January 24, 2018

James Smith, Project Manager
U.S. Nuclear Regulatory Commission
Division of Decommissioning, Uranium Recovery, and Waste Programs
Material Decommissioning Branch
TWFN Mail Stop T-8F5
Rockville, MD 20852

**SUBJECT: DOE CONTRACT NO. DE-SC0014664
INDEPENDENT CONFIRMATORY SURVEY REPORT FOR SUBSURFACE INVESTIGATIONS AND SAMPLING OF SURVEY UNITS LSA 10-05 AND LSA 10-14 AT THE HEMATITE DECOMMISSIONING PROJECT, FESTUS, MISSOURI
RFTA NO. 17-004; DCN 5184-SR-09-0**

Dear Mr. Smith:

The Oak Ridge Institute for Science and Education (ORISE) is pleased to provide the attached final report that details the confirmatory survey activities performed during the period of October 16 through October 19, 2017 at the Hematite Decommissioning Project in Festus, Missouri. NRC's comments on the draft report have been incorporated.

Please feel free to contact me at 865.574.9646 or Erika Bailey at 865.576.6659 if you have any questions or comments.

Sincerely,

Jason D. Lee
Assistant Project Manager
ORAU

JDL:lw

Attachment

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J. D. Lee

FINAL REPORT

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NOTICES

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OAK RIDGE INSTITUTE FOR SCIENCE AND EDUCATION

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January 2018

FINAL REPORT

Prepared for the
U.S. Nuclear Regulatory Commission

This document was prepared for the U.S. Nuclear Regulatory Commission (NRC) by the Oak Ridge Institute for Science and Education (ORISE) through an interagency agreement (NRC FIN No. F-1244) between the NRC and the U.S. Department of Energy (DOE). ORISE is managed by Oak Ridge Associated Universities under DOE contract number DE-SC0014664.

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INDEPENDENT CONFIRMATORY SURVEY REPORT FOR SUBSURFACE INVESTIGATIONS AND SAMPLING OF SURVEY UNITS LSA 10-05 AND LSA 10-14 AT THE HEMATITE DECOMMISSIONING PROJECT FESTUS, MISSOURI

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FINAL REPORT

JANUARY 2018

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ACRONYMS

cpm	counts per minute
CsI	cesium iodide
$DCGL_W$	derived concentration guideline level
DNAPL	dense non-aqueous phase liquid
DOE	U.S. Department of Energy
DP	decommissioning plan
DPT	direct-push technology
HDP	Hematite Decommissioning Project
ITP	Intercomparison Testing Program
LSA	land survey area
MDC	minimum detectable concentration
NaI	sodium iodide
NIST	National Institute of Standards and Technology
NRC	U.S. Nuclear Regulatory Commission
ORAU	Oak Ridge Associated Universities
ORISE	Oak Ridge Institute for Science and Education
PCE	tetrachloroethylene
pCi/g	picocuries per gram
PPE	personal protective equipment
RCRA	Resource Conservation and Recovery Act
ROC	radionuclide of concern
TAP	total absorption peak
TCE	trichloroethylene
TCLP	Toxicity Characteristic Leaching Procedure
WEC	Westinghouse Electric Company, LLC

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INDEPENDENT CONFIRMATORY SURVEY REPORT FOR SUBSURFACE INVESTIGATIONS AND SAMPLING OF SURVEY UNITS LSA 10-05 AND LSA 10-14 AT THE HEMATITE DECOMMISSIONING PROJECT FESTUS, MISSOURI

EXECUTIVE SUMMARY

The U.S. Nuclear Regulatory Commission requested that the Oak Ridge Institute for Science and Education (ORISE) perform an independent confirmatory survey at the Hematite Decommissioning Project in Festus, Missouri. The survey units investigated during this confirmatory survey were land survey area (LSA) 10-05 and LSA 10-14, both of which are located within a portion of the site referred to as the documented burial area.

ORISE performed confirmatory survey activities, including subsurface soil sampling using direct-push technology, sample core scanning, and borehole scanning/data logging from October 16–19, 2017. ORISE collected a total of 44 samples consisting of 22 core samples taken from the backfill/native soil interface region, 21 composite samples collected from backfill elevations, and one composite waste profile sample. The results of the ORISE gamma and beta surveys, along with laboratory analytical results, did not identify any site-related contaminants above the respective uniform stratum derived concentration guideline level values (most restrictive) in the selected investigation areas in LSA 10-05 or 10-14.

INDEPENDENT CONFIRMATORY SURVEY REPORT FOR SUBSURFACE INVESTIGATIONS AND SAMPLING OF SURVEY UNITS LSA 10-05 AND LSA 10-14 AT THE HEMATITE DECOMMISSIONING PROJECT FESTUS, MISSOURI

1. INTRODUCTION

Westinghouse Electric Company, LLC (WEC), a former fuel cycle facility near Festus, Missouri, operated from 1956 to 2001 manufacturing nuclear fuel from natural and enriched uranium. The site ceased operational activities in September 2001, and WEC is decommissioning the facility, now known as the Hematite Decommissioning Project (HDP). From its inception in 1956 through 1974, the facility was used primarily in support of government contracts that required the production of highly enriched uranium products. From 1974 through plant closure in 2001, the focus changed from government contracts to commercial fuel production. Specifically, operations included the conversion of uranium hexafluoride gas of various uranium enrichments to uranium oxide, uranium carbide, uranium dioxide pellets, and uranium metal. Secondary operations included research and development and uranium scrap recovery processes. The facility's central land area and the site creek were impacted by the fuel fabrication activities. As part of the overall site decommissioning, WEC performed remediation of land areas, including former burial trenches. Depth of excavations varied with the maximum depth reached of 7.5 meters (24.5 feet), encountering the water table interface (phreatic zone) at some locations. Final status surveys were then performed and excavations were backfilled with soil that was either obtained from off-site borrow areas and/or on-site reuse soil stockpiles.

The U.S. Nuclear Regulatory Commission (NRC) is responsible for oversight of permitted decommissioning activities that are in accordance with the sites' decommissioning plan and NRC License SNM-33. As the goal of the HDP is to release the site for unrestricted use, the NRC has opted to perform independent (third party) confirmatory investigations at the site in order to verify the final status radiological conditions. The NRC has requested support from the Oak Ridge Institute of Science and Education (ORISE) to perform independent confirmatory subsurface sampling to determine whether residual radioactive material above approved derived concentration guideline levels ($DCGL_W$s) may be present within two of the remediated and backfilled HDP Land Survey Areas (LSAs). The excavations within these LSAs were backfilled prior to the performance of confirmatory surveys and sampling.

2. SITE DESCRIPTION

The Hematite facility is located in Jefferson County, Missouri, less than 4 miles west of the town of Festus, Missouri and 35 miles south of the city of St. Louis. The site is surrounded by forest, agricultural lands, and low-density residential housing. The entire site consists of approximately 228 acres; however, the impacted portion of the site, referred to as the central tract, only includes approximately 19 acres. The central tract of the site is bounded by State Road P to the north, the northeast site creek to the east, Union-Pacific railroad tracks to the south, and the site creek/pond to the west.

LSAs 10-05 and 10-14 are located within the portion of the site referred to as the documented burial area. Both LSAs are located near an area of the site that was used for waste handling during the decommissioning. The proximity of staged waste material to LSAs 10-05 and 10-14 could have resulted in the migration of contaminated materials into the excavations due to runoff during heavy rain events.

Figure 2.1 shows the site overview with the burial pit and waste handling locations identified, and Figure 2.2 provides an overview of the site and identifies the location of the various LSAs. Figures 2.3 and 2.4 present LSAs 10-05 and 10-14 following remediation and show the proximity of the waste piles to the excavations. Figure 2.5 displays the backfill depth topography following remediation.

Figure 2.1. Aerial Photo Showing Burial and Waste Handling Areas

Figure 2.2. Burial Area LSAs

Figure 2.3. LSAs 10-14 and 10-05 Looking Northwest

Figure 2.4. LSA 10-14 Looking West-Northwest with View of Waste Piles

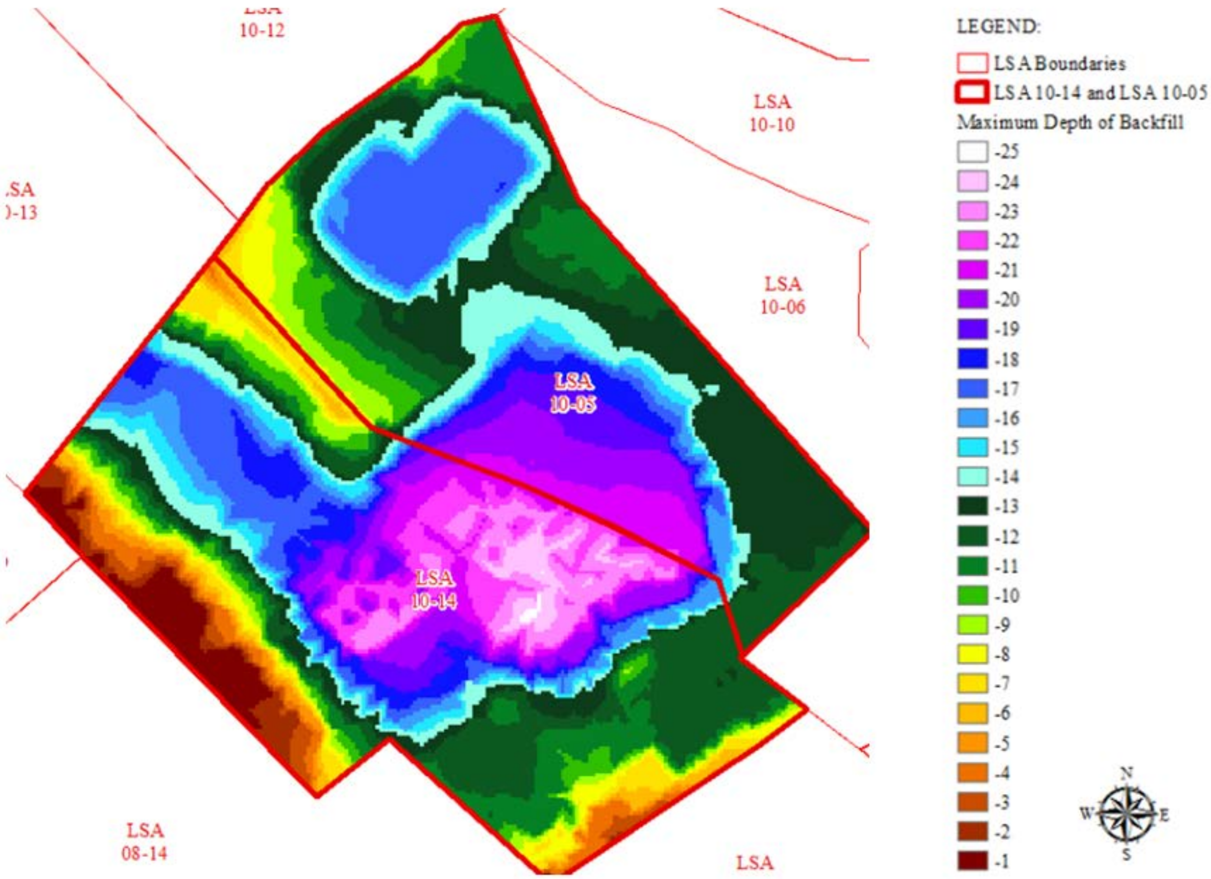

Figure 2.5. LSAs 10-14 and 10-05 Backfill Depth (in feet) Topographic Map

3. RADIONUCLIDES OF CONCERN

The historical site operations at HDP resulted in several radionuclides of concern (ROCs). The primary ROCs are technetium-99 (Tc-99), thorium-232 (Th-232), radium-226 (Ra-226), uranium-234 (U-234), uranium-235 (U-235), and uranium (U-238). The isotopic abundances of uranium vary based on the enrichment levels of U-235 involved during fuel manufacturing and uranium scrap recovery. There has also been lesser impact due to secondary ROCs, including neptunium-237 (Np-237), plutonium-239/240 (Pu-239/240), and americium-241 (Am-241). $DCGL_W$s were developed for all ROCs. The soil $DCGL_W$s were based on a number of possible future site use exposure scenarios considering where the residual contamination may have been located in the various near surface and subsurface soil strata. These strata are represented in Figure 3.1. This subsurface investigation targeted the interface between the backfill cover and unsaturated zone, representing native soil. Table 3.1 provides the site-specific soil $DCGL_W$s by stratum.

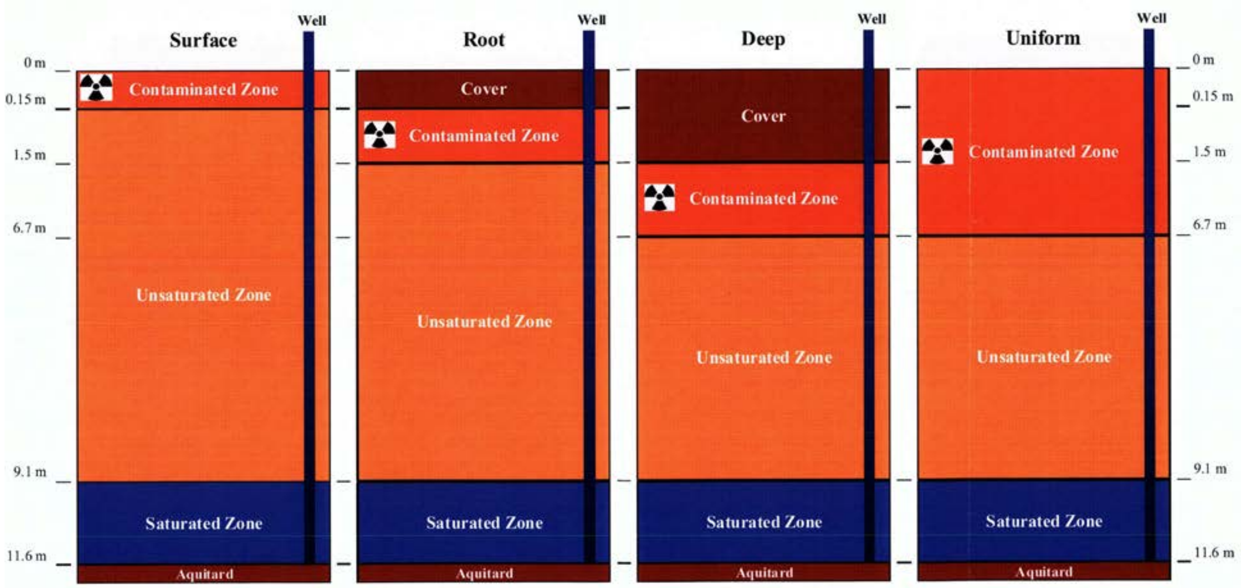

Figure 3.1. Conceptual Site Models for Site-Specific DCGL$_W$s

Table 3.1. Site-Specific Soil DCGL$_W$s by Stratum

Radionuclide	DCGL$_W$ Values (pCi/g)[a]				
	Shallow[b] Stratum	Root Stratum	Deep Stratum	Excavation Scenario	Uniform Stratum
Uranium-234	508.5	235.6	2,890	872.4	195.4
Uranium-235+D[c]	102.3	64.1	3,034	208.1	51.6
Uranium-238+D[c]	297.6	183.3	3,028	551.1	168.8
Technetium-99	151.0	30.1	98,649	74.0	25.1
Thorium-232+C[d]	4.7	2.0	9,279	5.2	2.0
Radium-226+C[d]	5.0	2.1	13,029	5.4	1.9

[a] The reported limits are the activities of the parent radionuclide, as specified.
[b] The decommissioning plan uses "shallow" interchangeably with "surface."
[c] +D refers to the parent radionuclide plus short-lived decay products.
[d] +C refers to the entire decay chain in secular equilibrium.

In addition to the radiological contaminants, dense non-aqueous phase liquid (DNAPL) organic compounds are also known to be present in the saturated or aquitard zones. Although DNAPLs are not the target objective of this investigation, the compounds were evaluated for health and safety and waste management purposes. Analytical results for DNAPL constituents are discussed in Section 7.4.

4. OBJECTIVES

The primary investigation objectives were to:

- Conduct subsurface sampling of the backfill and native soil interface at pre-selected locations within both LSAs.
- Determine if radionuclide concentrations satisfy the $DCGL_W$s and/or indicate that residual contamination remains either at the interface or within the backfill column, based on downhole logging and/or screening of soil cores.
- Evaluate confirmatory samples from the backfill material to ensure that any site-related contaminants detected are at levels that satisfy license conditions for off-site borrow and reuse soil.

5. PROCEDURES

From October 16–19, 2017, ORISE performed confirmatory survey activities within LSAs 10-05 and 10-14. The activities were in accordance with a project-specific plan (ORISE 2017). The confirmatory survey activities were also conducted in accordance with the *ORAU Radiological and Environmental Survey Procedures Manual* and the *ORAU Environmental Services and Radiation Training Quality Program Manual* (ORAU 2016a and ORAU 2016b).

5.1 SUBSURFACE SAMPLING LOCATION SELECTION

Subsurface sampling locations in LSAs 10-05 and 10-14 were selected based on professional judgment using available photographic records, such as those provided in Figures 2.3 and 2.4, and a backfill topographic map (Figure 2.5). The photographic records and maps were reviewed to identify storm water runoff pathways and accumulation points associated with the former waste staging areas that could have impacted LSAs 10-05 and/or 10-14. Once the areas with highest potential for impact were delineated, specific borehole locations were generated in those areas based on a random-start/systematic placement approach. Borehole locations were distributed proportional to the size of the associated area. The configuration of the investigation area and the random-start point resulted in 21 locations being plotted. Figure A.1 illustrates the location of these points in relation to the LSA boundaries. Individual borehole locations were designated via global positioning coordinates using the NAD 1983 Missouri State Plane East Zone coordinate system.

5.2 Subsurface Sampling

Subsurface sampling and investigation was conducted at 21 locations throughout LSAs 10-05 and 10-14. The terminal penetration depth at each of the pre-selected locations was based on spatial data received from WEC and interpreted by ORISE. Figure A.2 presents an excavation depth map with the pre-selected sample locations identified. Table 5.1 summarizes the various borehole terminal depths achieved and estimated point of interface for each location.

Table 5.1. Bore Depth and Point of Interface Summary

FID[a]	Sample IDs		Coordinates (m)[b]		Interface Depth (m)[b]	Terminal Bore Depth (m)[b]
	Interface	Backfill	X	Y		
0	5184S0184	5184S0183	252252	263634	5.8	6.1
1	5184S0192	5184S0191	252259	263634	5.2	6.1
2	5184S0198	5184S0197	252266	263634	6.4	6.7
3	5184S0194	5184S0193	252255	263640	5.2	6.1
4	5184S0196	5184S0195	252263	263640	6.1	6.7
5	5184S0204	5184S0203	252270	263640	6.4	7.3
6	5184S0186	5184S0185	252259	263622	3.4	4.6
7	5184S0188	5184S0187	252266	263622	3.0	4.6
8	5184S0190	5184S0189	252263	263628	4.0	4.6
9	5184S0200	5184S0199	252270	263628	3.4	4.6
10	5184S0202	5184S0201	252274	263634	4.9	6.1
11	5184S0214	5184S0213	252277	263640	5.8	7.6
12	5184S0216	5184S0215	252282	263640	5.2	6.1
13	5184S0212	5184S0211	252272	263646	5.2	6.1
14	5184S0218	5184S0217	252279	263646	5.2	6.1
15	5184S0206	5184S0205	252262	263652	4.9	6.1
16	5184S0210	5184S0209	252269	263652	4.9	6.1
17	5184S0220	5184S0219	252275	263652	4.3	5.5
18[c]	5184S0224	5184S0223	252282	263652	2.7	4.6
	5184S0225				3.7	
19	5184S0208	5184S0207	252265	263658	3.7	4.6
20	5184S0222	5184S0221	252272	263658	4.0	4.6

[a] Field identification
[b] Units converted from feet to meters and rounded to one decimal place
[c] Due to difficulty in identifying the native soil/backfill interface, two samples were collected

Following soil core removal, a sample representative of the backfill/native soil interface was collected in equal portions from the 15-centimeter interval above and below the interface as identified by visual inspection and/or excavation depth information provided by WEC. Additionally, a single composite sample was collected per borehole consisting of equal volume aliquots taken from each of the incremental 1.5-meter cores. The composite sample was representative of the entire backfill layer at that borehole location.

5.3 Sample Core Screening

Gamma scans of extracted cores were performed using a Ludlum Model 44-10 2-inch × 2-inch sodium iodide (NaI) scintillation detector. Beta scans were performed using Ludlum Model 44-142 plastic scintillation detector. Detectors were coupled to Ludlum Model 2221 ratemeter-scalers with audible indicators. Each soil core was scanned and the audio response monitored to identify the presence of any elevated direct radiation indicative of residual contamination. Beta and gamma detector response ranges were recorded individually for each of the 1.5-meter soil cores. In addition, cores were also screened for volatile organic compounds using a RAE Systems MiniRAE 3000 photoionization detector.

5.4 Borehole Logging

After the backfill/native soil interface was reached and the sample cores extracted, gamma radiation detection equipment connected to a ratemeter and Trimble Geo 7X datalogger was lowered into the borehole while observing the detector's audio response. Gamma radiation count rates were electronically logged at one-second intervals as the detector was lowered at a rate of approximately 25 centimeters per second.

It was initially planned to conduct borehole logging using only the NaI detector with the outer direct-push technology (DPT) casing in place. However, the inner diameter of the casing was too small to accept the NaI detector. The casing was removed in order to facilitate scanning, but the NaI detector could not consistently reach the backfill/native soil interface due to compression in the borehole following removal of the casing. A smaller diameter Ludlum Model 44-159-1 cesium iodide (CsI) detector was used in addition to the NaI. The CsI detector was able to reach the backfill/native soil interface at all borehole locations. A 30-second static gamma measurement was collected at the backfill/native soil interface and at approximately 1.5-meter intervals as the detector was retrieved. Since the NaI detector failed to consistently reach the backfill/native soil interface, static measurement data were collected using primarily the CsI. Location 0 is the exception to this because the NaI was able to reach interface depth.

5.5 DECONTAMINATION, WASTE MANAGEMENT, AND BOREHOLE ABANDONMENT

Investigation derived wastes included water generated during decontamination activities, excess soil sample cores, used DPT liners and caps, plastic sheeting from the decontamination pad, disposable personal protective equipment, and decontamination wipes.

All downhole equipment making contact with the native soil layer was decontaminated between boreholes. Decontamination consisted of a combination of dry wiping to remove visible soil and cleaning with a phosphate-free detergent solution. All liquids generated during decontamination activities were captured and containerized for on-site water treatment and discharge by WEC.

Excess soil collected from the backfill layer was containerized independently by borehole in sealable plastic buckets. Excess native soil from all boreholes was segregated from backfill material and placed into a single 55-gallon drum. A composite sample of the native soil was collected and submitted for radiological and Toxicity Characteristic Leaching Procedure (TCLP) analysis. All materials pending laboratory analysis were custody sealed, labeled, and stored onsite to await an appropriate disposition pathway determination.

Used DPT liners and caps and plastic sheeting were containerized separately in 55-gallon drums and left at the site pending laboratory analysis of associated soils. The small volume of personal protective equipment (PPE) generated was returned to ORISE for analysis by gamma spectroscopy.

All boreholes were immediately backfilled with bentonite from surface elevation to full depth. Abandonment activities were conducted with oversight by a Missouri Department of Natural Resources representative to ensure the process was in accordance with local, state, and federal regulations.

6. SAMPLE ANALYSIS AND DATA INTERPRETATION

Radiological samples and data collected at the site were transported to the ORISE facility in Oak Ridge, Tennessee for analysis and interpretation. Radiological sample custody was transferred to the ORISE Radiological and Environmental Analytical Laboratory. Radiological sample analyses were performed in accordance with the ORAU *Radiological and Environmental Analytical Laboratory Procedures Manual* (ORAU 2017). Soil samples were analyzed by gamma spectroscopy for U-238, U-235, Th-232, and Ra-226, and results were also reviewed for other site-specific gamma-emitting ROCs—results were reported in units of picocuries per gram (pCi/g). All confirmatory soil samples were compared directly with the uniform stratum $DCGL_W$s presented in Table 3.1.

Alpha spectroscopy was not performed; therefore, U-234 was calculated based on the U-238 to U-235 concentration ratio. Uranium-234 was calculated in the same manner as described in Section 14.1.4.3.3 of the approved decommissioning plan (DP) (WEC 2013).

Samples were analyzed for Tc-99 by chemical separation and liquid scintillation counting. Analytical results were reported in pCi/g.

In addition to radiological analysis, the native soils composite sample was submitted to a subcontracted laboratory for TCLP analysis. The primary analytes of concern include the DNAPL compounds trichloroethylene (TCE) and tetrachloroethylene (PCE). Data was compared to Resource Conservation and Recovery Act (RCRA) limits for the classification of characteristic hazardous wastes.

7. FINDINGS AND RESULTS

7.1 RADIOLOGICAL CONCENTRATIONS IN SOIL

A complete summary of analytical results for ROCs identified as site-related contaminants are presented in Appendix B, Table B.1. ROC concentration ranges for interface and backfill soils, including summary statistics, are provided in Table 7.1. Radiological analysis indicates all ROCs are below their respective $DCGL_W$s. Individual sample results were not corrected for background.

Table 7.1. Range of Radionuclide Concentration in Soil Cores (pCi/g)									
ROC	Uniform $DCGL_W$	Interface				Backfill Composite			
		Min	Max	Mean	Stdev	Min	Max	Mean	Stdev
Tc-99	25.1	-0.14	1.04	0.27	0.27	-0.26	0.55	0.11	0.22
U-234[a]	195.4	0.38	8.89	3.04	2.27	0.70	5.37	2.54	1.20
U-235	51.6	0.01	0.49	0.16	0.13	0.03	0.29	0.13	0.07
U-238	168.8	1.09	2.40	1.68	0.35	1.05	2.6	1.71	0.44
Th-232	2.0	0.99	1.43	1.20	0.11	1.09	1.48	1.26	0.10
Ra-226	1.9	0.82	1.13	0.98	0.09	0.794	1.04	0.92	0.07

[a] Appendix E provides the details for the calculation of U-234 concentration.

7.2 Sample Core Screening

Each 1.5-meter section of sample core was scanned for both beta and gamma radiation using the instruments mentioned in Section 5.3. No audible indication of elevated radiation was identified during scanning. Beta scans ranged from 270 to 700 counts per minute (cpm), with an average background of approximately 450 cpm. Gamma scans ranged from 8,000 to 12,200 cpm, with an average background of approximately 9,500 cpm. A summary of the collected soil core screening data is provided in Table 7.2. No judgmental samples were collected based on scan results.

Table 7.2. Sample Core Screening Results				
FID[a]	Sample IDs		Measurement Ranges (cpm)	
	Interface	Backfill	Beta	Gamma
0	5184S0184	5184S0183	300 - 700	8,500 - 10,500
1	5184S0192	5184S0191	330 - 500	8,600 - 11,000
2	5184S0198	5184S0197	320 - 450	8,200 - 10,400
3	5184S0194	5184S0193	330 - 510	8,800 - 10,100
4	5184S0196	5184S0195	340 - 500	8,000 - 10,200
5	5184S0204	5184S0203	300 - 540	9,000 - 11,800
6	5184S0186	5184S0185	385 - 620	8,500 - 10,000
7	5184S0188	5184S0187	350 - 550	10,300 - 12,000
8	5184S0190	5184S0189	300 - 520	9,400 - 12,000
9	5184S0200	5184S0199	340 - 450	8,400 - 10,000
10	5184S0202	5184S0201	300 - 500	9,600 - 12,200
11	5184S0214	5184S0213	330 - 530	8,700 - 10,300
12	5184S0216	5184S0215	330 - 530	8,700 - 11,100
13	5184S0212	5184S0211	350 - 550	8,600 - 10,700
14	5184S0218	5184S0217	300 - 460	8,700 - 11,400
15	5184S0206	5184S0205	300 - 480	9,100 - 11,100
16	5184S0210	5184S0209	350 - 500	8,800 - 10,300

Table 7.2. Sample Core Screening Results				
FID[a]	Sample IDs		Measurement Ranges (cpm)	
	Interface	Backfill	Beta	Gamma
17	5184S0220	5184S0219	310 - 470	9,100 - 11,100
18	5184S0224	5184S0223	270 - 460	8,400 - 9,900
	5184S0225			
19	5184S0208	5184S0207	350 - 470	8,400 - 10,500
20	5184S0222	5184S0221	314 - 520	8,800 - 10,800

[a] field identification

7.3 BOREHOLE LOGGING

There was no audible indication of elevated direct radiation identified during scanning. Comprehensive results of all borehole logging data are provided in Appendix A, Figures A.3 and A.4 as histograms. Data for the NaI and CsI detectors were evaluated individually. Since the NaI was consistently unable to reach the backfill/native soil interface, scan data presented in the aforementioned histograms should not be considered representative of the entire study area. Results generated by the NaI rarely included data points collected from the backfill/native soil interface region. The exception to this statement would include scan data from Locations 0, 1, 18, and 20, which either reached the interface or came reasonably close.

Both figures indicate data are representative of background consistent with a normal distribution, where 97% of NaI data points and 99% percent of CsI data points fall within three standard deviations of the mean. It is noted that both histograms are bimodal. The lower intensity peak is related to detector response above and just inside of the borehole, while the higher intensity peak results from detector responses generated inside the borehole. Use of histograms in the evaluation of scan data is discussed further in Section E.3.2.

Static measurements were collected at various intervals as described in Section 5.4. Due to the inability of the NaI to consistently reach the backfill/native soil interface depth because of borehole compression, static measurements were collected and evaluated primarily with the CsI. It is noted that Location 0 was the first borehole surveyed and did not exhibit the same issues with borehole compression. As a result, static measurement data from Location 0 was collected with the NaI. A complete evaluation of static measurement data indicates all measurements fall within the 1,900 cpm to 2,900 cpm background range for the CsI detector as established from the comprehensive collection of scan data. The minimum and maximum static CsI measurements were

2,000 cpm and 2,500 cpm, respectively. NaI measurements collected from Location 0 fall within the 16,000 cpm to 22,000 cpm background range established from collected data. As previously mentioned, NaI scan data consists primarily of the backfill layer. A complete summary of static measurement data is provided in Appendix B, Table B.2. An evaluation of the scan sensitivity of the CsI detector is presented in Appendix E.

7.4 WASTE SAMPLING

TCLP results for the native soils composite sample were all below their respective characteristic hazardous waste limit. It is noted that PCE was present at 0.074 mg/L, which is still below the 0.7 mg/L regulatory limit for PCE characteristic hazardous waste. Results of TCLP analysis are provided in Appendix C. Radiological analysis of the composite waste sample indicates all ROCs are below their respective $DCGL_W$s. Analytical results are presented in Appendix B, Table B.1

Gamma spectroscopy results indicated the PPE could be disposed of as regular trash.

8. SUMMARY AND CONCLUSION

At NRC's request, ORISE conducted independent confirmatory subsurface investigations and sampling in the documented burial area. The areas investigated were LSAs 10-05 and 10-14. The survey was conducted October 16–19, 2017. The survey activities included subsurface soil sampling, sample core scanning, and borehole scanning/data logging. ORISE collected a total of 44 samples consisting of 22 samples taken from the backfill/native soil interface region, 21 composite samples collected from backfill elevations, and one composite waste profile sample. All individual confirmatory measurement results were below the respective uniform stratum $DCGL_W$ values (most restrictive) for the ROCs specified in the approved DP.

9. REFERENCES

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APPENDIX A
FIGURES

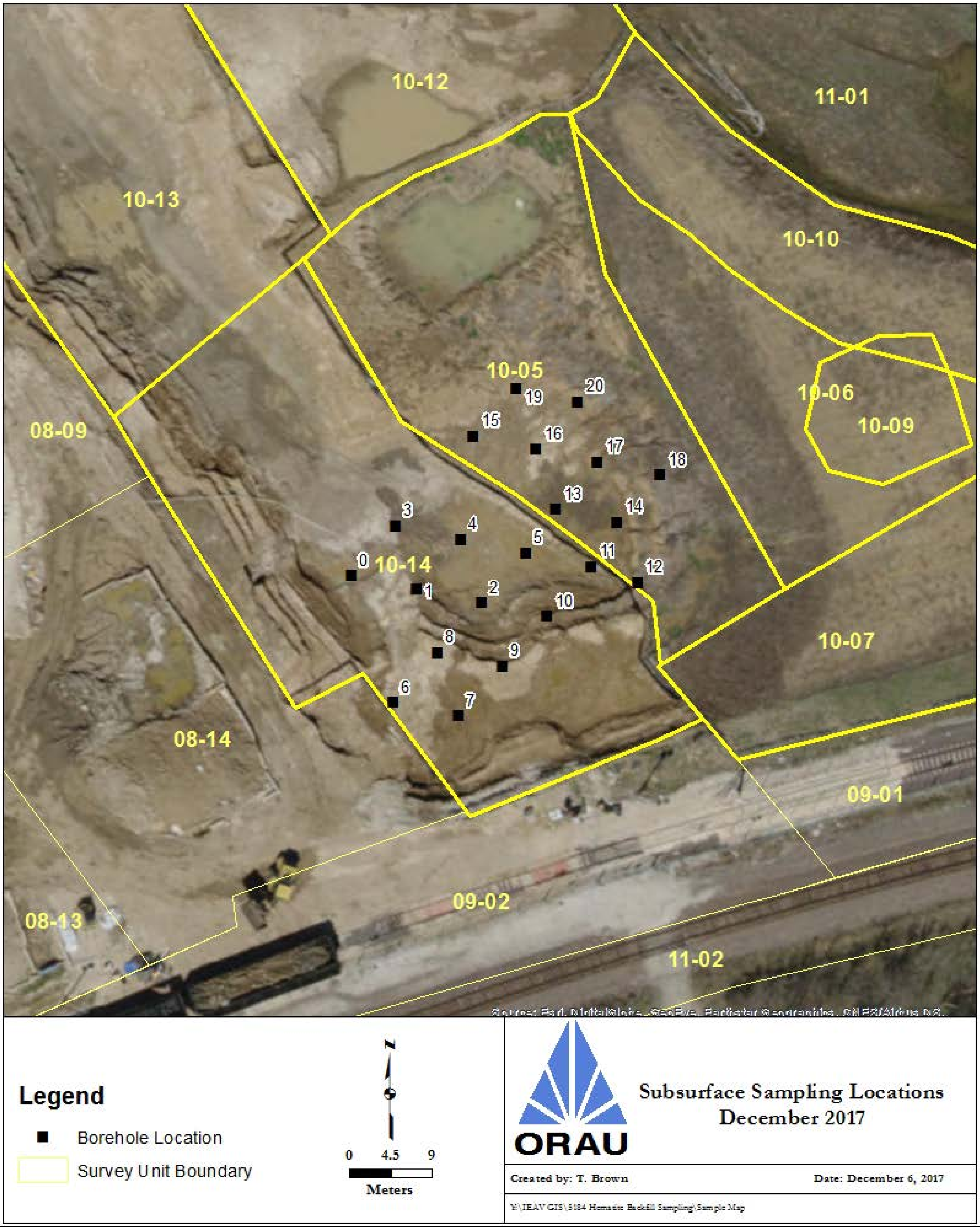

Figure A.1. Borehole Locations

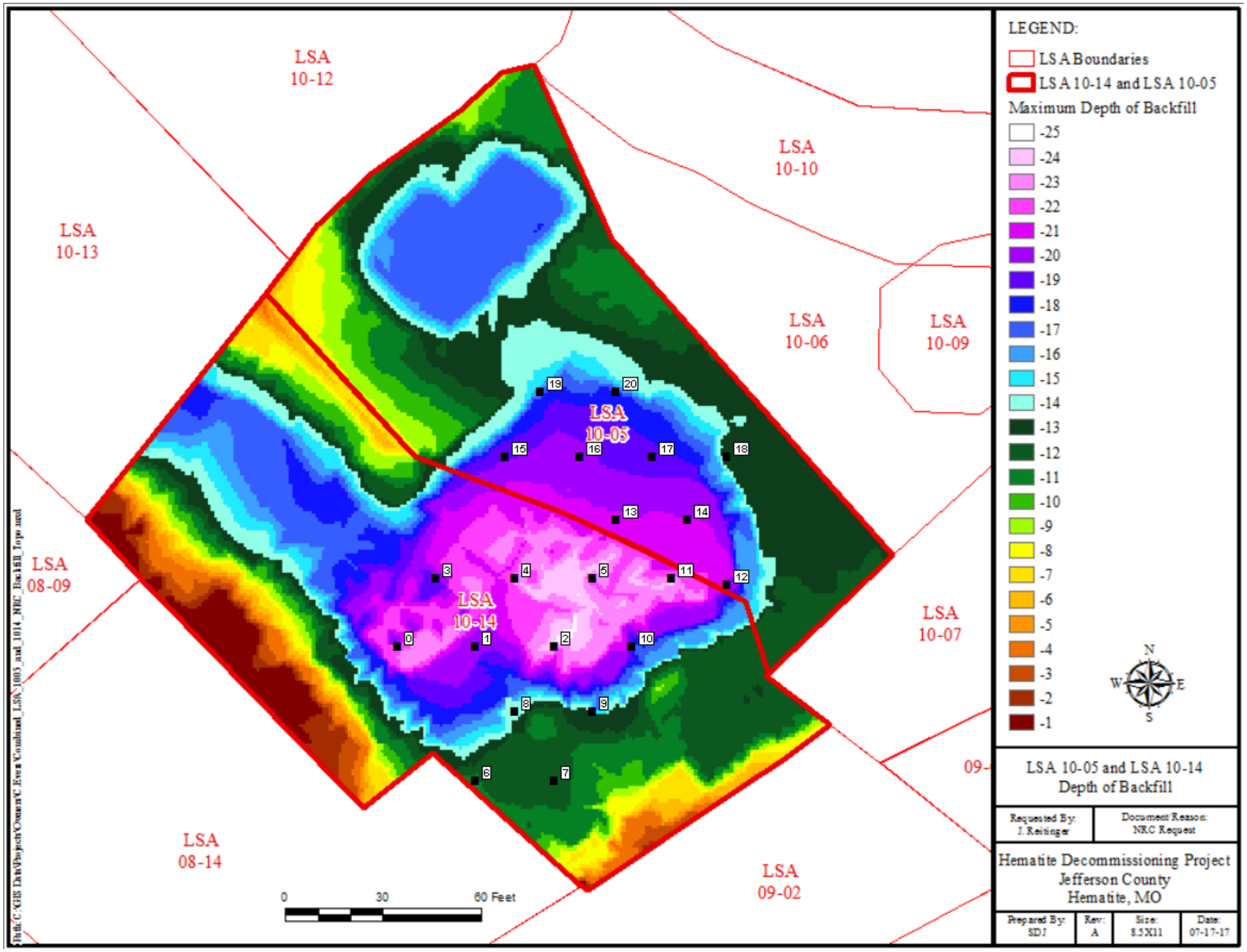

Figure A.2. Excavation Depth Map (in feet)

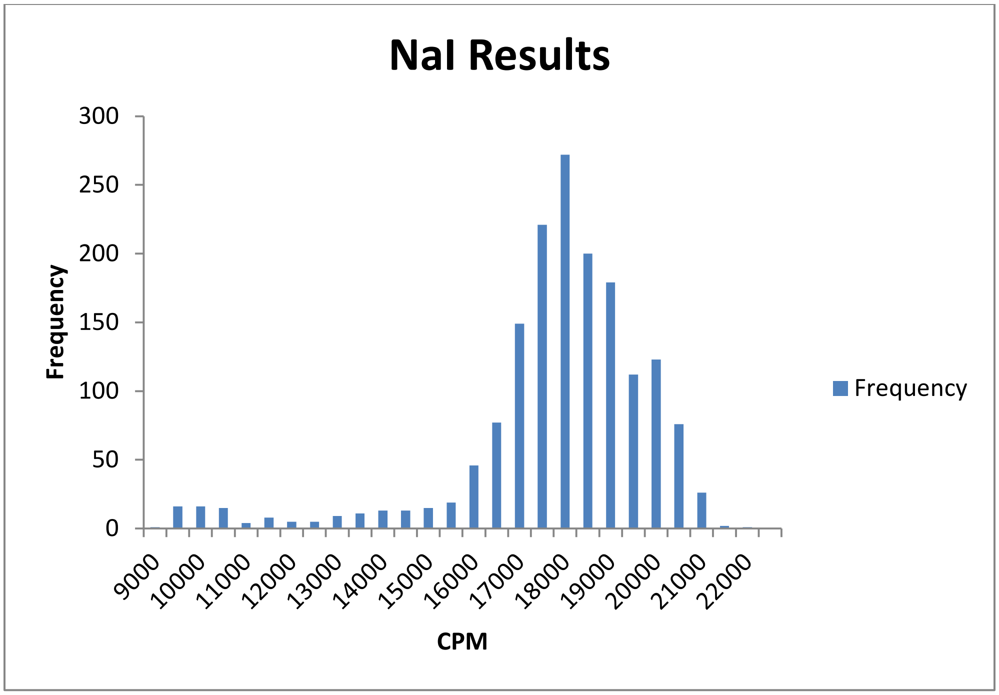

Figure A.3. NaI Detector Borehole Logging Data Histogram

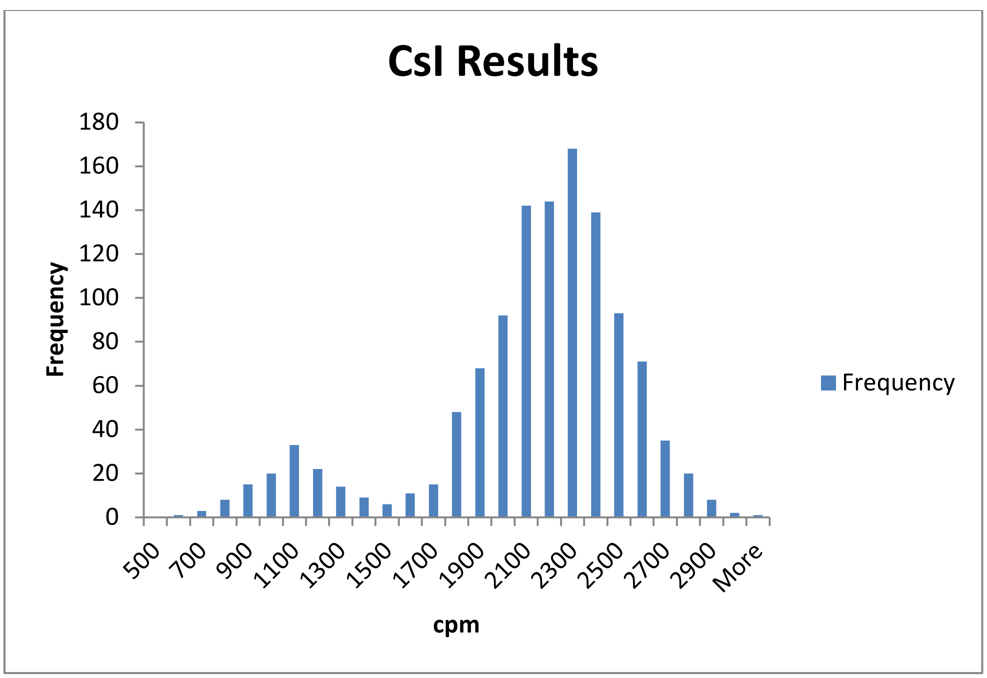

Figure A.4. CsI Detector Borehole Logging Data Histogram

APPENDIX B
TABLES

Table B.1. ROC Concentration in Sample Cores (pCi/g)[a, b]

Sample ID[c]	Tc-99	MDC	U-234[d]	U-235	MDC	U-238	MDC	Th-232	MDC	Ra-226	MDC
Interface Samples											
5184S0184	0.34 ± 0.36	0.60	1.8 ± 2.0	0.09 ± 0.10	0.26	1.50 ± 0.54	0.94	1.27 ± 0.19	0.28	0.979 ± 0.070	0.097
5184S0186	0.93 ± 0.36	0.55	2.7 ± 2.7	0.14 ± 0.14	0.34	1.91 ± 0.77	1.46	1.43 ± 0.25	0.36	0.94 ± 0.10	0.13
5184S0188	0.03 ± 0.33	0.59	1.2 ± 2.4	0.05 ± 0.10	0.25	2.01 ± 0.62	0.97	1.19 ± 0.19	0.29	0.965 ± 0.072	0.101
5184S0190	0.31 ± 0.36	0.60	7.3 ± 2.4	0.40 ± 0.13	0.29	2.40 ± 0.77	1.24	1.23 ± 0.21	0.31	0.883 ± 0.094	0.119
5184S0192	0.12 ± 0.36	0.62	7.1 ± 3.1	0.39 ± 0.17	0.39	1.8 ± 1.1	2.3	1.23 ± 0.19	0.28	0.871 ± 0.095	0.140
5184S0194	0.16 ± 0.37	0.64	8.9 ± 2.2	0.49 ± 0.12	0.37	2.1 ± 1.1	2.4	1.18 ± 0.19	0.30	0.868 ± 0.097	0.146
5184S0196	-0.14 ± 0.35	0.64	4.1 ± 1.9	0.22 ± 0.10	0.226	1.92 ± 0.55	0.80	1.34 ± 0.17	0.18	0.914 ± 0.060	0.080
5184S0198	0.20 ± 0.36	0.62	2.9 ± 2.3	0.15 ± 0.12	0.30	1.63 ± 0.65	1.22	1.22 ± 0.19	0.27	1.063 ± 0.099	0.114
5184S0200	0.12 ± 0.36	0.63	4.5 ± 2.4	0.24 ± 0.13	0.29	2.03 ± 0.99	2.03	1.202 ± 0.099	0.193	0.975 ± 0.094	0.126
5184S0202	0.05 ± 0.37	0.65	4.6 ± 1.3	0.246 ± 0.070	0.219	2.03 ± 0.59	0.86	1.17 ± 0.17	0.23	0.984 ± 0.064	0.085
5184S0204	1.04 ± 0.39	0.58	1.2 ± 2.0	0.051 ± 0.089	0.212	1.54 ± 0.51	0.84	1.15 ± 0.15	0.19	1.004 ± 0.071	0.098
5184S0206	0.23 ± 0.34	0.59	3.3 ± 2.6	0.18 ± 0.14	0.31	1.2 ± 1.1	2.4	1.07 ± 0.16	0.22	1.025 ± 0.092	0.110
5184S0208	0.22 ± 0.33	0.57	1.0 ± 1.7	0.046 ± 0.078	0.186	1.23 ± 0.41	0.71	1.03 ± 0.12	0.13	0.909 ± 0.054	0.069
5184S0210	0.52 ± 0.36	0.58	2.2 ± 1.8	0.117 ± 0.095	0.222	1.31 ± 0.51	0.96	0.99 ± 0.16	0.26	0.828 ± 0.078	0.092
5184S0212	0.34 ± 0.35	0.59	0.4 ± 5.6	0.01 ± 0.15	0.35	1.09 ± 0.92	2.08	1.37 ± 0.18	0.23	1.072 ± 0.098	0.125
5184S0214	0.36 ± 0.36	0.60	1.5 ± 2.2	0.069 ± 0.098	0.247	1.87 ± 0.55	0.78	1.23 ± 0.16	0.17	1.115 ± 0.069	0.085
5184S0216	0.22 ± 0.34	0.59	1.3 ± 2.8	0.06 ± 0.13	0.30	1.44 ± 0.62	1.22	1.12 ± 0.19	0.31	1.08 ± 0.11	0.16
5184S0218	0.15 ± 0.32	0.55	3.7 ± 3.0	0.20 ± 0.16	0.38	1.49 ± 0.94	2.03	1.17 ± 0.16	0.23	1.088 ± 0.099	0.128
5184S0220	0.25 ± 0.35	0.59	1.4 ± 1.8	0.065 ± 0.087	0.206	1.34 ± 0.46	0.81	1.33 ± 0.17	0.21	0.957 ± 0.068	0.091
5184S0222	0.05 ± 0.34	0.59	2.2 ± 2.0	0.11 ± 0.10	0.24	1.56 ± 0.68	1.34	1.26 ± 0.18	0.22	1.003 ± 0.094	0.111
5184S0224	0.17 ± 0.35	0.61	1.4 ± 3.7	0.06 ± 0.16	0.39	2.0 ± 1.0	2.0	1.10 ± 0.17	0.27	0.862 ± 0.091	0.134
5184S0225	0.28 ± 0.34	0.57	2.2 ± 2.6	0.11 ± 0.13	0.31	1.57 ± 0.64	1.21	1.16 ± 0.18	0.24	1.13 ± 0.10	0.12
Backfill Composite Samples											
5184S0183	0.01 ± 0.34	0.60	3.9 ± 2.4	0.21 ± 0.13	0.30	1.88 ± 0.64	1.18	1.17 ± 0.19	0.27	0.829 ± 0.089	0.115
5184S0185	-0.01 ± 0.32	0.58	3.4 ± 3.4	0.18 ± 0.18	0.42	1.9 ± 1.1	2.4	1.48 ± 0.21	0.29	0.99 ± 0.11	0.16
5184S0187	-0.08 ± 0.32	0.58	0.7 ± 2.3	0.030 ± 0.096	0.157	1.05 ± 0.53	1.09	1.25 ± 0.18	0.26	0.963 ± 0.092	0.113
5184S0189	0.01 ± 0.35	0.62	3.5 ± 3.3	0.18 ± 0.17	0.40	2.6 ± 1.1	2.2	1.22 ± 0.18	0.27	0.906 ± 0.098	0.146
5184S0191	0.19 ± 0.32	0.55	2.0 ± 2.0	0.10 ± 0.10	0.24	1.72 ± 0.56	0.90	1.18 ± 0.17	0.22	0.853 ± 0.074	0.110

Table B.1. ROC Concentration in Sample Cores (pCi/g)[a, b]											
Sample ID[c]	Tc-99	MDC	U-234[d]	U-235	MDC	U-238	MDC	Th-232	MDC	Ra-226	MDC
5184S0193	0.25 ± 0.36	0.61	3.8 ± 2.1	0.20 ± 0.11	0.26	2.22 ± 0.63	0.88	1.13 ± 0.17	0.25	0.860 ± 0.075	0.113
5184S0195	-0.17 ± 0.36	0.65	1.8 ± 3.1	0.08 ± 0.14	0.34	2.33 ± 0.78	1.30	1.41 ± 0.22	0.31	0.92 ± 0.10	0.13
5184S0197	-0.10 ± 0.34	0.61	4.3 ± 3.1	0.23 ± 0.17	0.40	1.7 ± 1.3	2.9	1.25 ± 0.20	0.28	1.00 ± 0.10	0.13
5184S0199	0.09 ± 0.37	0.65	3.1 ± 1.8	0.167 ± 0.095	0.218	1.56 ± 0.52	0.88	1.28 ± 0.17	0.22	0.974 ± 0.065	0.090
5184S0201	-0.26 ± 0.34	0.62	5.4 ± 2.4	0.29 ± 0.13	0.30	2.19 ± 0.69	1.10	1.21 ± 0.19	0.27	0.898 ± 0.088	0.110
5184S0203	-0.19 ± 0.35	0.64	1.6 ± 2.2	0.08 ± 0.11	0.26	1.43 ± 0.46	1.05	1.22 ± 0.19	0.27	0.910 ± 0.087	0.10
5184S0205	0.01 ± 0.32	0.57	3.1 ± 2.9	0.17 ± 0.16	0.38	1.06 ± 0.90	2.03	1.30 ± 0.18	0.25	0.933 ± 0.092	0.127
5184S0207	0.55 ± 0.37	0.60	1.8 ± 2.0	0.09 ± 0.10	0.24	1.55 ± 0.53	0.90	1.10 ± 0.15	0.20	0.856 ± 0.077	0.092
5184S0209	0.47 ± 0.37	0.60	2.5 ± 2.5	0.13 ± 0.13	0.31	1.43 ± 0.92	2.00	1.27 ± 0.17	0.23	0.811 ± 0.088	0.132
5184S0211	0.50 ± 0.36	0.59	2.3 ± 1.8	0.119 ± 0.093	0.218	1.76 ± 0.51	0.76	1.09 ± 0.15	0.21	0.975 ± 0.065	0.088
5184S0213	0.13 ± 0.33	0.57	1.6 ± 2.0	0.08 ± 0.10	0.24	1.35 ± 0.58	1.14	1.29 ± 0.19	0.25	0.890 ± 0.09	0.115
5184S0215	0.07 ± 0.33	0.58	2.8 ± 3.3	0.14 ± 0.17	0.40	2.0 ± 1.1	2.3	1.40 ± 0.18	0.25	1.04 ± 0.10	0.14
5184S0217	0.36 ± 0.34	0.56	1.6 ± 2.0	0.079 ± 0.095	0.223	1.51 ± 0.48	0.76	1.16 ± 0.16	0.20	0.982 ± 0.068	0.094
5184S0219	0.21 ± 0.34	0.58	1.6 ± 2.5	0.07 ± 0.11	0.26	2.20 ± 0.73	1.20	1.38 ± 0.21	0.30	1.04 ± 0.11	0.14
5184S0221	0.11 ± 0.35	0.60	1.4 ± 2.8	0.07 ± 0.14	0.34	1.21 ± 0.91	2.03	1.30 ± 0.17	0.22	0.794 ± 0.087	0.131
5184S0223	0.11 ± 0.33	0.58	1.0 ± 2.8	0.047 ± 0.085	0.215	1.18 ± 0.41	0.70	1.27 ± 0.16	0.20	0.915 ± 0.059	0.081
Native Soil Waste Sample Composite											
5184S0226	0.07 ± 0.34	0.60	1.8 ± 1.8	0.09 ± 0.09	0.21	1.58 ± 0.48	0.72	1.20 ± 0.17	0.23	0.949 ± 0.067	0.089

[a] Uncertainties represent the total propagated uncertainties reported at the 95% confidence level.
[b] Individual sample results are not corrected for background contributions.
[c] Refer to Figure A.1 for sample locations.
[d]Appendix E provides the details for the calculation of U-234 concentration.

Table B.2. Static Measurement Results				
LSA	**Location ID**	**Interface Depth (m)**	**Measurement Depth (m)**	**Static Measurement[a] (cpm)**
14-10	0[b]	5.8	1.8	17206
			3.0	19648
			4.3	19370
			5.5	19754
			Min	**17206**
			Max	**19754**
			Average	**18995**
14-10	1	5.2	1.5	2050
			2.4	2260
			3.7	2322
			5.2	2330
			Min	**2050**
			Max	**2330**
			Average	**2241**
14-10	2	6.4	1.5	2010
			3.0	2384
			4.6	2354
			6.4	2450
			Min	**2010**
			Max	**2450**
			Average	**2300**
14-10	3	5.2	1.5	2090
			2.4	2314
			3.7	2212
			5.2	2412
			Min	**2090**
			Max	**2412**
			Average	**2257**
14-10	4	6.1	1.5	2156
			3.0	2270
			4.6	2528
			6.1	2346
			Min	**2156**
			Max	**2528**
			Average	**2325**
14-10	5	6.4	1.5	2206
			3.0	2306
			4.6	2278
			6.4	2328
			Min	**2206**
			Max	**2328**
			Average	**2280**

Table B.2. Static Measurement Results				
LSA	**Location ID**	**Interface Depth (m)**	**Measurement Depth (m)**	**Static Measurement[a] (cpm)**
14-10	6	3.4	1.5	2292
			3.4	2182
			Min	**2182**
			Max	**2292**
			Average	**2237**
14-10	7	3.0	1.5	2400
			3.0	2418
			Min	**2400**
			Max	**2418**
			Average	**2409**
14-10	8	4.0	1.5	2078
			3.0	2348
			4.0	2346
			Min	**2078**
			Max	**2348**
			Average	**2257**
14-10	9	3.4	1.5	2142
			3.4	2350
			Min	**2142**
			Max	**2350**
			Average	**2246**
14-10	10	4.9	1.5	2224
			3.0	2466
			4.9	2368
			Min	**2224**
			Max	**2466**
			Average	**2353**
14-10	11	5.8	1.5	2244
			3.0	2330
			4.6	2394
			5.8	2202
			Min	**2202**
			Max	**2394**
			Average	**2293**
14-05	12	5.2	1.5	2112
			3.0	2166
			5.2	2496
			Min	**2112**
			Max	**2496**
			Average	**2258**
14-05	13	5.2	1.5	2224
			3.0	2142
			5.2	2460
			Min	**2142**
			Max	**2460**
			Average	**2275**

Table B.2. Static Measurement Results				
LSA	**Location ID**	**Interface Depth (m)**	**Measurement Depth (m)**	**Static Measurement[a] (cpm)**
14-05	14	5.2	1.5	2218
			3.0	2174
			5.2	2416
			Min	**2174**
			Max	**2416**
			Average	**2269**
14-05	15	4.9	1.5	2134
			3.0	2366
			Min	**2134**
			Max	**2366**
			Average	**2250**
14-05	16	4.9	1.5	2060
			3.0	2198
			4.9	2366
			Min	**2060**
			Max	**2366**
			Average	**2208**
14-05	17	4.3	1.5	2326
			3.0	2136
			4.3	2198
			Min	**2136**
			Max	**2326**
			Average	**2220**
14-05	18	2.7	1.5	2200
			2.7	2210
			3.7	2204
			Min	**2200**
			Max	**2210**
			Average	**2205**
14-05	19	3.7	1.8	2226
			3.7	2154
			Min	**2154**
			Max	**2226**
			Average	**2190**
14-05	20	4.0	1.5	2078
			3.0	2398
			4.0	2314
			Min	**2078**
			Max	**2398**
			Average	**2263**

[a] 30 second static measurement was collected and converted to units of counts per minute.

[b] First borehole did not present compression issues. No comparable CsI data collected.

APPENDIX C
CHEMICAL ANALYSIS RESULTS

GEL Laboratories LLC
a member of The GEL Group INC

PO Box 30712 Charleston, SC 29417
2040 Savage Road Charleston, SC 29407
P 843.556.8171
F 843.766.1178

gel.com

November 15, 2017

Mr. Jason Lee
Oak Ridge Associated Universities
PO Box 117
Oak Ridge, Tennessee 37831

Re: Soil Analysis for Chemical Constituents
Work Order: 436338

Dear Mr. Lee:

GEL Laboratories, LLC (GEL) appreciates the opportunity to provide the enclosed analytical results for the sample(s) we received on October 26, 2017. This original data report has been prepared and reviewed in accordance with GEL's standard operating procedures.

Our policy is to provide high quality, personalized analytical services to enable you to meet your analytical needs on time every time. We trust that you will find everything in order and to your satisfaction. If you have any questions, please do not hesitate to call me at (843) 556-8171, ext. 4504.

Sincerely,

Erin Trent

Erin Trent
Project Manager

Purchase Order: 603523
Enclosures

GEL LABORATORIES LLC

2040 Savage Road Charleston SC 29407 − (843) 556−8171 − www.gel.com

Certificate of Analysis Report
for

ORAU002 ORAU (603523)

Client SDG: 436338 GEL Work Order: 436338

The Qualifiers in this report are defined as follows:

*	A quality control analyte recovery is outside of specified acceptance criteria
**	Analyte is a Tracer compound
**	Analyte is a surrogate compound
J	Value is estimated
U	Analyte was analyzed for, but not detected above the MDL, MDA, MDC or LOD.

Where the analytical method has been performed under NELAP certification, the analysis has met all of the requirements of the NELAC standard unless qualified on the Certificate of Analysis.

The designation ND, if present, appears in the result column when the analyte concentration is not detected above the limit as defined in the 'U' qualifier above.

This data report has been prepared and reviewed in accordance with GEL Laboratories LLC standard operating procedures. Please direct any questions to your Project Manager, Erin Trent.

Reviewed by ______________________

GEL LABORATORIES LLC
2040 Savage Road Charleston SC 29407 - (843) 556-8171 - www.gel.com

Certificate of Analysis

Report Date: November 15, 2017

Company :	Oak Ridge Associated Universities
Address :	PO Box 117
	Oak Ridge, Tennessee 37831
Contact:	Mr. Jason Lee
Project:	Soil Analysis for Chemical Constituents

Client Sample ID:	5184S0226	Project:	ORAU00200
Sample ID:	436338001	Client ID:	ORAU002
Matrix:	Soil		
Collect Date:	19-OCT-17 13:30		
Receive Date:	26-OCT-17		
Collector:	Client		

Parameter	Qualifier	Result	DL	RL	Units	PF	DF	Analyst	Date	Time	Batch	Method
Mercury Analysis-CVAA												
TCLP Hg in Solid "As Received"												
Mercury	U	ND	0.00067	0.002	mg/L	10.0	1	MTM1	11/15/17	1414	1718693	1
Metals Analysis-ICP												
TCLP ICP Metals - 1311/3010A/6010C "As Received"												
Arsenic	U	ND	0.050	0.300	mg/L	10.0	1	JWJ	11/10/17	2045	1713664	2
Barium		1.03	0.010	0.050	mg/L	10.0	1					
Cadmium	U	ND	0.010	0.050	mg/L	10.0	1					
Chromium		0.0633	0.010	0.050	mg/L	10.0	1					
Lead	U	ND	0.033	0.100	mg/L	10.0	1					
Selenium	J	0.0711	0.060	0.300	mg/L	10.0	1					
Silver	U	ND	0.010	0.050	mg/L	10.0	1					
Semi-Volatile-GC/MS												
TCLP SVOA- 1311/3510C/8270D "As Received"												
1,4-Dichlorobenzene	U	ND	15.0	50.0	ug/L	0.005	1	JLD1	10/31/17	1922	1713446	3
2,4,5-Trichlorophenol	U	ND	15.0	50.0	ug/L	0.005	1					
2,4,6-Trichlorophenol	U	ND	15.0	50.0	ug/L	0.005	1					
2,4-Dinitrotoluene	U	ND	15.0	50.0	ug/L	0.005	1					
Hexachlorobenzene	U	ND	15.0	50.0	ug/L	0.005	1					
Hexachlorobutadiene	U	ND	15.0	50.0	ug/L	0.005	1					
Hexachloroethane	U	ND	15.0	50.0	ug/L	0.005	1					
Nitrobenzene	U	ND	15.0	50.0	ug/L	0.005	1					
Pentachlorophenol	U	ND	15.0	50.0	ug/L	0.005	1					
Pyridine	U	ND	15.0	50.0	ug/L	0.005	1					
m,p-Cresols	U	ND	18.5	50.0	ug/L	0.005	1					
o-Cresol	U	ND	15.0	50.0	ug/L	0.005	1					
Volatile Organics												
TCLP Volatiles, Solid "As Received"												
1,1-Dichloroethylene	U	ND	3.33	10.0	ug/L		10	JP1	11/09/17	2017	1717560	4
1,2-Dichloroethane	U	ND	3.33	10.0	ug/L		10					
1,4-Dichlorobenzene	U	ND	3.33	10.0	ug/L		10					
2-Butanone	U	ND	16.7	50.0	ug/L		10					
Benzene	U	ND	3.33	10.0	ug/L		10					
Carbon tetrachloride	U	ND	3.33	10.0	ug/L		10					
Chlorobenzene	U	ND	3.33	10.0	ug/L		10					
Chloroform	U	ND	3.33	10.0	ug/L		10					
Tetrachloroethylene		74.2	3.33	10.0	ug/L		10					

Certificate of Analysis

Report Date: November 15, 2017

Company :	Oak Ridge Associated Universities
Address :	PO Box 117
	Oak Ridge, Tennessee 37831
Contact:	Mr. Jason Lee
Project:	Soil Analysis for Chemical Constituents

Client Sample ID:	5184S0226	Project:	ORAU00200
Sample ID:	436338001	Client ID:	ORAU002

Parameter	Qualifier	Result	DL	RL	Units	PF	DF	Analyst	Date	Time	Batch	Method
Volatile Organics												
TCLP Volatiles, Solid "As Received"												
Trichloroethylene	U	ND	3.33	10.0	ug/L		10					
Vinyl chloride	U	ND	3.33	10.0	ug/L		10					

The following Prep Methods were performed:

Method	Description	Analyst	Date	Time	Prep Batch
SW846 1311	SW846 1311 TCLP Leaching	JP2	10/26/17	1445	1713251
SW846 1311	SW846 1311 TCLP Leaching	JP2	10/26/17	1445	1713252
SW846 1311	SW846 1311 TCLP Volatiles Prep	JP2	10/26/17	1450	1713253
SW846 3010A	ICP-TRACE TCLP by SW846 3010A	SXW1	10/27/17	0951	1713663
SW846 3510C	3510C BNA TCLP/SPLP Prep-GC/MS Analysis	DXF4	10/31/17	0500	1713445
SW846 7470A Prep	EPA 7470A Mercury Prep TCLP Liquid	AXS5	11/14/17	1414	1718692

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	SW846 7470A	
2	SW846 3010A/6010C	
3	SW846 3510C/8270D	
4	SW846 8260B	

Surrogate/Tracer Recovery	Test	Result	Nominal	Recovery%	Acceptable Limits
2-Fluorobiphenyl	TCLP SVOA- 1311/3510C/8270D "As Received"	166 ug/L	250	66	(32%-112%)
Nitrobenzene-d5	TCLP SVOA- 1311/3510C/8270D "As Received"	203 ug/L	250	81	(36%-115%)
p-Terphenyl-d14	TCLP SVOA- 1311/3510C/8270D "As Received"	217 ug/L	250	87	(36%-121%)
2,4,6-Tribromophenol	TCLP SVOA- 1311/3510C/8270D "As Received"	252 ug/L	500	50	(32%-124%)
2-Fluorophenol	TCLP SVOA- 1311/3510C/8270D "As Received"	231 ug/L	500	46	(15%-88%)
Phenol-d5	TCLP SVOA- 1311/3510C/8270D "As Received"	142 ug/L	500	28	(15%-91%)
1,2-Dichloroethane-d4	TCLP Volatiles, Solid "As Received"	521 ug/L	50.0	104	(71%-134%)
Bromofluorobenzene	TCLP Volatiles, Solid "As Received"	501 ug/L	50.0	100	(70%-131%)
Toluene-d8	TCLP Volatiles, Solid "As Received"	489 ug/L	50.0	98	(74%-124%)

Notes:

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Certificate of Analysis

Report Date: November 15, 2017

Company :	Oak Ridge Associated Universities
Address :	PO Box 117
	Oak Ridge, Tennessee 37831
Contact:	Mr. Jason Lee
Project:	Soil Analysis for Chemical Constituents

Client Sample ID:	5184S0226	Project:	ORAU00200
Sample ID:	436338001	Client ID:	ORAU002

Parameter	Qualifier	Result	DL	RL	Units	PF	DF	Analyst	Date	Time	Batch	Method

Column headers are defined as follows:

DF: Dilution Factor	Lc/LC: Critical Level
DL: Detection Limit	PF: Prep Factor
MDA: Minimum Detectable Activity	RL: Reporting Limit
MDC: Minimum Detectable Concentration	SQL: Sample Quantitation Limit

GEL LABORATORIES LLC

2040 Savage Road Charleston, SC 29407 - (843) 556-8171 - www.gel.com

QC Summary

Report Date: November 15, 2017

Oak Ridge Associated Universities
PO Box 117
Oak Ridge, Tennessee

Contact: **Mr. Jason Lee**

Workorder: **436338**

Parmname	NOM	Sample	Qual	QC	Units	RPD%	REC%	Range	Anlst	Date Time
Metals Analysis-ICP										
Batch 1713664										
QC1203906605 436338001 DUP										
Arsenic	U	ND	J	0.0572	mg/L	200			JWJ	11/10/17 20:47
Barium		1.03		0.945	mg/L	8.4		(0%-20%)		
Cadmium	U	ND	U	ND	mg/L	N/A				
Chromium		0.0633	J	0.0314	mg/L	67.6 ^		(+/-0.050)		
Lead	U	ND	U	ND	mg/L	N/A				
Selenium	J	0.0711	U	ND	mg/L	200 ^				
Silver	U	ND	U	ND	mg/L	N/A				
QC1203906604 LCS										
Arsenic	5.00			5.23	mg/L		105	(80%-120%)		11/10/17 20:44
Barium	5.00			5.06	mg/L		101	(80%-120%)		
Cadmium	5.00			4.93	mg/L		98.5	(80%-120%)		
Chromium	5.00			4.98	mg/L		99.6	(80%-120%)		
Lead	5.00			5.18	mg/L		104	(80%-120%)		
Selenium	5.00			4.82	mg/L		96.4	(80%-120%)		

QC Summary

Workorder: **436338**

Parmname	NOM		Sample	Qual	QC	Units	RPD%	REC%	Range	Anlst	Date Time
Metals Analysis-ICP											
Batch 1713664											
Silver	5.00				4.87	mg/L		97.3	(80%-120%)	JWJ	11/10/17 20:44
QC1203906603 MB											
Arsenic				U	ND	mg/L					11/10/17 20:38
Barium				U	ND	mg/L					
Cadmium				U	ND	mg/L					
Chromium				U	ND	mg/L					
Lead				U	ND	mg/L					
Selenium				U	ND	mg/L					
Silver				U	ND	mg/L					
QC1203905601 436338001 MS											
Arsenic	5.00	U	ND		5.22	mg/L		104	(75%-125%)		11/10/17 20:49
Barium	10.0		1.03		10.7	mg/L		96.3	(75%-125%)		
Cadmium	1.00	U	ND		0.949	mg/L		94.5	(75%-125%)		
Chromium	5.00		0.0633		4.90	mg/L		96.8	(75%-125%)		
Lead	5.00	U	ND		4.99	mg/L		99.2	(75%-125%)		
Selenium	1.00	J	0.0711		1.00	mg/L		92.9	(75%-125%)		

QC Summary

Workorder: 436338

Parmname	NOM		Sample	Qual	QC	Units	RPD%	REC%	Range	Anlst	Date Time
Metals Analysis-ICP											
Batch 1713664											
Silver	0.503	U	ND		0.479	mg/L		95.4	(75%-125%)	JWJ	11/10/17 20:49
QC1203906607 436338001 SDILT											
Arsenic		U	ND	U	ND	ug/L	N/A		(0%-10%)		11/10/17 20:51
Barium			103		21.1	ug/L	2.6		(0%-10%)		
Cadmium		U	ND	U	ND	ug/L	N/A		(0%-10%)		
Chromium			6.33	J	1.31	ug/L	3.58		(0%-10%)		
Lead		U	ND	U	ND	ug/L	N/A		(0%-10%)		
Selenium		J	7.11	U	ND	ug/L	N/A		(0%-10%)		
Silver		U	ND	U	ND	ug/L	N/A		(0%-10%)		
QC1203905602 TB											
Arsenic				U	ND	mg/L					11/10/17 20:41
Barium				J	0.0221	mg/L					
Cadmium				U	ND	mg/L					
Chromium				J	0.023	mg/L					
Lead				U	ND	mg/L					
Selenium				U	ND	mg/L					

QC Summary

Workorder: **436338**

Parmname	NOM		Sample	Qual	QC	Units	RPD%	REC%	Range	Anlst	Date Time
Metals Analysis-ICP											
Batch 1713664											
Silver				U	ND	mg/L				JWJ	11/10/17 20:41
Metals Analysis-Mercury											
Batch 1718693											
QC1203919366 436338001 DUP											
Mercury		U	ND	U	ND	mg/L	N/A			MTM1	11/15/17 14:18
QC1203919365 LCS											
Mercury	0.020				0.0217	mg/L		109	(80%-120%)		11/15/17 14:13
QC1203919364 MB											
Mercury				U	ND	mg/L					11/15/17 14:09
QC1203905601 436338001 MS											
Mercury	0.020	U	ND		0.021	mg/L		105	(75%-125%)		11/15/17 14:16
QC1203919368 436338001 SDILT											
Mercury		U	ND	U	ND	ug/L	N/A		(0%-10%)		11/15/17 14:19
QC1203905602 TB											
Mercury				U	ND	mg/L					11/15/17 14:11
Semi-Volatile-GC/MS											
Batch 1713446											
QC1203906080 LCS											
1,4-Dichlorobenzene	50.0				34.3	ug/L		69	(38%-96%)	JLD1	10/31/17 14:11
2,4,5-Trichlorophenol	50.0				43.8	ug/L		88	(55%-116%)		
2,4,6-Trichlorophenol	50.0				42.8	ug/L		86	(55%-120%)		
2,4-Dinitrotoluene	50.0				45.9	ug/L		92	(57%-124%)		

QC Summary

Workorder: 436338

Parmname	NOM	Sample	Qual	QC	Units	RPD%	REC%	Range	Anlst	Date Time
Semi-Volatile-GC/MS										
Batch 1713446										
Hexachlorobenzene	50.0			42.8	ug/L		86	(54%-115%)	JLD1	10/31/17 14:11
Hexachlorobutadiene	50.0			27.8	ug/L		56	(35%-98%)		
Hexachloroethane	50.0			32.0	ug/L		64	(36%-96%)		
Nitrobenzene	50.0			49.3	ug/L		99	(53%-115%)		
Pentachlorophenol	50.0			48.7	ug/L		97	(41%-116%)		
Pyridine	50.0			23.4	ug/L		47	(27%-89%)		
m,p-Cresols	50.0			37.2	ug/L		74	(43%-102%)		
o-Cresol	50.0			38.1	ug/L		76	(41%-101%)		
**2,4,6-Tribromophenol	100			85.2	ug/L		85	(32%-124%)		
**2-Fluorobiphenyl	50.0			38.5	ug/L		77	(32%-112%)		
**2-Fluorophenol	100			53.4	ug/L		53	(15%-88%)		
**Nitrobenzene-d5	50.0			46.1	ug/L		92	(36%-115%)		
**Phenol-d5	100			32.5	ug/L		33	(15%-91%)		
**p-Terphenyl-d14	50.0			46.0	ug/L		92	(36%-121%)		
QC1203906079 MB										
1,4-Dichlorobenzene			U	ND	ug/L					10/31/17 11:37

QC Summary

Workorder: 436338

Parmname	NOM	Sample	Qual	QC	Units	RPD%	REC%	Range	Anlst	Date	Time
Semi-Volatile-GC/MS											
Batch 1713446											
2,4,5-Trichlorophenol			U	ND	ug/L				JLD1	10/31/17	11:37
2,4,6-Trichlorophenol			U	ND	ug/L						
2,4-Dinitrotoluene			U	ND	ug/L						
Hexachlorobenzene			U	ND	ug/L						
Hexachlorobutadiene			U	ND	ug/L						
Hexachloroethane			U	ND	ug/L						
Nitrobenzene			U	ND	ug/L						
Pentachlorophenol			U	ND	ug/L						
Pyridine			U	ND	ug/L						
m,p-Cresols			U	ND	ug/L						
o-Cresol			U	ND	ug/L						
**2,4,6-Tribromophenol	100			84.4	ug/L		84	(32%-124%)			
**2-Fluorobiphenyl	50.0			40.8	ug/L		82	(32%-112%)			
**2-Fluorophenol	100			55.0	ug/L		55	(15%-88%)			
**Nitrobenzene-d5	50.0			50.3	ug/L		101	(36%-115%)			

QC Summary

Workorder: **436338**

Parmname	NOM		Sample	Qual	QC	Units	RPD%	REC%	Range	Anlst	Date Time
Semi-Volatile-GC/MS											
Batch 1713446											
**Phenol-d5	100				35.6	ug/L		36	(15%-91%)	JLD1	10/31/17 11:37
**p-Terphenyl-d14	50.0				52.3	ug/L		105	(36%-121%)		
QC1203906081 435603014 MS											
1,4-Dichlorobenzene	250	U	ND		161	ug/L		64	(28%-97%)		10/31/17 15:45
2,4,5-Trichlorophenol	250	U	ND		215	ug/L		86	(42%-120%)		
2,4,6-Trichlorophenol	250	U	ND		212	ug/L		85	(39%-124%)		
2,4-Dinitrotoluene	250	U	ND		210	ug/L		84	(45%-125%)		
Hexachlorobenzene	250	U	ND		203	ug/L		81	(40%-118%)		
Hexachlorobutadiene	250	U	ND		139	ug/L		55	(26%-98%)		
Hexachloroethane	250	U	ND		153	ug/L		61	(29%-94%)		
Nitrobenzene	250	U	ND		232	ug/L		93	(38%-123%)		
Pentachlorophenol	250	U	ND		287	ug/L		115	(35%-121%)		
Pyridine	250	U	ND		152	ug/L		61	(24%-93%)		
m,p-Cresols	250	U	ND		193	ug/L		77	(36%-120%)		
o-Cresol	250	U	ND		192	ug/L		77	(34%-109%)		
**2,4,6-Tribromophenol	500		392		413	ug/L		83	(32%-124%)		

QC Summary

Workorder: 436338

Parmname	NOM	Sample	Qual	QC	Units	RPD%	REC%	Range	Anlst	Date Time
Semi-Volatile-GC/MS										
Batch 1713446										
**2-Fluorobiphenyl	250	157		179	ug/L		72	(32%-112%)	JLD1	10/31/17 15:45
**2-Fluorophenol	500	171		275	ug/L		55	(15%-88%)		
**Nitrobenzene-d5	250	202		224	ug/L		90	(36%-115%)		
**Phenol-d5	500	118		170	ug/L		34	(15%-91%)		
**p-Terphenyl-d14	250	191		224	ug/L		90	(36%-121%)		
QC1203906082 435603014 MSD										
1,4-Dichlorobenzene	250 U	ND		145	ug/L	10	58	(0%-30%)		10/31/17 16:16
2,4,5-Trichlorophenol	250 U	ND		213	ug/L	1	85	(0%-30%)		
2,4,6-Trichlorophenol	250 U	ND		205	ug/L	3	82	(0%-30%)		
2,4-Dinitrotoluene	250 U	ND		203	ug/L	4	81	(0%-30%)		
Hexachlorobenzene	250 U	ND		202	ug/L	0	81	(0%-30%)		
Hexachlorobutadiene	250 U	ND		129	ug/L	7	52	(0%-30%)		
Hexachloroethane	250 U	ND		137	ug/L	11	55	(0%-30%)		
Nitrobenzene	250 U	ND		216	ug/L	7	86	(0%-30%)		
Pentachlorophenol	250 U	ND		281	ug/L	2	112	(0%-30%)		
Pyridine	250 U	ND		141	ug/L	7	57	(0%-30%)		

QC Summary

Workorder: 436338

Parmname	NOM		Sample	Qual	QC	Units	RPD%	REC%	Range	Anlst	Date Time
Semi-Volatile-GC/MS											
Batch 1713446											
m,p-Cresols	250	U	ND		165	ug/L	15	66	(0%-30%)	JLD1	10/31/17 16:16
o-Cresol	250	U	ND		164	ug/L	16	66	(0%-30%)		
**2,4,6-Tribromophenol	500		392		408	ug/L		82	(32%-124%)		
**2-Fluorobiphenyl	250		157		170	ug/L		68	(32%-112%)		
**2-Fluorophenol	500		171		220	ug/L		44	(15%-88%)		
**Nitrobenzene-d5	250		202		203	ug/L		81	(36%-115%)		
**Phenol-d5	500		118		141	ug/L		28	(15%-91%)		
**p-Terphenyl-d14	250		191		231	ug/L		93	(36%-121%)		
QC1203905603 TB											
1,4-Dichlorobenzene				U	ND	ug/L					10/31/17 13:09
2,4,5-Trichlorophenol				U	ND	ug/L					
2,4,6-Trichlorophenol				U	ND	ug/L					
2,4-Dinitrotoluene				U	ND	ug/L					
Hexachlorobenzene				U	ND	ug/L					
Hexachlorobutadiene				U	ND	ug/L					
Hexachloroethane				U	ND	ug/L					

QC Summary

Workorder: 436338

Parmname	NOM	Sample	Qual	QC	Units	RPD%	REC%	Range	Anlst	Date Time
Semi-Volatile-GC/MS										
Batch 1713446										
Nitrobenzene			U	ND	ug/L				JLD1	10/31/17 13:09
Pentachlorophenol			U	ND	ug/L					
Pyridine			U	ND	ug/L					
m,p-Cresols			U	ND	ug/L					
o-Cresol			U	ND	ug/L					
**2,4,6-Tribromophenol	500			391	ug/L		78	(32%-124%)		
**2-Fluorobiphenyl	250			190	ug/L		76	(32%-112%)		
**2-Fluorophenol	500			227	ug/L		45	(15%-88%)		
**Nitrobenzene-d5	250			228	ug/L		91	(36%-115%)		
**Phenol-d5	500			155	ug/L		31	(15%-91%)		
**p-Terphenyl-d14	250			217	ug/L		87	(36%-121%)		
Volatile-GC/MS										
Batch 1717560										
QC1203916313 LCS										
1,1-Dichloroethylene	50.0			48.1	ug/L		96	(66%-126%)	JP1	11/09/17 10:53
1,2-Dichloroethane	50.0			47.8	ug/L		96	(74%-122%)		
1,4-Dichlorobenzene	50.0			46.4	ug/L		93	(71%-120%)		

QC Summary

Workorder: **436338**

Parmname	NOM	Sample	Qual	QC	Units	RPD%	REC%	Range	Anlst	Date Time
Volatile-GC/MS										
Batch 1717560										
2-Butanone	250			243	ug/L		97	(55%-138%)	JP1	11/09/17 10:53
Benzene	50.0			46.2	ug/L		92	(72%-121%)		
Carbon tetrachloride	50.0			49.5	ug/L		99	(72%-140%)		
Chlorobenzene	50.0			46.9	ug/L		94	(74%-120%)		
Chloroform	50.0			47.3	ug/L		95	(76%-123%)		
Tetrachloroethylene	50.0			48.2	ug/L		96	(69%-129%)		
Trichloroethylene	50.0			48.1	ug/L		96	(74%-125%)		
Vinyl chloride	50.0			54.1	ug/L		108	(65%-137%)		
**1,2-Dichloroethane-d4	50.0			50.4	ug/L		101	(71%-134%)		
**Bromofluorobenzene	50.0			49.6	ug/L		99	(70%-131%)		
**Toluene-d8	50.0			49.6	ug/L		99	(74%-124%)		
QC1203916312 MB										
1,1-Dichloroethylene			U	ND	ug/L					11/09/17 13:14
1,2-Dichloroethane			U	ND	ug/L					
1,4-Dichlorobenzene			U	ND	ug/L					
2-Butanone			U	ND	ug/L					

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QC Summary

Workorder: 436338

Parmname	NOM	Sample	Qual	QC	Units	RPD%	REC%	Range	Anlst	Date Time
Volatile-GC/MS										
Batch 1717560										
Benzene			U	ND	ug/L				JP1	11/09/17 13:14
Carbon tetrachloride			U	ND	ug/L					
Chlorobenzene			U	ND	ug/L					
Chloroform			U	ND	ug/L					
Tetrachloroethylene			U	ND	ug/L					
Trichloroethylene			U	ND	ug/L					
Vinyl chloride			U	ND	ug/L					
**1,2-Dichloroethane-d4	50.0			50.5	ug/L		101	(71%-134%)		
**Bromofluorobenzene	50.0			49.8	ug/L		100	(70%-131%)		
**Toluene-d8	50.0			48.9	ug/L		98	(74%-124%)		
QC1203916314 437257001 PS										
1,1-Dichloroethylene	50.0	U ND		41.6	ug/L		83	(59%-130%)		11/09/17 21:14
1,2-Dichloroethane	50.0	U ND		47.2	ug/L		94	(69%-130%)		
1,4-Dichlorobenzene	50.0	U ND		33.4	ug/L		67	(55%-125%)		
2-Butanone	250	U ND		172	ug/L		69	(25%-143%)		
Benzene	50.0	U ND		41.1	ug/L		82	(66%-125%)		

QC Summary

Workorder: 436338

Parmname	NOM		Sample	Qual	QC	Units	RPD%	REC%	Range	Anlst	Date Time
Volatile-GC/MS											
Batch 1717560											
Carbon tetrachloride	50.0	U	ND		41.4	ug/L		83	(66%-143%)	JP1	11/09/17 21:14
Chlorobenzene	50.0	U	ND		38.2	ug/L		76	(64%-124%)		
Chloroform	50.0	U	ND		43.9	ug/L		88	(71%-129%)		
Tetrachloroethylene	50.0	U	ND		35.4	ug/L		71	(60%-130%)		
Trichloroethylene	50.0	U	ND		40.1	ug/L		80	(65%-131%)		
Vinyl chloride	50.0	U	ND		46.3	ug/L		93	(58%-140%)		
**1,2-Dichloroethane-d4	50.0		51.6		52.2	ug/L		104	(71%-134%)		
**Bromofluorobenzene	50.0		49.9		50.5	ug/L		101	(70%-131%)		
**Toluene-d8	50.0		49.5		49.5	ug/L		99	(74%-124%)		
QC1203916315 437257001 PSD											
1,1-Dichloroethylene	50.0	U	ND		40.4	ug/L	3	81	(0%-20%)		11/09/17 21:42
1,2-Dichloroethane	50.0	U	ND		44.8	ug/L	5	90	(0%-20%)		
1,4-Dichlorobenzene	50.0	U	ND		31.7	ug/L	5	63	(0%-20%)		
2-Butanone	250	U	ND		162	ug/L	6	65	(0%-20%)		
Benzene	50.0	U	ND		39.1	ug/L	5	78	(0%-20%)		
Carbon tetrachloride	50.0	U	ND		39.7	ug/L	4	79	(0%-20%)		

QC Summary

Workorder: **436338**

Parmname	NOM		Sample	Qual	QC	Units	RPD%	REC%	Range	Anlst	Date Time
Volatile-GC/MS											
Batch 1717560											
Chlorobenzene	50.0	U	ND		35.4	ug/L	8	71	(0%-20%)	JP1	11/09/17 21:42
Chloroform	50.0	U	ND		42.0	ug/L	5	84	(0%-20%)		
Tetrachloroethylene	50.0	U	ND		32.8	ug/L	8	66	(0%-20%)		
Trichloroethylene	50.0	U	ND		37.6	ug/L	7	75	(0%-20%)		
Vinyl chloride	50.0	U	ND		45.6	ug/L	2	91	(0%-20%)		
**1,2-Dichloroethane-d4	50.0		51.6		50.3	ug/L		101	(71%-134%)		
**Bromofluorobenzene	50.0		49.9		49.6	ug/L		99	(70%-131%)		
**Toluene-d8	50.0		49.5		49.3	ug/L		99	(74%-124%)		
QC1203905604 TB											
1,1-Dichloroethylene				U	ND	ug/L					11/09/17 17:00
1,2-Dichloroethane				U	ND	ug/L					
1,4-Dichlorobenzene				U	ND	ug/L					
2-Butanone				U	ND	ug/L					
Benzene				U	ND	ug/L					
Carbon tetrachloride				U	ND	ug/L					
Chlorobenzene				U	ND	ug/L					

QC Summary

Workorder: **436338**

Parmname	NOM	Sample	Qual	QC	Units	RPD%	REC%	Range	Anlst	Date Time
Volatile-GC/MS										
Batch 1717560										
Chloroform			U	ND	ug/L				JP1	11/09/17 17:00
Tetrachloroethylene			U	ND	ug/L					
Trichloroethylene			U	ND	ug/L					
Vinyl chloride			U	ND	ug/L					
**1,2-Dichloroethane-d4	50.0			51.6	ug/L		103	(71%-134%)		
**Bromofluorobenzene	50.0			50.5	ug/L		101	(70%-131%)		
**Toluene-d8	50.0			49.4	ug/L		99	(74%-124%)		

Notes:

The Qualifiers in this report are defined as follows:

- ** Analyte is a surrogate compound
- < Result is less than value reported
- > Result is greater than value reported
- A The TIC is a suspected aldol-condensation product
- B The target analyte was detected in the associated blank.
- C Analyte has been confirmed by GC/MS analysis
- D Results are reported from a diluted aliquot of the sample
- E %difference of sample and SD is >10%. Sample concentration must meet flagging criteria
- E Concentration of the target analyte exceeds the instrument calibration range
- FB Mercury was found present at quantifiable concentrations in field blanks received with these samples. Data associated with the blank are deemed invalid for reporting to regulatory agencies
- H Analytical holding time was exceeded
- J Value is estimated
- JNX Non Calibrated Compound
- N Metals--The Matrix spike sample recovery is not within specified control limits
- N Organics--Presumptive evidence based on mass spectral library search to make a tentative identification of the analyte (TIC). Quantitation is based on nearest internal standard response factor
- N Presumptive evidence based on mass spectral library search to make a tentative identification of the analyte (TIC). Quantitation is based on nearest

QC Summary

Workorder: 436338

Parmname	NOM	Sample	Qual	QC	Units	RPD%	REC%	Range	Anlst	Date	Time

	internal standard response factor
N/A	RPD or %Recovery limits do not apply.
N1	See case narrative
ND	Analyte concentration is not detected above the detection limit
NJ	Consult Case Narrative, Data Summary package, or Project Manager concerning this qualifier
P	Organics--The concentrations between the primary and confirmation columns/detectors is >40% different. For HPLC, the difference is >70%.
Q	One or more quality control criteria have not been met. Refer to the applicable narrative or DER.
R	Sample results are rejected
U	Analyte was analyzed for, but not detected above the MDL, MDA, MDC or LOD.
UJ	Compound cannot be extracted
X	Consult Case Narrative, Data Summary package, or Project Manager concerning this qualifier
Y	Other specific qualifiers were required to properly define the results. Consult case narrative.
Y	QC Samples were not spiked with this compound
^	RPD of sample and duplicate evaluated using +/-RL. Concentrations are <5X the RL. Qualifier Not Applicable for Radiochemistry.
h	Preparation or preservation holding time was exceeded

N/A indicates that spike recovery limits do not apply when sample concentration exceeds spike conc. by a factor of 4 or more or %RPD not applicable.
^ The Relative Percent Difference (RPD) obtained from the sample duplicate (DUP) is evaluated against the acceptance criteria when the sample is greater than five times (5X) the contract required detection limit (RL). In cases where either the sample or duplicate value is less than 5X the RL, a control limit of +/- the RL is used to evaluate the DUP result.
* Indicates that a Quality Control parameter was not within specifications.
For PS, PSD, and SDILT results, the values listed are the measured amounts, not final concentrations.

Where the analytical method has been performed under NELAP certification, the analysis has met all of the requirements of the NELAC standard unless qualified on the QC Summary.

Technical Case Narrative
ORAU (ORAU)
SDG #: 436338

GC/MS Volatile

Product: **Volatile Organic Compounds (VOC) by Gas Chromatograph/Mass Spectrometer**
Analytical Method: SW846 8260B
Analytical Procedure: GL-OA-E-038 REV# 26
Analytical Batch: 1717560

TCLP Preparation Method: SW846 1311
TCLP Preparation Procedure: GL-LB-E-006 REV# 21
TCLP Preparation Batch: 1713253

The following samples were analyzed using the above methods and analytical procedure(s).

GEL Sample ID#	Client Sample Identification
436338001	5184S0226
1203905604	Tumble Blank (TB)
1203916312	Method Blank (MB)
1203916313	Laboratory Control Sample (LCS)
1203916314	437257001(NonSDG) Post Spike (PS)
1203916315	437257001(NonSDG) Post Spike Duplicate (PSD)

The samples in this SDG were analyzed on an "as received" basis.

Data Summary:

All sample data provided in this report met the acceptance criteria specified in the analytical methods and procedures for initial calibration, continuing calibration, instrument controls and process controls where applicable, with the following exceptions.

Technical Information

Sample Dilutions/Methanol Dilutions
Due to problems associated with the nature of the TCLP matrix, volatile extracts are routinely diluted before analysis. The dilution factor does not increase detection limits above the regulatory limits required by the client.

Analyte	436338 001
Several	10X

GC/MS Semivolatile

Product: **Analysis of Semivolatile Organic Compounds by Gas Chromatography/Mass Spectrometry**
Analytical Method: SW846 3510C/8270D

Analytical Procedure: GL-OA-E-009 REV# 39
Analytical Batch: 1713446

Preparation Method: SW846 3510C
Preparation Procedure: GL-OA-E-013 REV# 32
Preparation Batch: 1713445

TCLP Preparation Method: SW846 1311
TCLP Preparation Procedure: GL-LB-E-006 REV# 21
TCLP Preparation Batch: 1713252

The following samples were analyzed using the above methods and analytical procedure(s).

GEL Sample ID#	Client Sample Identification
436338001	5184S0226
1203905603	Tumble Blank (TB)
1203906079	Method Blank (MB)
1203906080	Laboratory Control Sample (LCS)
1203906081	435603014(NonSDG) Matrix Spike (MS)
1203906082	435603014(NonSDG) Matrix Spike Duplicate (MSD)

The samples in this SDG were analyzed on an "as received" basis.

Data Summary:

There are no exceptions, anomalies or deviations from the specified methods. All sample data provided in this report met the acceptance criteria specified in the analytical methods and procedures for initial calibration, continuing calibration, instrument controls and process controls where applicable.

Metals

TCLP Preparation Method: SW846 1311
TCLP Preparation Procedure: GL-LB-E-006 REV# 21
TCLP Preparation Batch: 1713251

The following samples were analyzed using the above methods and analytical procedure(s).

GEL Sample ID#	Client Sample Identification
436338001	5184S0226
1203905602	Tumble Blank (TB)
1203905601	436338001(5184S0226S) Matrix Spike (MS)

The samples in this SDG were analyzed on an "as received" basis.

Data Summary:

There are no exceptions, anomalies or deviations from the specified methods. All sample data provided in this report met the acceptance criteria specified in the analytical methods and procedures for initial calibration, continuing calibration, instrument controls and process controls where applicable.

Product: Determination of Metals by ICP

Analytical Method: SW846 3010A/6010C
Analytical Procedure: GL-MA-E-013 REV# 30
Analytical Batch: 1713664

Preparation Method: SW846 3010A
Preparation Procedure: GL-MA-E-008 REV# 19
Preparation Batch: 1713663

TCLP Preparation Method: SW846 1311
TCLP Preparation Procedure: GL-LB-E-006 REV# 21
TCLP Preparation Batch: 1713251

The following samples were analyzed using the above methods and analytical procedure(s).

GEL Sample ID#	Client Sample Identification
436338001	5184S0226
1203905602	Tumble Blank (TB)
1203906603	Method Blank (MB)**ICP**
1203906604	Laboratory Control Sample (LCS)
1203906607	436338001(5184S0226L) Serial Dilution (SD)
1203906605	436338001(5184S0226D) Sample Duplicate (DUP)
1203905601	436338001(5184S0226S) Matrix Spike (MS)

The samples in this SDG were analyzed on an "as received" basis.

Data Summary:

All sample data provided in this report met the acceptance criteria specified in the analytical methods and procedures for initial calibration, continuing calibration, instrument controls and process controls where applicable, with the following exceptions.

Technical Information

Preparation Information
The samples and associated matrix QC were prepared at a ten times or greater dilution factor to minimize potential interferences arising from the high sodium content in the TCLP leaching solution.

Product: **Mercury Analysis Using the Perkin Elmer Automated Mercury Analyzer**
Analytical Method: SW846 7470A
Analytical Procedure: GL-MA-E-010 REV# 36
Analytical Batch: 1718693

Preparation Method: SW846 7470A Prep
Preparation Procedure: GL-MA-E-010 REV# 36
Preparation Batch: 1718692

TCLP Preparation Method: SW846 1311
TCLP Preparation Procedure: GL-LB-E-006 REV# 21
TCLP Preparation Batch: 1713251

The following samples were analyzed using the above methods and analytical procedure(s).

GEL Sample ID# **Client Sample Identification**

436338001	5184S0226
1203905602	Tumble Blank (TB)
1203919364	Method Blank (MB)**CVAA**
1203919365	Laboratory Control Sample (LCS)
1203919368	436338001(5184S0226L) Serial Dilution (SD)
1203919366	436338001(5184S0226D) Sample Duplicate (DUP)
1203905601	436338001(5184S0226S) Matrix Spike (MS)

The samples in this SDG were analyzed on an "as received" basis.

<u>Data Summary:</u>

All sample data provided in this report met the acceptance criteria specified in the analytical methods and procedures for initial calibration, continuing calibration, instrument controls and process controls where applicable, with the following exceptions.

<u>Technical Information</u>

Preparation Information
The samples and associated matrix QC were prepared at a ten times or greater dilution factor to minimize potential interferences arising from the high sodium content in the TCLP leaching solution.

<u>Certification Statement</u>

Where the analytical method has been performed under NELAP certification, the analysis has met all of the requirements of the NELAC standard unless otherwise noted in the analytical case narrative.

436338

Page: ____1____ of ________

Project #:

ORISE Chain of Custody and Analytical Request

OAK RIDGE INSTITUTE FOR SCIENCE AND EDUCATION

ORISE
1299 Bethel Valley Road, Bldg SC-200
Oak Ridge, TN 37831
Phone: (865) 241-3242
Fax: (865) 241-3248

Client Name: ORAU **Phone #:** 865-574-9646
Site/Task #: 5184 **Fax #:**
Site/Task Name: 5184 **e-mail:** jason.lee@orau.org
Address:
Collected by: J. Lee **Send Results To:** J. Lee

Sample Analysis Requested (3)

Client Sample ID * For composites - indicate start and stop date/time	Date Collected (mm-dd-yy)	*Time Collected (Military) (hhmm)	Sample Matrix (1)	Field Filtered (2)	ORISE Lab Sample ID (Lab Use Only)	Total # of containers	TCLP Metals	TCLP Volatiles	TCLP Semi Volatiles	Comments
						<-- Preservative Type (4)				
5184S0226	10-19-17	13:30	Soil	NA		1	x	x	x	

TAT Requested: Normal 28 Business Days: Rush (Specify): (Contact ORISE Lab) Fax Results?: Yes No Fax #:

Remarks: *List any known hazards applicable to these samples. List any anomalies with sample receipt.*

*Sample Collection Time Zone Eastern / Central / Mountain / Pacific / Other______

Chain of Custody Signatures

	Relinquished By (Signed)	Date	Time	Received By (Signed)	Date	Time	Received in Good Condition?(5)	
1	Jason Lee	10/25/17	1600	[signature]	10/26/17	8:58	Yes	No
2							Yes	No
3							Yes	No

Sample Shipping and Delivery Details

ORISE PM: Phone #:
Method of Shipment: Date Shipped:
Airbill #:
Airbill #:
PM or Sample Manager Approval Initials: [initials] Date: 10/25/17

1) Matrix Codes: **S**=Soil, **W**=Water, **M**=Miscellaneous, **A**=Air Filter, **R**=Smear/Wipe
2) Field Filtered: For liquid matrices, indicate with a **- Y -** for yes the sample was field filtered or **- N -** for sample was not field filtered.
3) Sample Analysis Requested: For gamma spec, indicate isotopes in comment field.
4) Preservative Type: **HCl** = Hydrochloric Acid, **HNO_3** = Nitric Acid, **C** = Cold, **O** = Other (specify), If no preservative is added = leave field blank
5) If the integrity of samples and/or sample packaging is in question, including absent or broken custody seals, hold time concerns, inadequate preservation (pH/temperature), insufficient volume, improper container type or incomplete custody forms/labels, provide details in the Remarks box along with the date and initials of the person making the entry.

WHITE = LABORATORY **YELLOW = FILE** **PINK = CLIENT**

GEL Laboratories LLC

SAMPLE RECEIPT & REVIEW FORM

Client: ~~ORAU~~ ORAU 10/30/17	SDG/AR/COC/Work Order: 436338
Received By: ZKW	Date Received: 10/26/17
Carrier and Tracking Number	Circle Applicable: FedEx Express FedEx Ground UPS Field Services Courier Other 7705 8615 6489

Suspected Hazard Information	Yes	No	*If Net Counts > 100cpm on samples not marked "radioactive", contact the Radiation Safety Group for further investigation.
Shipped as a DOT Hazardous?		✓	Hazard Class Shipped: UN#:
COC/Samples marked or classified as radioactive?		✓	Maximum Net Counts Observed* (Observed Counts - Area Background Counts): 0 CPM mR/Hr Classified as: Rad 1 Rad 2 Rad 3
Is package, COC, and/or Samples marked HAZ?		✓	If yes, select Hazards below, and contact the GEL Safety Group. PCB's Flammable Foreign Soil RCRA Asbestos Beryllium Other:

	Sample Receipt Criteria	Yes	NA	No	Comments/Qualifiers (Required for Non-Conforming Items)
1	Shipping containers received intact and sealed?	✓			Circle Applicable: Seals broken Damaged container Leaking container Other (describe)
2	Chain of custody documents included with shipment?	✓			
3	Samples requiring cold preservation within (0 ≤ 6 deg. C)?*	✓			Preservation Method: Wet Ice Ice Packs Dry ice None Other: *all temperatures are recorded in Celsius TEMP: 2C
4	Daily check performed and passed on IR temperature gun?	✓			**Temperature Device Serial #:** IR3-16 Secondary Temperature Device Serial # (If Applicable):
5	Sample containers intact and sealed?	✓			Circle Applicable: Seals broken Damaged container Leaking container Other (describe)
6	Samples requiring chemical preservation at proper pH?		✓		Sample ID's and Containers Affected: If Preservation added, Lot#:
7	Do any samples require Volatile Analysis?			✓	If Yes, Are Encores or Soil Kits present? Yes___ No___ (If yes, take to VOA Freezer) Do VOA vials contain acid preservation? Yes___ No___ N/A___ (If unknown, select No) VOA vials free of headspace? Yes___ No___ N/A___ Sample ID's and containers affected:
8	Samples received within holding time?	✓			ID's and tests affected:
9	Sample ID's on COC match ID's on bottles?	✓			Sample ID's and containers affected:
10	Date & time on COC match date & time on bottles?	✓			Sample ID's affected:
11	Number of containers received match number indicated on COC?	✓			Sample ID's affected:
12	Are sample containers identifiable as GEL provided?			✓	
13	COC form is properly signed in relinquished/received sections?	✓			

Comments (Use Continuation Form if needed):

PM (or PMA) review: Initials JL Date 10/30/17 Page 1 of 1

GL-CHL-SR-001 Rev 5

List of current GEL Certifications as of 15 November 2017

State	Certification
Alaska	UST−0110
Arkansas	88−0651
CLIA	42D0904046
California	2940
Colorado	SC00012
Connecticut	PH−0169
Delaware	SC00012
DoD ELAP/ ISO17025 A2LA	2567.01
Florida NELAP	E87156
Foreign Soils Permit	P330−15−00283, P330−15−00253
Georgia	SC00012
Georgia SDWA	967
Hawaii	SC00012
Idaho Chemistry	SC00012
Idaho Radiochemistry	SC00012
Illinois NELAP	200029
Indiana	C−SC−01
Kansas NELAP	E−10332
Kentucky SDWA	90129
Kentucky Wastewater	90129
Louisiana NELAP	03046 (AI33904)
Louisiana SDWA	LA170010
Maryland	270
Massachusetts	M−SC012
Michigan	9976
Mississippi	SC00012
Nebraska	NE−OS−26−13
Nevada	SC000122018−1
New Hampshire NELAP	205415
New Jersey NELAP	SC002
New Mexico	SC00012
New York NELAP	11501
North Carolina	233
North Carolina SDWA	45709
North Dakota	R−158
Oklahoma	9904
Pennsylvania NELAP	68−00485
Puerto Rico	SC00012
S.Carolina Radchem	10120002
South Carolina Chemistry	10120001
Tennessee	TN 02934
Texas NELAP	T104704235−17−12
Utah NELAP	SC000122017−24
Vermont	VT87156
Virginia NELAP	460202
Washington	C780
West Virginia	997404

APPENDIX D
MAJOR INSTRUMENTATION

The display of a specific product is not to be construed as an endorsement of the product or its manufacturer by the author or his employer.

D.1 SCANNING AND MEASUREMENT INSTRUMENT/DETECTOR COMBINATIONS

D.1.1 Gamma

Ludlum NaI Scintillation Detector Model 44-10, Crystal: 5.1 cm × 5.1 cm
(Ludlum Measurements, Inc., Sweetwater, Texas)
coupled to:
Ludlum Ratemeter-scaler Model 2221
(Ludlum Measurements, Inc., Sweetwater, Texas)
coupled to:
Trimble Geo 7X (Trimble Navigation Limited, Sunnyvale, California)

Ludlum CsI Scintillation Detector Model 44-159-1, Crystal: 18 mm × 18 mm
(Ludlum Measurements, Inc., Sweetwater, Texas)
coupled to:
Ludlum Ratemeter-scaler Model 2221
(Ludlum Measurements, Inc., Sweetwater, Texas)
coupled to:
Trimble Geo 7X (Trimble Navigation Limited, Sunnyvale, California)

D.1.2 Beta

Ludlum Plastic Scintillation Detector Model 44-142
(Ludlum Measurements, Inc., Sweetwater, Texas)
coupled to:
Ludlum Ratemeter-scaler Model 2221
(Ludlum Measurements, Inc., Sweetwater, Texas)

D.2 LABORATORY ANALYTICAL INSTRUMENTATION

High-Purity, Extended Range Intrinsic Detector
CANBERRA/Tennelec Model No: ERVDS30-25195
(Canberra, Meriden, Connecticut)
Used in conjunction with:
Lead Shield Model G-11
(Nuclear Lead, Oak Ridge, Tennessee) and
Multichannel Analyzer
Canberra's Gamma Software
Dell Workstation
(Canberra, Meriden, Connecticut)

High-Purity, Intrinsic Detector
Model No. GMX-45200-5
CANBERRA Model No: GC4020

(Canberra, Meriden, Connecticut)
Used in conjunction with:
Lead Shield Model G-11
Lead Shield Model SPG-16-K8
(Nuclear Data)
Multichannel Analyzer
Canberra's Gamma Software
Dell Workstation
(Canberra, Meriden, Connecticut)

Tri-Carb Liquid Scintillation Analyzer
Model 3100
(Packard Instrument Co., Meriden, Connecticut)

APPENDIX E
SURVEY AND ANALYTICAL PROCEDURES

E.1 PROJECT HEALTH AND SAFETY

ORISE performed all survey activities in accordance with the *ORAU Health and Safety Manual,* the *ORAU Radiation Protection Manual*, and the *ORAU Radiological and Environmental Survey Procedures Manual* (ORAU 2016c, ORAU 2014, and ORAU 2016a). Prior to on-site activities, a work-specific hazard checklist was completed for the project and discussed with field personnel. The planned activities were thoroughly discussed with site personnel prior to implementation to identify hazards present. Additionally, prior to performing work, a pre-job briefing and walk-down of the survey areas were completed with field personnel to identify hazards present and discuss safety concerns. Should ORISE have identified a hazard not covered in the *ORAU Radiological and Environmental Survey Procedures Manual* (ORAU 2016a)or the project's work-specific hazard checklist for the planned survey and sampling procedures, work would not have been initiated or continued until it was addressed by an appropriate job hazard analysis and hazard controls.

E.2 CALIBRATION AND QUALITY ASSURANCE

Calibration of all field instrumentation was based on standards/sources, traceable to National Institute of Standards and Technology (NIST).

Field survey activities were conducted in accordance with procedures from the following ORAU documents:

- *ORAU Radiological and Environmental Survey Procedures Manual* (ORAU 2016a)
- *ORAU Environmental Services and Radiation Training Quality Program Manual* (ORAU 2016b)
- *ORAU Radiological and Environmental Analytical Laboratory Procedures Manual* (ORAU 2017)

The procedures contained in these manuals were developed to meet the requirements of the U.S. Department of Energy (DOE) Order 414.1D and the U.S. Nuclear Regulatory Commission *Quality Assurance Manual for the Office of Nuclear Material Safety and Safeguards* and contain measures to assess processes during their performance.

Quality control procedures include:

- Daily instrument background and check-source measurements to confirm that equipment operation is within acceptable statistical fluctuations.

- Participation in Mixed-Analyte Performance Evaluation Program, NIST Radiochemistry Intercomparison Program, and DOE Radiological and Environmental Science Laboratory Intercomparison Test Program.
- Training and certification of all individuals performing procedures.
- Periodic internal and external audits.

E.3 SURVEY PROCEDURES

E.3.1 SAMPLE CORE SCANS

Scans for elevated radiation were performed by passing the detector slowly over the surface of the core sample. A Ludlum Model 44-10 NaI detector was used for gamma radiation and a Ludlum Model 44-142 plastic scintillator was used for beta radiation. The detectors were used as a qualitative means to identify elevated radiation levels in excess of background identified by an increase in the audible signal from the indicating instrument.

E.3.2 BOREHOLE LOGGING

Scans for elevated gamma radiation were performed by passing Ludlum Model 44-10 NaI and Ludlum Model 44-159-1 CsI detectors slowly down the borehole. The detectors were used as a qualitative means to identify elevated radiation levels in excess of background. Identification of elevated radiation levels that could exceed the site criteria were determined based on an increase in the audible signal and evaluation of subsequent logged data.

Histograms were generated by dividing logged detector data into a series of intervals (bins) and plotting it against the number of results falling within each bin (frequency). Histograms were then evaluated to determine the frequency distribution of results and to identify the presence of any outliers indicative of contamination. A symmetrically shaped histogram represents a normal distribution indicative of background conditions.

Scan sensitivity of the CsI detector was evaluated using an adapted method of that presented in NUREG-1507 (NRC 1998). MicroShield, version 7.03, was used to determine the exposure rate from the assumed contamination geometry. The source term was modeled as an annular cylinder with diameter of 40.6 cm and a height of 30.5 cm, the inner annulus had a diameter of 5.08 cm, representing the borehole. Exposure rate-to-concentration ratios (in units of μR/hr per pCi/g) were generated for each of the gamma-emitting ROCs, including short-lived decay products. Exposure rates were evaluated at the center of the annulus. The source material was assumed to be concrete—as MicroShield does not have a soil matrix—with a density of 1.3 g/cm^3. Net instrument responses due to individual ROC concentrations equal to their respective DCGL$_W$ were calculated using the exposure rate-to-concentration ratios. Scan MDCs were calculated based on the minimum detectable exposure rate from a surveyor with an efficiency of 0.5 (NUREG-1507 default). Both the net instrument response due to an ROC concentration at the DCGL$_W$ and down-hole scan MDCs are presented in Table E.1 below.

Table E.1. Borehole Scan Sensitivity for the CsI Detector

ROC	µR/hr[a]	µR/hr/ pCi/g	µR/hr at DCGL	net cpm at DCGLw	cpm/ µR/hr	Scan MDC (pCi/g)
3% EU	5.32E-01	1.75E-02	2.97	2,350	791	125
20% EU	3.98E-01	1.31E-02	2.25	2,181	969	136
Th-232	1.83E+02	6.00E+00	18.01	1,858	103	2.8
Ra-226	1.23E+02	4.04E+00	11.31	1,189	105	4.1
Scan MDC Inputs						
Bkg	2,300	cpm	d'		3.28	
i	1	s	MDCR		1218	cpm
bi	38.3	cpm	MDCRsurveyor		1723	cpm

[a] Calculated from Microshield based on an annular cylinder geometry and a ROC concentration of 30.5 pCi/g

E.3.3 SOIL SAMPLING

Soil sampling was facilitated using DPT equipment with a dual-tube core collection system. The system consisted of an outer rod (stainless steel casing) and smaller diameter inner rod housing the plastic sample collection liner approximately 1.5 meters in length. Rods were advanced vertically into the soil in 1.5-meter (5-foot) increments. The soil core was then extracted and a new liner inserted into the casing to collect the next incremental soil core. After each incremental core was collected, the sample tube was delivered to ORISE personnel for scanning and sample collection. Soil samples representative of the backfill/native soil interface were collected in equal portions from the 15-centimeter interval above and below the interface, using a clean garden trowel and transferred into a new sample container. In addition, a single composite sample was collected per borehole consisting of equal volume aliquots taken from each incremental core. The samples were not field sieved and were delivered to the laboratory as collected.

E.4 RADIOLOGICAL ANALYSIS

E.4.1 GAMMA SPECTROSCOPY

Samples were dried, mixed, crushed, and/or homogenized as necessary, and a portion sealed in a 0.5-liter Marinelli beaker. The quantity placed in the beaker was chosen to reproduce the calibrated counting geometry. Net material weights were determined and the samples counted using intrinsic, high purity, germanium detectors coupled to a pulse height analyzer system. Background and Compton stripping, peak search, peak identification, and concentration calculations were performed using the computer capabilities inherent in the analyzer system. All total absorption peaks (TAPs) associated with the ROCs were reviewed for consistency of activity. Spectra were also reviewed for other identifiable TAPs. TAPs used for determining the activities of ROCs and the typical associated MDCs for a one-hour count time are presented in Table E.2.

Table E.2. Typical MDCs

Radionuclide[a]	TAP (keV[b])	MDC (pCi/g)
U-235	143.76	0.24
U-238 by Th-234	63.29	0.75
Th-232 by Ac-228	911.20	0.12
Ra-226 by Pb-214	351.92[b]	0.24

[a] Spectra were also reviewed for other identifiable TAPs.
[b] kilo electron volt

E.4.2 TC-99 ANALYSIS

Technetium-99 was analyzed by using the Oak Ridge Radiological and Environmental Analytical Laboratory procedures AP5 and CP4. The samples were processed such that any technetium was converted into the pertechnatate anion. The pertechnatate anion was selectively absorbed on a chromatographic resin. Interfering elements were not retained under the correct conditions. The resin was counted with an appropriate liquid scintillation counting cocktail. The typical MDC for this procedure was 0.28 pCi/g.

E.4.3 DETECTION LIMITS

Detection limits, referred to as MDCs, were based on 95% confidence level. Because of variations in background levels, measurement efficiencies, and contributions from other radionuclides in samples, the detection limits differ from sample to sample and instrument to instrument.

E.4.4 U-234 CALCULATION

The U-234 concentration was calculated by using the method specified in WEC 2013. First, the U-238 to U-235 ratio was calculated. The corresponding U-234 to U-235 ratio, determined using Table 14-5 in Chapter 14 of the HDP DP, was multiplied by the U-235 concentration to yield the U-234 concentration. If the U-238 to U-235 ratio was not specified in Table 14-5, the U-234 to U-235 value was linearly interpolated. If the U-235 value was negative, a U-234 to U-235 ratio of 21.07 was assumed—the ratio for natural uranium. The uncertainty for the calculated U-234 value was propagated assuming the U-234 to U-235 ratio had no uncertainty. The uranium enrichment was determined based on the U-238 to U-235 ratio in the same manner as the U-234 to U-235 ratio. Table E.3, presented below, details the calculation of U-234.

Table E.3. U-234 Calculation

Sample ID	U-235 (pCi/g)			U-238 (pCi/g)			U-238/ U-235	U-234/ U-235	Enrichment (%)	U-234 (pCi/g)		
5184S0184	0.09	±	0.1	1.5	±	0.54	16.67	20.09	0.9	1.81	±	2.01
5184S0186	0.14	±	0.14	1.91	±	0.77	13.64	19.54	1.1	2.74	±	2.74
5184S0188	0.05	±	0.1	2.01	±	0.62	40.20	24.47	0.3	1.22	±	2.45
5184S0190	0.4	±	0.13	2.4	±	0.77	6.00	18.31	2.5	7.32	±	2.38
5184S0192	0.39	±	0.17	1.8	±	1.1	4.62	18.16	3.2	7.08	±	3.09
5184S0194	0.49	±	0.12	2.1	±	1.1	4.29	18.14	3.5	8.89	±	2.18
5184S0196	0.221	±	0.1	1.92	±	0.55	8.69	18.70	1.7	4.13	±	1.87
5184S0198	0.15	±	0.12	1.63	±	0.65	10.87	19.06	1.4	2.86	±	2.29
5184S0200	0.24	±	0.13	2.03	±	0.99	8.46	18.67	1.8	4.48	±	2.43
5184S0202	0.246	±	0.07	2.03	±	0.59	8.25	18.63	1.8	4.58	±	1.30
5184S0204	0.051	±	0.089	1.54	±	0.51	30.20	22.59	0.5	1.15	±	2.01
5184S0206	0.18	±	0.14	1.2	±	1.1	6.67	18.40	2.2	3.31	±	2.58
5184S0208	0.046	±	0.078	1.23	±	0.41	26.74	21.94	0.5	1.01	±	1.71
5184S0210	0.117	±	0.095	1.31	±	0.51	11.20	19.11	1.3	2.24	±	1.82
5184S0212	0.01	±	0.15	1.09	±	0.92	109.00	37.51	0.1	0.38	±	5.63
5184S0214	0.069	±	0.098	1.87	±	0.55	27.10	22.01	0.5	1.52	±	2.16
5184S0216	0.06	±	0.13	1.44	±	0.62	24.00	21.43	0.6	1.29	±	2.79
5184S0218	0.2	±	0.16	1.49	±	0.94	7.45	18.51	2	3.70	±	2.96

Table E.3. U-234 Calculation												
Sample ID	U-235 (pCi/g)			U-238 (pCi/g)			U-238/ U-235	U-234/ U-235	Enrichment (%)	U-234 (pCi/g)		
5184S0220	0.065	±	0.087	1.34	±	0.46	20.62	20.81	0.72	1.35	±	1.81
5184S0222	0.11	±	0.1	1.56	±	0.68	14.18	19.64	1	2.16	±	1.96
5184S0224	0.06	±	0.16	2	±	1	33.33	23.18	0.4	1.39	±	3.71
5184S0225	0.11	±	0.13	1.57	±	0.64	14.27	19.65	1	2.16	±	2.55
5184S0183	0.21	±	0.13	1.88	±	0.64	8.95	18.74	1.7	3.94	±	2.44
5184S0185	0.18	±	0.18	1.9	±	1.1	10.56	19.01	1.4	3.42	±	3.42
5184S0187	0.03	±	0.096	1.05	±	0.53	35.00	23.49	0.4	0.70	±	2.26
5184S0189	0.18	±	0.17	2.6	±	1.1	14.44	19.68	1	3.54	±	3.35
5184S0191	0.1	±	0.1	1.72	±	0.56	17.20	20.18	0.8	2.02	±	2.02
5184S0193	0.2	±	0.11	2.22	±	0.63	11.10	19.10	1.3	3.82	±	2.10
5184S0195	0.08	±	0.14	2.33	±	0.78	29.13	22.39	0.5	1.79	±	3.13
5184S0197	0.23	±	0.17	1.7	±	1.3	7.39	18.50	2	4.25	±	3.14
5184S0199	0.167	±	0.095	1.56	±	0.52	9.34	18.81	1.6	3.14	±	1.79
5184S0201	0.29	±	0.13	2.19	±	0.69	7.55	18.52	2	5.37	±	2.41
5184S0203	0.08	±	0.11	1.43	±	0.46	17.88	20.31	0.8	1.62	±	2.23
5184S0205	0.17	±	0.16	1.06	±	0.9	6.24	18.34	2.4	3.12	±	2.93
5184S0207	0.09	±	0.1	1.55	±	0.53	17.22	20.19	0.8	1.82	±	2.02
5184S0209	0.13	±	0.13	1.43	±	0.92	11.00	19.08	1.3	2.48	±	2.48
5184S0211	0.119	±	0.093	1.76	±	0.51	14.79	19.74	1	2.35	±	1.84
5184S0213	0.08	±	0.1	1.35	±	0.58	16.88	20.13	0.9	1.61	±	2.01
5184S0215	0.14	±	0.17	2.0	±	1.1	14.29	19.65	1	2.75	±	3.34
5184S0217	0.079	±	0.095	1.51	±	0.48	19.11	20.53	0.8	1.62	±	1.95
5184S0219	0.07	±	0.11	2.2	±	0.73	31.43	22.82	0.4	1.60	±	2.51
5184S0221	0.07	±	0.14	1.21	±	0.91	17.29	20.20	0.8	1.41	±	2.83
5184S0223	0.047	±	0.085	1.18	±	0.41	25.11	21.64	0.6	1.02	±	2.83
5184S0226	0.09	±	0.09	1.58	±	0.48	17.56	20.25	0.8	1.82	±	1.82