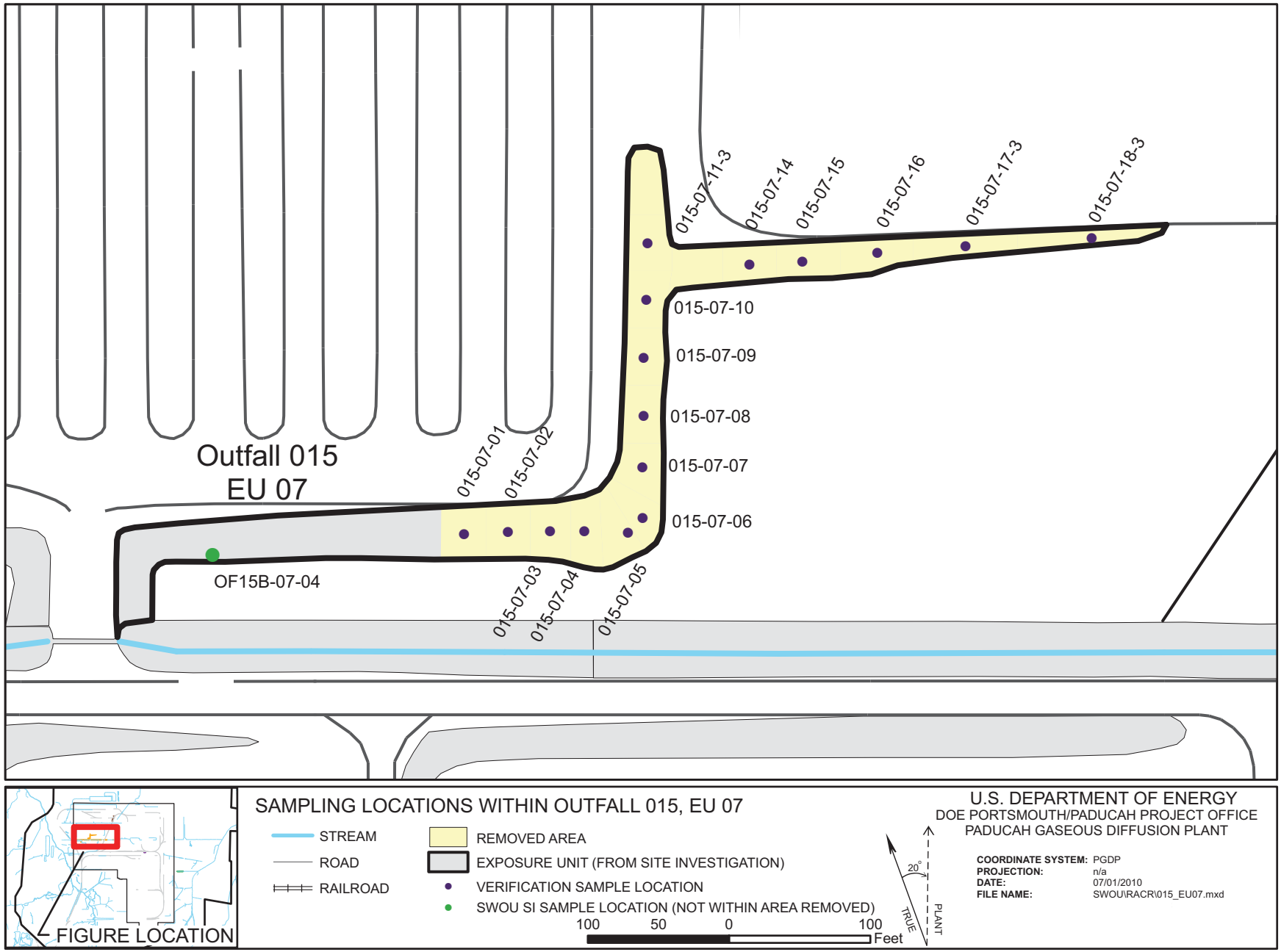

Figure C1.8. Sampling Locations within Outfall 015, EU 07

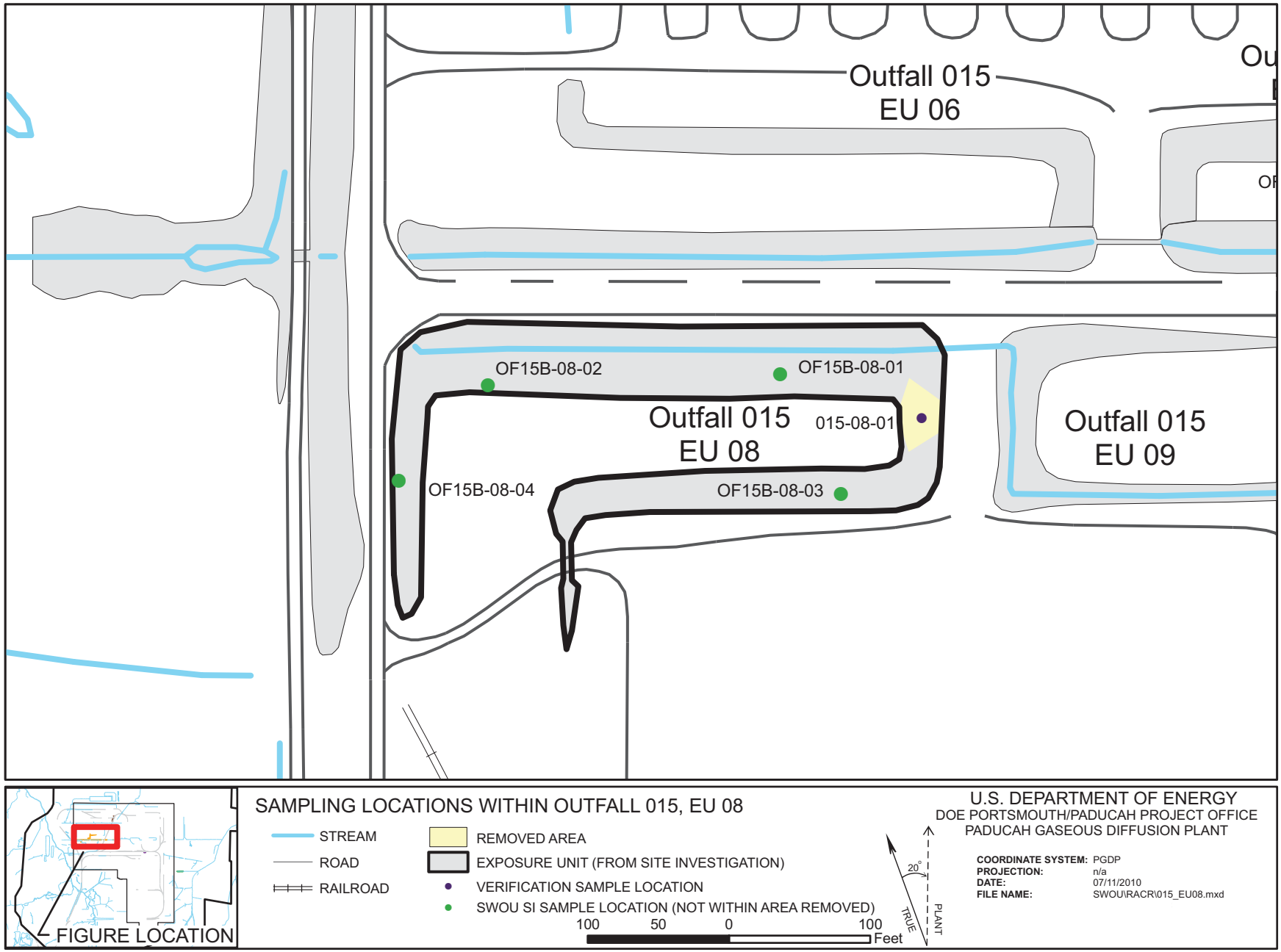

Figure C1.9. Sampling Locations within Outfall 015, EU 08

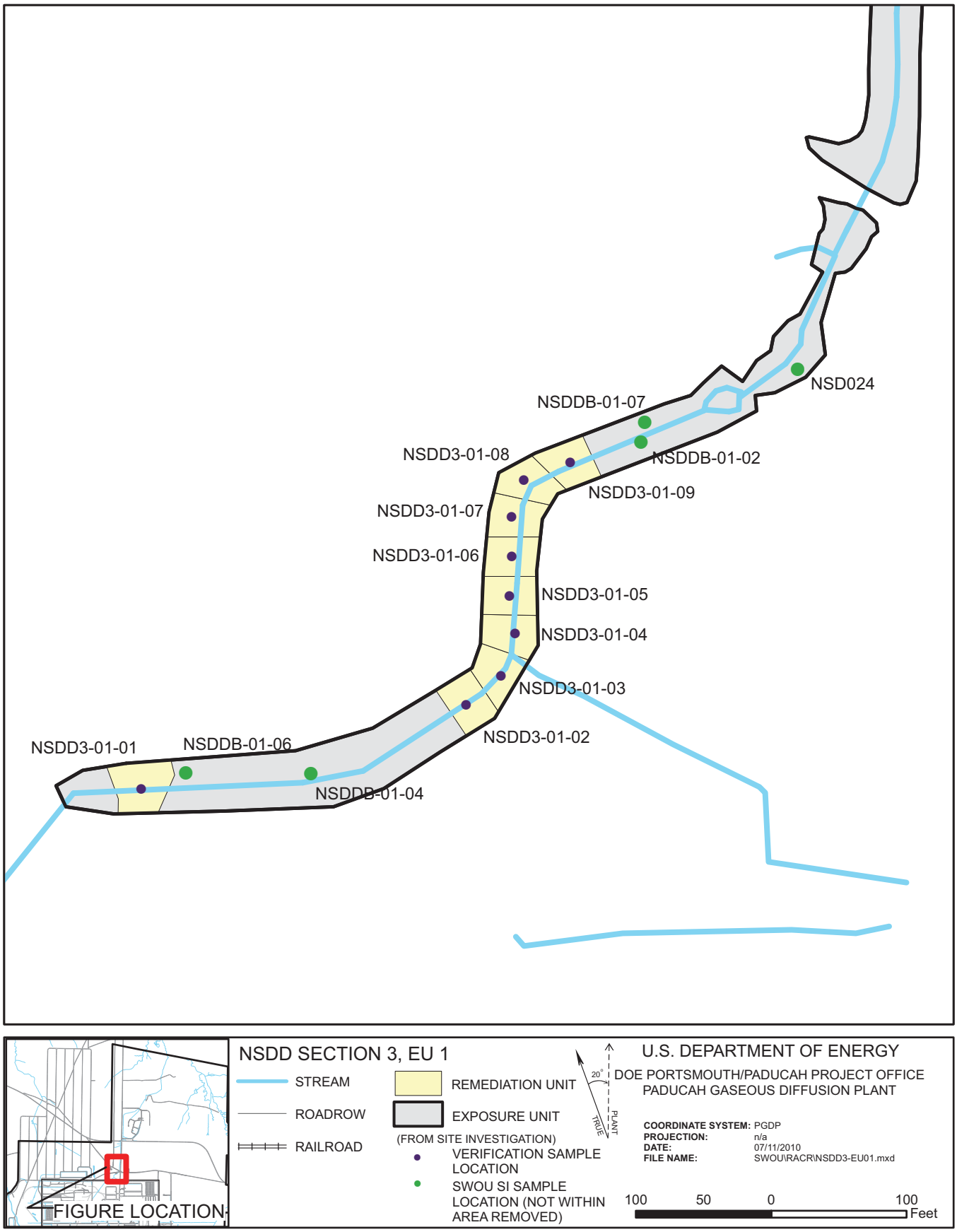

Figure C1.10. NSDD Section 3, EU 1

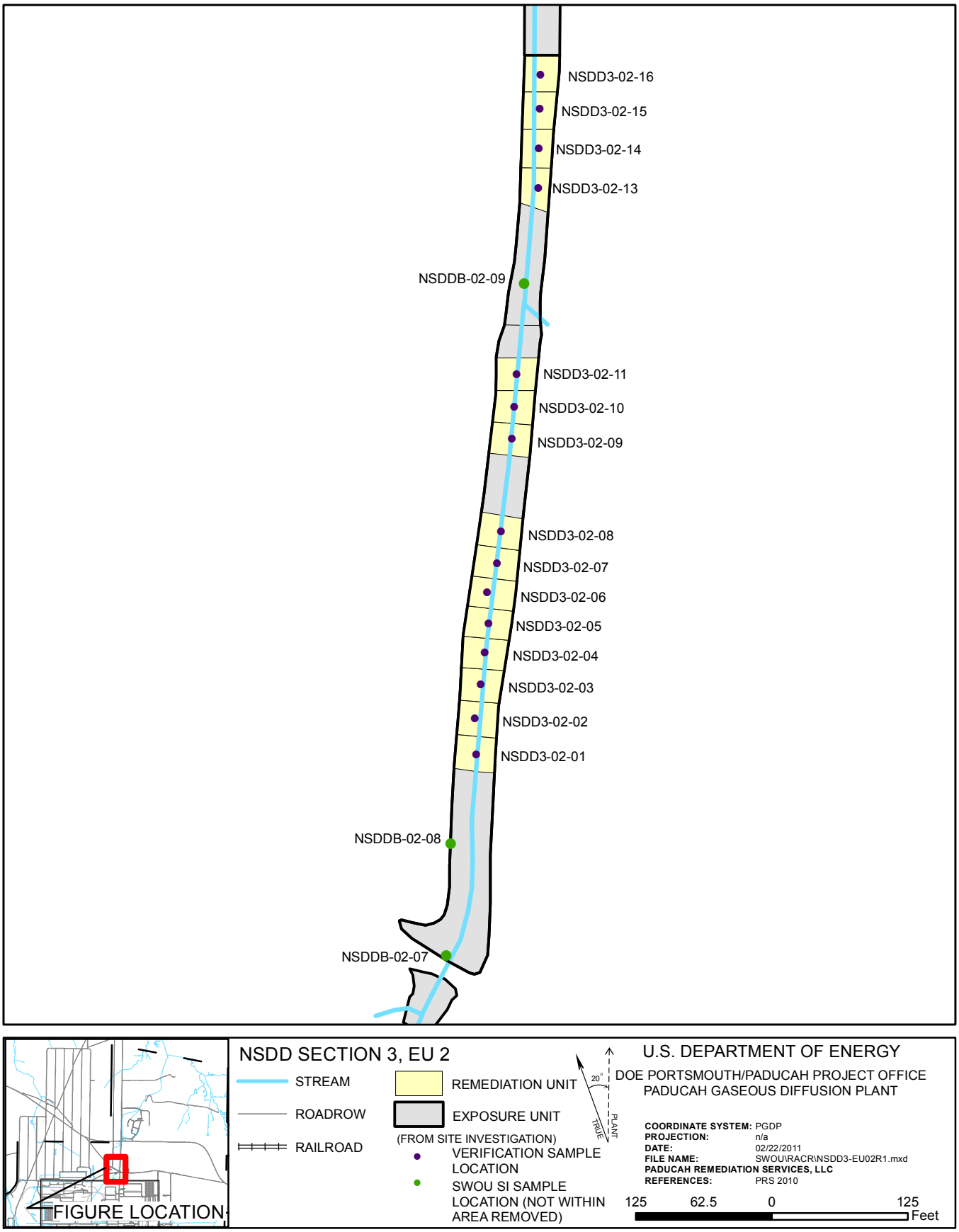

Figure C1.11. NSDD Section 3, EU 2

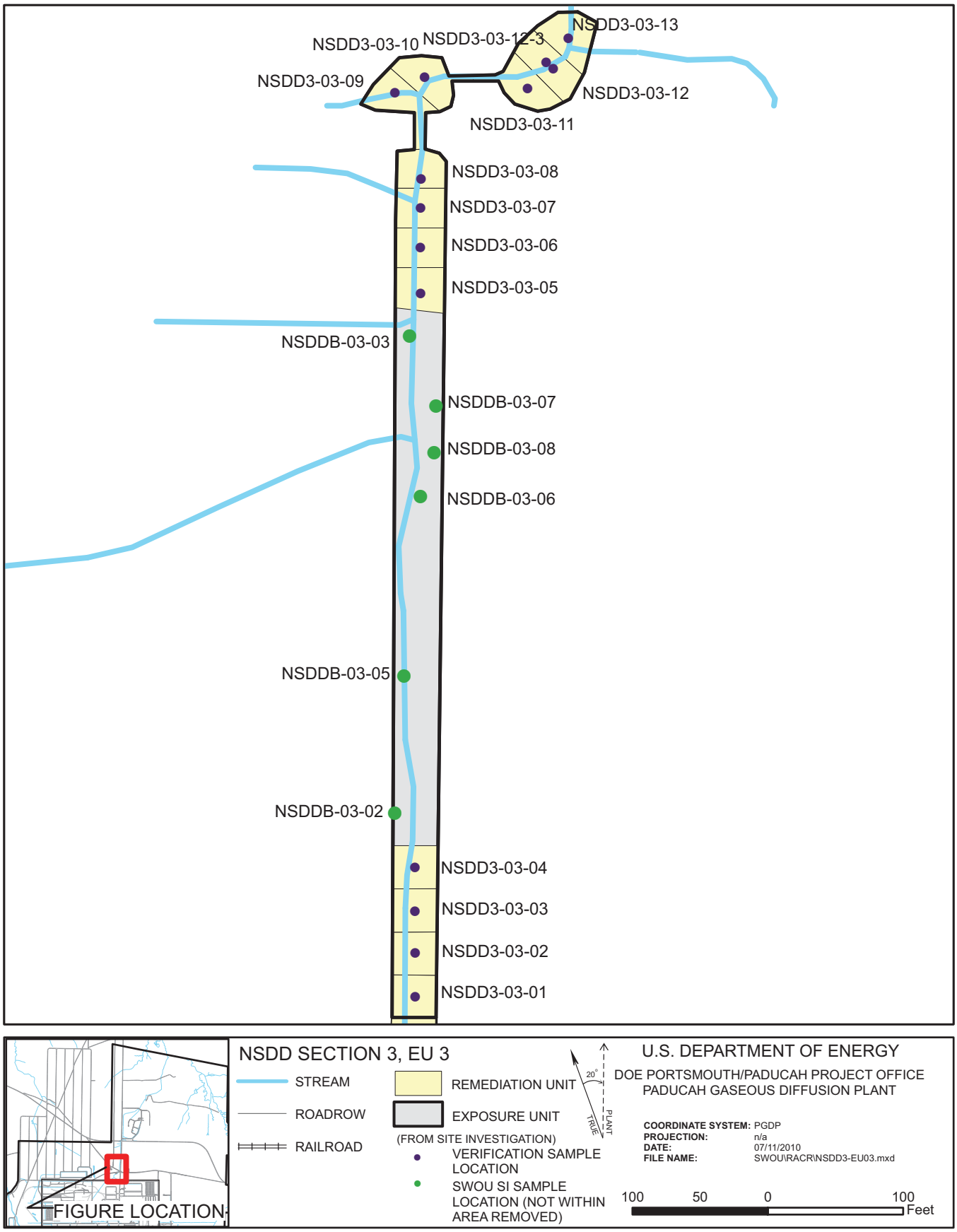

Figure C1.12. NSDD Section 3, EU 3

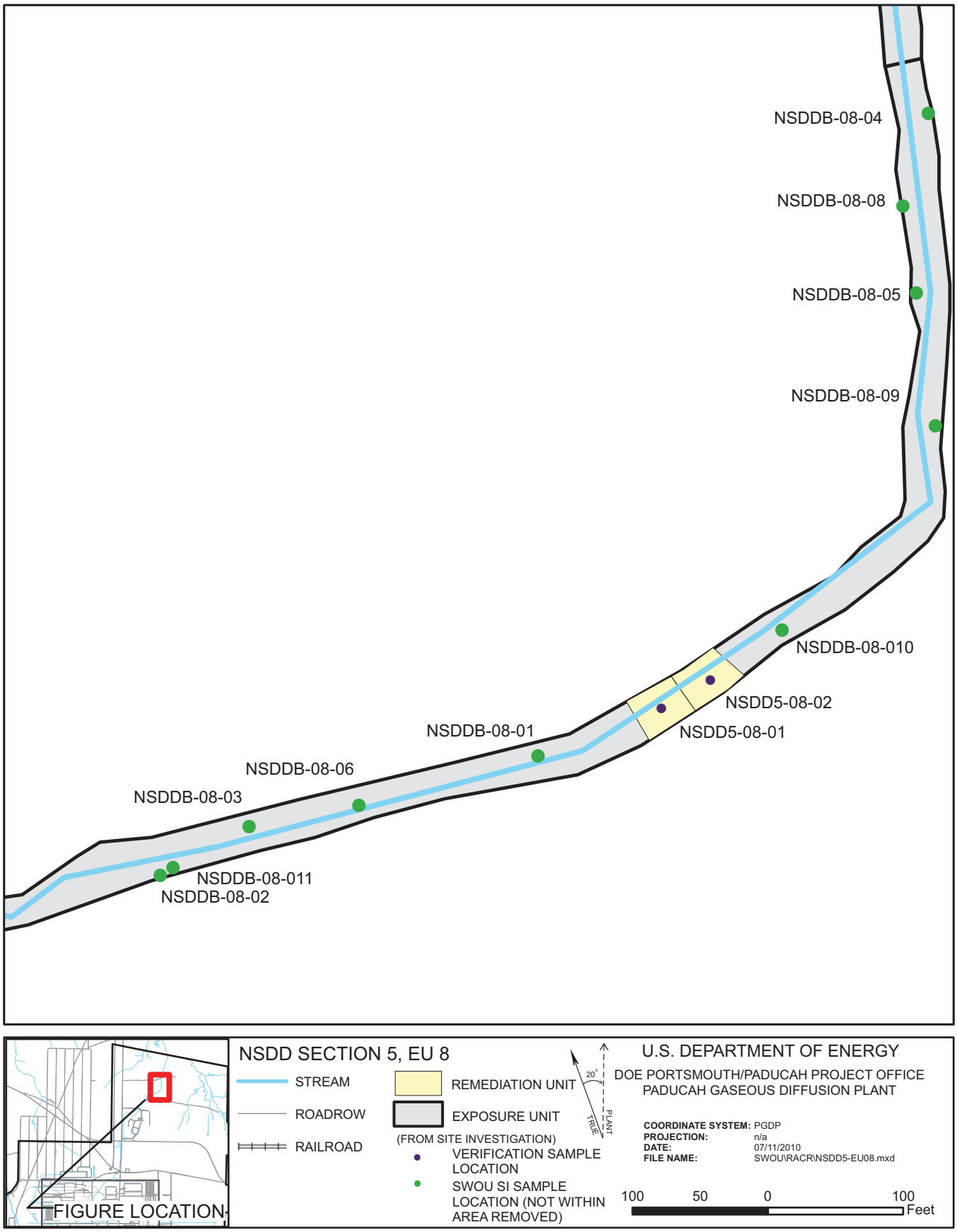

Figure C1.13. NSDD Section 5, EU 8

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APPENDIX D

CLEAN FILL VENDOR CERTIFICATION

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Martin Marietta Materials

3565 Lone Oak Road, Suite 4
Paducah, Kentucky 42003

Johnny L. Boyd
Sales Representative

Thursday, February 18, 2010

Dear Valued Customer:

We would like to thank you for the recent purchase of the channel lining rip rap being produced at our three Rivers Quarry located in Smithland KY. The Three Rivers Quarry is approved by several different states as well as the Corps of Engineers. The material is produced form state approved formations and is a well graded material free from any chemical contamination. If you have any other questions please feel free to contact me.

Sincerely,

Johnny L. Boyd
Martin Marietta Materials

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API Contractors

2950 Little Cypress Rd. • Calvert City, KY 42029
(270) 898-8090 • Fax (270) 898-8910

Submitted To	Phone	Date
LATA of Kentucky		**September 16, 2010**
Street	Job Name	
City, State, and Zip Code	Job Location	
Kevil, KY	**PGDP**	

Attn: Frank Overby

RE: Soil Letter

Frank,

The soil we are furnishing to LATA is excavated from a site we own that is original undisturbed soils. To the best of my knowledge, there is nothing that could be considered contaminated or debris containing. The only thing other than soils would be organic matter, weeds, grass, sticks, etc.

Sincerely,

Van Rudolph

VR:wd

Excel/MSJobs/LATA-General/Soil Letter 09-16-10

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APPENDIX E

PHOTOGRAPHS

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Figure E.1. Outfall 001 11-12-09 (Before)

Figure E.2. Outfall 001 11-12-09 (Before)

Figure E.3. Outfall 001 07-12-10 (During)

Figure E.4. Outfall 001 07-12-10 (During)

Figure E.5. Outfall 001 07-22-10 (After)

Figure E.6. Outfall 001 07-22-10 (After)

Figure E.7. Outfall 010 11-12-09 (Before)

Figure E.8. Outfall 010 06-25-10 (During)

Figure E.9. Outfall 010 07-12-10 (After)

Figure E.10. Outfall 011 11-12-09 (Before)

Figure E.11. Outfall 011 02-24-10 (During)

Figure E.12. Outfall 011 07-12-10 (After)

Figure E.13. Outfall 015, EU02 11-12-09 (Before)

Figure E.14. Outfall 015, EU02 11-12-09 (Before)

Figure E.15. Outfall 015 EU03 11-12-09 (Before)

Figure E.16. Outfall 015 EU03 11-12-09 (Before)

Figure E.17. Outfall 015 EU04 11-12-09 (Before)

Figure E.18. Outfall 015 EU04 11-12-09 (Before)

Figure E.19. Outfall 015 EU04 11-12-09 (Before)

Figure E.20. Outfall 015 EU07 11-12-09 (Before)

Figure E.21. Outfall 015 EU08 11-12-09 (Before)

Figure E.22. Outfall 015, EU 03 04-28-10 (During)

Figure E.23. Outfall 015, EU 03 04-28-10 (During)

Figure E.24. Outfall 015, EU 02 04-28-10 (During)

Figure E.25. Outfall 015, EU 02 07-12-10 (After)

Figure E.26. Outfall 015, EU 02/03 07-12-10 (After)

Figure E.27. Outfall 015, EU 03 07-12-10 (After)

Figure E.28. Outfall 015, EU 04 07-12-10 (After)

Figure E.29. North-South Diversion Ditch Section 3, EU 01 11-12-09 (Before)

Figure E.30. North-South Diversion Ditch Section 3, E U01 11-12-09 (Before)

Figure E.31. North-South Diversion Ditch Section 3, EU 02 11-12-09 (Before)

Figure E.32. North-South Diversion Ditch Section 3, EU 03 11-12-09 (Before)

Figure E.33. North-South Diversion Ditch Section 3, EU 03 11-12-09 (Before)

Figure E.34. North-South Diversion Ditch Section 3, EU 03 11-12-09 (Before)

Figure E.35. North-South Diversion Ditch Section 5 11-12-09 (Before)

Figure E.36. North-South Diversion Ditch Section 3 EU 02 3-26-10 (During)

Figure E.37. North-South Diversion Ditch Section 3 EU 02/03 03-26-10 (During)

Figure E.38. North-South Diversion Ditch Section 3 EU 03 03-26-10 (During)

Figure E.39. North-South Diversion Ditch Section 3 EU 01 07-13-10 (After)

Figure. E.40. North-South Diversion Ditch Section 3 EU 02 07-13-10 (After)

Figure E.41. North-South Diversion Ditch Section 3 EU 03 07-13-10 (After)

Figure E.42. North-South Diversion Ditch Section 5 07-13-10 (After)

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REMOVAL ACTION REPORT FOR CONTAMINATED SEDIMENT ASSOCIATED WITH THE SURFACE WATER OPERABLE UNIT (ON-SITE) AT THE PADUCAH GASEOUS DIFFUSION PLANT, PADUCAH, KENTUCKY

Description of the Removal Action Implemented

As documented in the approved *Removal Notification for the Surface Water Operable Unit Removal Action Unit (On-Site) at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-0011; the *Engineering Evaluation/Cost Analysis for Contaminated Sediment Associated with the Surface Water Operable Unit Removal Action Unit (On-Site) at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-0012; and the subsequent *Action Memorandum for Contaminated Sediment Associated with the Surface Water Operable Unit (On-Site) at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-0119&D2/R1, a non-time-critical removal action for the Surface Water Operable Unit (SWOU) (On-Site) was warranted. The specific areas or defined units called exposure units[1] (EUs) are located within the Paducah Gaseous Diffusion Plant (PGDP) at PGDP Outfalls 001, 008, 010, 011, and 015 and their associated internal ditches and specific areas or EUs located within the North-South Diversion Ditch (NSDD) Sections 3 and 5 that contained contaminated soils and sediments. Each EU is further subdivided into remediation units[2] (RUs) and the RUs are further divided into survey units[3] (SUs).

In support of this report, the following appendices are included.

- Appendix A Figures (e.g., Excavation Locations)
- Appendix B Data Tables
- Appendix C Residual Risk Evaluation
- Appendix D Clean Fill Vendor Certification
- Appendix E Photographs

As documented in the Engineering Evaluation/Cost Analysis, direct contact with sediment was the exposure pathway of concern at the site, and, as a result, removal of contaminated sediment was the primary focus of the removal action. A complete listing of the contaminants of concern (COCs) can be found in Appendix C, Residual Risk Evaluation, Table C.1, of this report. In addition to removal of sediment contaminated with COCs, areas from which total excess lifetime cancer risk (ELCR) exceeded a target of 1E-05 also were removed.

The Removal Action Objectives (RAOs) for this removal action are consistent with the overall RAOs for the SWOU and meet the intent of the Section X, Removal Actions, of the Federal Facility Agreement (FFA). The RAOs for this action are as follows:

[1] An EU is defined as approximately 0.5 acres.
[2] An RU is defined as approximately 1,225 ft^2 (100m^2).
[3] An SU is defined as approximately one-fourth of a RU or 269 ft^2 (25m^2).

- Ensure direct contact risk at the on-site ditches for the current industrial worker falls within the U.S. Environmental Protection Agency (EPA) risk range.

- Ensure direct contact risk at the NSDD for both the current industrial worker and recreational user falls within the EPA risk range.

Completion of this removal action reduces the risk to current and future workers, excavation workers, and recreators from direct contact by removing known sources of contamination. Appendix C provides the residual risk analysis for the complete listing of COCs, as found in Table C.1.

Summaries of Results

Under this action, identified hot spots were removed and verification of cleanup was conducted.

As documented in the RAWP, Appendix F, F.3. Field Sampling Plan, surrogate COCs were used during the removal action surveys. This decision is supported by *Co-Contamination Study for the Removal of Contaminated Soil and Sediment Associated with the Surface Water On-Site.* This study indicates that the surrogate use of the chemicals and action levels listed in Table 1 during the evaluation of postexcavation samples provides an acceptably low-level of failure during the evaluation of verification samples. (Failure is defined as the chance that postexcavation samples will contain COCs at concentrations that exceed cleanup levels.)

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Table 1. Surrogate COCs

On-Site Ditches	
Total PCB	10 mg/kg
Cesium-137	5 pCi/g
Uranium-238	65 pCi/g
Uranium	150 mg/kg
NSDD	
Total PCB	10 mg/kg
Thorium-230	100 pCi/g
Uranium	150 mg/kg

Once all the surrogate COC concentrations were less than or equal to the action levels in postexcavation samples, excavation was deemed complete and cleanup level samples were obtained for verification that the cleanup level for all COCs have been achieved.

Each outfall (001, 008, 010, 011, and 015, and its associated internal ditches and areas within PGDP) and the NSDD are discussed here. Figures showing the site locations are included in Appendix A. The following discussion refers to many units and subunits within each outfall and/or ditch, and the enclosed figures (Appendix A) can be used in conjunction with the text to aid in understanding the discussion.

Outfall 001

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At Outfall 001, EU 15, containing 10 RUs over an area of approximately 1,240 yd^2, was to be excavated. Prior to conducting work at this location, additional preexcavation samples similar to those specified in the removal action work plan (RAWP) were collected to confirm the presence of contamination within the 10 RUs of Outfall 001and, as a result, four of the 10 RUs (RUs 02, 08, 09, and 10) were not

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excavated. This methodology was discussed and agreed upon with the regulators during an FFA Managers Meeting on June 17, 2010.

Uranium was the surrogate COC at Outfall 001, EU 15, Area 2 [at Area 1, polychlorinated biphenyl (PCB) was the surrogate COC] and during the planning process, the extent of contamination in Area 2 had been established based on just two total uranium results, one elevated and one not elevated (642 mg/kg and 8 mg/kg, as compared to a cleanup criteria of 227 mg/kg). In an effort to define more clearly the horizontal extent of contamination at Area 2, sampling was undertaken in this area utilizing the postexcavation sampling protocol specified in the RAWP. The results of this sampling effort indicated that contamination above the total uranium action limit of 150 mg/kg was limited to the northern half of RU 03 and RUs 04–07. Verification sample results for uranium confirmed that RUs 02 and 08–10, as well as the southern half of RU 03, are not impacted above the cleanup level of 227 mg/kg total uranium. Additionally, sample results indicated that in all RUs within Area 2, all COCs, except uranium and uranium-238 (U-238), were below their respective cleanup levels. Figure A.3 found in Appendix A shows the results of this sampling effort, and Appendix B includes the data results in Tables B.1.1 and B.1.2. Sample locations are shown in Figure C1.1 found in Appendix C.

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In light of the foregoing, a revised approach to Outfall 001, Area 2, was proposed and agreed to at the June 17, 2010, FFA Managers Meeting. Excavation would be limited to those RUs that were impacted above the action limit of 150 mg/kg for total uranium. This included the northern half of RU 03 and RUs 04, 05, 06, and 07. The southern half of RU 03 and RUs 02, 08, 09, and 10 were not excavated because the data show that these areas are not impacted above the action limits or the cleanup levels.

At the five RUs addressed under this action, one RU, RU 6, was excavated to 2 ft. The remaining RUs were excavated to 3 ft at some SUs and 4 ft at other SUs (see Figure A.4). The walkover survey results and the field screening results indicate that all RUs were remediated to below their respective action levels (65 pCi/g for U-238, 5 pCi/g for Cs-137, 150 mg/kg for total uranium, and 10 mg/kg for PCBs), and verification sample results indicate that the cleanup levels have been achieved. Additionally, two field screen samples collected from the surface at the southern half of RU 03 (the portion not excavated) indicate that the surrogate COC concentrations are below the action levels. Figure A.4, found in Appendix A, shows the final excavation limits, and the data results are included in Appendix B, Tables B.1.1 and B.1.2. Photographs of the excavation area before, during, and after the removal action are shown in Figures E.1 through E.6 in Appendix E.

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At Outfall 001, 926 yd^3 of soils were removed; 501 yd^3 were disposed of at Energy*Solutions* in Clive, Utah; and 425 yd^3 were disposed of at the C-746-U Landfill.

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Outfall 008

At Outfall 008, EU 11, containing two RUs, over an area of approximately 200 yd^2, was excavated. Soils were removed to a depth of 2 ft at this location.

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At the two RUs excavated under this action, the walkover survey results and the field screening results indicate that all RUs were remediated to below their respective action limits, and verification sample results indicate that the cleanup levels have been achieved. Figure A.5, found in Appendix A, shows the final excavation limits, and Appendix B includes the data results in Tables B.2.1 and B.2.2. Sample locations are shown in Figure C1.2 found in Appendix C.

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At Outfall 008, 244 yd^3 of soils were removed and disposed of at Energy*Solutions* in Clive, Utah.

No problems were encountered at Outfall 008, and no deviations from the Work Plan were required during performance of the work.

Outfall 010

At Outfall 010, EU 1, containing four RUs over an area of approximately 400 yd^2, was excavated. Soils were removed to a depth of 2.5 ft at three of the RUs, and 2 ft at one RU.

A French drain was encountered at the south end of the outfall (along Tennessee Avenue) at a depth of 2 ft-6 inches. As a result, work at Outfall 010 was suspended until repair/replacement could be arranged. Repair/replacement was considered necessary to ensure the continued stability of Tennessee Avenue. When work resumed at the site in June 2010, the decision was made to remove an additional 6 inches from the three RUs that had been remediated in January and to resample each. The French drain also was removed at this time (to native soils or 2 ft-6 inches below ground surface).

The walkover survey results and the field screening results indicate that all RUs were remediated to below respective action limits, and verification sample results indicate that the cleanup levels[6] had been achieved. Twelve samples also were collected beneath the French drain (one every 10 ft). One sample exceeded 10 ppm PCB (as indicated by field analyses), resulting in an additional 6 inches of excavation, subsequently followed by a sample that was below 10 ppm PCB (as indicated by field analyses). The additional excavation was from one clean sample to the next clean sample, encompassing the one area that exceeded the PCB thresholds of 10 ppm. One verification sample also was collected beneath the former French drain. These results likewise show that this area was remediated to below action limit and cleanup levels[6] for the site. Figure A.6, found in Appendix A, shows the final excavation limits, and the data results are included in Appendix B, Tables B.3.1 and B.3.2. Sample locations are shown in Figure C1.3 found in Appendix C. Photographs of the excavation area before, during, and after the removal action are shown in Figures E.7 through E.9 in Appendix E.

At Outfall 010, 642 yd^3 of soils were removed and disposed of at Energy*Solutions* in Clive, Utah.

Outfall 011

At Outfall 011, one EU containing 14 RUs, over an area of approximately 1,500 yd^2, was excavated. Initially, soil/sediment was removed to 2 ft below grade. During Activity 1 (i.e., field screening) sampling, the walkover surveys indicated that consistently elevated levels of uranium were present at 2 ft below grade. A decision was made to excavate all 14 RUs identified within Outfall 011 an additional ft to 3 ft below grade before conducting additional Activity 1 sampling.

After excavation to 3 ft, 13 of the 14 RUs had achieved the site cleanup goals. One SU, within RU 01, at the northwest corner of Outfall 011, did not. Excavation of an additional ft, to a depth of 4 ft, was performed within this SU. While field screen results at the 4-ft depth indicated that uranium levels continued to exceed the action limits, the verification sample results show that the RU had achieved cleanup goals. Walkover survey results at RU 01 indicated that contamination extended further to the west than the defined limits of excavation (i.e., beyond the bounds of RU 01). Excavation of this area was postponed until such time as a path forward was determined. Once a plan was developed to address the contamination outside the boundary of RU 01, excavation on the west side of Outfall 011 resumed on June 9, 2010. At this time, an area approximately 450 ft^2 was excavated to a depth of 4 ft, yielding an additional 76 yd^3 of soils for disposal. Additional field screens and verification samples were collected, the results indicate that action limit and cleanup goals[7] were achieved in this area outside the boundary of RU 01, west of RU 01.

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Figure A.7, found in Appendix A, shows the final excavation limits, and the data results are included in Appendix B, Tables B.4.1 and B.4.2. Sample locations are shown in Figure C1.4 found in Appendix C. Photographs of the excavation area before, during, and after the removal action are shown in Figures E.10 through E.12 in Appendix E.

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In Outfall 011, 3,900 yd^3 of soil, sediment, and debris were removed. Of this, 457 yd^3 was disposed of at Energy*Solutions* in Clive, Utah; and 3,443 yd^3 was disposed of at the C-746-U Landfill.

Outfall 015

At Outfall 015, five EUs containing 67 RUs, over an area of approximately 8,800 yd^2, were excavated. At the majority of the RUs, soil/sediment was removed to a depth of 2 ft. Some RUs were excavated to 3–4 ft. Specifically, RU 03 in EU 03 was excavated an additional 1 ft due to elevated cesium at the 2-ft depth; RU 12 in EU 02 was excavated an additional 1 ft due to elevated uranium (total and U-238); and RUs 14–18 (inclusive) in EU 07 were excavated an additional 2 ft due to elevated uranium in the field screen samples. Additionally, some SUs were excavated an additional 1 ft based on walkover survey results.

Upon completion of excavation, the X-ray fluorescence (XRF) and PCB field screening results indicate that the all RUs were remediated to below respective action limits of 150 mg/kg uranium and 10 mg/kg total PCB, with the exception of one SU at EU 07, RU 17, which had an XRF result for uranium of 349 mg/kg at 4 ft (the verification result for uranium for this RU indicated 2.4 mg/kg uranium).

Walkover surveys were not performed at EU 03, RUs 09–14, because the banks were considered unstable and not safe for workers.

No problems were encountered and no deviations were required from the RAWP for EU 04 and EU 08. EU 04 was excavated for total ELCR and EU 8 was excavated for PCB contamination.

Verification sample results indicate that the cleanup levels had been achieved at all RUs at Outfall 015. Figure A.8, found Appendix A, shows the final excavation limits, and the data results are included in Appendix B, Tables B.5.1 and B.5.2. Sample locations are shown in Figures C1.5 through C1.9 found in Appendix C. Photographs of the excavation area before, during, and after the removal action are shown in Figures E.13 through E.28 in Appendix E.

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Yellow/green-stained soils and gravel were encountered on the south wall of the excavation at Outfall 015, EU 07, RU 16. After the excavation was backfilled, the seam was delineated on August 31, 2010, by using direct push technology. Cores from 11 locations at depths of approximately 10 ft each, south of the excavated area, were collected. The cores were surveyed, radiologically and visually, and only one of the 11 cores (closest to the previously exposed seam) identified the yellow/green stained soils with radiological readings above instrument background (seam was present in the 2–4 ft level below ground surface). The area investigated was less than 500 ft^2 and resulted in identifying the seam approximately 8 ft by 3 ft by 1 ft adjacent to the previously exposed excavation at Outfall 015, EU 07, RU 16. Removal of these soils took place on September 14/15, 2010, and resulted in an additional 34 yd^3 of soil that was disposed of at Energy*Solutions* facility in Clive, Utah. XRF and PCB samples were collected below the excavation and resulted in less than 150 mg/kg uranium and less than 10 ppm PCBs.

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At Outfall 015, 10,009 yd^3 of soil, sediment, and debris was removed. Of this, a total of 4,983 yd^3 was disposed of at Energy*Solutions* in Clive, Utah; and a total of 5,026 yd^3 was disposed of at the C-746-U Landfill.

NSDD Sections 3 and 5

At NSDD, four EUs (EUs 01, 02, 03, and 08) containing 40 RUs, over an area of approximately 5,200 yd^2, was addressed. At the majority of the RUs, soil/sediment was removed to a depth of 2 ft. Two RUs (RUs 11 and 12 at EU 03), were excavated to 3 ft based on elevated gross alpha results. RU 12 was excavated an additional ft upon receipt of verification sample results that indicated Th-230 levels were present in the area above the cleanup goals. One RU (RU 12 at EU 02) was not addressed due to the presence of a high pressure gas line immediately underneath, an area approximately 1,225 ft^2. Sampling results—collected previously from areas not excavated and from areas excavated—were used in the risk evaluation for this EU. The residual risk for this EU was below the cumulative risk goal; therefore, the inability to excavate the area around the gas line did not affect the attainment of the project's RAO. Lastly, RUs that extended into Ogden Landing Road (including RUs 08, 09, and 11 in EU 03) were excavated by sloping at 1:1 from the edge of the road so as not to impair the stability of the road.

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Activity 1 (i.e., field screening) uranium and PCB field screening sampling was performed at NSDD, as described in the RAWP; however, gross alpha analyses, from samples collected from the center of each SU, with the application of a conservative assumption that all gross alpha activity be considered Th-230, were substituted for the walkover surveys that were specified in the Work Plan. This modification was implemented because of the inability to reliably quantify Th-230 at the action limit of 100 pCi/g. The following is the reason Th-230 cannot be quantified reliably, as described in the Work Plan.

Typical radiological methods for detection of radionuclides in a field setting depend upon the ability to detect gamma radiation emitted from a radionuclide or its daughters. Th-230, which primarily decays by the emission of an alpha particle, does not emit gamma or X-ray radiation at a sufficient quantity or energy to facilitate its direct detection in a field setting. Alpha particles are attenuated by soil, moisture, and debris and, when coupled with their very short range, this makes them unsuitable for measurement of radioactivities in a field setting. While Th-230 does not emit reliably detectable gamma radiation, its daughter, Ra-226, has a very high energy gamma ray that is emitted at a readily usable yield. Because of the detectability of Ra-226, it is possible to use field techniques to quantify *naturally occurring* Th-230 using the Ra-226 daughter which, in nature, exists in equilibrium with the Th-230 parent (i.e., Ra-226 is used as a surrogate for Th-230 because the equilibrium is constant).

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PGDP received uranium feed material that had been separated chemically and converted from its natural form. As a result of the separation and conversion process, the uranium daughters, which naturally are found to be in equilibrium, were separated and removed from the feed stream. Additionally, the processes employed at PGDP produced uranium residuals from the feed stream that generated various radionuclides in various proportions generally not found in nature. The U-234 and Th-230 daughters (including Ra-226) that ultimately will equilibrate with the parent are produced slowly and will not reach equilibrium for many thousands of years. In other words, the processes imposed upon the uranium utilized at PGDP that resulted in the generation of Th-230 disrupted the natural equilibrium between the Th-230 parent and its daughter Ra-226.

While it may be possible to quantify *naturally occurring* levels of Th-230 through the detection of gamma rays emitted by the Ra-226 daughter, in the case of NSDD, this does not provide a reliable mechanism for quantification of PGDP-derived (i.e., not naturally occurring) Th-230. Due to the separation and conversion processes, equilibrium of long-lived daughters, such as Th-230 and Ra-226, has not been achieved; therefore, any measurement of Th-230 using Ra-226 as a surrogate would bias negatively the reported activity of Th-230.

To illustrate this point, an analysis was performed to calculate the activity of Ra-226 from a Th-230 parent, assuming a 50-year in-growth period. For a Th-230 activity of 100 pCi, the Ra-226 activity after 50 years would be 2.1 pCi. This level is comparable to naturally occurring Ra-226 and is not practically achievable in a field setting as that found in the NSDD. A review of sampling data for Ra-226 in the NSDD confirms that there are no areas of detectable Ra-226 in excess of 2.2 pCi/g.

At the completion of excavation activities, the gross alpha and field screening results indicated that all RUs that were excavated were below the respective action limits, and verification sample results indicated that the cleanup levels had been achieved. Figures A.9 through A.11 show the final excavation limits and are included in Appendix A. Appendix B includes the data results in Tables B.6.1 and B.6.2. Sample locations are shown in Figures C1.10 through C1.13 found in Appendix C. Photographs of the excavation area before, during, and after the removal action are shown in Figures E.29 through E.42 in Appendix E.

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From NSDD Sections 3 and 5, a total of 6,956 yd^3 of soil, sediment, and debris was removed. Of this, 5,690 yd^3 was disposed of at Energy*Solutions* in Clive, Utah; and 1,266 yd^3 was disposed of at the C-746-U Landfill.

General

Backfilling and site restoration were conducted following excavation by using a track hoe excavator and a tracked skid-steer loader for placement of the cover material. Both the tracks and the buckets of the equipment were used to compact the cover material once it was in place. Final grading was accomplished with the skid-steer loader and hand tools working to grade stakes installed by a local engineering firm. Generally, the cover material consisted of soil, as discussed in the next paragraph; however, in areas where the existing slope had been too steep to allow for placement of soil, areas were backfilled with riprap. Riprap was used for portions of Outfall 011 and NSDD Section 3 and all of NSDD Section 5.

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Clean backfill that was generated as part of the construction of the Northwest Storm Water Collection Basin in 2001 was brought in for site restoration. The backfill material utilized for the SWOU Remedial Action was the same material as referenced in the Soils Operable Unit Inactive Facilities Removal Action Report D1 as submitted on August 4, 2010.

Clean riprap was used at Outfall 001, Outfall 011, and NSDD. The vendor of this product provided certification as to the uncontaminated nature of the fill. This certification is included as Appendix D. Restoration also included replacement of the French drain at Outfall 010. In addition, off-site clean fill (soil) was brought in for backfilling the seam area at Outfall 015 ditch, EU 07, RU 16, and a certification is included in Appendix D.

Refer to Appendix E for photographs showing the condition of the excavation areas following restoration. Consistent with the RAWP, inspections and site maintenance will continue to control erosion until the affected areas are stable.

Verification of Cleanup

The enclosed data tables (Appendix B) show a comparison of the ELCR-based and hazard index (HI)-based cleanup levels to the sampling results. Appendix C addresses residual risk associated with the excavated EUs.

Comparison of Cleanup Levels to Sampling Results

At Outfalls 001, 008 and 010, all sample results show that cleanup levels had been met at these locations.

One sample at Outfall 011 did not achieve the cleanup levels (OF011-01-01-V-3). This area subsequently was excavated one additional ft. Sample OF011-01-01-V-4a, collected at the 4-ft depth, at the completion of excavation, is representative of the soils remaining at RU 01. This sample indicates that the area achieved the cleanup goals for the site.

At Outfall 015, two samples, OF015-07-12-V-2 and OF015-03-03-V-2, did not achieve the cleanup levels. These areas subsequently were excavated one additional ft, and samples OF015-07-12-V-3 and OF015-03-03-V-3, collected at the 3-ft depth at the completion of excavation, are representative of the soils remaining at EU 07, RU 12 and EU 03, RU 03, respectively. These sample results indicate that the area achieved the cleanup goals for the site.

Yellow/green-stained soils and gravel were encountered on the south wall of the excavation at Outfall 015, EU 07, RU 16. XRF and PCB samples were collected below the excavation and resulted in less than 150 mg/kg uranium and less than 10 ppm PCBs.

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At NSDD, only two samples did not achieve the cleanup levels (NSDD3-03-12-V-2 and NSDD3-03-12-V-3). Both of these samples were collected at RU12 at EU 03 in the NSDD (one at the 2-ft depth, the other at the 3-ft depth). This area subsequently was excavated one additional ft. Sample NSDD3-03-12-V-4, collected at the 4-ft depth at the completion of excavation, is representative of the soils remaining at RU12 at EU 03. This sample indicates that the area achieved the cleanup goals for the site.

In summary, upon completion of all excavation activities, all RUs that were addressed under this removal action were remediated to below the cleanup levels established for this action for all COCs, as specified in Table 1 of the RAWP.

Risk Evaluation

Appendix C presents the residual risk that remains at PGDP Outfalls 001, 008, 010, 011, and 015, and their associated internal ditches, and Sections 3 and 5 of the NSDD after completion of the removal action. Results of the risk evaluation indicate that the cumulative ELCR and HI for COCs from EUs with excavated hot spots and areas identified in the RAWP within PGDP Outfalls 001, 008, 010, 011, and 015, and their associated internal ditches, and Sections 3 and 5 of the NSDD achieved the RAO of a cumulative ELCR of 1E-05 and a cumulative HI of 1.0. A complete listing of the COCs can be found in Appendix C, Residual Risk Evaluation, Table C.1 of this report.

As a result, the overall RAO for this project, to reduce the direct contact risk to the current and future industrial worker and recreational user within the EPA risk range, was achieved.

Summaries of Problems Encountered

Deviations from the RAWP were minor field changes as discussed above and as summarized below.

Outfall 001

No problems were encountered during excavation of Outfall 001. As indicated previously, with concurrence of the FFA managers, RUs 02, 08, 09, and 10 in Area 2 were not excavated because the data show that these areas are not impacted above the action limits or cleanup levels.

Areas where the existing slope had been too steep to allow for placement of soil were backfilled with riprap. Clean riprap was used at Outfall 001, Outfall 011, and NSDD.

Outfall 008

No problems were encountered at Outfall 008, and no deviations from the Work Plan were required during performance of the work.

Outfall 010

A French drain was encountered at the south end of the outfall (along Tennessee Avenue) at a depth of 2 ft-6 inches. The French drain was removed to a depth of 2 ft-6 inches; samples were collected from underneath the system; and the French drain replaced with 4-inch perforated polyvinyl chloride surrounded by #9 gravel, fabric filter, and flowable fill.

Due to the length of time between beginning and completing excavation in this area, the three RUs that were excavated in January (RUs 01, 02, and 03) were excavated an additional 6 inches and resampled to ensure that any contamination that had moved between RUs was removed.

Outfall 011

Contamination extended beyond the bounds defined in the Work Plan at the west end of the outfall. The contamination was addressed by removing soils/sediments in this area and extending the horizontal limits of excavation outside the bounds of RU 01. See Figure A.12 for actual excavation limits (Appendix A).

Often there was a discrepancy between the walkover survey results for uranium and the XRF results for uranium. It has been speculated that lack of reliability of the walkover survey may be due to the walkover results being biased high, and geometry of Outfall 011 (i.e., steep sidewalls) can elevate the results from field instruments and provide false positives. In all cases where the walkover survey results and the XRF results did not agree, the XRF results were considered the valid results.

Outfall 015

Yellow/green stained soils and gravel were encountered on the south wall of the excavation at Outfall 015, EU 07, RU 16. These soils, as discussed previously, were delineated and removed. After excavation to 4 ft at Outfall 015, EU 07, RU 16, field screen sample results and the verification sample indicate that action limits and cleanup goals were achieved at this RU, as well at as the surrounding RUs.

In some cases, the walkover survey results were ambiguous. It is believed that walkover results are biased high, and geometry, such as steep banks, can elevate the results from field instruments and provide false positives. Consequently, when there was a discrepancy between the walkover survey results for uranium and the XRF results for uranium, the XRF results were considered the more accurate of the two field screening methods.

NSDD

As previously described, Activity 1 sampling at NSDD was modified such that gross alpha analyses, instead of walkover surveys, was used to determine if the action limit of 100 pCi/g for Th-230 had been met.

One RU (RU 12 at EU 02) was not addressed due to the presence of a high pressure gas line immediately underneath.

RUs that extended into Ogden Landing Road (including RUs 08, 09, and 11 in EU03) were excavated by sloping at 1:1 from the edge of the road so as not to impair the stability of the road.

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General

In some instances, excavations that might have been backfilled were left open longer than anticipated resulting in the excavations filling with water. The fact that excavations had filled with water delayed collection of field screening and verification samples and delayed overall progress of work because manpower was diverted from excavating soils to managing water in accordance with the approved Work Plan. As weather allowed, accumulated water in excavated areas was bypass-pumped downstream of the active RU, was bypass-pumped to an adjacent ditch that is not part of the project, and/or containerized as appropriate.

Actual excavation volumes exceeded planning estimates by over 50%. This is believed to be due primarily to two factors:

(1) Volume estimates were developed using areas calculated based on plan views multiplied by a depth of 2 ft. Most excavation areas associated with the removal action were not flat, but were U- or V-shaped. As such, the method of calculating the area of each ditch should have been based on cross sections, multiplying the area of the face of each surface times a depth of 2 ft.

(2) The Site Investigation collected samples at 1- and 2-ft depths; consequently, volume estimates were based on an excavation depth of 2 ft. However, at several locations, excavation proceeded to 3 and 4 ft before cleanup could be considered complete.

Due to contamination levels being at a higher percentage than forecast, more waste was generated than anticipated that could not be disposed of in the on-site C-746-U Landfill. As a result more waste and a higher percentage of all waste generated was disposed of at the off-site waste disposal facility in Clive, Utah.

Summaries of Accomplishments and/or Effectiveness of the Removal Action

The overall RAO for this project, to reduce the direct contact risk to the current and future industrial worker and recreational user within the EPA risk range, was achieved. Table 2 depicts volumes removed from each location.

Table 2. Volumes of Contaminated Sediments Dispositioned

Location	Disposition (yd^3)				
	C-746-U Landfill	Energy*Solutions*, Clive, UT	Total Volume Disposed Of (yd^3)	Original Estimated Excavation Volume (yd^3)	Additional Volume Generated (%)
Outfall 001	425	501	926	~995	-7
Outfall 008	0	244	244	~220	20
Outfall 010	0	642	642	~320	101
Outfall 011	3,443	457	3,900	~1,200	225
Outfall 015	5,026	4,983	10,009	~7,040	42
NSDD Section 3	1,266	5,287	6,553	~3,760	74
NSDD Section 5	0	403	403	~400	0
Total	10,160	12,517	22,677	13,935	63

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Relevant laboratory/monitoring data are included as Appendix B.

Summary of Project Costs

Table 3 below depicts project costs.[4]

Table 3. Costs Associated with Project

Activity	Cost
Excavation	$14,458,980
Waste Management	$ 681,534
Off-Site Disposal	$ 3,171,849
Total	**$18,312,363**

These costs are higher than the estimate provided in the Engineering Evaluation/Cost Analysis of $7,635,816. The higher costs can be directly attributed to the deviations and project problems discussed on pages 8, 9, and 10 of this report.

[4] The accounting of expenditures is based on an estimate governed by figures known at the time the report was written.

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APPENDIX A

FIGURES

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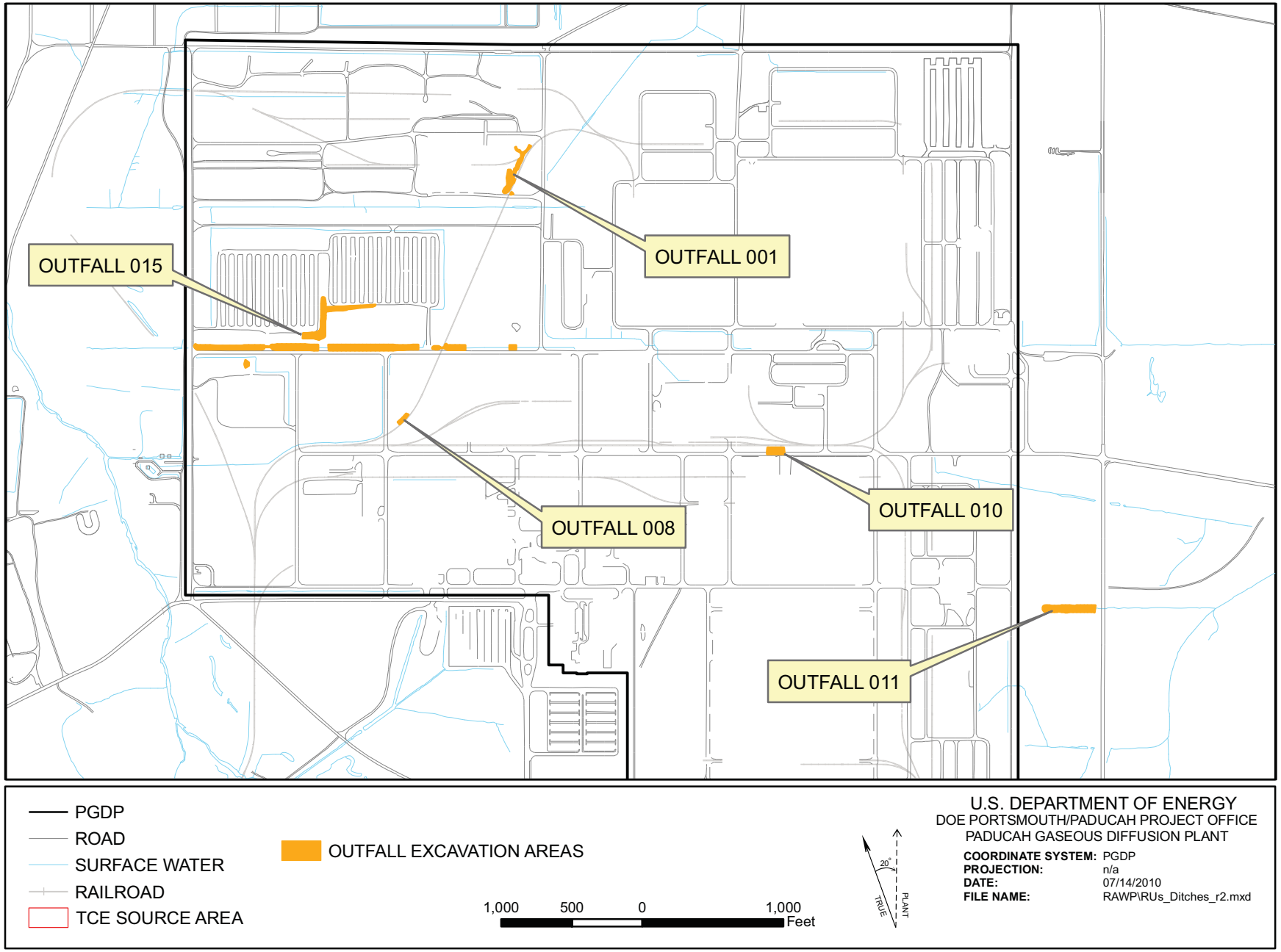

Figure A.1. Location of Outfalls for On-Site Ditches

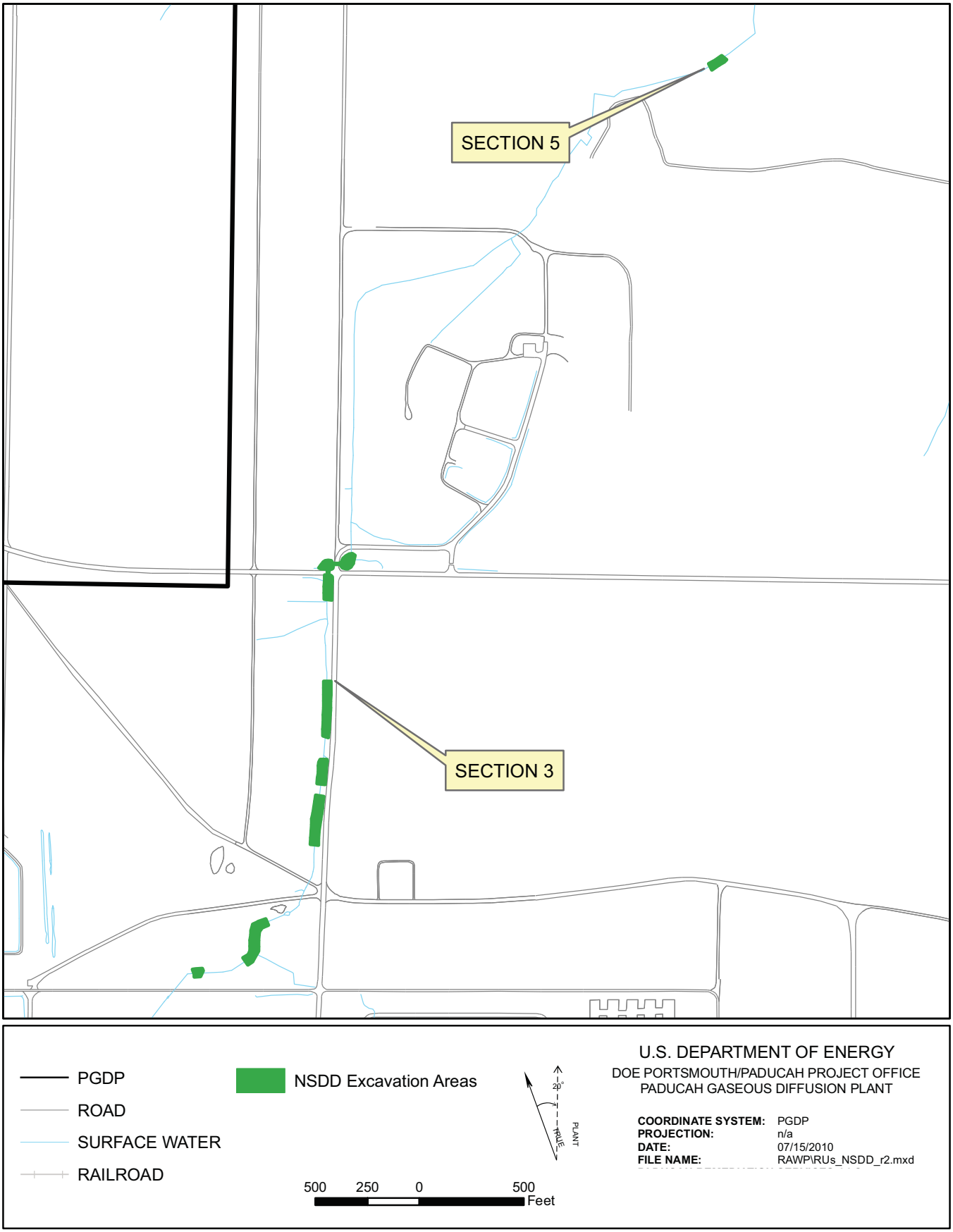

Figure A.2. Location of NSDD Sections 3 and 5

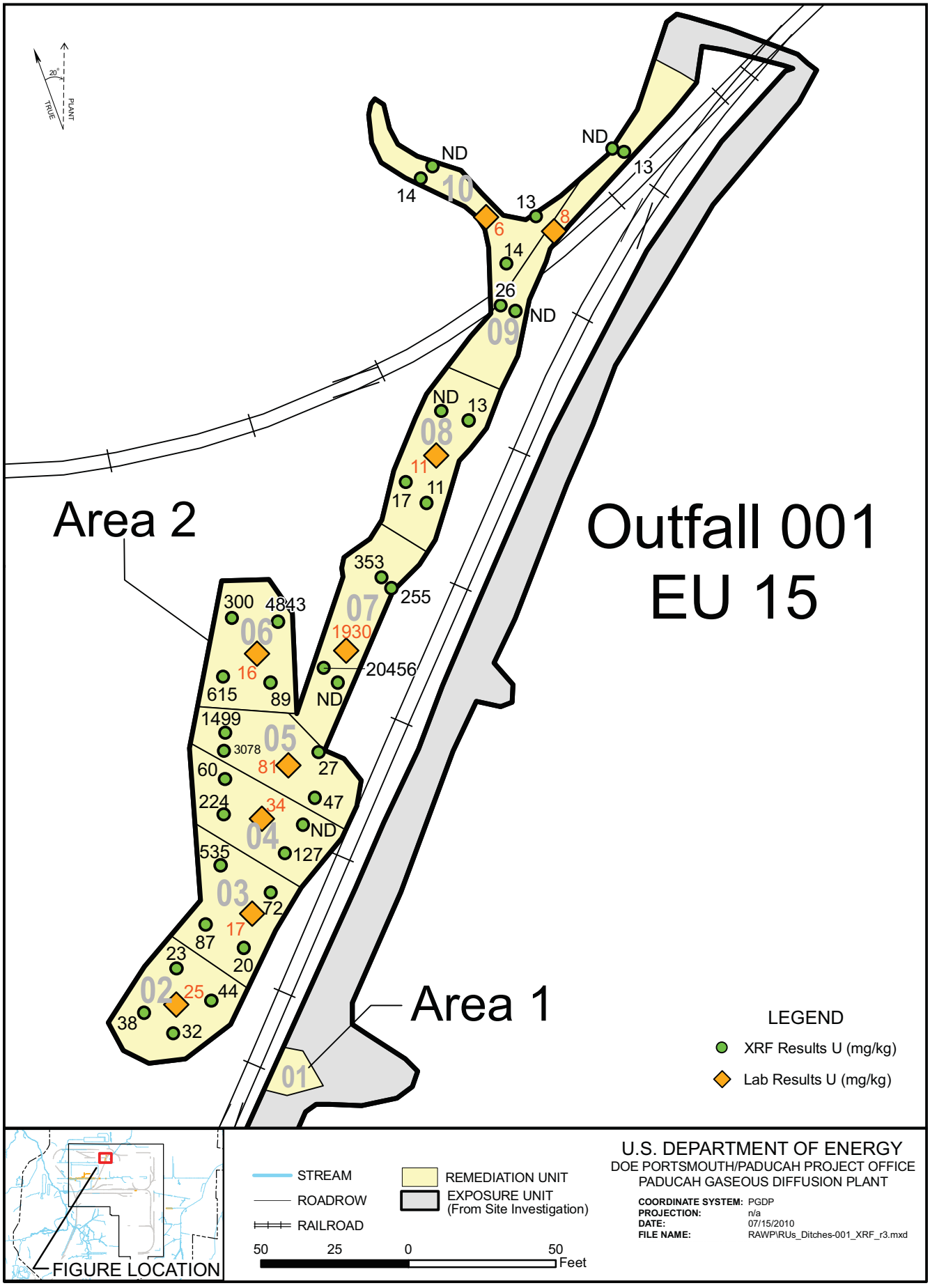

Figure A.3. Outfall 001 Preexcavation (5/18/10) Sample Results

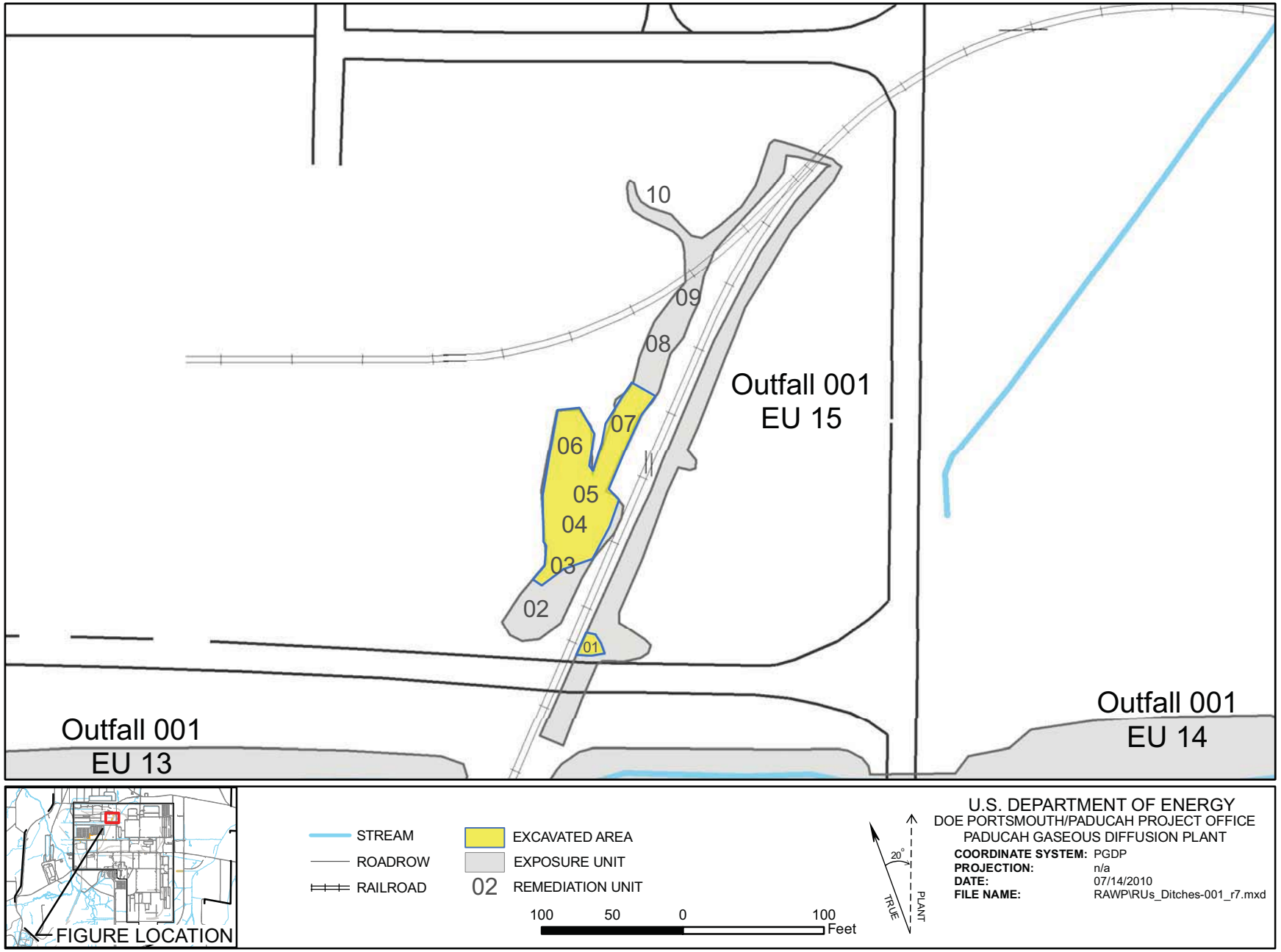

Figure A.4. Outfall 001 Actual Excavation Limits

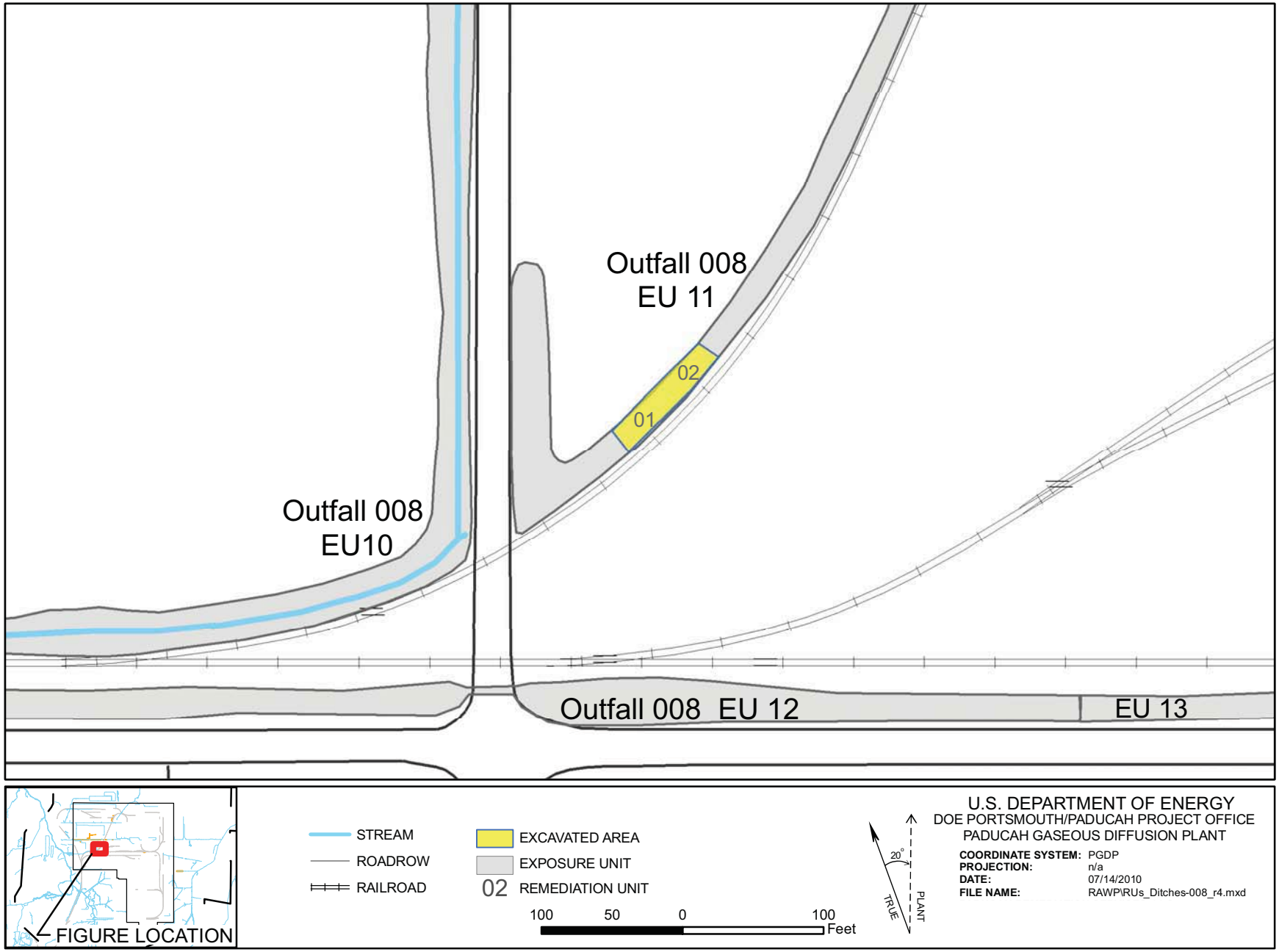

Figure A.5. Outfall 008 Actual Excavation Limits

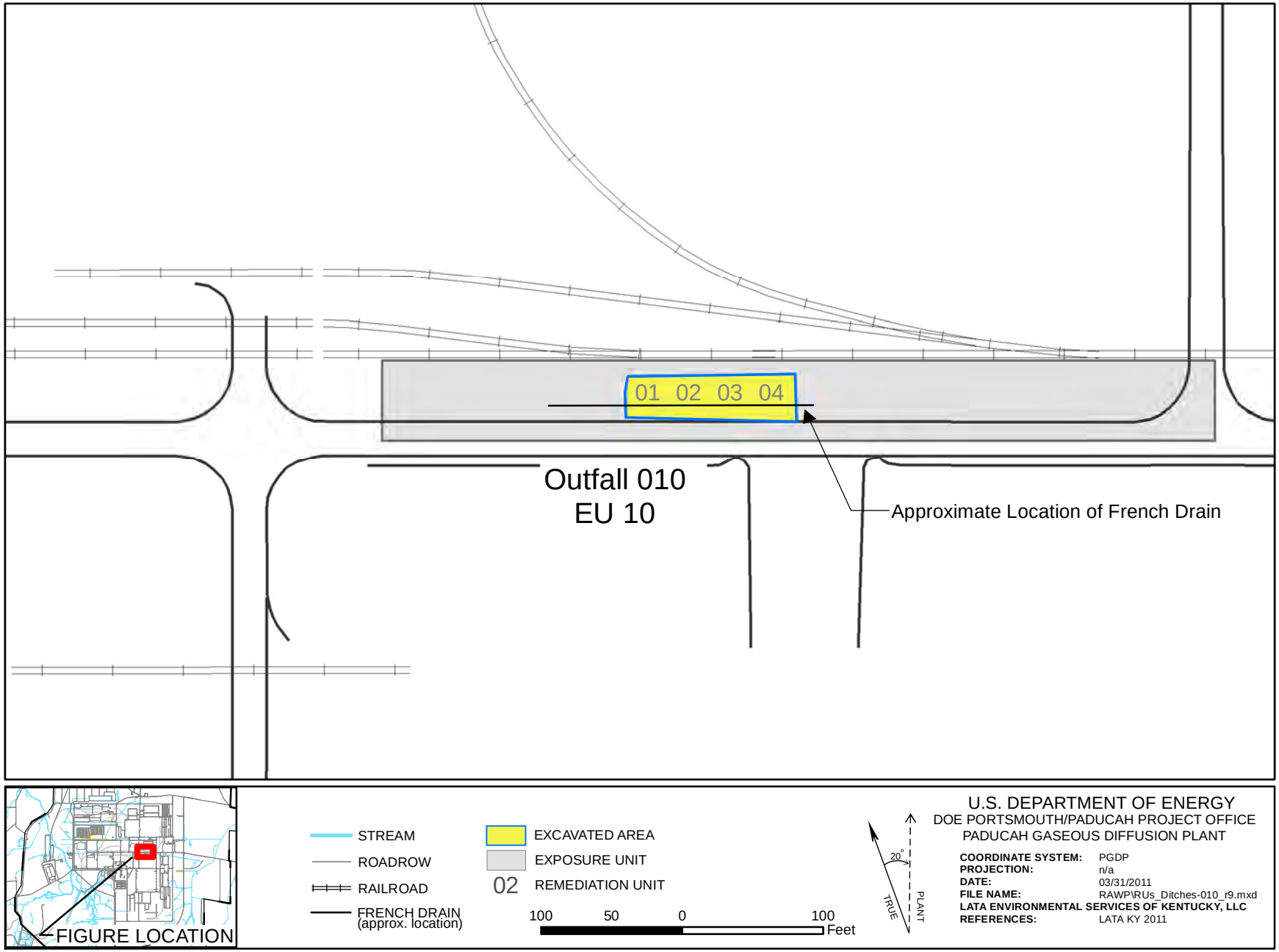

Figure A.6. Outfall 010 Actual Excavation Limits

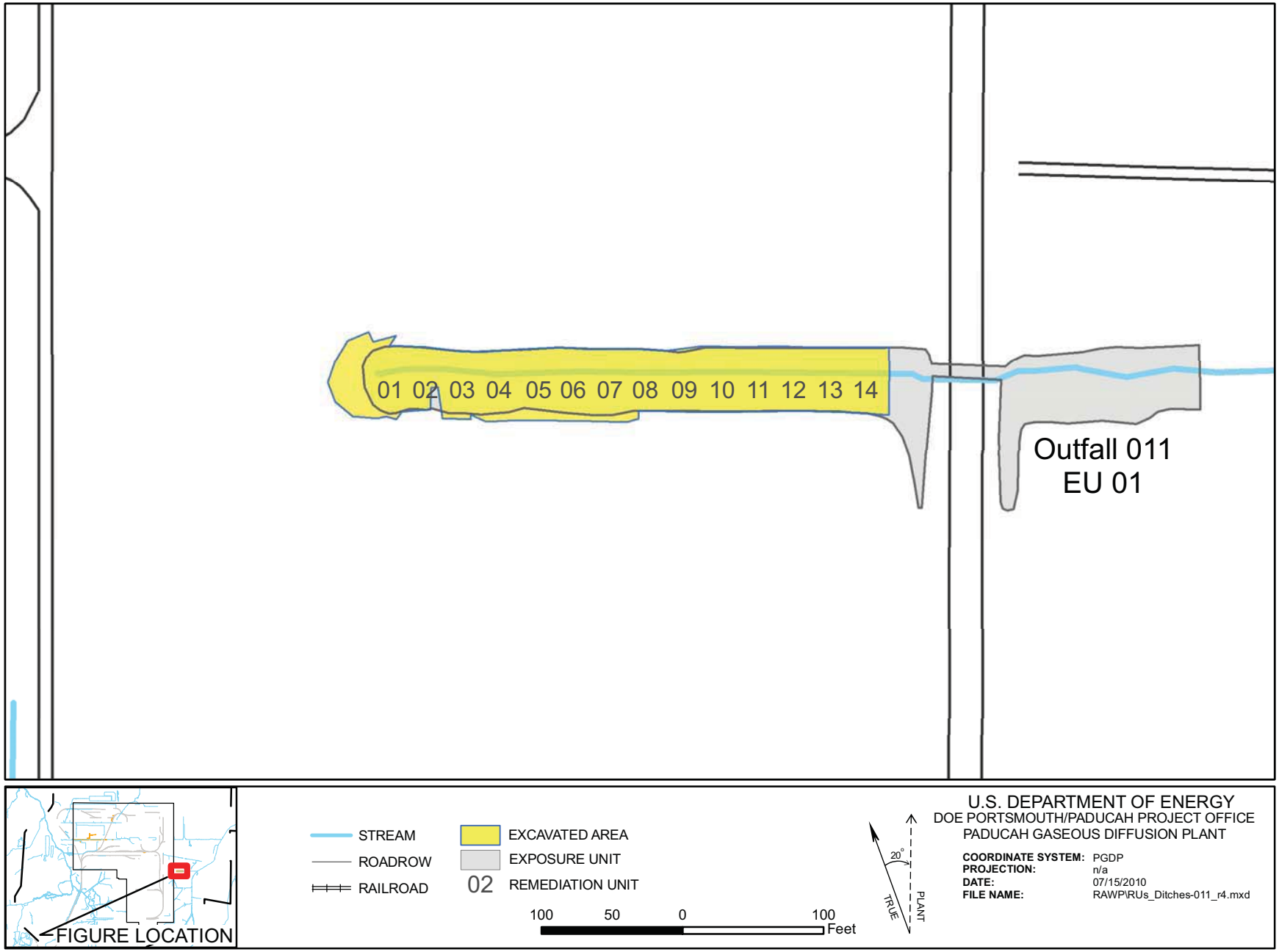

Figure A.7. Outfall 011 Actual Excavation Limits

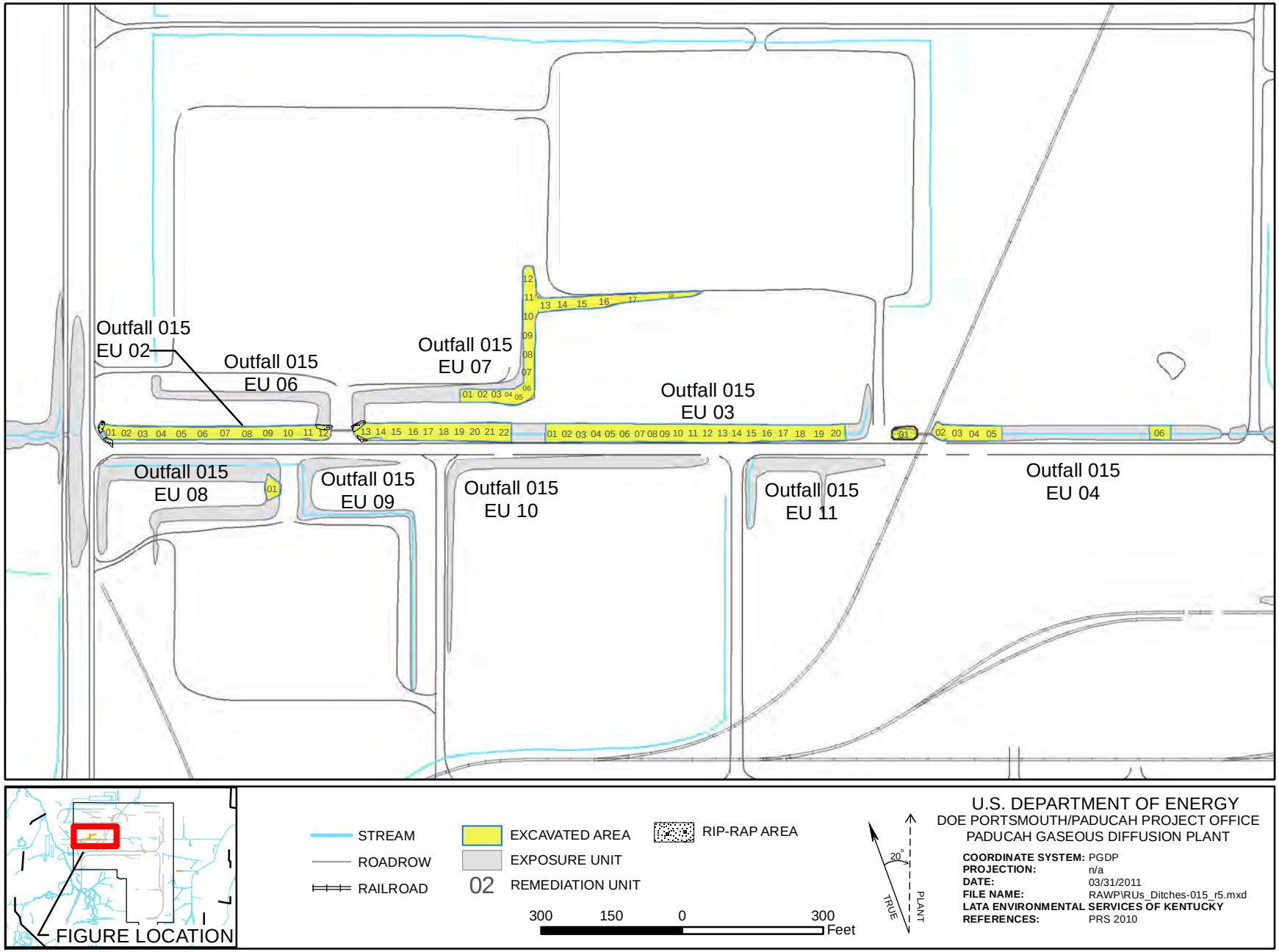

Figure A.8. Outfall 015 Actual Excavation Limits

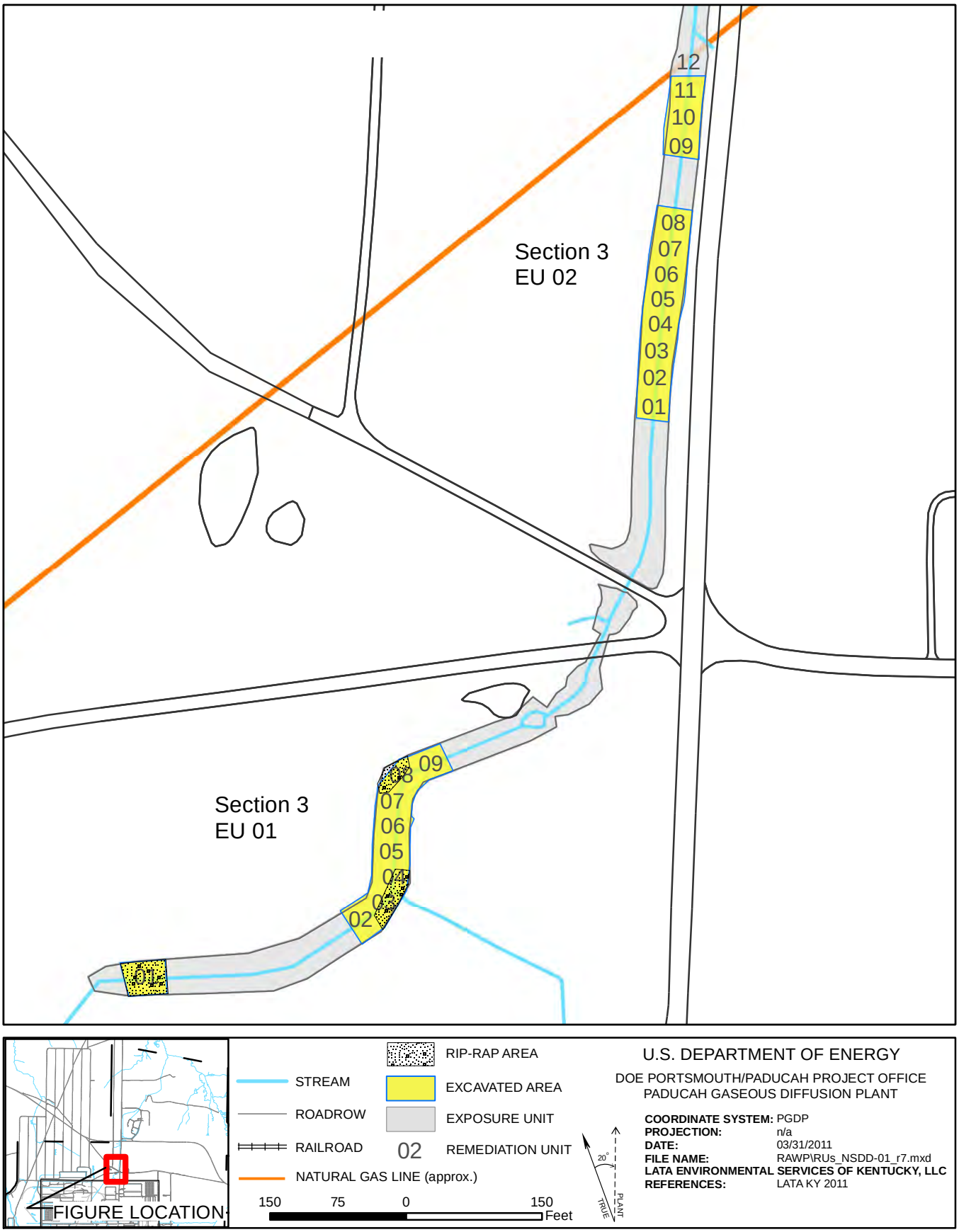

Figure A.9. NSDD Section 3 EUs 01 & 02 Actual Excavation Limits

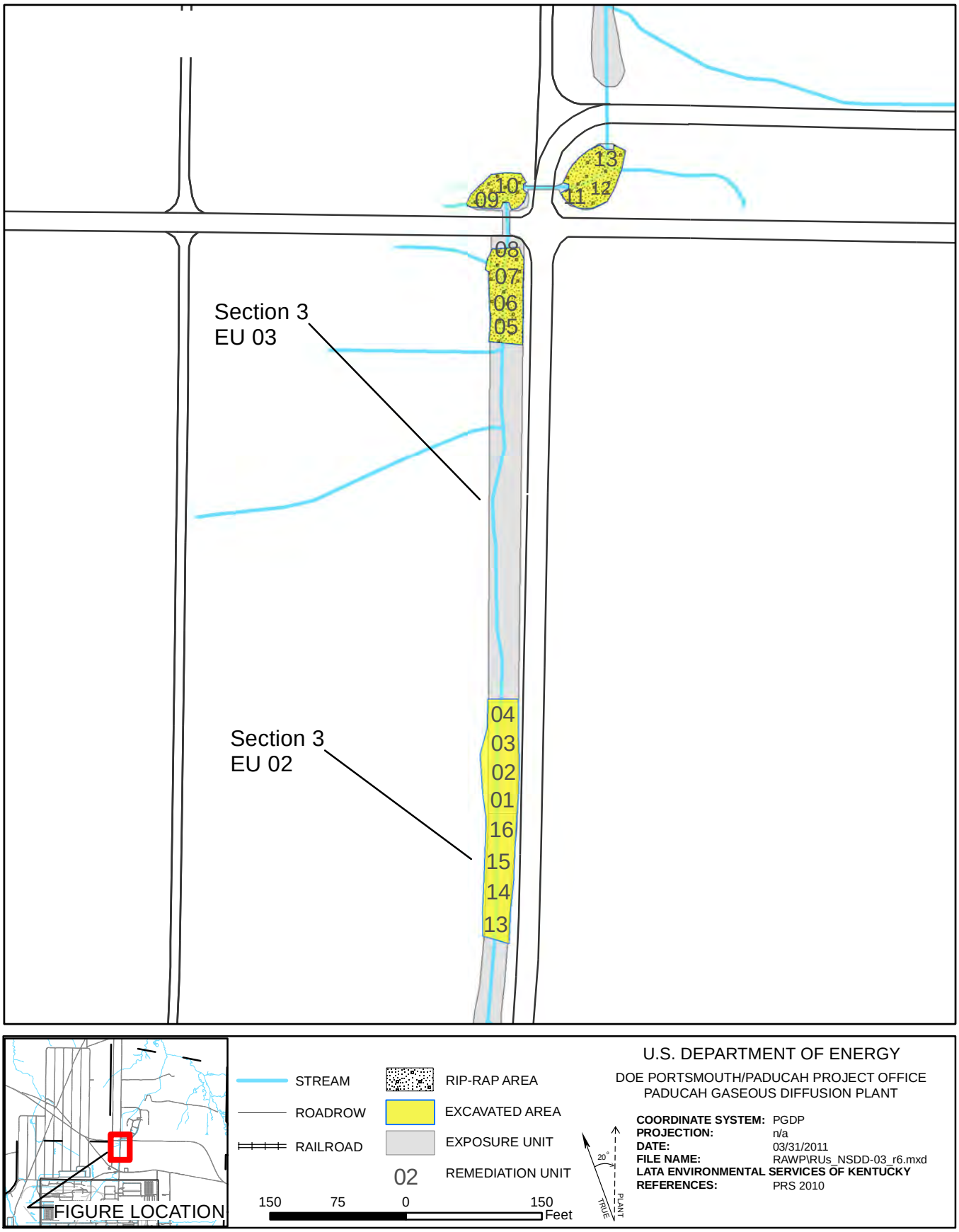

Figure A.10. NSDD Section 3 EUs 02 & 03 Actual Excavation Limits

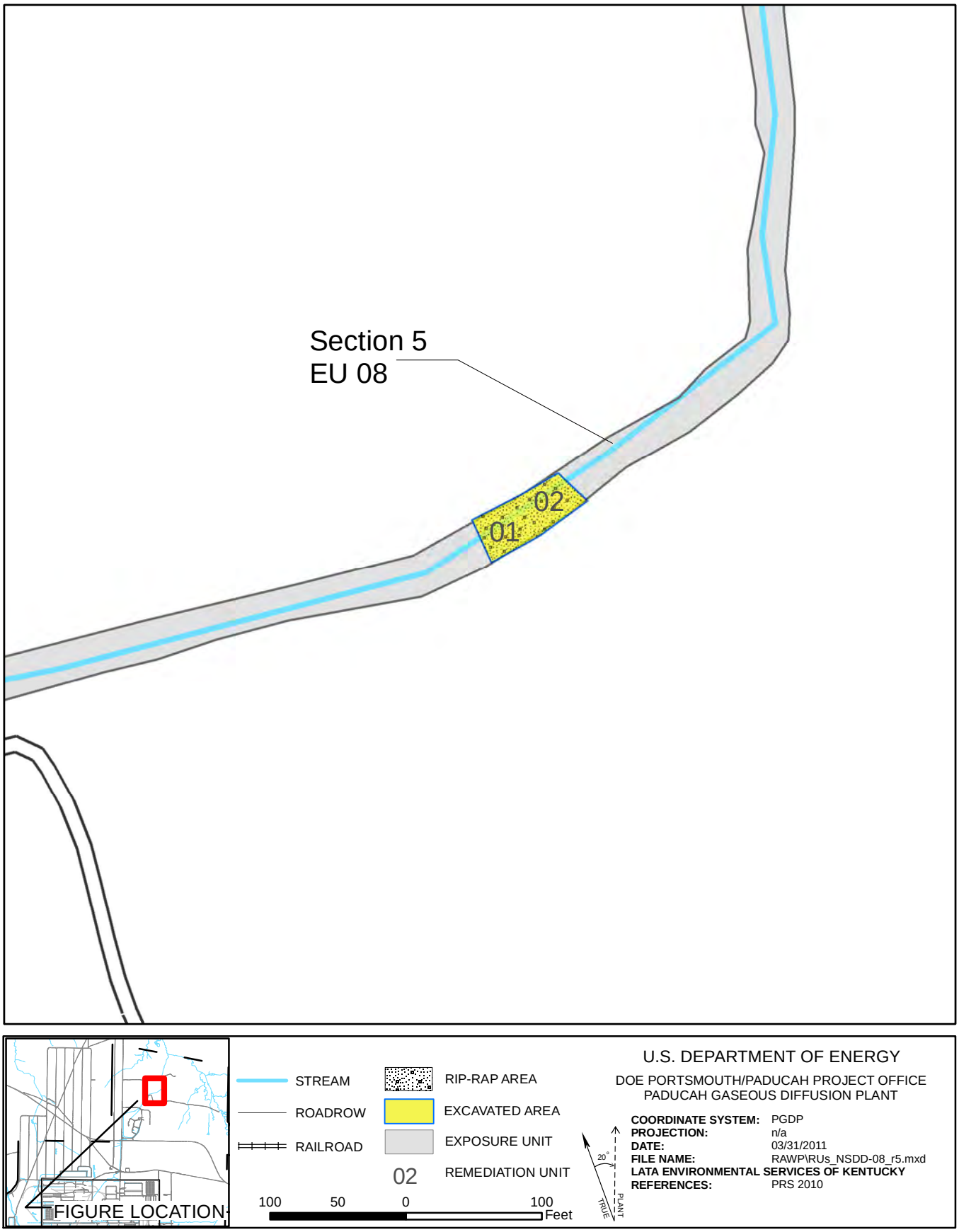

Figure A.11. NSDD Section 5 Actual Excavation Limits

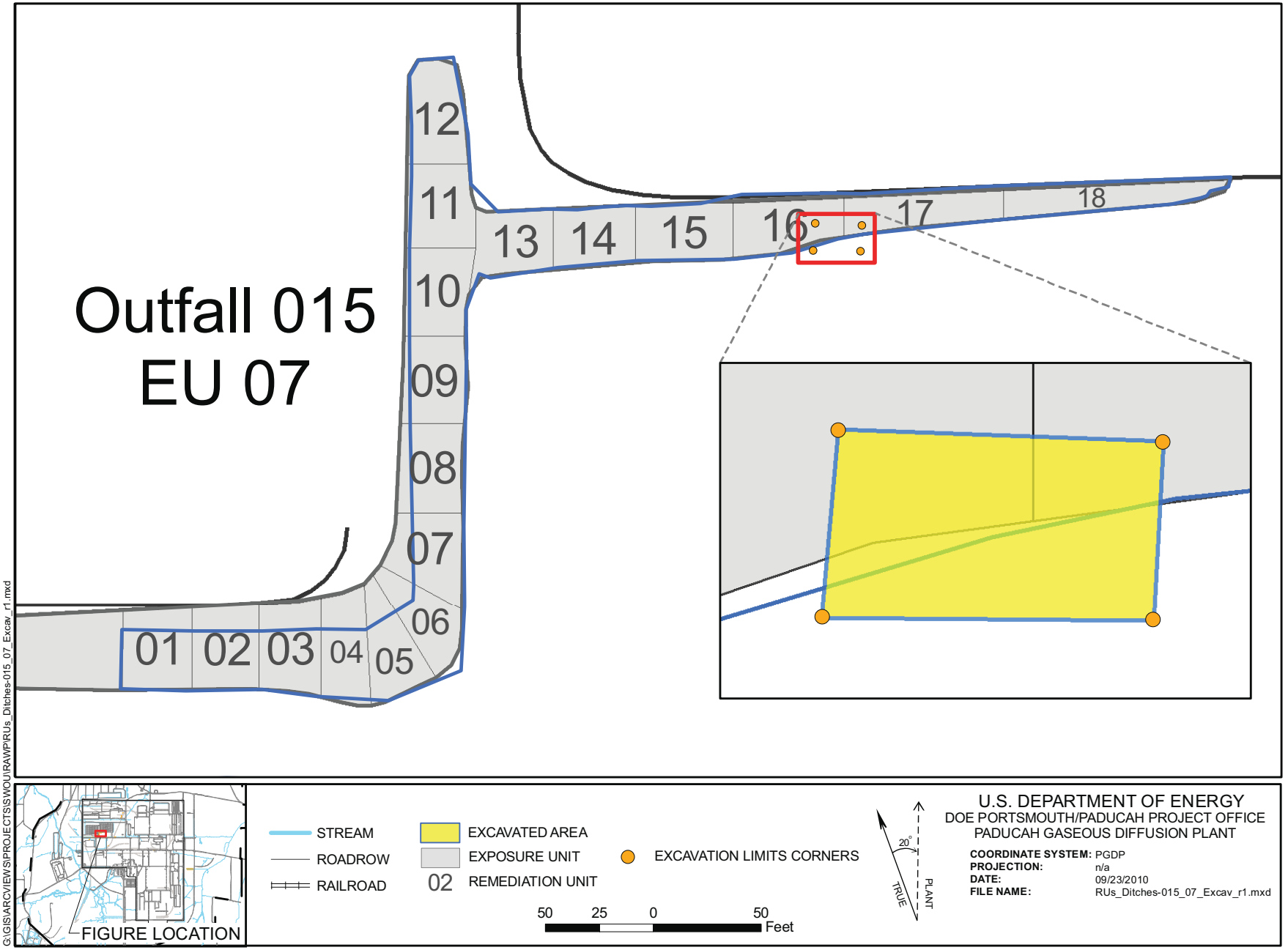

Figure A.12. Outfall 015 "Seam" Excavation

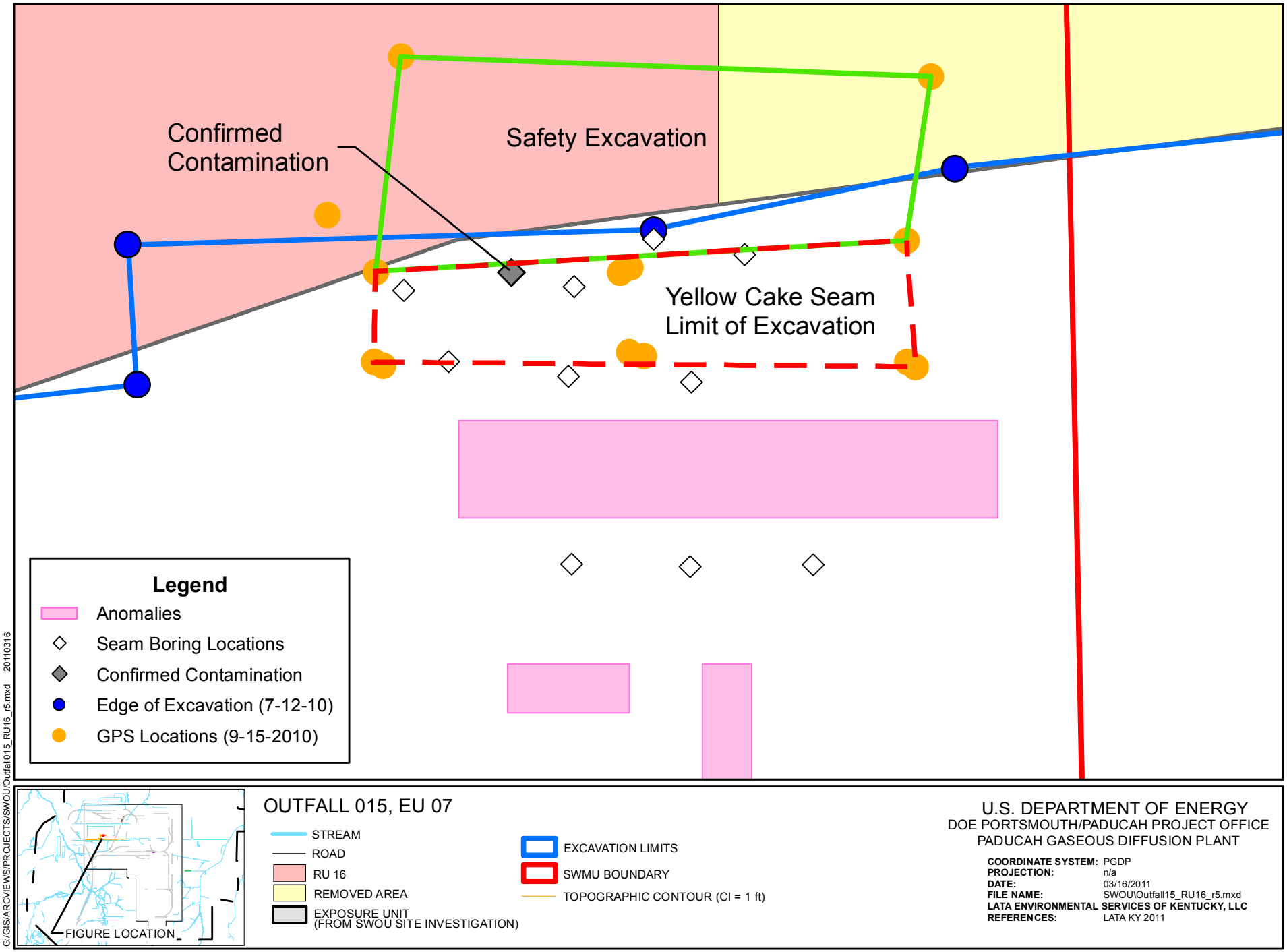

Figure A.13. Outfall 015 Surveying Points Yellow Cake Seam

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APPENDIX B

DATA TABLES

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APPENDIX B

DATA TABLES (ON CD)

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APPENDIX C

RESIDUAL RISK EVALUATION

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RESIDUAL RISK EVALUATION FOR THE SWOU REMOVAL ACTION

In accordance with the *Removal Action Work Plan for Contaminated Sediment Associated with the Surface Water Operable Unit (On-Site) at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky,* (DOE 2009) hot spots were removed. These areas were identified in the Removal Action Work Plan (RAWP) using a cumulative excess lifetime cancer risk (ELCR) of 1E-05 and a cumulative hazard index (HI) of 1.0 based upon the information presented in Appendix F, "Risk-Based Cost-Benefit Analysis," of the Engineering Evaluation/Cost Analysis. The risk evaluation calculates the cumulative residual risk and hazard for exposure units with excavated hot spots within Surface Water Operable Unit (SWOU) Removal Action for the industrial worker at all locations and for the recreational user at the North-South Diversion Ditch (NSDD). This enclosure serves to provide verification of cleanup to a cumulative excess lifetime cancer risk (ELCR) of 1E-05 and a cumulative HI of 1.0. Consistent with the results of the risk-based cost-benefit analysis, verification of cleanup is based upon comparisons between sampling results and chemical-specific ELCR-based cleanup levels. The ELCR and HI target used in deriving the cleanup levels[1] are 5E-06 and 1.0, respectively, for individual contaminants of concern (COCs) in order to ensure the cumulative values were reached. The cancer risk-based and hazardous-based cleanup levels that are used in the comparison for the SWOU On-Site Project are shown in Table C.1.

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Table C.1. Cleanup Levels Based on Carcinogenic Risk and Hazard[a]

COC	Risk-Based Concentration	
Arsenic	27	mg/kg
Beryllium	50,000	mg/kg
Total PCB	16	mg/kg
Americium-241	115	pCi/g
Cesium-137	8	pCi/g
Neptunium-237	22	pCi/g
Plutonium-239/240	108	pCi/g
Technetium-99	3,825	pCi/g
Thorium-230	147	pCi/g
Thorium-232	129	pCi/g
Uranium-234	188	pCi/g
Uranium-235	30	pCi/g
Uranium-238	94	pCi/g
COC	**Hazard-Based Concentration**	
Uranium	227	mg/kg

Table C.1 is taken from the *Removal Action Work Plan for Contaminated Sediment Associated with the Surface Water Operable Unit (On-Site) at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-0221&D2/R1, December 2009.

[a]The cleanup levels for SWOU were established in the Engineering Evaluation/Cost Analysis to be protective of both recreational user and industrial worker scenarios.

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Exposure units (EUs) were developed for the SWOU Site Investigation. Each EU is approximately 0.5 acres and is consistent with the area defined in the Risk Methods Document (DOE 2001) for determining risk. Each outfall and NSDD EU that required excavation is evaluated separately. For each COC, the exposure concentration was the maximum detected concentration remaining in place (i.e., concentrations from removed soil were not used) if fewer than 10 results were available for the EU. For EUs with 10 or more results available, the lesser of the maximum detected concentration and the 95% upper confidence limit (UCL) on the mean of the appropriate distribution was used as the exposure concentration (DOE 2010). The U.S. Environmental Protection Agency (EPA) software program ProUCL was used for determining the appropriate 95% UCL value. The attachment (Exposure Unit Sample

Locations, Figures C1.1 through C1.13) to this risk evaluation shows the locations of the EUs and the sample locations from which the exposure concentrations were derived.

The equation used to derive the risk estimate for each COC (i.e., chemical-specific cancer risk or hazard) is as follows:

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$$\textbf{Risk} = \frac{\textbf{Exposure Concentration}}{\textbf{Cleanup Value}} \times \textbf{Target Risk Value}$$

where:

Risk = calculated chemical-specific cancer risk or hazard value.
Exposure Concentration = Maximum or 95% UCL concentration taken from Table C.2.
Cleanup Value = Risk-based or hazard-based concentration taken from Table C.1. For the recreational scenario calculations, the values are taken from Tables E.1 and E.2 of the *Engineering Evaluation/Cost Analysis for Contaminated Sediment Associated with the Surface Water Operable Unit (On-Site) at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-0012&D2, September 2008, and are shown below.

Reference Information[a]

COC	Recreational User ELCR=1E-5	
Arsenic	18.1	mg/kg
Beryllium	100,000	mg/kg
Total PCB	6.44	mg/kg
Americium-241	811	pCi/g
Cesium-137	11.9	pCi/g
Neptunium-237	37.8	pCi/g
Plutonium-239/240	2,370	pCi/g
Technetium-99	70,600	pCi/g
Thorium-230	3,020	pCi/g
Thorium-232	2,790	pCi/g
Uranium-234	4,070	pCi/g
Uranium-235	55.3	pCi/g
Uranium-238	246	pCi/g
COC	**Recreational User HI=1**	
Uranium	5,310	mg/kg

[a] Cleanup levels for the SWOU were established in the Engineering Evaluation/Cost Analysis and were established to be protective of both recreational user and industrial worker scenarios. See "Cleanup Value" information above for table reference.

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Target Risk Value = Cancer risk 5E-06 or hazard (1) upon which the target cleanup value is based. For the recreational scenario calculations, the values are cancer risk 1E-05 or hazard (1), upon which the target cleanup value is based.

Results of the application of this equation are presented in Table C.3. After risk estimates for each COC were determined, a cumulative risk for each EU was calculated as follows:

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$$\text{Total Risk} = \sum \text{Analyte-specific Risks}$$

Deleted: The cumulative hazard and cancer risk for the EUs are listed in Table C.4.¶

Table C.2. Exposure Concentrations for SWOU EUs

EU	Arsenic (mg/kg)	Beryllium (mg/kg)	Total PCB (mg/kg)	Uranium (mg/kg)	Am-241 (pCi/g)	Cs-137 (pCi/g)	Np-237 (pCi/g)	Pu-239/240 (pCi/g)	Tc-99 (pCi/g)	Th-230 (pCi/g)	Th-232 (pCi/g)	U-234 (pCi/g)	U-235 (pCi/g)	U-238 (pCi/g)
Outfall 001														
15	5.381	0.459	10.5	16.53	0.223	0.115	0.135	0.15	16.09	1.809	0.806	3.252	0.197	5.907
Outfall 008														
11	4.91	0.491	9.22	15.9	0.0972	0.45	0.152	0.274	7.76	2.08	0.883	2.54	0.156	3.76
Outfall 010														
10	12.6	0.58	3.36	12	0.198	0.726	0.172	0.109	8.44	1.23	0.934	2.47	0.155	4.66
Outfall 011														
01	3.561	0.495	1.338	65.86	0.0752	0.0669	0.0108	0.0275	3.761	0.891	0.705	3.11	0.238	47.64
Outfall 015														
02	4.626	0.409	0.0754	22.29	0.153	1.17	0.157	0.214	4.65	8.607	0.919	3.294	0.386	6.357
03	3.724	0.391	0.08	27.14	0.128	0.646	0.12	0.392	0.816	10.31	0.922	3.792	0.271	9.092
04	10.4	1.08	0.81	36.1	0.184	11.2[a]	0.527	2.42	21.6	8.73	1.03	2.36	0.171	9.64
07	6.088	0.55	0.0813	30.5	0.129	0.125	0.0167	0.174	0.882	1.236	0.932	3.869	0.216	25.57
08	46.9[b]	0.495	0.13	55.7	0.083	0.443	0.0638	0.0434	3.31	1.43	0.989	0.588	0.0405	0.843
NSDD, Section 3														
01	4.315	0.5	0.979	35.8	0.713	0.593	0.802	2.236	40.86	26.42	0.879	9.106	0.848	13.11
02	4.213	0.504	0.729	27.38	1.633	0.774	1.898	8.277	105.3	54.99	0.938	6.194	0.389	8.533
03	4.268	0.44	0.583	45.23	1.99	1.516	1.382	9.512	306.4	101.2	0.914	6.525	0.389	8.171
NSDD, Section 5														
08	15.99	0.695	0.798	87.8	0.694	1.667	0.199	2.027	24.62	26.05	0.646	3.385	0.235	4.956

Am-241 = Americium-241 Cs-137 = Cesium-137 Np-237 = Neptunium-237 Pu-239/240 = Plutonium-239/240 Tc-99 = Technetium-99 Th-230 = Thorium-230
Th-232 = Thorium-232 U-234 = Uranium-234 (reported as Uranium-233/234) U-235 = Uranium-235 U-238 = Uranium-238

[a] The value shown is above the chemical-specific cleanup level as shown in Table C.1 because it is the maximum value for the EU and is from a historical data sample. The area from which the historical data sample was collected was not excavated because the Cs-137 value was not higher than the individual 1E-5 ELCR value defined in the Engineering Evaluation/Cost Analysis (15.2 pCi/g) (DOE 2008).

[b] The value shown is above the chemical-specific cleanup level as shown in Table C.1 because it is the maximum value for the EU and is from a historical data sample. The area from which the historical data sample was collected was not excavated because the arsenic value was not higher than the individual 1E-5 ELCR value defined in the Engineering Evaluation/Cost Analysis (54.8) (DOE 2008).

Table C.3. Risk and Hazard Estimates for SWOU EUs

EU	Arsenic	Beryllium	Total PCB	Uranium	Am-241	Cs-137	Np-237	Pu-239/240	Tc-99	Th-230	Th-232	U-234	U-235	U-238
INDUSTRIAL WORKER														
							Outfall 001							
15	9.96E-07	4.59E-11	3.28E-06	0.1	9.70E-09	7.19E-08	3.07E-08	6.94E-09	2.10E-08	6.15E-08	3.12E-08	8.65E-08	3.28E-08	3.14E-07
							Outfall 008							
11	9.09E-07	4.91E-11	2.88E-06	0.1	4.23E-09	2.81E-07	3.45E-08	1.27E-08	1.01E-08	7.07E-08	3.42E-08	6.76E-08	2.60E-08	2.00E-07
							Outfall 010							
10	2.33E-06	5.80E-11	1.05E-06	0.1	8.61E-09	4.54E-07	3.91E-08	5.05E-09	1.10E-08	4.18E-08	3.62E-08	6.57E-08	2.58E-08	2.48E-07
							Outfall 011							
01	6.59E-07	4.95E-11	4.18E-07	0.3	3.27E-09	4.18E-08	2.45E-09	1.27E-09	4.92E-09	3.03E-08	2.73E-08	8.27E-08	3.97E-08	2.53E-06
							Outfall 015							
02	8.57E-07	4.09E-11	2.36E-08	0.1	6.65E-09	7.31E-07	3.57E-08	9.91E-09	6.08E-09	2.93E-07	3.56E-08	8.76E-08	6.43E-08	3.38E-07
03	6.90E-07	3.91E-11	2.50E-08	0.1	5.57E-09	4.04E-07	2.73E-08	1.81E-08	1.07E-09	3.51E-07	3.57E-08	1.01E-07	4.52E-08	4.84E-07
04	1.93E-06	1.08E-10	2.53E-07	0.2	8.00E-09	7.00E-06	1.20E-07	1.12E-07	2.82E-08	2.97E-07	3.99E-08	6.28E-08	2.85E-08	5.13E-07
07	1.13E-06	5.52E-11	2.54E-08	0.1	5.61E-09	7.81E-08	3.80E-09	8.06E-09	1.15E-09	4.20E-08	3.61E-08	1.03E-07	3.60E-08	1.36E-06
08	8.69E-06	4.95E-11	4.06E-08	0.2	3.61E-09	2.77E-07	1.45E-08	2.01E-09	4.33E-09	4.86E-08	3.83E-08	1.56E-08	6.75E-09	4.48E-08
							NSDD, Section 3							
01	7.99E-07	5.00E-11	3.06E-07	0.2	3.10E-08	3.71E-07	1.82E-07	1.04E-07	5.34E-08	8.99E-07	3.41E-08	2.42E-07	1.41E-07	6.97E-07
02	7.80E-07	5.04E-11	2.28E-07	0.1	7.10E-08	4.84E-07	4.31E-07	3.83E-07	1.38E-07	1.87E-06	3.64E-08	1.65E-07	6.48E-08	4.54E-07
03	7.90E-07	4.40E-11	1.82E-07	0.2	8.65E-08	9.48E-07	3.14E-07	4.40E-07	4.01E-07	3.44E-06	3.54E-08	1.74E-07	6.48E-08	4.35E-07
							NSDD, Section 5							
08	2.96E-06	6.95E-11	2.49E-07	0.4	3.02E-08	1.04E-06	4.52E-08	9.38E-08	3.22E-08	8.86E-07	2.50E-08	9.00E-08	3.92E-08	2.64E-07

Table C.3. Risk and Hazard Estimates for SWOU EUs (Continued)

RECREATIONAL USER														
NSDD, Section 3														
01	2.38E-06	5.00E-11	1.52E-06	<0.1	8.79E-09	4.98E-07	2.12E-07	9.43E-09	5.79E-09	8.75E-08	3.15E-09	2.24E-08	1.53E-07	5.33E-07
02	2.33E-06	5.04E-11	1.13E-06	<0.1	2.01E-08	6.50E-07	5.02E-07	3.49E-08	1.49E-08	1.82E-07	3.36E-09	1.52E-08	7.03E-08	3.47E-07
03	2.36E-06	4.40E-11	9.05E-07	<0.1	2.45E-08	1.27E-06	3.66E-07	4.01E-08	4.34E-08	3.35E-07	3.28E-09	1.60E-08	7.03E-08	3.32E-07
NSDD, Section 5														
08	8.83E-06	6.95E-11	1.24E-06	<0.1	8.56E-09	1.40E-06	5.26E-08	8.55E-09	3.49E-09	8.63E-08	2.32E-09	8.32E-09	4.25E-08	2.01E-07

Am-241 = Americium-241 Cs-137 = Cesium-137 Np-237 = Neptunium-237 Pu-239/240 = Plutonium-239/240 Tc-99 = Technetium-99 Th-230 = Thorium-230
Th-232 = Thorium-232 U-234 = Uranium-234 (reported as Uranium-233/234) U-235 = Uranium-235 U-238 = Uranium-238

The cumulative hazard and cancer risk for the EUs are listed in Table C.4.

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Table C.4. Cumulative ELCR and HI for SWOU EUs

Outfall/ NSDD Section	EU	ELCR (Cancer)	HI (Hazard)
INDUSTRIAL WORKER			
Outfall 001	15	4.9E-06	0.1
Outfall 008	11	4.5E-06	0.1
Outfall 010	10	4.3E-06	0.1
Outfall 011	1	3.8E-06	0.3
Outfall 015	2	2.5E-06	0.1
	3	2.2E-06	0.1
	4	1.0E-05	0.2
	7	2.8E-06	0.1
	8	9.2E-06	0.2
Section 3	1	3.9E-06	0.2
	2	5.1E-06	0.1
	3	7.3E-06	0.2
Section 5	8	5.8E-06	0.4
RECREATIONAL USER			
Section 3	1	5.4E-06	<0.1
	2	5.3E-06	<0.1
	3	5.8E-06	<0.1
Section 5	8	1.2E-05	<0.1

UNCERTAINTIES IN CALCULATION OF CUMULATIVE RESIDUAL RISK AND HAZARDS FOR COCs

Several uncertainties should be taken into account when considering the calculation of cumulative residual risk and hazards for COCs for excavated hot spots within SWOU internal ditches and the NSDD.

One uncertainty for consideration is that the laboratory-reported results from samples collected during the SWOU Site Investigation for uranium isotopes present at or near background values may be biased low based on the extraction method the laboratory historically has used. It should be noted that this uncertainty occurs only when using SWOU Site Investigation data (not removal verification data). Estimated risk from uranium isotopes are well within acceptable ranges; thus, this uncertainty is not considered significant.

Only risk and hazard contributed by chemicals considered COCs and listed in the Table C.1 were included in the calculation, as specified in the RAWP.

Chemicals not detected at their laboratory sample quantitation limit (SQL) were used in the calculation at the full SQL value. Additionally, results detected below site background were included in the calculation. This may have resulted in an exaggerated value of cumulative risk and hazard.

Any risk or hazard associated with the removal of the French drain within Outfall 010 was not considered in this evaluation. All laboratory data associated with this removal were well below cleanup levels, so this area is not expected to have any adverse effect to the cumulative risk or hazard for Outfall 010, EU 10.

RESULTS OF CALCULATION OF CUMULATIVE RESIDUAL RISK AND HAZARDS FOR COCs FROM EXPOSURE UNITS WITH EXCAVATED HOT SPOTS WITHIN SWOU REMOVAL ACTION

The calculation of cumulative residual risk and hazard for COCs from EUs with excavated hot spots within SWOU Removal Action indicates that the removal goal of cleanup to a cumulative ELCR of 1E-05 and a cumulative HI of 1.0 was achieved.

REFERENCES

DOE 2001. *Methods for Conducting Risk Assessments and Risk Evaluations at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky Volume 1, Human Health,* DOE/OR/07-1506&D2, December.

DOE 2008. *Engineering Evaluation/Cost Analysis for Contaminated Sediment Associated with the Surface Water Operable Unit (On-Site) at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky,* DOE/LX/07-0012&D2, September.

DOE 2009. *Removal Action Work Plan for Contaminated Sediment Associated with the Surface Water Operable Unit (On-Site) at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky,* DOE/LX/07-0221&D2/R1, December.

DOE 2010. *Methods for Conducting Risk Assessments and Risk Evaluations at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky Volume 1, Human Health,* DOE/LX/07-0107&D2/V1, July.

EPA 2010. ProUCL Version 4.00.05 Technical Guide (Draft). EPA/600/R-07/041 Technical Support Center, Characterization and Monitoring Branch, Las Vegas, NV, May. (Model available at www.epa.gov/nerlesd1/tsc/software.htm)

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ATTACHMENT

EXPOSURE UNIT SAMPLE LOCATIONS

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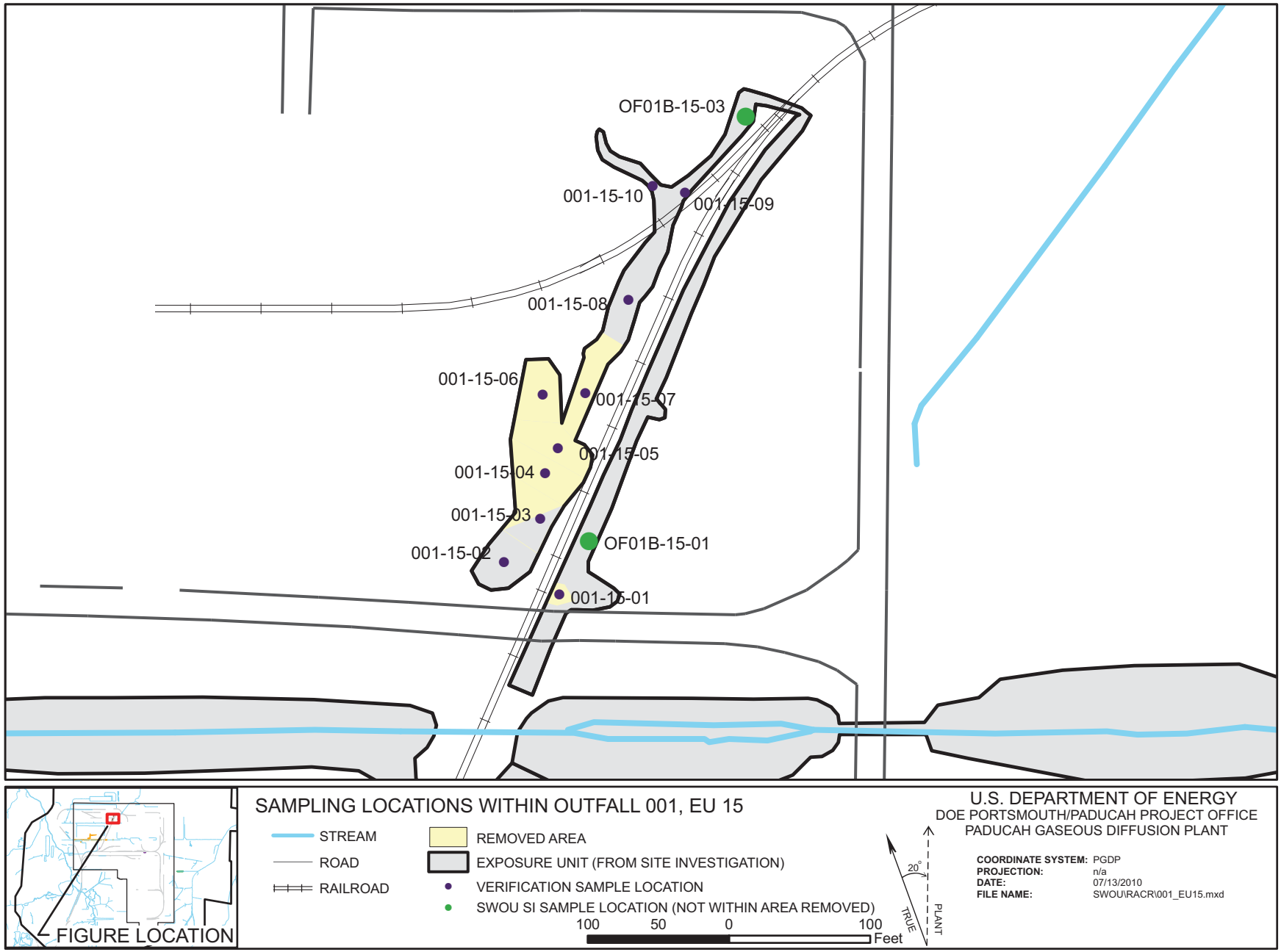

Figure C1.1. Sampling Locations within Outfall 001, EU 15

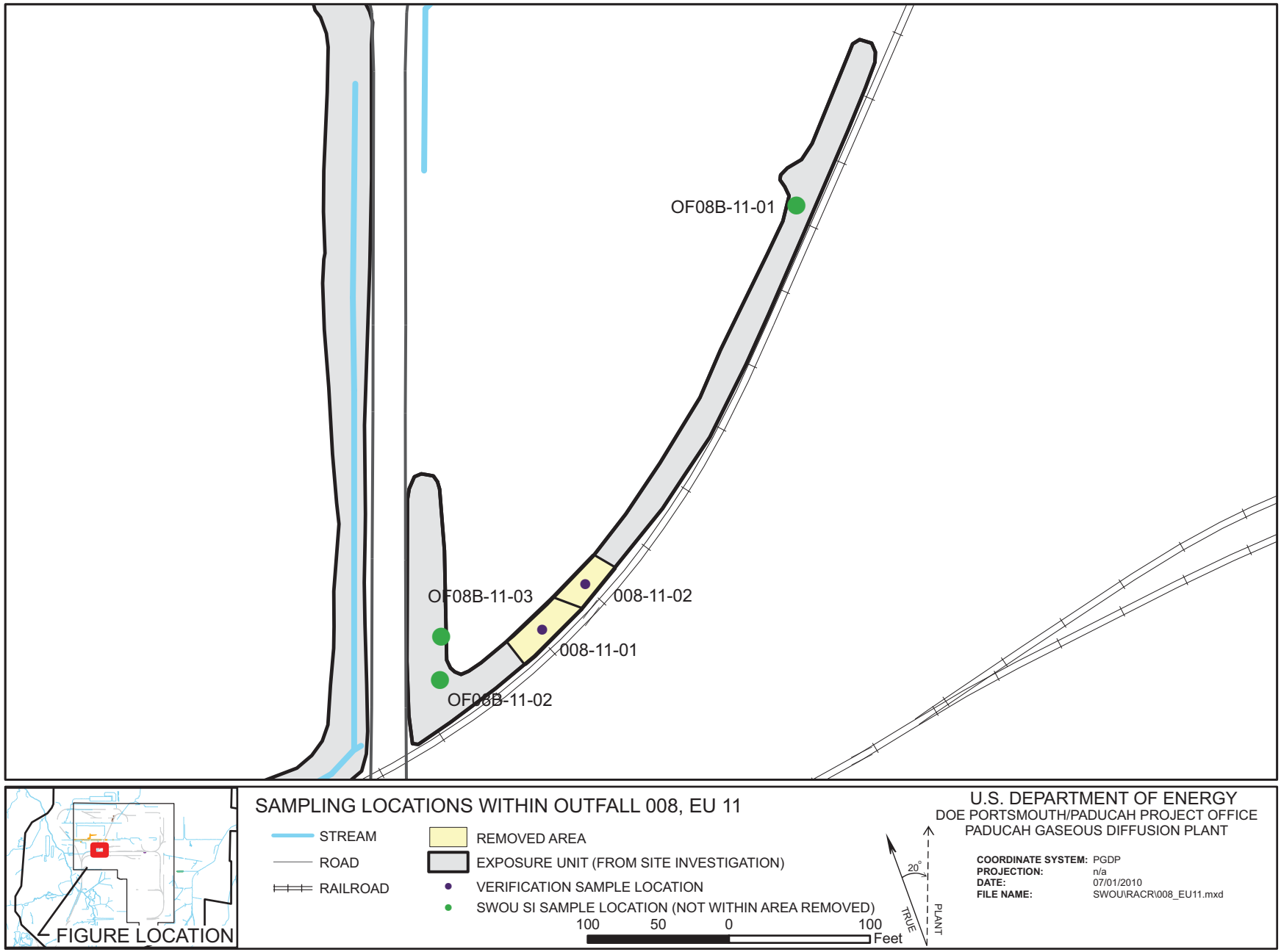

Figure C1.2. Sampling Locations within Outfall 008, EU 11

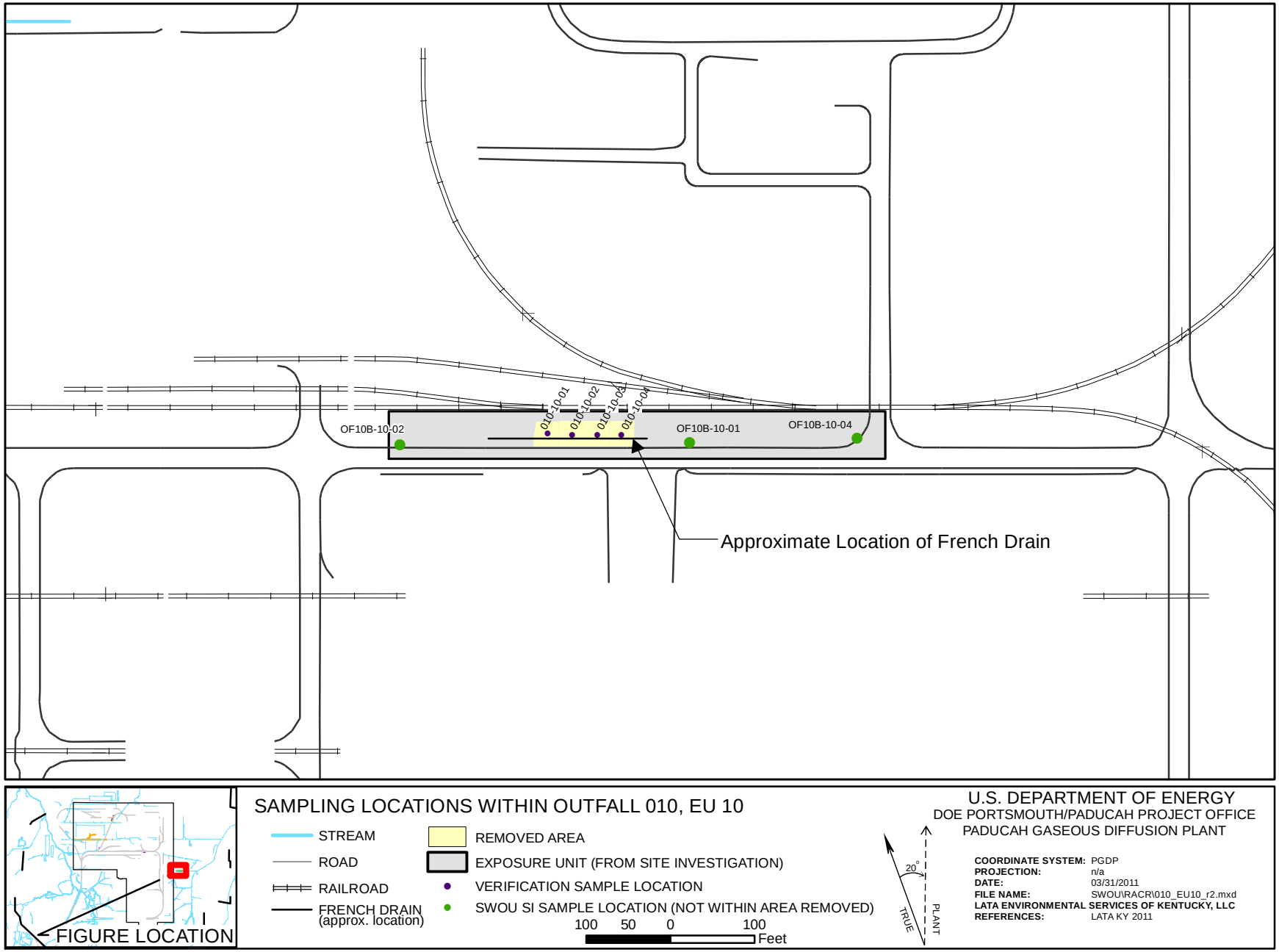

Figure C1.3. Sampling Locations Within Outfall 010, EU 10

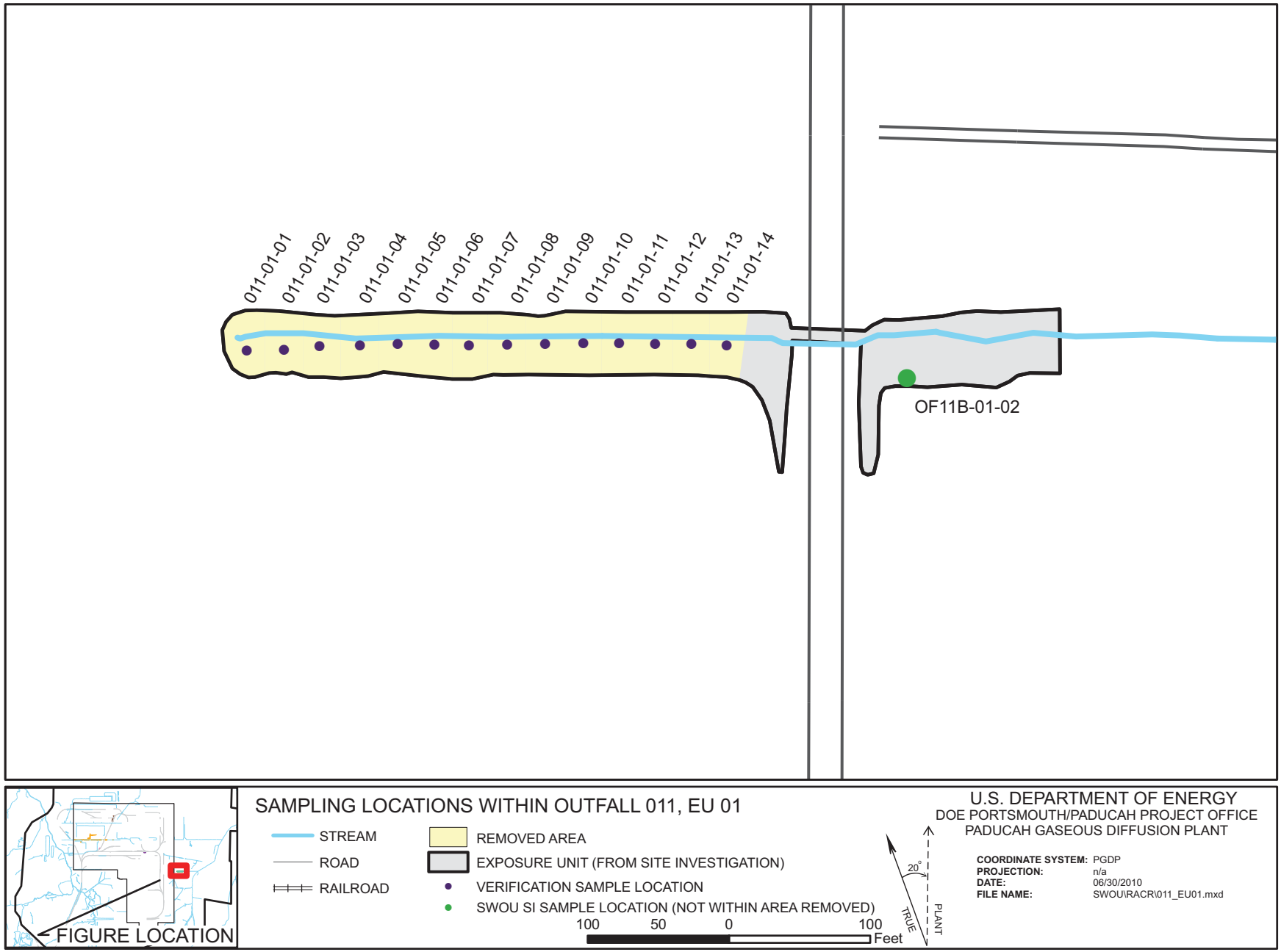

Figure C1.4. Sampling Locations within Outfall 011, EU 01

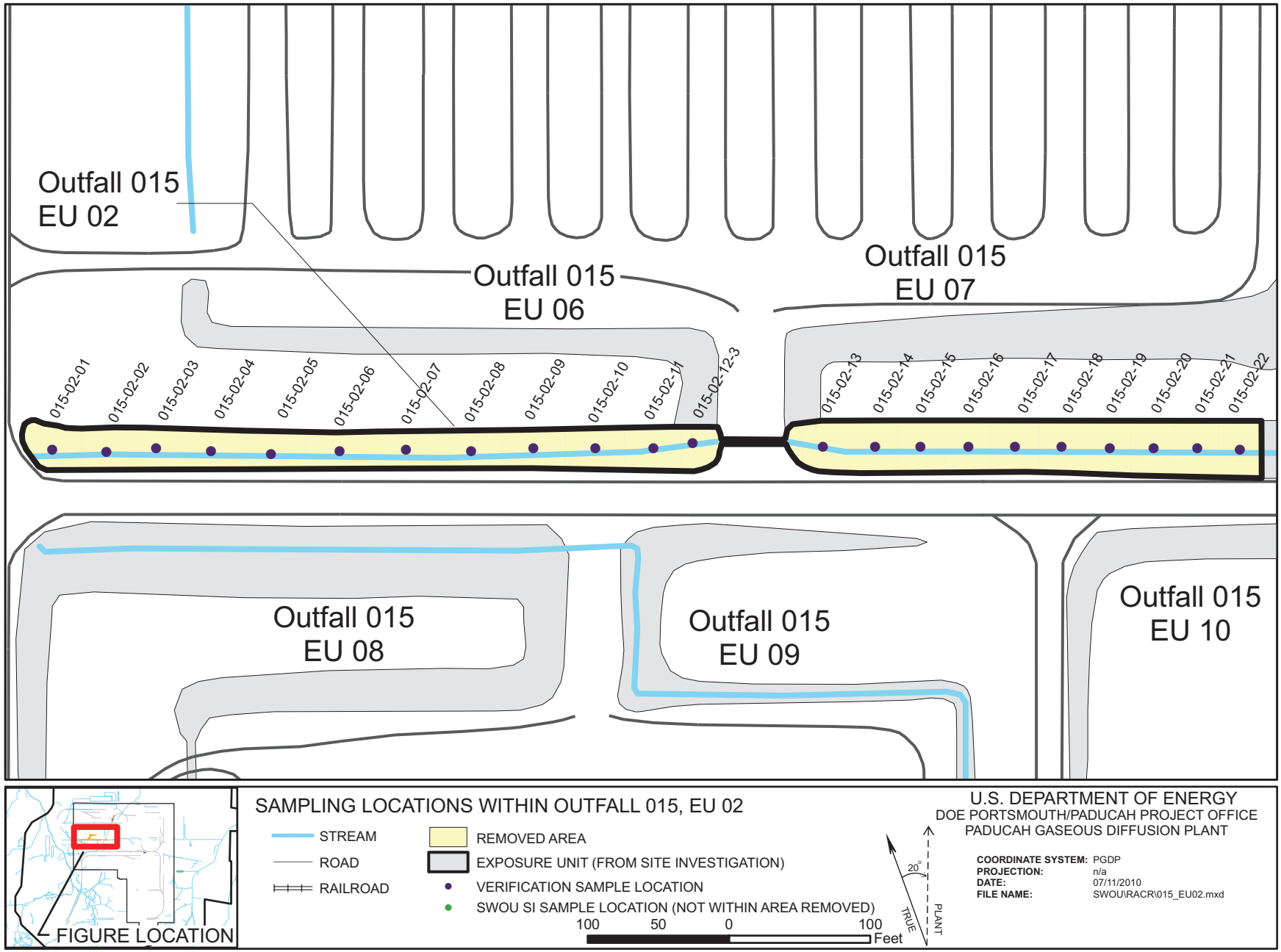

Figure C1.5. Sampling Locations within Outfall 015, EU 02

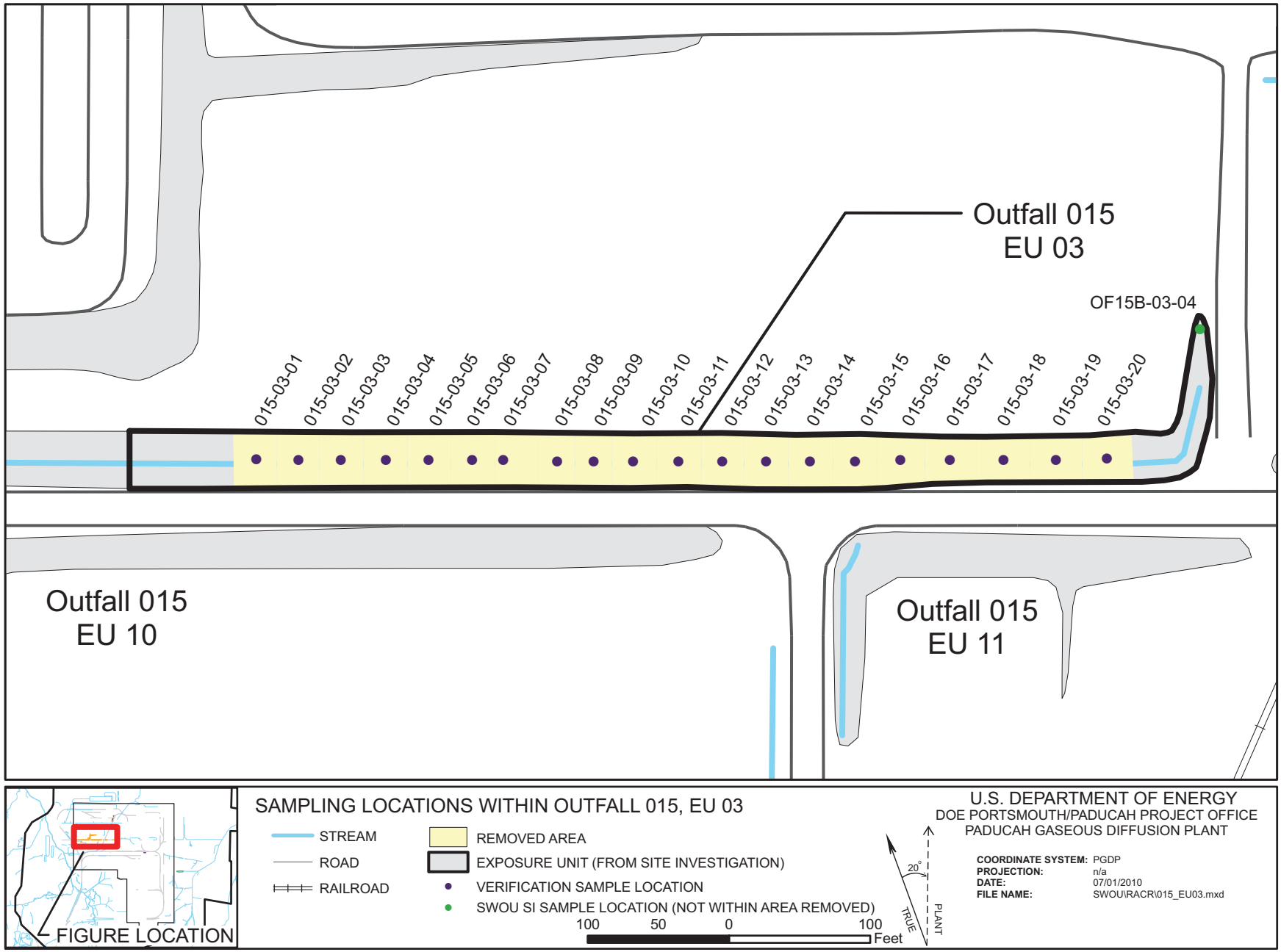

Figure C1.6. Sampling Locations within Outfall 015, EU 03

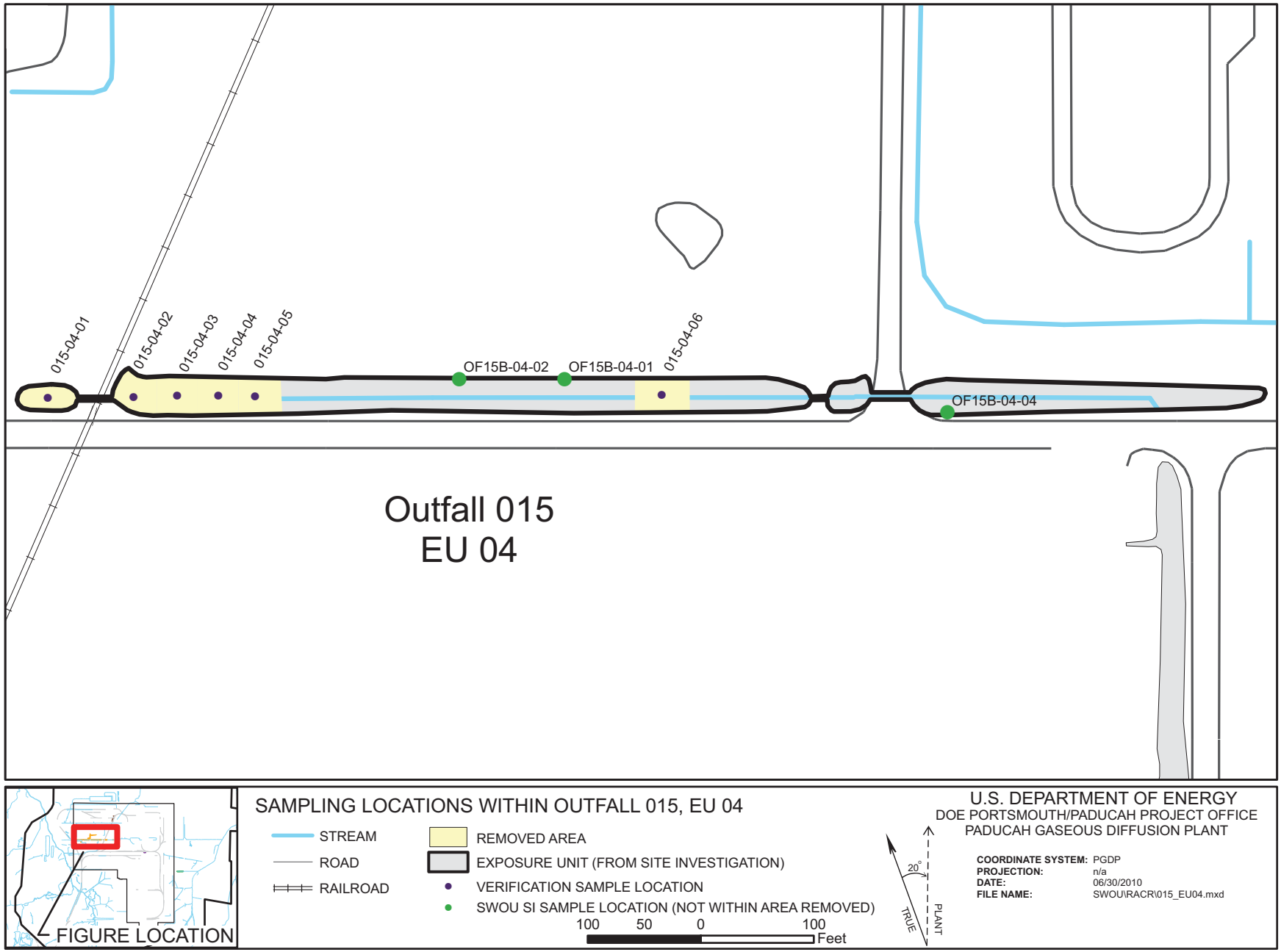

Figure C1.7. Sampling Locations within Outfall 015, EU 04

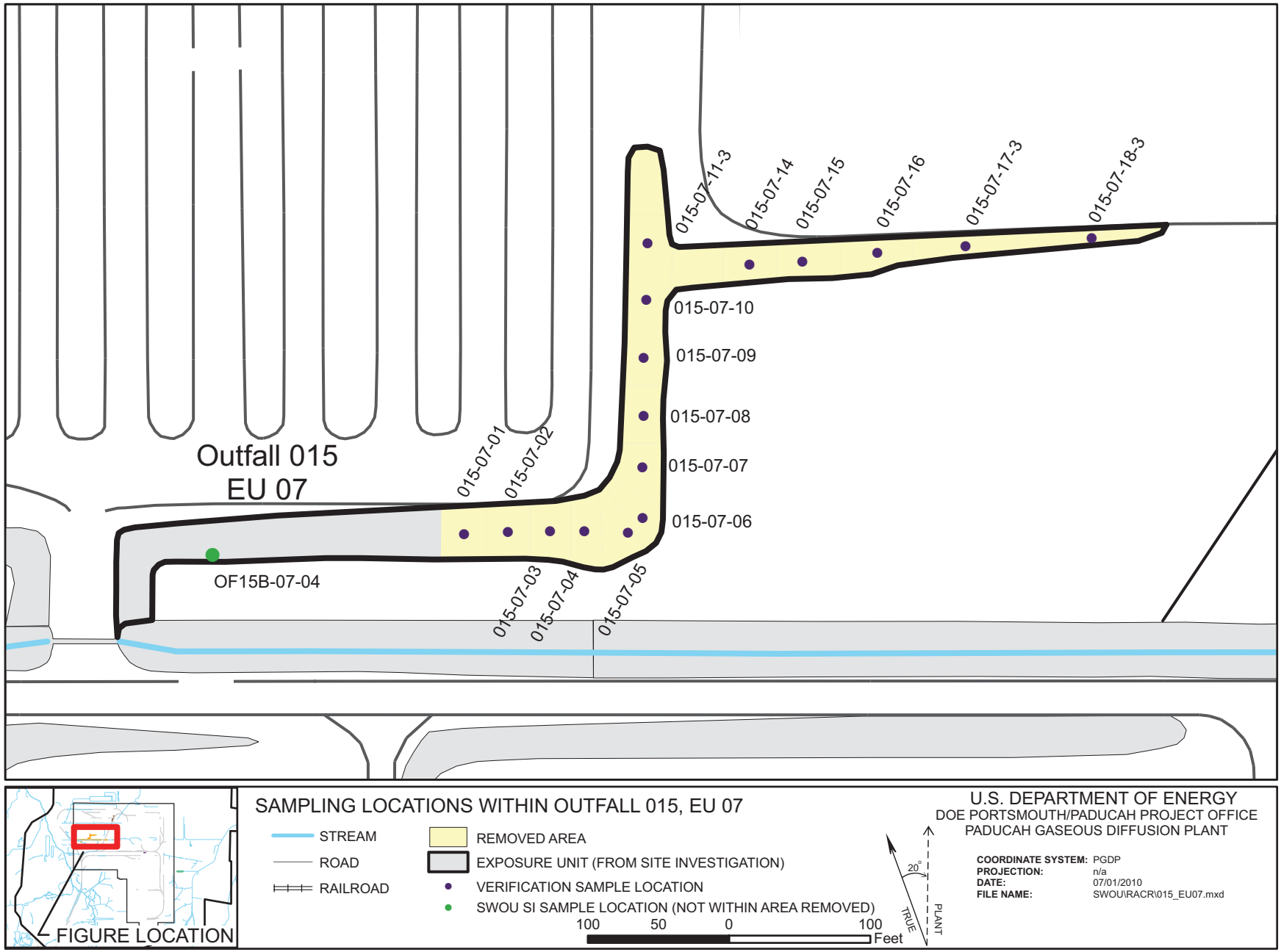

Figure C1.8. Sampling Locations within Outfall 015, EU 07

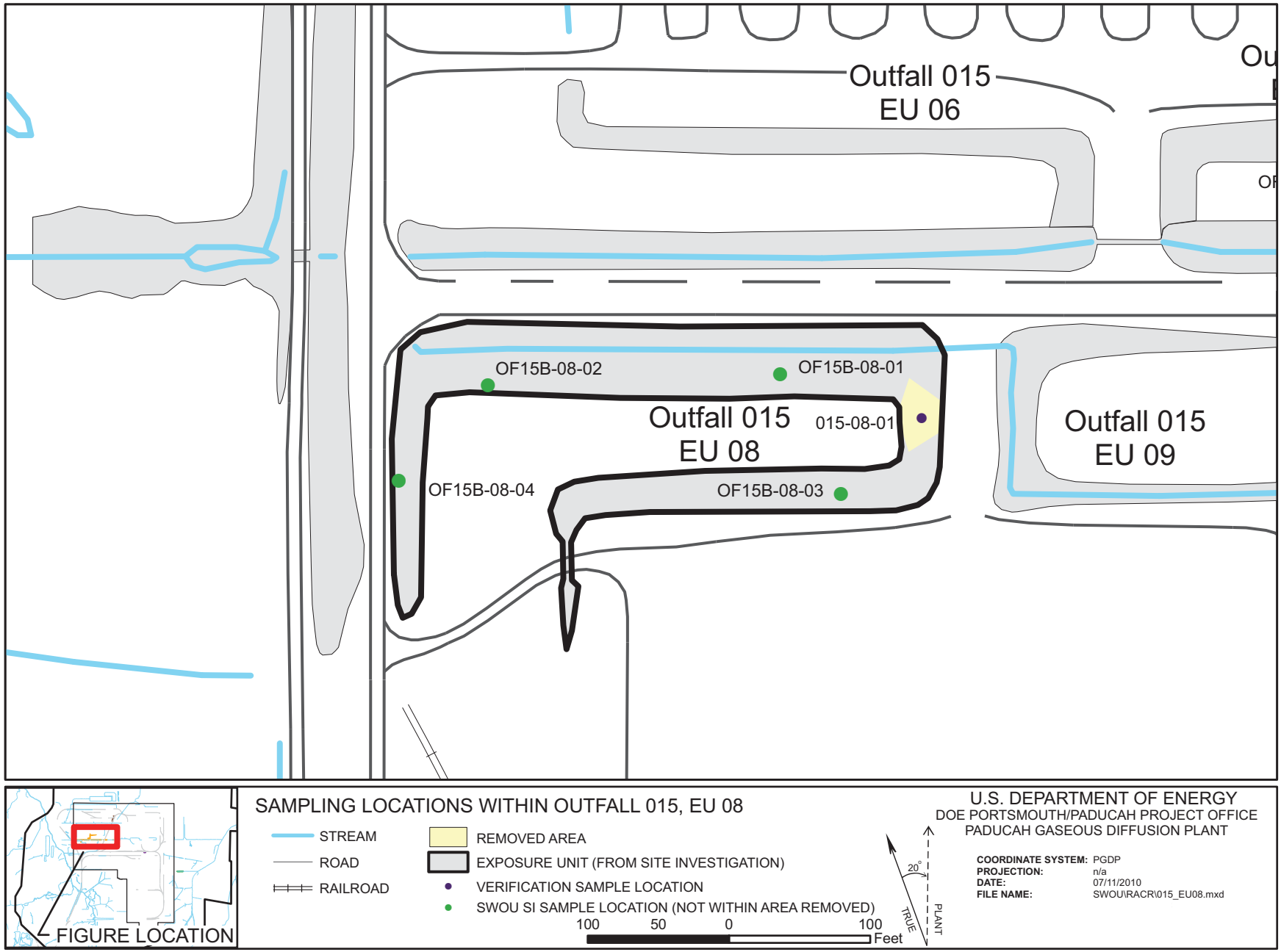

Figure C1.9. Sampling Locations within Outfall 015, EU 08

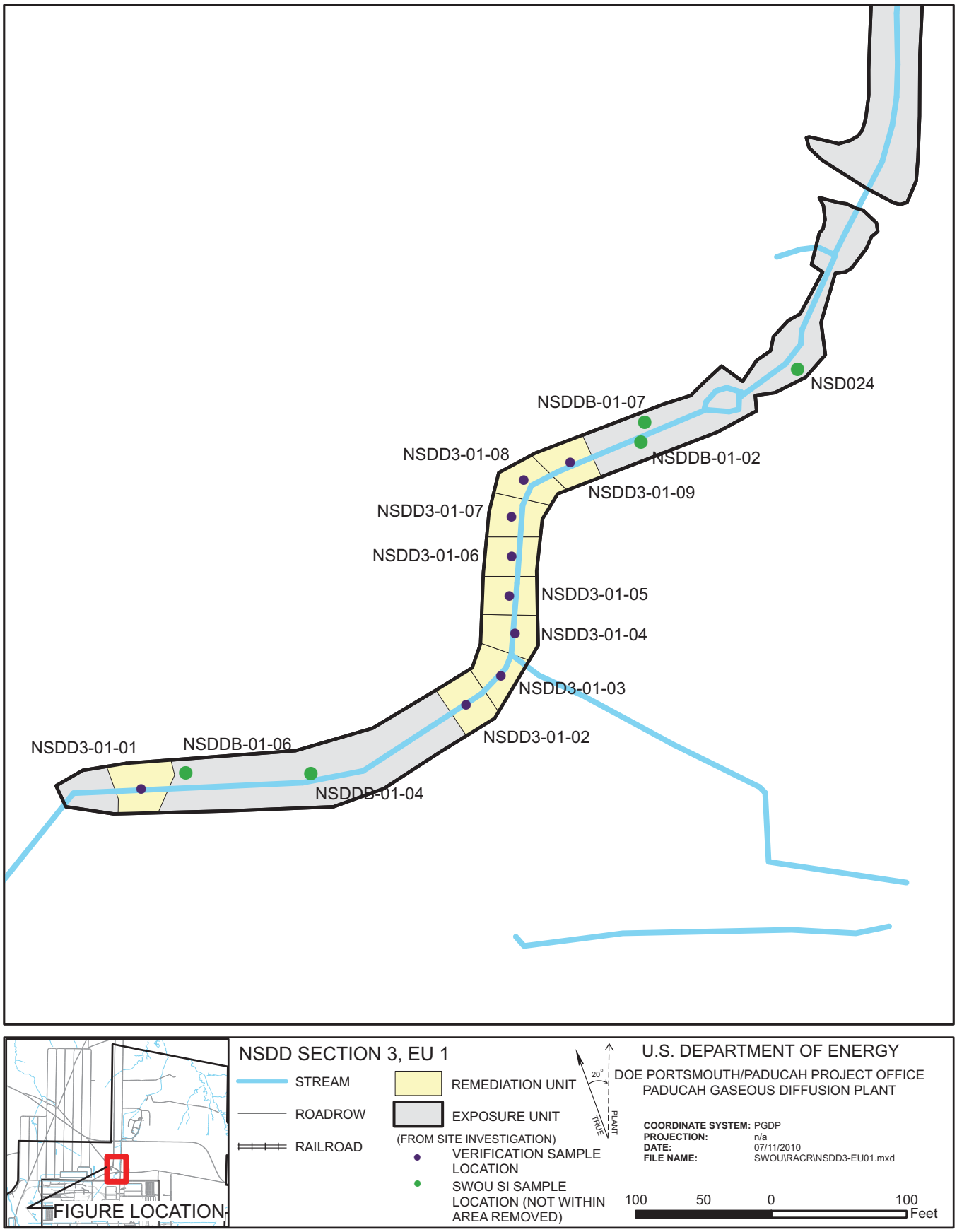

Figure C1.10. NSDD Section 3, EU 1

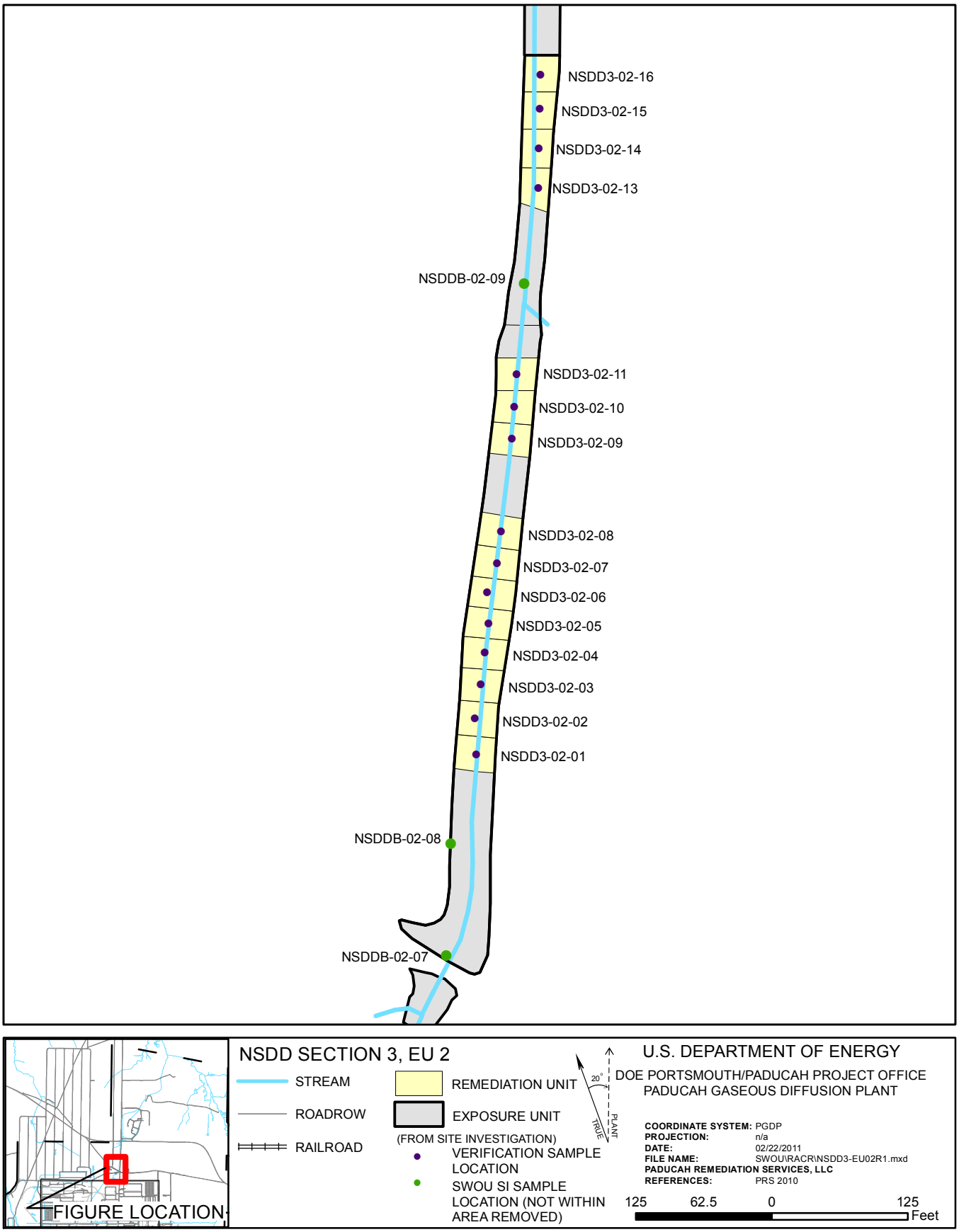

Figure C1.11. NSDD Section 3, EU 2

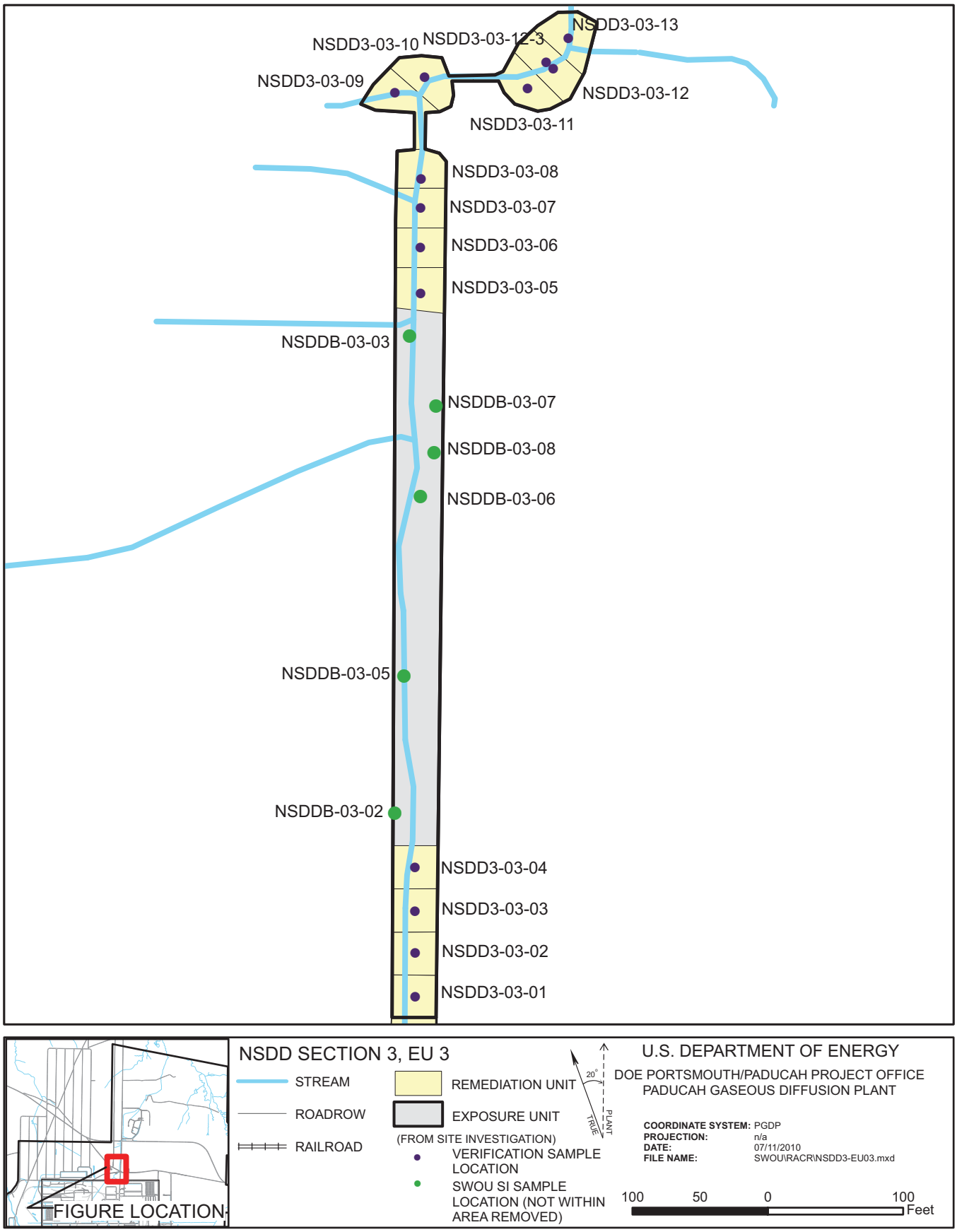

Figure C1.12. NSDD Section 3, EU 3

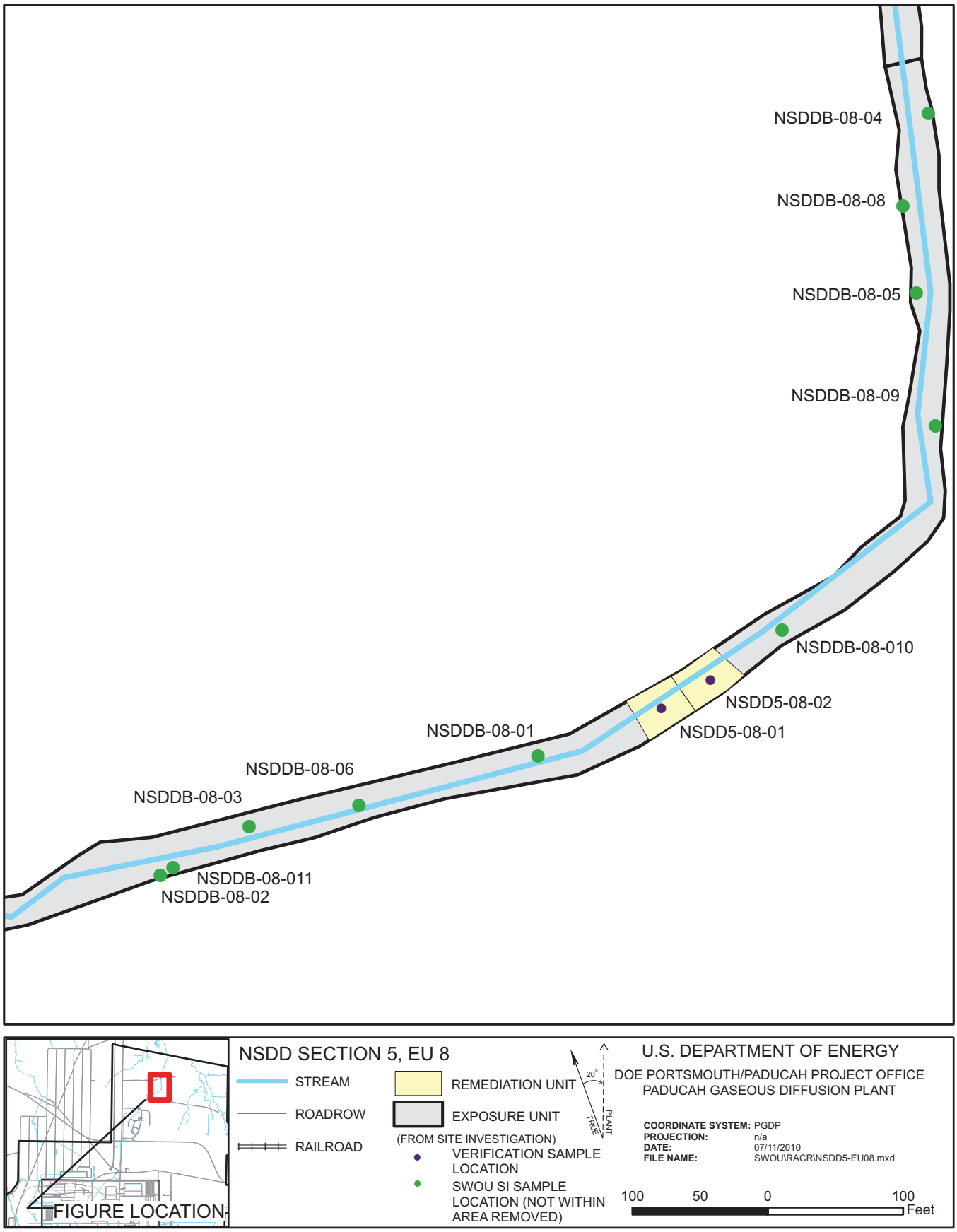

Figure C1.13. NSDD Section 5, EU 8

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APPENDIX D

CLEAN FILL VENDOR CERTIFICATION

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Martin Marietta Materials

3565 Lone Oak Road, Suite 4
Paducah, Kentucky 42003

Johnny L. Boyd
Sales Representative

Thursday, February 18, 2010

Dear Valued Customer:

We would like to thank you for the recent purchase of the channel lining rip rap being produced at our three Rivers Quarry located in Smithland KY. The Three Rivers Quarry is approved by several different states as well as the Corps of Engineers. The material is produced form state approved formations and is a well graded material free from any chemical contamination. If you have any other questions please feel free to contact me.

Sincerely,

Johnny L. Boyd
Martin Marietta Materials

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API Contractors

2950 Little Cypress Rd. • Calvert City, KY 42029
(270) 898-8090 • Fax (270) 898-8910

Submitted To	Phone	Date
LATA of Kentucky		**September 16, 2010**
Street	Job Name	
City, State, and Zip Code	Job Location	
Kevil, KY	**PGDP**	

Attn: Frank Overby

RE: Soil Letter

Frank,

The soil we are furnishing to LATA is excavated from a site we own that is original undisturbed soils. To the best of my knowledge, there is nothing that could be considered contaminated or debris containing. The only thing other than soils would be organic matter, weeds, grass, sticks, etc.

Sincerely,

Van Rudolph

VR:wd

Excel/MSJobs/LATA-General/Soil Letter 09-16-10

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APPENDIX E

PHOTOGRAPHS

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Figure E.1. Outfall 001 11-12-09 (Before)

Figure E.2. Outfall 001 11-12-09 (Before)

Figure E.3. Outfall 001 07-12-10 (During)

Figure E.4. Outfall 001 07-12-10 (During)

Figure E.5. Outfall 001 07-22-10 (After)

Figure E.6. Outfall 001 07-22-10 (After)

Figure E.7. Outfall 010 11-12-09 (Before)

Figure E.8. Outfall 010 06-25-10 (During)

Figure E.9. Outfall 010 07-12-10 (After)

Figure E.10. Outfall 011 11-12-09 (Before)

Figure E.11. Outfall 011 02-24-10 (During)

Figure E.12. Outfall 011 07-12-10 (After)

Figure E.13. Outfall 015, EU02 11-12-09 (Before)

Figure E.14. Outfall 015, EU02 11-12-09 (Before)

Figure E.15. Outfall 015 EU03 11-12-09 (Before)

Figure E.16. Outfall 015 EU03 11-12-09 (Before)

Figure E.17. Outfall 015 EU04 11-12-09 (Before)

Figure E.18. Outfall 015 EU04 11-12-09 (Before)

Figure E.19. Outfall 015 EU04 11-12-09 (Before)

Figure E.20. Outfall 015 EU07 11-12-09 (Before)

Figure E.21. Outfall 015 EU08 11-12-09 (Before)

Figure E.22. Outfall 015, EU 03 04-28-10 (During)

Figure E.23. Outfall 015, EU 03 04-28-10 (During)

Figure E.24. Outfall 015, EU 02 04-28-10 (During)

Figure E.25. Outfall 015, EU 02 07-12-10 (After)

Figure E.26. Outfall 015, EU 02/03 07-12-10 (After)

Figure E.27. Outfall 015, EU 03 07-12-10 (After)

Figure E.28. Outfall 015, EU 04 07-12-10 (After)

Figure E.29. North-South Diversion Ditch Section 3, EU 01 11-12-09 (Before)

Figure E.30. North-South Diversion Ditch Section 3, E U01 11-12-09 (Before)

Figure E.31. North-South Diversion Ditch Section 3, EU 02 11-12-09 (Before)

Figure E.32. North-South Diversion Ditch Section 3, EU 03 11-12-09 (Before)

Figure E.33. North-South Diversion Ditch Section 3, EU 03 11-12-09 (Before)

Figure E.34. North-South Diversion Ditch Section 3, EU 03 11-12-09 (Before)

Figure E.35. North-South Diversion Ditch Section 5 11-12-09 (Before)

Figure E.36. North-South Diversion Ditch Section 3 EU 02 3-26-10 (During)

Figure E.37. North-South Diversion Ditch Section 3 EU 02/03 03-26-10 (During)

Figure E.38. North-South Diversion Ditch Section 3 EU 03 03-26-10 (During)

Figure E.39. North-South Diversion Ditch Section 3 EU 01 07-13-10 (After)

Figure. E.40. North-South Diversion Ditch Section 3 EU 02 07-13-10 (After)

Figure E.41. North-South Diversion Ditch Section 3 EU 03 07-13-10 (After)

Figure E.42. North-South Diversion Ditch Section 5 07-13-10 (After)

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Response to Environmental Protection Agency Region 4
Comments submitted November 23, 2010,
Removal Action Report for Contaminated Sediment Associated with Surface Water Operable Unit (On-Site) at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky
DOE/LX/07-0357&D1, dated October 2010

General Comments:

Comment 1: NSDD Sections 3 and 5, Page 6: The text states that a 50-year in-growth period was assumed to calculate the activity of Ra-226 from a Th-230 parent. Th-230 alpha spec analysis should be included to prove justification of a 50-year in-growth period. If this data is not available, can samples be re-analyzed for Th-230 alpha spec?

Response 1: The text referenced from page 6 of the Removal Action Report discusses the replacement of walkover surveys [as directed by the Removal Action Work Plan (RAWP)] with gross alpha analytical measurements for field screening. Verification samples collected at completion of excavation were analyzed by the fixed-base laboratory for Th-230 using alpha spectroscopy. This data is available in Appendix B of the Removal Action Report.

Comment 2: General Section, Page 7: The text references the Inactive Facilities Removal Action Report as for the clean fill documentation rather than attaching the *Fill and Cover Materials Verification for Stockpile of Soil from Construction of the Northwest Storm Water Collection Basin, PRS-ENR-0037/R4*. The fill verification documentation should be included as part of the subject document. An electronic copy could be included on the CD with the Appendix B data.

Response 2: An electronic copy of the *Fill and Cover Materials Verification for Stockpile of Soil from Construction of the Northwest Storm Water Collection Basin, PRS-ENR-0037/R4* will be included on the CD with the Appendix B data.

Comment 3: General Section, Page 7: DOE states that "off-site clean fill (soil) was brought in for backfilling the seam area at Outfall 015 ditch, EU 07, RU 16, and a certification is included in Appendix D." Please provide the confirmation sampling results that indicate the fill material is acceptable.

Response 3: In accordance with the draft "Fill and Cover Material Verification Protocol" submitted as Appendix H in the Removal Action Work Plan (RAWP), and later finalized as "Fill and Cover Material Verification Guidance," (PRS-ENR-0036), "Commercial suppliers of soil for fill or cover will be asked for assurances that soil is uncontaminated as part of contracting." The assurance letter from the commercial supplier is included in Appendix D of the Removal Action Completion Report.

Comment 4: Verification of Cleanup, Page 7: The text states that verification sampling "indicate that the cleanup levels have been achieved." However, there is no indication of which approach, e.g. MARSSIM, was used to statistically meet cleanup goals. The report should clarify the procedure/approach used during the removal action for statistically meeting cleanup goals for radionuclides and PCBs.

Response 4: The RAWP stated the following:

> If the average concentration[2] of each COC analyzed in an area designated for cleanup is less than its cleanup level, then declare cleanup level attained.
>
> [2]The use of concentrations averaged over all samples collected to ascertain attainment of cleanup levels is consistent with agreements reached for implementation of the NSDD Sections 1 and 2 Remedial Action (BJC

2003). Additionally, the use of averages is consistent with guidance in Methods for Evaluating Attainment of Cleanup Standards, Volume 1: Soil and Solid Media (EPA 1989).

Each COC analyzed in each remediation unit was less than its cleanup level, therefore the cleanup level was attained.

Comment 5: General Section, Page 9: It is not appropriate to complain about the excavation/survey/sampling delays in the document. These types of delays can occur for any removal/remedial project. Many projects do not have the ability to use a field instrument [e.g. XRF, NaI] and a surrogate, and instead rely solely on lab analysis and the inherent delays associated with that. If the guidance from MARSSIM was used on remedial support surveys and final status surveys, and those methods caused excessive delays and problems, then documenting how and why MARSSIM guidance caused delays should be discussed with the core team.

Response 5: The paragraph has been reworded to the following: "In some instances, excavations that might have been backfilled were left open longer than anticipated, resulting in the excavations filling with water. The fact that excavations had filled with water delayed collection of field screening and verification samples and delayed overall progress of work because manpower was diverted from excavating soils to managing water in accordance with the approved Work Plan. As weather allowed, water accumulation in excavated areas was bypass pumped downstream of the active RU or was bypass pumped to an adjacent ditch not part of the project."

Response to Kentucky Division of Waste Management
Comments submitted February 17, 2011,
Removal Action Report for Contaminated Sediment Associated with Surface Water Operable Unit (On-Site) at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky
DOE/LX/07-0357&D1, dated October 2010

General Comments:

Comment 1: Please replace the word "cleanup" with "contaminant removal" throughout the document. This project is not meant as a final action, and in this context, the word "cleanup" is misleading.

Response 1: The text has not been revised. The text used in the document is consistent with text used in the EE/CA, the AM, and the RAWP.

Comment 2: Please replace the word "levels" as associated with "cleanup levels" to "concentrations" throughout the document. It is more accurate and directly comparable to the list of the Contaminant-of-Concern (COC) Risk-Based Concentrations (Table C-1).

Response 2: The terminology "cleanup levels" has been consistent throughout the EE/CA, the AM, and the RAWP. No change has been made to the document. A cleanup level is a concentration.

Comment 3: In each Summaries of Results subsection, there is a statement "Appendix A contains a figure showing the results….." Please state the exact Figure reference as it allows the reader to quickly access the relevant information.

Response 3: The following text has been added to p. 3:
"Figure A.3 found in Appendix A shows the results of this sampling effort…"
"Figure A.4, found in Appendix A, shows the final excavation limits…"
"Figure A.5, found in Appendix A, shows the final excavation limits…"
The following text has been added to p. 4:
"Figure A.6, found in Appendix A, shows the final excavation limits…"
"Figure A.7, found in Appendix A, shows the final excavation limits…"
The following text has been added to p. 5:
"Figure A.8, found Appendix A, shows the final excavation limits…"
The following text has been added to p. 7:
"Figures A.9 through A.11 show the final excavation limits…"

Comment 4: In each Summaries of Results subsection, please reference the appropriate Sampling Location maps (Attachment C1). This would allow the reader to quickly access the relevant information.

Response 4: The following text has been added to p. 3:
"Sample locations are shown in Figure C1.1 found in Appendix C."
The following text has been added to p. 4:
"Sample locations are shown in Figure C1.2 found in Appendix C."
"Sample locations are shown in Figure C1.3 found in Appendix C."
The following text has been added to p. 5:
"Sample locations are shown in Figure C1.4 found in Appendix C."
"Sample locations are shown in Figures C1.5 through C1.9 found in Appendix C."
The following text has been added to p. 7:
Sample locations are shown in Figures C1.10 through C1.13 found in Appendix C.

Comment 5: Please number and reference the photographs presented in Appendix E in the main text. Referencing the appropriate photos in the appropriate work activity sections would allow for a better visual reference of work performed.

Response 5: Photographs presented in Appendix E have been numbered and referenced.

Specific Comments:

Comment 1: Summaries of Results, Outfall 001, Page 2, 1st Sentence: This sentence should reference the "one EU" as "EU 15".

Response 1: The sentence now states "At Outfall 001, EU 15, containing 10 RUs…"

Comment 2: Summaries of Results, Outfall 001, Page 2, 2nd Sentence: This sentence states that four of the 10 RUs in EU 15 were not excavated. In the text, please state which four RUs were not excavated.

Response 2: The sentence now states "…four of the 10 RUs (RUs 02, 08, 09, and 10) were not excavated."

Comment 3: Summaries of Results, Outfall 001, Page 3, 4th Paragraph, 1st & 2nd Sentences: Please state which RUs were excavated to what depth below grade. This information could also be added visually (via shading, coloring or reference) in Figure A.4.

Response 3: The text now reads as follows:
"At the five RUs addressed under this action, one RU, RU 6, was excavated to 2 ft. The remaining RUs were excavated to 3 ft at some SUs and 4 ft at other SUs (see Figure A.4)."

Comment 4: Summaries of Results, Outfall 008, Page 3, 1st Paragraph: This sentence should reference the "one EU" as "EU 11".

Response 4: The sentence now states "At Outfall 008, EU 11, containing two RUs…"

Comment 5: Summaries of Results, Outfall 010, Page 4, 1st Paragraph
Please include location of the French drain in Figures A.6 and C1.3 (Outfall 010).

Response 5: The exact location of the French drain is not available. The drain ran parallel and immediately adjacent to the road depicted in Figures A.6 and C1.3, and the approximate location has been added to both figures.

Comment 6: Summaries of Results, Outfall 011, Page 4, 1st Paragraph: This sentence should reference the "one EU" as "EU 01".

Response 6: The sentence now states "At Outfall 010, EU 1, containing four RUs…"

Comment 7: Summaries of Results, Outfall 011, Page 4, 2nd Paragraph: What was the approximate square footage of the additional excavated area and to what depth below grade surface was it excavated to?

Response 7: The paragraph now states the following:

"At this time, an area approximately 450 ft^2 was excavated to a depth of 4 ft. yielding an additional 76 yd^3

of soils for disposal. Additional field screens and verification samples were collected, the results indicate that action limit and cleanup goals[7] were achieved in this area outside the boundary of RU 01, west of RU 01."

Comment 8: Summaries of Results, Outfall 015, Page 5, 2nd Paragraph: Please provide an explanation (if there is one) for the large discrepancy between the XRF result and the laboratory result for Uranium in EU 07, RU 17.

Response 8: Both the XRF and verification sample were at 4 ft. Given the heterogeneous distribution of concentration both at depth and on the surface, the high uranium result is not unexpected. The attached figure shows the layout of this sample with surrounding features. The variance in sample collection methodology between XRF and lab samples also exacerbates the possibilities and magnitude of discrepancies.

Comment 9: Summaries of Results, Outfall 015, Page 5, 6th Paragraph: Please add a specific direct push sample location map for the excavation performed in EU 07, RU 16. Please include the excavation depths (differing depths could be shaded or colored differently) and the location of the seam of yellow/green stained soils.

Response 9: Figure A.13 has been added.

Comment 10: Summaries of Results, Outfall 015, Page 5, 6th Paragraph, Last Sentence: The units given for XRF uranium results are pCi/g. Shouldn't this be mg/kg? Please revise the text accordingly.

Response 10: The sentence now states "XRF and PCB samples were collected below the excavation and resulted in less than 150 mg/kg uranium and less than 10 ppm PCBs."

Comment 11: Summaries of Results, NSDD Sections 3 and 5, Page 5, 1st Paragraph, 1st Sentence: This sentence should state which "four EUs" were involved in the removal action.

Response 11: The sentence now states "At NSDD, four EUs (EUs 01, 02, 03, and 08) containing 40 RUs…"

Comment 12: Summaries of Results, NSDD Sections 3 and 5, Page 5, 1st Paragraph, 4th Sentence: Please add the location of the high pressure gas line on Figures A.9 and C1-13. Please state the approximate square footage that was not addressed and provide an explanation of how not performing a removal action at a slated-for-excavation RU would affect the Residual Risk Evaluation for this EU.

Response 12: The verification sample for RU 12 was removed from Figure C1.11. The square footage not excavated (approximately 1,225 ft^2) also was added to the report, and text was added explaining why not excavating the identified area did not affect achievement of the project's RAO. The explanation included is as follows, "Sampling results collected previously from areas not excavated and collected from areas excavated were used in the risk evaluation for this EU. The residual risk for this EU was below the cumulative risk goal; therefore, the inability to excavate the area around the gas line did not affect the attainment of the project's RAO."

Comment 13: Summaries of Results, General, Page 7, 1st Paragraph: Please expand the paragraph concerning backfilling and site restoration. Briefly describe the equipment used, compaction methods, final grading procedures and type(s) of cover material used. References to Appendix E photos would be useful. Also, the use of riprap does not appear to have been anticipated in the RAWP. This deviation from the RAWP should be discussed in the appropriate location(s) in this document.

Response 13: The paragraph now states the following:

"Backfilling and site restoration were conducted following excavation by utilizing a track hoe excavator and a tracked skid-steer loader for placement of the cover material. Both the tracks and the buckets of the equipment were used to compact the cover material once it was in place. Final grading was accomplished with the skid-steer loader and hand tools working to grade stakes installed by a local engineering firm. Generally, the cover material consisted of soil, as discussed in the next paragraph; however, in areas where the existing slope had been too steep to allow for placement of soil, they were backfilled with riprap. Riprap was added to the RAWP via errata pages that were transmitted December 14, 2009. Riprap was used for portions of Outfall 011, Outfall 015 and NSDD Section 3 and all of NSDD Section 5." Figures A.8, A.9, A.10, and A.11 have been revised to indicate the areas were riprap was used.

Comment 14: Verification of Cleanup, Page 7, 5th Paragraph, Last line: The units given for XRF uranium results are pCi/g. Shouldn't this be mg/kg? Please revise the text accordingly.

Response 14: The sentence now states "XRF and PCB samples were collected below the excavation and resulted in less than 150 mg/kg uranium and less than 10 ppm PCBs."

Comment 15: Summaries of Problems Encountered, Outfall 010, Page 8, 2nd Paragraph: This sentence states "the three RUs that were excavated in January…." Please state which RUs were excavated.

Response 15: The sentence now states "Due to the length of time between beginning and completing excavation in this area, the three RUs that were excavated in January (RUs 01, 02, and 03) were excavated an additional 6 inches…"

Comment 16: Summaries of Problems Encountered, General, Page 9, 1st Paragraph: Please include a description of how the water was handled to alleviate the need for the reader to look through another document to find the answer. The addition of one sentence can eliminate that need and make the RAR more complete.

Response 16: The following text was added to the paragraph: "As weather allowed, water accumulation in excavated areas was bypass pumped downstream of the active RU or was bypass pumped to an adjacent ditch not part of the project."

Comment 17: Summaries of Accomplishments and/or Effectiveness of the Removal Action, Page 10, Table 2: Please expand Table 2 to include the originally planned excavation amount (yd^3) next to the existing actual volume excavated as well as the percentage of additional volume generated. These columns would include volumes sent both to the U-Landfill and Envirosolutions. This would put, in one table, a visual comparison of the original and additional volumes as well as percentages for above-anticipated removal volumes for all locations.

Response 17: Table 2 has been expanded to include the originally planned excavation amount (yd^3) next to the existing actual volume excavated as well as the percentage of additional volume generated. These columns include volumes sent both to the U-Landfill and Energy*Solutions*.

Comment 18: Appendix C, Page C-3, Table C.1: Table C.1 is titled "Cleanup Levels Based on Carcinogenic Risk and Hazard". Is Table C.1 the table for the excavation worker? If so, please note that in the table title. The next table with the Recreational User is not labeled with a table designation. It has been assumed that it is part of Table C.1.

Response 18: There was only one set of cleanup levels for the SWOU removal action. These levels were not separated into industrial worker and recreational user. The cleanup levels for SWOU were established in the EE/CA and are based on an industrial worker scenario, under the assumption that the risk-based concentrations calculated for the current industrial worker are "protective" of the current recreational user (see Appendix F of the EE/CA). The title for Table C.1 has been footnoted to indicate this. The undesignated table is information taken from "Tables E.1 and E.2 of the *Engineering Evaluation/Cost Analysis for Contaminated Sediment Associated with the Surface Water Operable Unit (On-Site) at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-0012&D2." An undesignated table title indicating "Reference Information" and a footnote indicating the following has been included; "Cleanup levels for the SWOU were established in the EE/CA and were established to be protective of both recreational user and industrial worker scenarios. See 'Cleanup Value' information above for table reference."

Response to Commonwealth of Kentucky Radiation Health Branch
Comments submitted February 17, 2011,
Removal Action Report for Contaminated Sediment Associated with Surface Water Operable Unit (On-Site) at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky
DOE/LX/07-0357&D1, dated October 2010

General Comments:

Comment 1: Gamma Walkover Survey (GWS) data was not provided as part of the initial data package for the Removal Action Report (RAR) for Contaminated Sediment Associated with the Surface Water Operable Unit (On-Site) D1. Kentucky requested walkover results on November 9, 2010 and the GWS survey plan with action levels in counts per minute (cpm) on November 15, 2010. Kentucky received the walkover data on December 20, 2010 and the action levels in cpm on January 4, 2011. The walkover data could not be reviewed until after this information was received, causing an unfortunate delay in the review and approval of the document.

The data eventually received was not in a usable form due to having no associated timestamps, and Kentucky was subsequently told that the times of the surveys could not be recovered due to the data recording method used. The only thing that could be determined from the supplied data was that contamination did exist in many ditches that had sediment removed. No statement can be made concerning the level of remaining contamination based on the GWS data, and the work performed in this project cannot be deemed a final action in the future due to the lack of a final walkover. Future projects of this nature should incorporate these comments and procedures in the data documentation and presentation.

Response 1: Addressed by the radiological technical working group (RTWG). Data collected for future projects will be time stamped.

Comment 2: According to Appendix F – Sampling and Analysis Plan of the approved D2 *Removal Action Work Plan (RAWP) for Contaminated Sediment Associated with the Surface Water Operable Unit (On-Site)*, the GWS data is an integral part of the decision process for this project and must be submitted before a complete review can occur. Without the GWS data, the RAR fails to convey to the reviewer how Activity I samples supported the excavation, or provided data to verify the achievement of action levels for indicator chemicals. Activity I samples, because the data was not retained, cannot nor could not "be used to update planning for post-excavation sampling." Future projects of this nature should incorporate the GWS data into a documented in presentable form.

Response 2: The issues concerning the reporting of the GWS data were addressed by the RTWG. The RTWG concluded that in future projects of this nature the GWS data should be appropriately time stamped to allow reviewers to understand how GWS data was used appropriately during the field effort.

Comment 3: This RAR discusses many instances of field deviations from the RAWP. In future projects, copies of logbook entries for all final GWS should be provided as an attachment. Where a required final GWS is not performed, provide copies of the logbook entries documenting the reason that the GWS is not being performed in accordance with the RAWP.

Response 3: Logbooks are submitted to the DOE Document Management Center (available upon request for review). These logbooks are not attached to CERCLA reports; however, deviations from the planned work are included in CERCLA reports.

Specific Comments:

Comment 1: Pg 3, Summaries of Results, Outfall 001, 3rd Paragraph; Pg 3; Summaries of Results, Outfall 008, 2nd Paragraph; & Pg 4, Summaries of Results, Outfall 010, 2nd Paragraph: The text states that GWS and field screenings indicate that all RUs were remediated below their respective action levels. This statement cannot be confirmed by available GWS data.

Response 1: As discussed with the Federal Facility Agreement (FFA) parties, no changes to the document are necessary. Data collected for future projects will be time stamped.

Comment 2: Page 4, Summaries of Results, Outfall 011, 2nd Paragraph and Page 7, Verification of Cleanup, Comparison of Cleanup Levels to Sampling Results: The text states that the field screening (XRF result of 2,953 mg/kg) indicated the presence of contamination at the 4-ft depth in one SU of Outfall 011. Considering all the data for this SU, it appears that the uranium result of 57.1 mg/kg is incorrect and should have been re-analyzed by the laboratory. In fact it appears that contamination increased at the 4-ft depth in this SU. Please see the laboratory data listed below:

OF011-01-01-V-3

U-235:	0.809 pCi/g
U-233/234:	6.32 pCi/g
U-238:	50.9 pCi/g
Uranium:	234 mg/kg

OF1011-01-01-V-4a

U-235:	0.97 pCi/g
U-233/234:	7.17 pCi/g
U-238:	60.6 pCi/g
Uranium:	57.1 mg/kg

The only contaminant that decreased at the 4-ft depth from the 3-ft depth was uranium (mg/kg). This is fundamentally impossible. It appears that this SU did not achieve cleanup goals. These results should have been questioned during data assessment. Future projects requiring data assessment should incorporate tighter QA/QC procedures.

Response 2: As discussed with the FFA parties, no changes to the document are necessary.

Comment 3: Page 5, Summaries of Results, Outfall 015, 1st Paragraph: The following verification sample for RU 15 in EU 07 of Outfall 015 should have been questioned during data assessment:

OF015-07-14-V-4

U-238:	83.3 pCi/g
Uranium:	155 mg/kg

While the U-238 result did not exceed the cleanup goal of 94 pCi/g, the fact that the uranium to U-238 ratio is roughly 2:1 instead of 3:1 should have been questioned. If the U-238 result is correct and the uranium result is not, it is possible that the amount of uranium in this sample is approximately 250 mg/kg, which would exceed the cleanup goal of 227 mg/kg. Future projects should ensure that results are consistent across all methods used to measure the same contaminant.

It is recognized that sometimes subsamples collected from a larger sample and analyzed by different methodologies will produce incongruent results, but these kinds of inconsistencies should be noted when they occur, and when possible, the samples should be reanalyzed. Finally, these kinds of inconsistencies should be rare.

Response 3: As discussed with the FFA parties, no changes to the document are necessary. Uranium activity and mass results will be assessed to ensure that they are consistent, recognizing that sometimes subsamples collected from a larger sample and analyzed by different methodologies will produce incongruent results. These kinds of inconsistencies will be further evaluated with the laboratory and noted when they occur.

Comment 4: Page 5 (continued on page 6), NSDD Sections 3 and 5, 2nd Paragraph and Page 9, Summaries of Problems Encountered, NSDD, 1st Paragraph: The RAWP, Page F-27, 1st paragraph, states: "For the NSDD, instrumentation capable of detecting a minimum of 100 pCi/g Th-230 during a walkover scan will be used." According to the cited section of the RAR, there was a major deviation from the RAWP. The reason given for the deviation was "because of the inability to reliably quantify Th-230 at the action limit of 100 pCi/g." The intention of the GWS in the RAWP has never been to quantify levels of contamination. The purpose of the Activity I sampling was to yield data to support the removal action of soils and sediments, i.e., result greater than action level. In the RAWP, the selection of instrumentation was based in part on the capability to detect 100 pCi/g of Th-230. It would be expected that a thorough evaluation of the impact of these deviations and changed assumptions be completed and that the evaluation would include all parties involved in developing the Work Plan.

Response 4: As discussed with the FFA parties, no changes to the document are necessary.

Comment 5: Page 9, Summaries of Problems Encountered, Outfall 11 & Outfall 15: At both outfalls, it is described that unfavorable GWS results were deemed unreliable or ambiguous, and therefore XRF results were used as the sole screening method in these cases. This demonstrates a fundamental issue with the unilateral modification of approved field procedures. These two methods vary greatly in scope and field usability. The GWS can demonstrate the average activity in the top layer of soil over a moderate sized (sq ft) area, while XRF identifies metal content in a postage-stamp sized area. Given an unknown level of homogeneity, the GWS can be more reliable in identifying contamination over larger areas that could otherwise be missed by either XRF or soil sampling. This fact is one of the factors in determining the number of samples and their locations in the work plan, and elimination of a method would influence the appropriate number of samples. Making changes to work plans or arbitrarily eliminating methods of assessing contaminant level without consulting the FFA parties is inappropriate and should not occur in future projects.

Response 5: As discussed with the FFA parties, no changes to the document are necessary.

Comment 6: Appendix B: Appendix B does not include the correct qualifier in "result qualifier" field. This field is empty for all rad results. Additionally, "Project Sample ID" and "Station" do not match on some samples, and "Station" seems to be used inconsistently. Please insure that the correct qualifier is used and other inconsistencies are corrected in future documents.

Response 6: In recognition that future users may not fully understand the meaning of the results without qualifiers applied, we will further evaluate the requirements with contracted laboratories and DOECAP to identify differing reporting requirements with respect to rad data qualifiers and request qualifiers be applied for future projects, if applicable.

The issue raised in the comment was passed to the data group for reconciliation with a recommendation that any rad result less than the project MDA/TPU have a "U" qualifier in the DATA_ASSESSMENT field in the D2 document.

“Project Sample ID” indicates the following:

OF011-01-02-V-3

Where OF011 indicates the outfall or NSDD Section
01 indicates the exposure unit
02 indicates the survey unit
V indicates a verification sample, and
3 indicates the depth of the sample collected.

For the “Station”
011-01-02

Where 011 indicates the outfall or NSDD section
01 indicates the exposure unit
02 indicates the remediation unit.

In some instances where work was necessary in addition to the initially planned work (such as the excavation of the French drain at Outfall 010 and the 6-ft excavation at Outfall 011), station names and project sample IDs varied.

After investigating the possibility of inconsistent use of “Station” and also “Project Sample ID” not matching “Station,” it was determined that a formatting error of the data tables caused some “Station” identifiers to be only partially visible. The formatting has been changed so that complete “Station” identifiers are now visible.