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Results of Submerged Sediment Core Sampling and Analysis on Par Pond, Pond C, and L Lake: July 1995 (U)

by

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Abstract

Sediment cores from shallow and deep water locations in Par Pond, Pond C, and L Lake were collected and analyzed in 1995 for radioactive and nonradioactive constituents. This core analysis was conducted to develop a defensible characterization of contaminants found in the sediments of Par Pond, Pond C, and L Lake.

Mercury was the only nonradiological constituent with a nonestimated quantity that was detected above the U.S Environmental Protection Agency Region IV potential contaminants of concern screening criteria. It was detected at a depth of 0.3-0.6 meters (1.0-2.0 feet) at one location in L Lake.

Cesium-137, promethium-146, plutonium-238, and zirconium-95 had significantly higher concentrations in Par Pond sediments than in sediments from the reference sites. Cobalt-60, cesium-137, plutonium-238, plutonium-239/240, and strontium-90 had significantly higher concentrations in L-Lake sediments than sediments from the reference sites.

1.0 Introduction

In July 1995, Westinghouse Savannah River Company (WSRC), Savannah River Technology Center Environmental Sciences Section conducted sediment core sampling in Par Pond, Pond C, and L Lake to characterize the contaminants in various layers of sediment. Sediment cores were taken from 12 locations in Par Pond, 8 locations in L Lake, and 2 locations in Pond C. In addition, cores were taken from five background locations. Four of the background locations were at streams on the Savannah River Site (SRS), and one was in Lake Marion, SC.

In 1958, the headwaters of Lower Three Runs were impounded with an earthen embankment to form Par Pond. Par Pond served as a recirculating reservoir for P and R Reactors through 1963 and for P Reactor alone until 1988. Pond C is separated from Par Pond by an earthen dam that keeps the water level in Pond C approximately 0.3 meters ([m]1 foot) above normal pool in Par Pond. It was separated from Par Pond to increase cooling efficiency during reactor operations. During the course of operations, the reactors released relatively small quantities of radionuclides into Par Pond. Predominant radionuclides included cesium-137 and tritium. Cesium-134, cobalt-60, and plutonium isotopes were released in much smaller quantities.

In order to maintain constant levels in the reservoir, Par Pond received makeup water pumped from the Savannah River to replace what was lost by evaporation and what was diverted to Lower Three Runs. Mercury from the Savannah River was introduced into Par Pond.

In 1991, a depression was discovered on the downstream slope of the Par Pond dam. To ensure the safety of residents downstream in the event of a dam failure, Par Pond was lowered from approximately 61 m (200 feet) above mean sea level (MSL) to approximately 55 m (181 feet) above MSL. The drop in water level exposed sediments contaminated with radioactive isotopes and mercury. Because Par Pond was listed as a potential Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) site in the SRS Federal Facilities Agreement, the U.S. Department of Energy (DOE) and the U.S. Environmental Protection Agency (EPA) considered the drawdown a removal action.

The Par Pond CERCLA unit was defined as the exposed sediments in Par Pond between approximately 55 m (181 feet) and approximately 61 m (200 feet) above MSL. It included the exposed sediments in Pond C between approximately 59 m (195 feet) and approximately 61 m (201 feet) above MSL. The sediments that remained under water after the drawdown were not part of the CERCLA unit. The lake was refilled in late 1995, after the dam was repaired.

L Lake was constructed on Steel Creek in 1985 as a once-through cooling water reservoir for L Reactor. Prior to construction of L Lake, P Reactor had released quantities of radioisotopes into Steel Creek. Predominant radioisotopes in the Steel Creek basin are similar to those found in Par Pond and Pond C and include cesium-137 and tritium. Cesium-134, cobalt-60, and plutonium isotopes are present, but in much smaller quantities.

L Lake receives makeup water pumped from the Savannah River to maintain its water level. Consequently, L Lake is contaminated with mercury. Without this makeup water, L Lake is expected to drain slowly because the watershed above the dam is not large enough to maintain the lake at full pool.

There are no plans to restart L Reactor. Allowing L Lake to drain is a cost-saving option being considered by DOE. The sediment analysis provides definitive information on the contaminants in L Lake. This information will be considered in the decision on the future of L Lake.

In response to the need for a full-scale contaminants screening study, a sampling program was established. This program was designed to develop a complete and defensible list of contaminants for Par Pond, Pond C, and L Lake and to identify all potential contaminants of concern (PCOC) in the sediments of those reservoirs. The results of the screening study will serve as the basis for future studies to determine in detail the spatial distribution and ecological effects of the contaminants.

2.0 Field Methods

Sediment core sampling services were contracted to Science Applications International Corporation (SAIC) with field sampling subcontracted to Athena Technologies. All sampling activities are described in detail in the SAIC field report issued to WSRC (SAIC 1995) and are summarized in this report.

Vibracoring was used to collect all samples. The vibracore machine is a gasoline-powered 8.5-horsepower (hp) engine equipped with a vibrating head on a flexible steel wire. This equipment is similar to that used in the construction industry for vibrating wet concrete. Attached to the vibrating head was a clamp that closes around a 3-inch diameter, thin-walled, aluminum pipe approximately 15 feet long. The bottom of the pipe is beveled. The pipe was raised to a vertical position with the beveled end resting against the substrate. When the engine started, the vibrating head vibrated the aluminum pipe into the sediment, capturing a solid core of material.

For lake bottom sampling, the equipment was set up on a barge that served as the coring platform. The coring barge consisted of four metal panels filled with foam flotation bolted to form a platform approximately 10 feet square. In its center was a rectangular hole approximately 2-by-4 feet. Bolted to the deck and centered over the hole was a steel derrick, approximately 10 feet high, which guided the coring drill string through the platform.

The basic vibracorer described previously was modified to advance the pipe under water by attaching a check valve assembly and lengths of 2-inch diameter galvanized drill pipe with quick-connect couplings to the coring pipe. The core pipe was lowered through the barge deck, and drill pipe lengths were added until the bottom of the core pipe rested on the lake bottom. When the pipe was on the lake bottom, the length of the drill string above the water surface was measured and subtracted from the overall drill-string length to determine water depth. A second measure of water depth was taken with a depth finder. When coring began, the drill string advanced via vibration for approximately five minutes or to refusal, whichever occurred first. Normally, initial penetration occurred rapidly because the pipe was advancing through the soft, organic layers. When the denser, more cohesive layers were encountered, penetration slowed or stopped. After five minutes or when the pipe was no longer penetrating the substrate, a strap was wrapped around the drill string and a crew member used his body weight to increase the penetration and to ensure that a plug of cohesive material was in the pipe's bottom to facilitate core recovery.

Electric and manual winching was used to pull the core pipe out of the sediments and onto the barge. The check valve assembly ensured suction was maintained on the core to prevent it from sliding out of the end of the pipe.

Once on the barge deck, the core-pipe bevel was cut off, and the bottom end was labeled and capped. The check valve assembly was removed, and the water in the top of the core pipe was gently decanted at a very shallow angle. After decanting the water, the length of the core was determined. A measure of compaction was not possible, and therefore, less than 100% recovery was always attributed to core loss, not compaction. The portion of the pipe above the core was cut away and the top end of the core was labeled and capped. The core was placed inside a wooden, insulated cooler with ice.

In the streams and Lake Marion (which had near-shore sample sites only), a portable vibracorer operated by a 1.5-hp engine mounted on a backpack was used to collect the cores. The coring procedure was the same as described for the deep water samples; however, no check valve assembly was used and no drill string was necessary.

When the core pipe had advanced to refusal, the vibracorer was turned off and the vibrating head was removed from the pipe. The portion of the pipe above the top of the core was measured. The length of pipe above the stream bed also was measured. These two numbers were used to quantify sample compaction. Compaction was significant in some cores due to their coarse-grained nature and the presence of extensive voids between grains. After the measurements were taken, the empty portion of pipe was carefully filled with water so as not to disturb the sediments, and a plumber's stopper was secured in the pipe top to create a suction to maintain the core in the pipe as it was removed from the sediments. An aluminum tripod was erected directly over the core pipe, and the pipe was manually winched out of the stream or lake bed. Once extracted, the samples were labeled and capped as described for the lake samples.

3.0 Sample Processing

Two cores were collected at each location to provide sufficient sample volume. Following core retrieval, cores were transported to the sample processing facility, where they were cut open longitudinally using a circular saw. Each core was divided into five segments representing depths of

0.0-1.0 foot (core segment 1), 1.0-2.0 feet (core segment 2), 2.0-4.0 feet (core segment 3), 4.0-6.0 feet (core segment 4), and 6.0-8.0 feet (core segment 5). In cases where the core was longer than 8 feet, the excess material was discarded. In most cases, the cores were shorter than 8 feet, and therefore, all five intervals were not fully represented.

Subsamples for volatile organic analytes (VOAs) were collected from the cores at approximately half of the sampling locations. When sampling these cores, the VOA samples were collected immediately upon opening the core tube. VOA containers were completely filled, leaving no head space. Following VOA collection, the field geologist examined the core and recorded detailed observations on a geologic log. Then each core segment was individually composited (homogenized) in a stainless-steel bowl. After a segment was adequately homogenized, sample containers were filled in order of volatilization sensitivity. Each container was labeled with the sample identification, date, time, and appropriate analysis. For the 1-foot segments (0.0-1.0-foot and 1.0-2.0-foot), sufficient sample volume was not available. Therefore, a minimum number of containers was filled from these core segments using the prioritization in the Work Plan Assessment (Nichols 1995). All 2-foot segments had ample sample volume.

Filled sample containers were immediately placed on ice in a portable cooler. Upon completion of sample processing for a particular location, the portable cooler was placed inside a walk-in cooler. Chain-of-custody sheets were filled out for each core segment and maintained with the samples. When all the cores had been processed, the samples were shipped to an analytical laboratory. Appropriate quality assurance/quality control procedures were followed at all times during sample collection and processing. Appendix A identifies all sample location codes. Analyses performed at each location are described in Appendix B. Some of the samples were analyzed for organics.

4.0 Sample Locations

Sampling locations were identified by Universal Transverse Mercator (UTM) coordinates in Par Pond and Pond C, by longitude and latitude coordinates in L Lake, and by maps for SRS streams and Lake Marion.

For Par Pond and Pond C (Figure 1), the UTM coordinates were plotted on a 7.5-minute topographic quadrangle map. Using the plotted locations on the map, the coring equipment was sited using the map and visual cues (landmarks, topographic features, etc.). Once in position, a Magellan®, Model 1500 Global Positioning System (GPS) was used to obtain exact position data in the form of longitude and latitude corrected to the 1927 North American datum corresponding to the 7.5-minute quadrangles. The coordinates for each location are presented in Table 1. As a check, map locations were converted from UTM to longitude and latitude and compared to the GPS readout for each location.

For L Lake (Figure 1), map locations and longitude and latitude coordinates were determined using the SRS digitized map. The coring equipment on L Lake was positioned in the same manner as at Par Pond (map/visual), and the GPS was used to determine exact location coordinates.

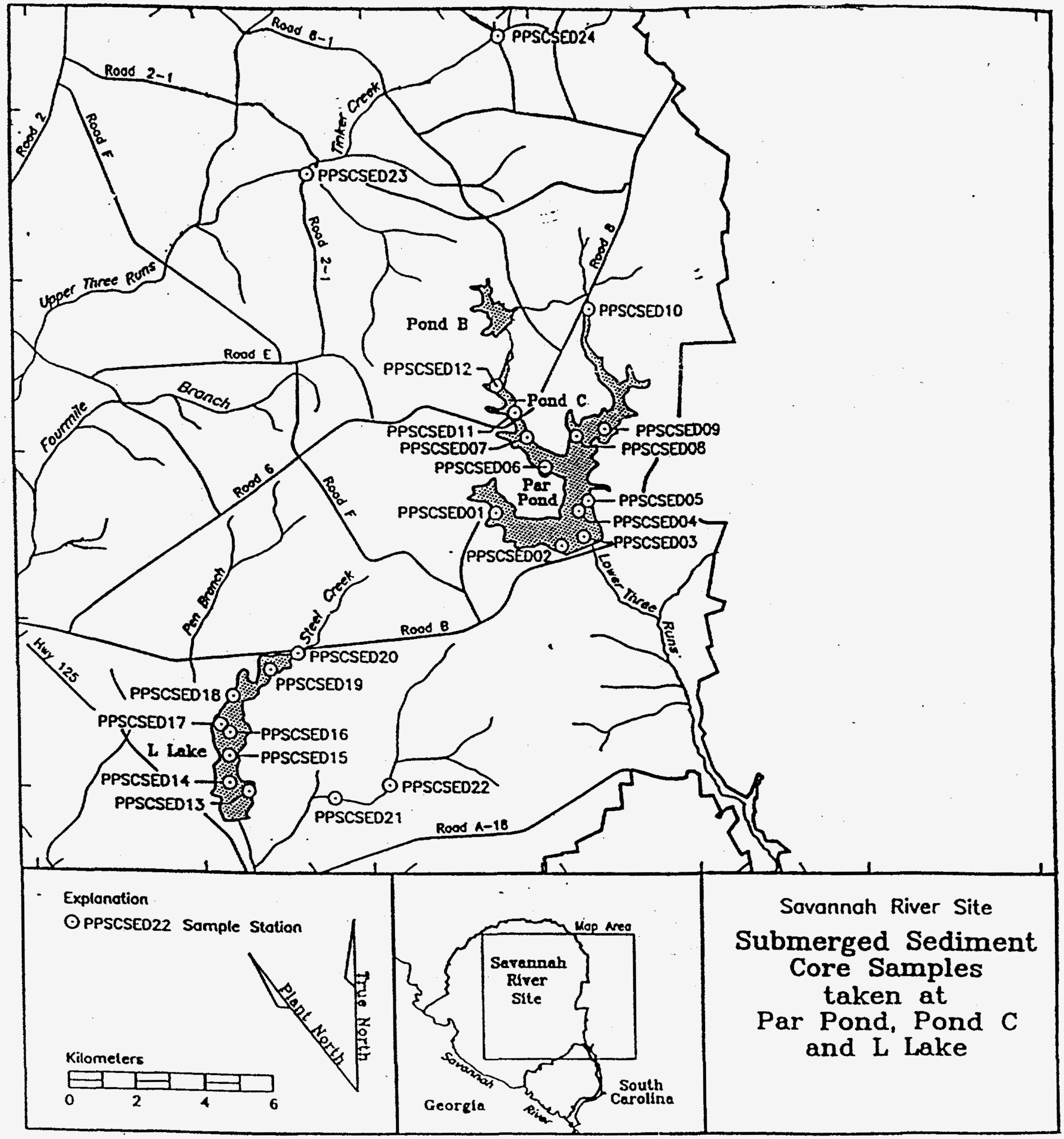

Figure 1. Sample locations for SRS sediment cores.

Table 1. Universal Transverse Mercator coordinates for all sediment core locations in Par Pond, Pond C, L Lake, Meyer's Branch, Mill Creek, Tinker Creek, and Lake Marion. 1995.

Location	Sample ID	Proposed location		Actual location	
		Longitude	Latitude	Longitude	Latitude
Par Pond	PPSC-SED01	81-32-53W	33-14-37N	81-32-59W	33-14-38N
	PPSC-SED02	81-31-30W	33-14-04N	81-31-41W	33-14-07N
	PPSC-SED03	81-31-11W	33-14-15N	81-31-14W	33-14-16N
	PPSC-SED04	81-31-17W	33-14-39N	81-31-20W	33-14-41N
	PPSC-SED05	81-31-05W	33-14-54N	81-31-08W	33-14-51N
	PPSC-SED06	81-32-00W	33-15-30N	81-31-59W	33-15-23N
	PPSC-SED07	81-32-20W	33-15-53N	81-32-20W	33-15-51N
	PPSC-SED08	81-31-25W	33-15-49N	81-31-21W	33-15-53N
	PPSC-SED09	81-30-50W	33-16-01N	81-30-46W	33-16-00N
	PPSC-SED10	81-31-03W	33-17-55N	81-31-05W	33-17-54N
Pond C	PPSC-SED11	81-32-36W	33-16-16N	81-32-34W	33-16-15N
	PPSC-SED12	81-32-58W	33-16-40N	81-32-56W	33-16-40N
L Lake	PPSC-SED13	81-37-51W	33-10-04N	81-37-47W	33-10-07N
	PPSC-SED14	81-38-12W	33-10-21N	81-38-09W	33-10-15N
	PPSC-SED15	81-38-12W	33-10-35N	81-38-09W	33-10-41N
	PPSC-SED16	81-38-11W	33-10-59N	81-38-08W	33-11-04N
	PPSC-SED17	81-38-11W	33-11-27N	81-38-18W	33-11-11N
	PPSC-SED18	81-38-05W	33-11-45N	81-38-04W	33-11-39N
	PPSC-SED19	81-37-21W	33-12-02N	81-37-20W	33-12-05N
	PPSC-SED20	81-37-00W	33-12-18N	81-36-47W	33-12-21N
Meyer's Branch	PPSC-SED21	NA[1]	NA	81-36-07W	33-10-01N
	PPSC-SED22	NA	NA	81-35-05W	33-10-14N
Mill Creek	PPSC-SED23	NA	NA	81-36-31W	33-20-01N
Tinker Creek	PPSC-SED24	NA	NA	81-32-51W	33-22-10N
Lake Marion	PPSC-SED25	NA	NA	80-30-15W	33-33-11N

[1]NA = not applicable

The SRS stream locations consisted of two sites on Meyer's Branch, one site on Mill Creek, and one site on Tinker Creek. UTM coordinates for the stream locations were not provided. However, locations were sited based on intersections of the streams with SRS roads. GPS was used to obtain longitude and latitude coordinates and the distance from a landmark (i.e., bridge) to the sampling sites was recorded. A similar method was used to locate the sample site at Lake Marion.

5.0 Field Results and Observations

5.1 Lacustrine/Alluvial Channel Sediment Thickness

Descriptions of each core are presented in Table 2.

5.1.1 Par Pond

At 8 of 10 sampling locations, recently deposited material was completely penetrated with the core bottoming out in undisturbed soils. Recently deposited material refers to material deposited in recent geologic time. At six of these eight locations, the undisturbed soil was in the "B" soil horizon described in Looney et al. (1989) and other SRS stratigraphic studies. The cores usually were composed of a clayey sand ranging from a fine grained to a very fine-to-coarse grained sand, with clay contents in ranges of 10-20% to 30-40%. The unit (a mass of sedimentary material occurring in a distinct layer classified as a unit based on character, property, or attribute) was always mottled; the dominant colors were dark yellowish orange and moderate reddish brown, and less frequently, very pale orange. Some cores were silty, medium to coarse-grained sand; one was a sandy silt.

At two locations, SED-03 and SED-09, apparently undisturbed soils that were distinct from the "B" soil horizon were encountered. These were dark yellowish-orange or light gray clayey sands. At all Par Pond locations where recently deposited sediments were fully penetrated, these sediments ranged from 1.5-4.8 feet thick. Five of these were shallow-water environments (flooded terrestrial sites under less than 6.4 m [21 feet] of water) and the remaining were former (prior to the construction of the reservoir) or ancestral alluvial channel sites. At two of the channel sites (SED-04 and SED-10), recent sediments were not fully penetrated even though the total lengths of these cores were 5.8 and 10.0 feet.

5.1.2 Pond C

Both Pond C sampling locations were in shallow water and undisturbed soils were encountered at both. Thickness of recent sediments ranged from 2.5-3.2 feet.

5.1.3 L Lake

In L-Lake cores, the "B" soil horizon was encountered in only the single nonchannel, or shallow water location (SED-13). Undisturbed soils were encountered at three other locations, and recent soils were not fully penetrated at the remaining four locations. Recent sediment thickness ranged from 3.6 to more than 10 feet, based on the cores never penetrating the recent material.

Table 2. Description of sediment cores from Par Pond, Pond C, L Lake, Meyer's Branch, Mill Creek, Tinker Creek, and Lake Marion. 1995.

Location	Sample ID	Location type	Thickness of recent sediment (feet)	Water depth (feet)	Undisturbed soil marker	Recent material
Par Pond	PPSC-SED01	Shallow	2.0	5.5	Mottled "B" Soil	Organic soil over sand
	PPSC-SED02	Shallow	4.8	10	Mottled "B" Soil	Sand
	PPSC-SED03	Channel	4.0	41	Light gray clayey sand	Sand
	PPSC-SED04	Channel	UK[1]	45[2]	NA[3]	Sand
	PPSC-SED05	Shallow	3.4	15[2]	Mottled "B" Soil	Sand, overlying organic soil
	PPSC-SED06	Channel	3.2	25	Mottled "B" Soil	Sand, silty sand with roots
	PPSC-SED07	Shallow	4.0	14	Mottled "B" Soil	Organic silty sand over sand
	PPSC-SED08	Shallow	1.5	21	Mottled "B" Soil	Organic silty/clayey sand over silty/clayey sand
	PPSC-SED09	Channel	3.0	37	Dark yellowish-orange clayey sand over light gray clayey sand	Sand
	PPSC-SED10	Channel	UK	9	NA	Silty sand over sand
Pond C	PPSC-SED11	Shallow	2.5	18	Mottled "B" Soil	Organic soil over sand
	PPSC-SED12	Shallow	3.2	9	Dark yellowish-orange SP-SC[4] interbedded with light gray clay.	Organic soil over sand
L Lake	PPSC-SED13	Shallow	6.3	10	Mottled "B" Soil	Sand
	PPSC-SED14	Channel	UK	47	NA	Sand over organic soil
	PPSC-SED15	Channel	9.9	51	Dark yellowish-orange sand with thin clay	Rooted clayey sand over organic rich sand and organic clay interbedded

[1]UK = unknown; recent sediment was not completely penetrated

[2]Approximate water depths from 7.5-minute topographic maps

[3]NA = not applicable

[4]SP-SC = poorly graded, sand-clayey sand

Table 2 (continued). Description of sediment cores from Par Pond, Pond C, L Lake, Meyer's Branch, Mill Creek, Tinker Creek, and Lake Marion. 1995.

Location	Sample ID	Location type	Thickness of recent sediment (feet)	Water depth (feet)	Undisturbed soil marker	Recent material
L Lake	PPSC-SED16	Channel	6.5	48	Tan clay of Dry Branch Formation	Organic soil over sand
	PPSC-SED17	Channel	3.6	32	Light gray SC with 20-30% clay	Sand
	PPSC-SED18	Channel	UK	17	NA	Sand
	PPSC-SED19	Channel	UK	22	NA	Clayey sand organic, over sand
	PPSC-SED20	Channel	UK	10^2	NA	Organic rich SC over sand with pebbles
Meyer's Branch	PPSC-SED21	Stream	UK	<1	NA	Sand over organic rich clay
	PPSC-SED22	Stream	3.9	<1	McBean yellowish-gray sand	Sand over sand with clay
Mill Creek	PPSC-SED23	Stream	6.8	<1	Green clay	Sand over organic soil over sand and SC
Tinker Creek	PPSC-SED24	Stream	4.1	<1	Green clay	Sand and gravel
Lake Marion	PPSC-SED25	Shallow Lake	UK	<1	NA	Sand

[1]UK = unknown; recent sediment was not completely penetrated

[2]Approximate water depths from 7.5-minute topographic maps

[3]NA = not applicable

[4]SP-SC = poorly graded, sand-clayey sand

5.1.4 Streams and Lake Marion

Stream sediments were fully penetrated at three of four locations with thickness of the sediments ranging from 3.9-6.8 feet. The total length of the core at the one remaining stream site was within the same range. At Lake Marion, the core was 5.7 feet long, but it is not clear whether undisturbed samples were encountered.

5.2 Lithology Of Recent Sediments

Recently deposited sediments encountered at Par Pond, Pond C, L Lake, and local streams included organic-rich, anoxic material representing very recent deposition or bioactivity; coarse grained sands representing channel fill and perhaps recent storm deposition; and silty and clayey sands, possibly indicative of less recent, buried lake bottom. Five distinct lithologic units were identified among the 25 sampling locations. Descriptions of the recent sediments at the sampling locations are provided in Table 2. No stratigraphic correlation was attempted, nor is any inferred; however, observed lithologic similarities may provide evidence of depositional processes and prove useful when attempting to correlate contaminant concentrations in the sediments. The five lithologic units are described in the following paragraphs.

5.2.1 Lithology 1

This lithology was found most frequently at Par Pond and Pond C, usually as the uppermost layer. It is associated with the shallower locations where bottom vegetation is present and active decay processes are evident. It was described as a very fine to fine grained silty sand or organic soil, from pale to dusky yellowish-brown, or more commonly, brownish- to greenish-black or dark gray. It was typically soft and saturated, and contained abundant organic material including roots and decaying twigs and leaves, with an earthy or sulfurous odor. In one location, small bivalve shells were present in the unit.

Lithology 1 was not common at L Lake, where most of the sampling locations were in deep water. At one stream location, this lithology was a buried layer, possibly representing a former levee or stream bank.

5.2.2 Lithology 2

Lithology 2 was similar to Lithology 1 but was lighter in color, contained less distinguishable organic matter, and was typically a buried horizon. It was observed at four locations in Par Pond, two locations in L Lake, and at Mill Creek. The lithology was described as silty or clayey sand, from very fine to coarse grained, and with silt or clay content from 10-30%. The color was typically pale to moderate yellowish-brown or light brownish-gray. The layer's texture was soft and fluffy, with a distinct lack of density. It may represent a stage of organic decay later than that of Lithology 1.

5.2.3 Lithology 3

This lithology was present at all but one Par Pond location, at one Pond C location, and at all L Lake and background locations. It included medium-to-coarse, and coarse grained, loose sands typical of alluvial channel fill, or colluvium or storm deposits in the shallower locations. The unit was described as a poorly graded sand, mostly medium-to-coarse grained and sometimes coarse grained (the stream sediments were coarser than the lake sediments). The color ranged from very pale orange to dark yellowish-orange, from pale to dark yellowish- brown, from light brown to light brownish-gray, and from light gray to grayish-orange. It rarely occurred as olive-black or brownish-black.

5.2.4 Lithology 4

Lithology 4 was also a sand unit but was finer grained than Lithology 3 and, consequently, firmer and more cohesive. It was described as a fine-to-medium or medium sand, pale to moderate to dark yellowish-brown, yellowish-gray, grayish-orange, brownish-gray, or medium light gray. This lithology was observed at three Par Pond, one Pond C, two L-Lake, and two stream locations. The unit was always buried, but never deeper than 1-2 feet.

5.2.5 Lithology 5

This lithology is distinct from Lithologies 3 and 4 only in that it includes a small-to-moderate percentage of matrix clay. The unit was observed at three Par Pond, one Pond C, and two background locations, including Lake Marion. It was not evident at L Lake. It was typically a thin unit (less than 2 feet thick) and was immediately below apparent recent sediments. It may represent an older soil horizon that has been softened by its submergence, however, it was not observed consistently above the "B" soil horizon. The unit was described as a clayey sand, usually fine-to-medium grained, with 5-20% clay. Colors observed in the unit included light brown, light gray, yellowish-gray, dark yellowish-orange, pale yellowish-brown, and light greenish-gray.

6.0 Analytical Results

6.1 Nonradiological Constituents Analysis

6.1.1 Data Analysis

The results from the nonradiological constituents were screened against the threshold values from the most recent EPA Region IV standards for potential contaminants of concern (PCOC) using the following protocol. The PCOCs and their screening values are presented in Table 3. Results were not statistically compared because only one analyte was detected above the screening value. Before the data were screened they were reviewed and treated as follows:

1. All data from laboratory blanks, trip blanks, field blanks, and rinsate blanks were removed from the results data file. These data were archived in a quality assurance file. All matrix spike results were removed from the data file.
2. All data qualified with an "R" were removed from the results data file.
3. All data qualified with a "U" were reported at one-half the detection limit (termed a modified result).
4. If a sample location was determined to have 100% nondetects of a given analyte, this analyte was eliminated from consideration as a PCOC for this location.
5. For each analyte and core segment, all modified results were averaged to get a sample mean value. The number of records used to produce the sample mean was recorded in another field.
6. For each analyte and core segment, results of duplicate and split samples were dropped and the parent result was used.
7. In all other cases, the results were not modified.
8. The analyte and core segment data were compared to the EPA sediment screening values and to each other.

6.1.2 Comparison of Results with EPA Region IV Screening Criteria

Tables 4, 5, and 6 summarize the results of screening the contaminants in Par Pond (including Pond C), L Lake, and the pooled background locations against EPA Region IV PCOC values.

Of all the organics and metals screened, only arsenic and mercury were detected. Most of these results were qualified as nondetected (u), and, to be conservative, reported at one-half the detection limit. Their reported concentrations sometimes exceeded screening values. Three results were detected, but estimated quantities were not used to identify PCOCs. Only one result, for mercury, was unqualified. Mercury was detected in one core segment in L Lake (Table 5).

Based on this analysis, no metals or organics were identified as PCOC in Par Pond, L Lake, or the background locations. A complete list of the analytical results is presented in the Quality Control Summary Report (WSRC 1995).

Table 3. EPA Region IV screening values for potential contaminants of concern. (EPA 1995).

Analyte (long)	Medium	Units[1]	CLP PQL[2]	Screening value
2-Methyl Naphthalene	sediments	µg/kg	330	330
Acenaphthene	sediments	µg/kg	330	330
Acenaphthylene	sediments	µg/kg	330	330
Anthracene	sediments	µg/kg	330	330
Antimony	sediments	mg/kg	12	12
Aroclor 1221	sediments	µg/kg	67	67
Arsenic	sediments	mg/kg	2	7.24
Benzo(a)anthracene	sediments	µg/kg	330	330
Benzo(a)pyrene	sediments	µg/kg	330	330
Bis(2-ethylhexyl)phthalate	sediments	µg/kg	3.6	182
Cadmium	sediments	mg/kg	1	1
Chlordane	sediments	µg/kg	1.7	1.7
Chromium	sediments	mg/kg	2	52.3
Chrysene	sediments	µg/kg	330	330
Copper	sediments	mg/kg	5	18.7
DDD	sediments	µg/kg	3.3	3.3
DDE	sediments	µg/kg	3.3	3.3
DDT	sediments	µg/kg	3.3	3.3
p,p'-DDD	sediments	µg/kg	3.3	3.3
p,p'-DDE	sediments	µg/kg	3.3	3.3
p,p'-DDT	sediments	µg/kg	3.3	3.3
Total DDT	sediments	µg/kg	3.3	3.3
Dibenz(a,h)anthracene	sediments	µg/kg	330	330
Dieldrin	sediments	µg/kg	3.3	3.3
Endrin	sediments	µg/kg	3.3	3.3
Fluoranthene	sediments	µg/kg	330	330
Fluorene	sediments	µg/kg	330	330
Lead	sediments	mg/kg	0.6	30.2
Lindane (gamma-BHC)	sediments	µg/kg	3.3	3.3
Mercury	sediments	mg/kg	0.02	0.13
Naphthalene	sediments	µg/kg	330	330
Nickel	sediments	mg/kg	8	15.9
PAHs (high molecular weight)	sediments	µg/kg	330	655
PAHs (low molecular weight)	sediments	µg/kg	330	330
Total PAHs	sediments	µg/kg	330	1684

1 µg/kg = microgram per kilogram or parts per billion; mg/kg = milligram per kilogram or parts per million.

2 CLP PQL = Contract Laboratory Program Practical Quantitation Limit.

Table 3 (continued). EPA Region IV screening values for potential contaminants of concern. (EPA 1995).

Analyte (long)	Medium	Units[1]	CLP PQL[2]	Screening value
Phenanthrene	sediments	µg/kg	330	330
Pyrene	sediments	µg/kg	330	330
Silver	sediments	mg/kg	2	2
Total PCBs	sediments	µg/kg	33	33
Zinc	sediments	mg/kg	4	124

1 µg/kg = microgram per kilogram or parts per billion; mg/kg = milligram per kilogram or parts per million.
2 CLP PQL = Contract Laboratory Program Practical Quantitation Limit.

6.2 Radiological Constituents

6.2.1 Data Analysis

EPA has not developed screening criteria for radiological constituents; therefore, no screening comparisons were done with the radiological results.

Results were statistically compared by pooling the background locations and comparing a single background value to Par Pond and to L Lake. Before the data were analyzed they were reviewed and treated as follows:

1. All data from laboratory blanks, trip blanks, field blanks, and rinsate blanks were removed from the results data file. These data were archived in a quality assurance file. All matrix spike results were removed from the data file.
2. All data qualified with an "R" were removed from the results data file.
3. All data qualified with a "U" were reported at one-half the detection limit (termed a modified result).
4. For each analyte and core segment, all modified results were averaged to get a sample mean value. The number of records used to produce the sample mean was recorded in another field.
5. For each analyte and core segment, results of duplicate and linked original samples results were averaged to get a mean value. The number of records used to calculate each value was recorded.
6. In all other cases, the results were not modified.
7. The analyte data were statistically compared with each other.

General descriptive statistics including the mean, degrees of freedom, standard error, and range were derived using SPSS Release 6.1. Tests of normality included the Lilliefors and Shapiro-Wilks tests. Differences in locations were evaluated using the Kruskal-Wallis one-way nonparametric analysis of variance.

Table 4. Results of a comparison of nonradiological contaminants in Par Pond core segments with EPA Region IV potential contaminants of concern screening values.

Analyte	Sample location[1]	Detection limit (mg/kg)	Analytical result (mg/kg)	Result qualifier code[2]	EPA Region IV Screening Value (mg/kg)
Arsenic	PPSC 0102	15.3	7.67	J	7.24
Arsenic	PPSC 0604	13.4	7.43	J	7.24
Arsenic	PPSC 0704	16.2	7.31	J	7.24
Arsenic	PPSC 0103	15.4	7.7	U	7.24
Arsenic	PPSC 0201	16.6	8.3	U	7.24
Arsenic	PPSC 0202	17.2	8.6	U	7.24
Arsenic	PPSC 0203	15.6	7.8	U	7.24
Arsenic	PPSC 0204	15.5	7.75	U	7.24
Arsenic	PPSC 0205	15.9	7.95	U	7.24
Arsenic	PPSC 0301	17.5	8.75	U	7.24
Arsenic	PPSC 0302	16.1	8.05	U	7.24
Arsenic	PPSC 0303	15.9	7.95	U	7.24
Arsenic	PPSC 0304	16.9	8.45	U	7.24
Arsenic	PPSC 0401	16.3	8.15	U	7.24
Arsenic	PPSC 0402	16.5	8.25	U	7.24
Arsenic	PPSC 0403	16.1	8.05	U	7.24
Arsenic	PPSC 0404	16.5	8.25	U	7.24
Arsenic	PPSC 0501	17.8	8.9	U	7.24
Arsenic	PPSC 0701	17.1	8.55	U	7.24
Arsenic	PPSC 0702	17.0	8.5	U	7.24
Arsenic	PPSC 0703	16.3	8.15	U	7.24
Arsenic	PPSC 0801	20.1	10.05	U	7.24
Arsenic	PPSC 0802	18.2	9.1	U	7.24
Arsenic	PPSC 0901	16.9	8.45	U	7.24
Arsenic	PPSC 0902	16.9	8.45	U	7.24
Arsenic	PPSC 0903	17.3	8.65	U	7.24
Arsenic	PPSC 1001	36.2	18.1	U	7.24
Arsenic	PPSC 1002	25.6	12.8	U	7.24
Arsenic	PPSC 1003	23.6	11.8	U	7.24
Arsenic	PPSC 1004	29.7	14.85	U	7.24
Arsenic	PPSC 1005	20.7	10.35	U	7.24

1 The first two digits identify the sample location; the second two digits identify the core segment.

2 U = a nondetect; J = an estimated quantity.

Table 5. Results of a comparison of nonradiological contaminants in L-Lake core segments with EPA Region IV potential contaminants of concern screening values.

Analyte	Sample location[1]	Detection limit (mg/kg)	Analytical result (mg/kg)	Result qualifier code[2]	EPA Region IV Screening Value (mg/kg)
Arsenic	PPSC 1301	17.1	8.55	U	7.24
Arsenic	PPSC 1302	16.8	8.40	U	7.24
Arsenic	PPSC 1303	17.2	8.60	U	7.24
Arsenic	PPSC 1304	16.5	8.25	U	7.24
Arsenic	PPSC 1401	15.1	7.55	U	7.24
Arsenic	PPSC 1402	16.9	8.45	U	7.24
Arsenic	PPSC 1403	17.0	8.50	U	7.24
Arsenic	PPSC 1501	27.0	13.50	U	7.24
Arsenic	PPSC 1502	21.4	10.70	U	7.24
Arsenic	PPSC 1503	23.6	11.80	U	7.24
Arsenic	PPSC 1504	20.4	10.20	U	7.24
Arsenic	PPSC 1505	19.7	9.85	U	7.24
Arsenic	PPSC 1601	21.5	10.75	U	7.24
Arsenic	PPSC 1602	20.7	10.35	U	7.24
Arsenic	PPSC 1603	17.3	8.65	U	7.24
Arsenic	PPSC 1604	18.0	9.00	U	7.24
Arsenic	PPSC 1605	18.9	9.45	U	7.24
Arsenic	PPSC 1701	16.4	8.20	U	7.24
Arsenic	PPSC 1702	16.2	8.10	U	7.24
Arsenic	PPSC 1703	16.2	8.10	U	7.24
Arsenic	PPSC 1704	16.5	8.25	U	7.24
Arsenic	PPSC 1801	16.7	8.35	U	7.24
Arsenic	PPSC 1802	16.2	8.10	U	7.24
Arsenic	PPSC 1803	16.4	8.20	U	7.24
Arsenic	PPSC 1902	16.5	8.25	U	7.24
Arsenic	PPSC 1903	18.2	9.10	U	7.24
Arsenic	PPSC 1904	17.6	8.80	U	7.24
Arsenic	PPSC 1905	18.8	9.40	U	7.24
Arsenic	PPSC 2001	25.0	12.50	U	7.24
Arsenic	PPSC 2002	18.0	9.00	U	7.24
Arsenic	PPSC 2003	17.1	8.55	U	7.24
Mercury	PPSC 1702	0.0	1.21		0.13

1 The first two digits identify the sample location; the second two digits identify the core segment.

2 U = a nondetect.

Table 6. Results of a comparison of nonradiological contaminants in background location core segments with EPA Region IV potential contaminants of concern screening values.

Location	Analyte	Sample location[1]	Detection limit (mg/kg)	Analytical result (mg/kg)	Result qualifier code[2]	EPA Region IV Screening Value (mg/kg)
Mill Creek	Arsenic	PPSC 2301	31.4	15.7	U	7.24
Mill Creek	Arsenic	PPSC 2302	20.0	10	U	7.24
Mill Creek	Arsenic	PPSC 2303	19.4	9.7	U	7.24
Mill Creek	Arsenic	PPSC 2304	18.2	9.1	U	7.24
Tinker Creek	Arsenic	PPSC 2401	18.3	9.15	U	7.24
Tinker Creek	Arsenic	PPSC 2402	17.0	8.5	U	7.24
Tinker Creek	Arsenic	PPSC 2403	16.3	8.15	U	7.24

1 The first two digits identify the sample location; the second two digits identify the core segment.

2 U = a nondetect.

6.2.2 <u>Comparison of Isotopes in Par Pond and L Lake with Background Locations</u>

A complete list of the analytical results is presented in the Quality Control Summary Report (WSRC 1995).

Many of the analytical results are reported as negative numbers due to the instrument sensitivity and the potential error in the datum point. Negative values were not truncated to 0.0 to keep the statistical analysis results from being biased high. All background results were pooled, and an average background concentration was used for the comparisons.

6.2.2.1 Par Pond

Par Pond samples had significantly greater concentrations of cesium-137, promethium-146, plutonium-238, and zirconium-95 than the background locations (Table 7).

6.2.2.2 L Lake

L-Lake samples had significantly greater concentrations of cobalt-60, cesium-137, plutonium-238, plutonium-239/240, and strontium-90 than the background locations (Table 8).

6.2.3 <u>Comparison of Specific Isotope Activity</u>

General descriptive statistics, including tests of normality, were performed on all the radioisotopes detected at least once during sample analysis (Tables 9-15). All locations and core segments were included in this analysis.

Table 7. Results of Kruskall-Wallis nonparametric test of concentrations of radioisotopes in Par Pond compared to all background locations.

Isotope	P value	Significant at P<0.05
Actinium-228	0.1616	
Antimony-124	0.0424	Y[1]
Antimony-125	0.4571	
Barium-133	0.9767	
Cerium-144	0.7986	
Cesium-134	0.6938	
Cesium-137	0.0049	Y
Cobalt-57	0.2020	
Cobalt-58	0.2494	
Cobalt-60	0.1137	
Europium-152	0.4397	
Europium-154	0.3977	
Europium-155	0.2518	
Gross alpha	0.5512	
Lead-212	0.2020	
Maganese-54	0.2839	
Neptunium-239	0.0615	
Nonvolatile beta	0.4238	
Plutonium-239/240	0.4128	
Plutonium-238	0.0042	Y
Potassium-40	0.1258	
Promethium-144	0.8099	
Promethium-146	0.0028	Y
Ruthenium-106	0.7930	
Sodium-22	0.1728	
Strontium-90	0.7694	
Thorium-234	0.3777	
Tin-113	0.1616	
Yttrium-88	0.3396	
Zinc-65	0.9014	
Zirconium-95	0.0301	Y

1 This was not considered significant because the mean was a negative value and, therefore, considered a background concentration.

Table 8. Results of Kruskall-Wallis nonparametric test of concentrations of radioisotopes in L Lake compared to all background locations.

Isotope	P value	Significant at P<0.05
Actinium-228	0.7552	
Antimony-124	0.5793	
Antimony-125	0.3770	
Barium-133	0.3770	
Cerium-144	0.9862	
Cesium-134	0.8898	
Cesium-137	0.0000	Y
Cobalt-57	0.2565	
Cobalt-58	0.6649	
Cobalt-60	0.0006	Y
Europium-152	0.9724	
Europium-154	0.8693	
Europium-155	0.5201	
Gross alpha	0.8931	
Lead-212	0.6776	
Maganese-54	0.8151	
Neptunium-239	0.0683	
Nonvolatile beta	0.8159	
Plutonium-239/240	0.0002	Y
Plutonium-238	0.0018	Y
Potassium-40	0.5215	
Promethium-144	0.4563	
Promethium-146	0.2589	
Ruthenium-106	0.0802	
Sodium-22	0.3631	
Strontium-90	0.0222	Y
Thorium-234	0.5443	
Tin-113	0.02271	Y[1]
Yttrium-88	0.6649	
Zinc-65	0.4407	
Zirconium-95	0.7460	

[1] This was not considered significant because the mean was a negative value and, therefore, considered a background concentration.

Table 9. General descriptive statistics for radioactive constituents (pCi/g) in Par Pond sediment cores.

Isotope	N	Mean	Median	Standard error	Minimum	Maximum
Actinium-228	42	1.2048	1.145	0.0635	0.514	2.21
Antimony-124	42	-0.0014	-0.0015	0.0007	-0.0129	0.0102
Antimony-125	42	0.0037	0.0056	0.0021	-0.045	0.041
Barium-133	42	-0.0075	-0.0002	0.0062	-0.217	0.09
Cerium-144	42	-0.0101	-0.0144	0.0049	-0.095	0.0826
Cesium-134	42	-0.008	-0.0003	0.0036	-0.101	0.01
Cesium-137	42	0.9841	0.0292	0.3619	-0.0207	11.5
Cobalt-57	42	0.0006	0.0005	0.0005	0.005	0.0096
Cobalt-58	42	-0.0025	-0.0024	0.0006	-0.0118	0.005
Cobalt-60	42	0.006	0.0006	0.0024	-0.0058	0.0741
Europium-152	42	0.0047	-0.0068	0.0099	-0.0265	0.4
Europium-154	42	-0.0099	-0.0087	0.0043	-0.0679	0.0558
Europium-155	42	0.0192	0	0.0091	0	0.33
Gross alpha	42	19.4563	18.25	1.2079	6.15	41.25
Lead-212	42	1.2487	1.215	0.0645	0.5275	2.34
Manganese-54	42	0.0204	0.0217	0.0015	-0.005	0.0383
Neptunium-239	42	0.0715	0.0054	0.0528	-0.0567	2.2
Nonvolatile beta	40	10.1132	9.575	0.6434	2.95	21.7
Plutonium-238	44	0.0202	0.0063	0.0091	-0.0043	0.39
Plutonium-239/240	44	0.0104	0.0008	0.0042	-0.005	0.119
Potassium-40	42	0.8467	0.7765	0.0631	0.165	1.77
Promethium-144	42	0.0009	-0.0002	0.0006	-0.0048	0.015
Promethium-146	42	0.0067	0.0061	0.001	-0.005	0.0307
Ruthenium-106	42	0.0001	-0.0015	0.005	-0.0705	0.0864
Sodium-22	42	0.0002	0.0006	0.0006	-0.01	0.0132
Strontium-90	43	0.1759	0.0319	0.0676	-0.274	1.52
Thorium-234	42	1.3172	1.125	0.1042	0.495	3.9
Tin-113	42	-0.0011	-0.0033	0.002	-0.0187	0.07
Yttrium-88	42	0.0034	0.0029	0.0006	-0.0044	0.015
Zinc-65	42	-0.0013	0.0015	0.002	-0.0446	0.0215
Zirconium-95	42	0.0146	0.0092	0.0029	-0.015	0.0698

Table 10. General descriptive statistics for radioactive constituents (pCi/g) in Pond C sediment cores.

Isotope	N	Mean	Median	Standard error	Minimum	Maximum
Actinium-228	7	1.4293	1.56	0.213	0.741	2.07
Antimony-124	7	-0.0009	0.0033	0.0031	-0.016	0.01
Antimony-125	7	0.0079	-0.0055	0.0179	-0.005	0.1038
Barium-133	7	0.0406	0.0032	0.0383	-0.0028	0.27
Cerium-144	7	0.015	-0.0118	0.0267	-0.0371	0.16
Cesium-134	7	0.0251	-0.0021	0.0275	-0.009	0.19
Cesium-137	7	6.8981	1.28	3.8926	0.0344	23.7
Cobalt-57	7	-0.0036	-0.0019	0.002	-0.0113	0.0018
Cobalt-58	7	-0.002	-0.0019	0.003	-0.015	0.0078
Cobalt-60	7	0.1271	0.0078	0.0706	-0.0025	0.4315
Europium-152	7	0.0714	0.0073	0.068	-0.055	0.47
Europium-154	7	-0.0755	-0.03	0.0341	-0.233	-0.0103
Europium-155	7	0.0037	0	0.0197	-0.095	0.0614
Gross alpha	7	18.8817	21.125	3.0258	7.34	25.9
Lead-212	7	1.5318	1.7	0.2344	0.782	2.33
Manganese-54	7	0.024	0.025	0.0056	0.0044	0.0476
Neptunium-239	7	0.4333	0.0217	0.4447	-0.091	3.1
Nonvolatile beta	6	16.4617	15.23	4.0606	7.04	27.7
Plutonium -239/240	9	0.0268	0.0034	0.019	0	0.171
Plutonium-238	9	0.0924	0.00128	0.0498	0.0027	0.392
Potassium-40	7	1.3628	0.98	0.3789	0.2999	3.09
Promethium-144	7	0.0015	0.0018	0.0023	-0.0074	0.0103
Promethium-146	7	0.0104	0.0074	0.005	0	0.038
Ruthenium-106	7	-0.018	0.0029	0.0255	-0.165	0.0286
Sodium-22	7	0.108	0.0007	0.1113	-0.0025	0.7754
Strontium-90	7	1.2477	1.345	0.2732	0	2.28
Thorium-234	7	1.6366	1.27	0.5006	0.45	3.83
Tin-113	7	0.0018	-0.0012	0.0054	-0.0136	0.0295
Yttrium-88	7	0.0076	0.0052	0.0028	-0.0027	0.0156
Zinc-65	7	0.0321	0.0048	0.0266	-0.0111	0.19
Zirconium-95	7	0.0046	0.0085	0.0088	-0.0389	0.0275

Table 11. General descriptive statistics for radioactive constituents (pCi/g) in L-Lake sediment cores.

Isotope	N	Mean	Median	Standard error	Minimum	Maximum
Actinium-228	34	1.1016	0.993	0.1324	0.262	3.58
Antimony-124	34	0.0008	0.0002	0.0008	-0.0116	0.0194
Antimony-125	34	0.0057	0.0025	0.0023	-0.0243	0.0464
Barium-133	34	-0.0023	0.0005	0.0038	-0.112	0.035
Cerium-144	34	-0.0038	-0.0061	0.0045	-0.0531	0.101
Cesium-134	34	-0.0021	0	0.0021	-0.0631	0.0143
Cesium-137	34	8.6949	0.0687	3.9186	0	103
Cobalt-57	34	0.002	0.0009	0.0012	-0.0051	0.0351
Cobalt-58	34	-0.0011	-0.0008	0.0005	-0.0098	0.0038
Cobalt-60	34	0.12	0.0017	0.0439	-0.0028	0.877
Europium-152	34	-0.0094	-0.0078	0.0026	-0.0516	0.026
Europium-154	34	-0.0003	-0.003	0.0048	-0.0537	0.0734
Europium-155	34	0.0051	0	0.0027	0	0.0744
Gross alpha	36	22.4261	15.45	3.5366	5.27	100
Lead-212	34	1.1411	1.045	0.1371	0.278	3.7
Manganese-54	34	0.0187	0.0146	0.0025	-0.0002	0.0608
Neptunium-239	34	0.016	0.0049	0.0062	-0.0661	0.0882
Nonvolatile beta	36	16.5206	9.975	3.6916	2.57	83.7
Plutonium-238	33	0.0872	0.0097	0.0415	-0.0117	1.21
Plutonium-239/240	32	0.0279	0.0051	0.0103	0	0.3
Potassium-40	34	1.5159	0.8085	0.2811	0.278	8.41
Promethium-144	34	-0.0001	-0.0003	0.0004	-0.0051	0.0039
Promethium-146	34	0.0043	0.0036	0.0012	-0.0189	0.0204
Ruthenium-106	34	0.0123	0.0057	0.0045	-0.0321	0.0847
Sodium-22	34	0.0003	-0.0002	0.0009	-0.0122	0.018
Strontium-90	34	0.7536	0.27	0.1387	-0.353	2.18
Thorium-234	34	1.2823	1.11	0.1007	0.598	2.79
Tin-113	34	-0.004	-0.003	0.0015	-0.0293	0.0261
Yttrium-88	34	0.0021	0.0014	0.0005	-0.0019	0.0086
Zinc-65	34	0.0018	0.0007	0.0017	-0.019	0.0286
Zirconium-95	34	0.0052	0.0005	0.0016	-0.0124	0.0338

Table 12. General descriptive statistics for radioactive constituents (pCi/g) in Meyer's Branch sediment cores.

Isotope	N	Mean	Median	Standard error	Minimum	Maximum
Actinium-228	8	0.7914	0.735	0.1326	0.39	1.5
Antimony-124	8	-0.0006	-0.0001	0.0009	-0.0035	0.0035
Antimony-125	8	0.0004	-0.0008	0.0016	-0.0049	0.008
Barium-133	8	-0.0024	-0.0003	0.002	-0.0159	0.0018
Cerium-144	8	-0.0073	-0.0048	0.0062	-0.0449	0.0112
Cesium-134	8	-0.0025	-0.0008	0.0023	-0.0182	0.0023
Cesium-137	8	0.0106	0.006	0.0049	-0.0012	0.0404
Cobalt-57	8	-0.0006	-0.0009	0.0004	-0.002	0.0014
Cobalt-58	8	-0.0001	-0.0011	0.0013	-0.0038	0.0081
Cobalt-60	8	0.0006	-0.0004	0.0007	-0.0014	0.0043
Europium-152	8	-0.0052	-0.0058	0.0005	-0.0068	-0.0026
Europium-154	8	0.0025	0.0049	0.0058	-0.0267	0.0278
Europium-155	8	0.0034	0	0.0023	0	0.0159
Gross alpha	7	14.4614	11.4	3.3761	5.4	28.7
Lead-212	8	0.8303	0.764	0.1459	0.365	1.6
Manganese-54	8	0.0112	0.0086	0.0033	0	0.0312
Neptunium-239	8	-0.0029	-0.0085	0.0037	-0.0118	0.0153
Nonvolatile beta	7	7.6343	6.51	1.6436	3.25	15.7
Plutonium-238	8	0.0006	-0.0008	0.0015	-0.0044	0.0066
Plutonium-239/240	7	0.0009	0.0007	0.0005	-0.0013	0.0022
Potassium-40	8	0.9366	0.786	0.2795	0.136	2.34
Promethium-144	8	-0.0007	-0.0005	0.0009	-0.0042	0.004
Promethium-146	8	0.0025	0.0016	0.0009	0	0.007
Ruthenium-106	8	-0.0054	-0.0099	0.0058	-0.0221	0.0296
Sodium-22	8	-0.0008	-0.0015	0.0006	-0.0026	0.002
Strontium-90	7	0.6354	nd	nd	-0.225	2.54
Thorium-234	8	0.9224	0.6855	0.1914	0.312	1.86
Tin-113	8	0.0003	0.0004	0.0008	-0.0029	0.0038
Yttrium-88	8	0.0025	0.0022	0.0009	-0.0006	0.0066
Zinc-65	8	-0.0014	-0.0039	0.0032	-0.3124	0.0158
Zirconium-95	8	0.0051	0.0024	0.0022	-0.0007	0.015

Table 13. General descriptive statistics for radioactive constituents (pCi/g) in Mill Creek sediment cores.

Isotope	N	Mean	Median	Standard error	Minimum	Maximum
Actinium-228	5	3.304	1.53	1.5851	0.62	9.22
Antimony-124	5	0.0017	0.0026	0.001	-0.0022	0.0036
Antimony-125	5	0.0032	-0.0003	0.0037	-0.0035	0.0152
Barium-133	5	-0.0054	0.0014	0.009	-0.0407	0.0095
Cerium-144	5	-0.0318	-0.0165	0.0196	-0.107	0.0002
Cesium-134	5	0.0009	-0.0017	0.0033	-0.0043	0.014
Cesium-137	5	0.0252	0.0068	0.0195	-0.002	0.102
Cobalt-57	5	0.0011	0	0.0021	-0.0025	0.0092
Cobalt-58	5	-0.0043	-0.0037	0.0029	-0.0144	0.0019
Cobalt-60	5	-0.0017	-0.0024	0.0008	-0.0037	0.0006
Europium-152	5	-0.0231	-0.0077	0.0178	-0.0935	0.0033
Europium-154	5	-0.0083	0.0078	0.0145	-0.0598	0.021
Gross alpha	5	41.42	24.3	14.6086	10.8	89.5
Lead-212	5	3.5492	1.62	1.7268	0.596	10
Manganese-54	5	0.0538	0.0243	0.0258	0.0086	0.149
Neptunium-239	5	-0.0004	0	0.0075	-0.0162	0.0268
Nonvolatile beta	5	21.39	10.8	7.938	7.04	46.1
Plutonium-238	6	0.0043	0	0.0055	-0.0109	0.0278
Plutonium-239/240	5	0.0074	0	0.0074	-0.0021	0.0369
Potassium-40	5	1.1866	0.679	0.5758	0	3.29
Promethium-144	5	0.0017	0.0033	0.0016	-0.0034	0.005
Promethium-146	5	0.0037	0.0045	0.0016	0	0.0078
Ruthenium-106	5	0.0004	0.0117	0.0161	-0.0514	0.0365
Sodium-22	5	0	0.0012	0.0022	-0.008	0.0049
Strontium-90	5	-0.0573	-0.0193	0.0584	-0.21	0.0744
Thorium-234	5	1.9646	1.66	0.5626	0.743	3.82
Tin-113	5	-0.004	0.0003	0.0049	-0.0231	0.0031
Yttrium-88	5	0.0061	0.0043	0.0034	-0.0014	0.0166
Zinc-65	5	0.0014	0	0.0044	-0.0073	0.0173
Zirconium-95	5	0.0018	0	0.0018	0	0.0089

Table 14. General descriptive statistics for radioactive concentrations (pCi/g) in Tinker Creek sediment cores.

Isotope	N	Mean	Median	Standard error	Minimum	Maximum
Actinium-228	4	1.5703	0.9055	0.8602	0.35	4.12
Antimony-124	4	0.0022	0.0018	0.0013	-0.0003	0.0055
Antimony-125	4	0.007	0.0039	0.0045	0.0005	0.0197
Barium-133	4	0.0014	0.0017	0.002	-0.0032	0.0055
Cerium-144	4	-0.0045	-0.0065	0.0067	-0.0186	0.0136
Cesium-134	4	0.0019	0.0019	0.0004	0.0011	0.003
Cesium-137	4	0.0016	0.0013	0.0032	-0.0055	0.0093
Cobalt-57	4	0.0007	0.0008	0.0003	0	0.0015
Cobalt-58	4	-0.0026	-0.0013	0.0018	-0.0078	-0.0001
Cobalt-60	4	0	0.0005	0.0008	-0.0029	0.0013
Europium-152	4	-0.0196	-0.0181	0.005	-0.0332	-0.0091
Europium-154	4	0.0007	-0.008	0.012	-0.0162	0.0349
Gross alpha	4	40.88	8.525	34.4653	2.47	144
Lead-212	4	1.6993	0.955	0.958	0.347	4.54
Manganese-54	4	0.0281	0.0175	0.0128	0.0111	0.0662
Neptunium-239	4	0.0494	0.0002	0.0505	-0.0037	0.201
Nonvolatile beta	4	20.8	8.945	14.2551	2.61	62.7
Plutonium-238	4	0.0046	0.007	0.0059	-0.011	0.0153
Plutonium-239/240	4	0.0007	0.001	0.0004	-0.0006	0.0013
Potassium-40	4	2.8185	2.3815	1.4243	0.191	6.32
Promethium-144	4	0.0003	0.0002	0.0009	-0.0018	0.0027
Promethium-146	4	0.0024	0.0021	0.0011	0	0.0053
Ruthenium-106	4	-0.0041	0	0.0047	-0.0182	0.0017
Sodium-22	4	-0.002	-0.0014	0.0013	-0.0056	0.0003
Strontium-90	4	0.0614	0.0403	0.099	-0.129	0.294
Thorium-234	4	1.2803	1.405	0.4137	0.181	2.13
Tin-113	4	-0.0059	-0.0038	0.0035	-0.0156	-0.0002
Yttrium-88	4	0.0009	0.0003	0.0011	-0.0009	0.0037
Zinc-65	4	0.0004	-0.0008	0.0057	-0.012	0.0153
Zirconium-95	4	0.0007	0.0005	0.0004	0	0.0017

Table 15. General descriptive statistics for radioactive constituents (pCi/g) in Lake Marion sediment cores.

Isotope	N	Mean	Median	Standard error	Minimum	Maximum
Actinium-228	4	0.9993	0.9405	0.2318	0.596	1.52
Antimony-124	4	0.0005	0.0001	0.0008	-0.0009	0.0026
Antimony-125	4	0.0024	0.0011	0.0035	-0.0046	0.0121
Barium-133	4	-0.0005	-0.0004	0.0002	-0.0011	-0.0001
Cerium-144	4	0.0015	0.0002	0.0019	-0.0014	0.007
Cesium-134	4	0.0008	0	0.001	-0.0005	0.0038
Cesium-137	4	0.0026	0.0006	0.0034	-0.0028	0.0119
Cobalt-57	4	-0.0003	-0.0005	0.0005	-0.0011	0.001
Cobalt-58	4	-0.0002	-0.0002	0.0016	-0.0042	0.0038
Cobalt-60	4	-0.0008	-0.0012	0.0011	-0.0029	0.002
Europium-152	4	-0.0048	-0.0027	0.0057	-0.0205	0.0065
Europium-154	4	-0.0259	-0.0171	0.0138	-0.0658	-0.0035
Gross alpha	4	20.85	17.3	4.7654	14	34.8
Lead-212	4	1.071	0.9935	0.253	0.627	1.67
Manganese-54	4	0.019	0.0181	0.0039	0.0106	0.029
Neptunium-239	4	-0.0072	-0.0041	0.008	-0.029	0.0084
Nonvolatile beta	4	23.225	23.55	2.2092	17.8	28
Plutonium-238	4	-0.0176	-0.0044	0.0167	-0.0672	0.0055
Plutonium-239/240	4	-0.0021	0	0.0037	-0.0127	0.0044
Potassium-40	4	7.4375	7.42	1.7053	3.71	0.0187
Promethium-144	4	0.0021	0.0024	0.0017	-0.0021	0.0056
Promethium-146	4	0.0017	0.0003	0.0016	0	0.0064
Ruthenium-106	4	0.0138	0.0154	0.0089	-0.0071	0.0316
Sodium-22	4	-0.0008	-0.0006	0.0019	-0.0057	0.0036
Strontium-90	4	-0.0921	-0.0852	0.1478	-0.461	0.263
Thorium-234	4	1.0502	0.8815	0.2415	0.688	1.75
Tin-113	4	-0.001	0.0001	0.003	-0.0092	0.0052
Yttrium-88	4	0.0016	0.002	0.0006	-0.0001	0.0025
Zinc-65	4	0.0023	0.0027	0.0023	-0.003	0.0058
Zirconium-95	4	0.0062	0.0063	0.0026	0	0.0121

6.2.3.1 Cesium-137

The mean volume-weighted cesium-137 concentration for all Par Pond cores was 0.98 picoCuries per gram ([pCi/g] range: background to 11.5 pCi/g; Table 9).

The mean volume-weighted cesium-137 concentration for all L-Lake cores was 8.69 pCi/g (range: background to 103 pCi/g; Table 11).

The mean volume-weighted cesium-137 concentration for all background cores was 0.01 pCi/g (range: background to 0.102 pCi/g; Tables 12-15).

6.2.3.2 Plutonium-238

The mean volume-weighted plutonium-238 concentration for all Par Pond cores was 0.02 pCi/g (range: background to 0.39 pCi/g; Table 9).

The mean volume-weighted plutonium-238 concentration for all L-Lake cores was 0.09 pCi/g (range: background to 1.21 pCi/g; Table 11).

The mean volume-weighted plutonium-238 concentration for all background cores was background (Tables 12-15).

6.2.3.3 Plutonium-239/240

The mean volume-weighted plutonium-239/240 concentration for all L-Lake cores was 0.03 pCi/g (range: background to 0.3 pCi/g; Table 11).

The mean volume-weighted plutonium-239/240 concentration for all background cores was background (Tables 12-15).

6.2.3.4 Cobalt-60

The mean volume-weighted cobalt-60 concentration for all L-Lake cores was 0.12 pCi/g (range: background to 0.88 pCi/g; Table 11).

The mean volume-weighted cobalt-60 concentration for all background cores was background (Tables 12-15).

6.2.3.5 Strontium-90

The mean volume-weighted strontium-90 concentration for all L-Lake cores was 0.75 pCi/g (range: background to 2.18 pCi/g; Table 11).

The mean volume-weighted strontium-90 concentration for all background cores was 0.14 pCi/g (range: background to 2.54; Tables 12-15).

6.2.3.6 Zirconium-95

The mean volume-weighted zirconium-95 concentration for all Par Pond cores was 0.015 pCi/g (range: background to 0.07 pCi/g; Table 9).

The mean volume-weighted zirconium-95 concentration for all background cores was background (Tables 12-15).

7.0 Summary

Sediment cores from shallow and deep water locations in Par Pond, Pond C, and L Lake were collected and analyzed in 1995 for radioactive and nonradioactive constituents. This core analysis was conducted to develop a defensible characterization of contaminants found in the sediments of Par Pond, Pond C, and L Lake.

Mercury was the only nonradiological constituent with a nonestimated result that was detected above the EPA Region IV potential contaminants of concern screening criteria. It was detected at a depth of 1.0-2.0 feet at one location in L Lake.

Cesium-137, promethium-146, plutonium-238, and zirconium-95 had significantly higher concentrations in Par Pond sediments than in sediments from the reference sites. Cobalt-60, cesium-137, plutonium-238, plutonium-239/240, and strontium-90 had significantly higher concentrations in L-Lake sediments than sediments from the reference sites.

8.0 References

EPA (U.S. Environmental Protection Agency). 1995. Supplemental Guidance to RAGS: Region IV Bulletins, Ecological Risk Assessment. U.S. Environmental Protection Agency, Region IV Waste Management Division. Atlanta, GA.

Looney, B. B., M. Ramdeen, J. Pickett, V. Rogers, P. A. Shirley, and M. T. Scott. 1989. *Geochemical and Physical Properties of Soils and Shallow Sediments at the Savannah River Plant* [redacted]. Savannah River Laboratory. E.I. du Pont de Nemours and Co., Aiken, SC.

Appendix A

Sample Identification Key for Analytical Results

Sample ID	Location	Sample ID	Location
PPSC-FB-01C	Field Blank	PPSC-SED21-(01-03)	Meyer's Branch
PPSC-FB-02C	Field Blank	PPSC-SED22-(01-04)	Meyer's Branch
PPSC-FB-03C	Field Blank	PPSC-SED23-(01-05)	Mill Creek
PPSC-FB-05C	Field Blank	PPSC-SED24-(01-04)	Tinker Creek
PPSC-SED01-(01-03)	Par Pond	PPSC-SED25-(01-04)	Lake Marion
PPSC-SED02-(01-05)	Par Pond	PPSC-SED26-01A[1]	Lake Marion
PPSC-SED03-(01-04)	Par Pond	PPSC-SED26-02D[1]	Lake Marion
PPSC-SED04-(01-04)[1]	Par Pond	PPSC-SED26-03A[1]	Lake Marion
PPSC-SED05-(01-03)	Par Pond	PPSC-SED27-01D[1]	Par Pond
PPSC-SED06-(01-04)	Par Pond	PPSC-SED27-02A[1]	Par Pond
PPSC-SED07-(01-04)	Par Pond	PPSC-SED27-03D[1]	Par Pond
PPSC-SED08-(01-03)	Par Pond	PPSC-SED27-04A[1]	Par Pond
PPSC-SED09-(01-03)[1]	Par Pond	PPSC-SED28-01A[1]	Pond C
PPSC-SED10-(01-05)	Par Pond	PPSC-SED28-02D[1]	Pond C
PPSC-SED11-(01-03)	Pond C	PPSC-SED28-03A[1]	Pond C
PPSC-SED12-(01-03)[1]	Pond C	PPSC-TB-(01B-09B)	Trip Blank
PPSC-SED13-(01-04)	L Lake	PPSC-TB-(15B-16B)	Trip Blank
PPSC-SED14-(01-03)	L Lake	PPSC-TB-(15B-16B)	Trip Blank
PPSC-SED15-(01-05)	L Lake		
PPSC-SED16-(01-05)	L Lake		
PPSC-SED17-(01-04)	L Lake		
PPSC-SED18-(01-03)	L Lake		
PPSC-SED19-(01-05)	L Lake		
PPSC-SED20-(01-03)	L Lake		

1 Four cores were taken at these locations to include duplicates and splits.

Appendix B

Analyte List

Location	Sample ID	Core segment	Sample locations	Analyte code[1]
Par Pond	PPSC-SED01	01	Intake Arm	1,2,3
	PPSC-SED01	02	Intake Arm	1,2,3
	PPSC-SED01	03	Intake Arm	1,2,3
	PPSC-SED01	04	Intake Arm	1,2,3
	PPSC-SED01	05	Intake Arm	1,2,3
	PPSC-SED02	01	Intake Arm	0,1,2
	PPSC-SED02	02	Intake Arm	0,1,2
	PPSC-SED02	03	Intake Arm	0,1,2
	PPSC-SED02	04	Intake Arm	0,1,2
	PPSC-SED02	05	Intake Arm	0,1,2
	PPSC-SED03	01	Cold Dam	0,1,2
	PPSC-SED03	02	Cold Dam	0,1,2
	PPSC-SED03	03	Cold Dam	0,1,2
	PPSC-SED03	04	Cold Dam	0,1,2
	PPSC-SED03	05	Cold Dam	0,1,2
	PPSC-SED04	01	Cold Dam	1,2,3
	PPSC-SED04	02	Cold Dam	1,2,3
	PPSC-SED04	03	Cold Dam	1,2,3
	PPSC-SED04	04	Cold Dam	1,2,3
	PPSC-SED04	05	Cold Dam	1,2,3
	PPSC-SED05	01	Cold Dam	0,1,2
	PPSC-SED05	02	Cold Dam	0,1,2
	PPSC-SED05	03	Cold Dam	0,1,2
	PPSC-SED05	04	Cold Dam	0,1,2
	PPSC-SED05	05	Cold Dam	0,1,2
	PPSC-SED06	01	Cold Dam	0,1,2
	PPSC-SED06	02	Cold Dam	0,1,2
	PPSC-SED06	03	Cold Dam	0,1,2
	PPSC-SED06	04	Cold Dam	0,1,2
	PPSC-SED06	05	Cold Dam	0,1,2
	PPSC-SED07	01	Cold Dam	0,1,2
	PPSC-SED07	02	Cold Dam	0,1,2
	PPSC-SED07	03	Cold Dam	0,1,2
	PPSC-SED07	04	Cold Dam	0,1,2
	PPSC-SED07	05	Cold Dam	0,1,2
	PPSC-SED08	01	Hot Dam	0,1,2
	PPSC-SED08	02	Hot Dam	0,1,2
	PPSC-SED08	03	Hot Dam	0,1,2
	PPSC-SED08	04	Hot Dam	0,1,2
	PPSC-SED08	05	Hot Dam	0,1,2
	PPSC-SED09	01	Hot Dam	1,2,3

[1] Analyte codes are:

- 0 - Target Analyte List metals.
- 1 - Specified analytes (nitrate/nitrite, total organic carbons, organic nitrogen, orthophosphate, total phosphate, chloride, particle size distribution, sulfide, cation exchange capacity).
- 2 - Radionuclides (gross alpha, nonvolatile beta, gamma pulse height analysis, strontium-90, plutonium series).
- 3 - Target Compound List with tentatively identified compounds.

Analyte List (continued)

Location	Sample ID	Core segment	Sample locations	Analyte code[1]
Par Pond (continued)	PPSC-SED09	02	Hot Dam	1,2,3
	PPSC-SED09	03	Hot Dam	1,2,3
	PPSC-SED09	04	Hot Dam	1,2,3
	PPSC-SED09	05	Hot Dam	1,2,3
	PPSC-SED10	01	North Arm	0,1,2
	PPSC-SED10	02	North Arm	0,1,2
	PPSC-SED10	03	North Arm	0,1,2
	PPSC-SED10	04	North Arm	0,1,2
	PPSC-SED10	05	North Arm	0,1,2
	PPSC-SED11	01	North Arm	1,2,3
	PPSC-SED11	02	North Arm	1,2,3
	PPSC-SED11	03	North Arm	1,2,3
	PPSC-SED11	04	North Arm	1,2,3
	PPSC-SED11	05	North Arm	1,2,3
	PPSC-SED12	01	North Arm	1,2,3
	PPSC-SED12	02	North Arm	1,2,3
	PPSC-SED12	03	North Arm	1,2,3
	PPSC-SED12	04	North Arm	1,2,3
	PPSC-SED12	05	North Arm	1,2,3
	PPSC-SED13	01	North Arm	0,1,2
	PPSC-SED13	02	North Arm	0,1,2
	PPSC-SED13	03	North Arm	0,1,2
	PPSC-SED13	04	North Arm	0,1,2
	PPSC-SED13	05	North Arm	0,1,2
Pond C	PPSC-SED14	01	Pond C	1,2,3
	PPSC-SED14	02	Pond C	1,2,3
	PPSC-SED14	03	Pond C	1,2,3
	PPSC-SED14	04	Pond C	1,2,3
	PPSC-SED14	05	Pond C	1,2,3
	PPSC-SED15	01	Pond C	0,1,2
	PPSC-SED15	02	Pond C	0,1,2
	PPSC-SED15	03	Pond C	0,1,2
	PPSC-SED15	04	Pond C	0,1,2
	PPSC-SED15	05	Pond C	0,1,2
L Lake	PPSC-SED16	01	L Lake	0,1,2
	PPSC-SED16	02	L Lake	0,1,2
	PPSC-SED16	03	L Lake	0,1,2
	PPSC-SED16	04	L Lake	0,1,2
	PPSC-SED16	05	L Lake	0,1,2
	PPSC-SED17	01	L Lake	1,2,3
	PPSC-SED17	02	L Lake	1,2,3
	PPSC-SED17	03	L Lake	1,2,3

[1] Analyte codes are:

0 - Target Analyte List metals.

1 - Specified analytes (nitrate/nitrite, total organic carbons, organic nitrogen, orthophosphate, total phosphate, chloride, particle size distribution, sulfide, cation exchange capacity).

2 - Radionuclides (gross alpha, nonvolatile beta, gamma pulse height analysis, strontium-90, plutonium series).

3 - Target Compound List with tentatively identified compounds.

Analyte List (continued)

Location	Sample ID	Core segment	Sample locations	Analyte code[1]
L Lake (continued)	PPSC-SED17	04	L Lake	1,2,3
	PPSC-SED17	05	L Lake	1,2,3
	PPSC-SED18	01	L Lake	0,1,2
	PPSC-SED18	02	L Lake	0,1,2
	PPSC-SED18	03	L Lake	0,1,2
	PPSC-SED18	04	L Lake	0,1,2
	PPSC-SED18	05	L Lake	0,1,2
	PPSC-SED19	01	L Lake	1,2,3
	PPSC-SED19	02	L Lake	1,2,3
	PPSC-SED19	03	L Lake	1,2,3
	PPSC-SED19	04	L Lake	1,2,3
	PPSC-SED19	05	L Lake	1,2,3
	PPSC-SED20	01	L Lake	0,1,2
	PPSC-SED20	02	L Lake	0,1,2
	PPSC-SED20	03	L Lake	0,1,2
	PPSC-SED20	04	L Lake	0,1,2
	PPSCSED20	05	L Lake	0,1,2
Meyer's Branch	PPSC-SED21	01	Meyer's Branch	1,2,3
	PPSC-SED21	02	Meyer's Branch	1,2,3
	PPSC-SED21	03	Meyer's Branch	1,2,3
	PPSC-SED21	04	Meyer's Branch	1,2,3
	PPSC-SED21	05	Meyer's Branch	1,2,3
	PPSC-SED22	01	Meyer's Branch	1,2,3
	PPSC-SED22	02	Meyer's Branch	1,2,3
	PPSC-SED22	03	Meyer's Branch	1,2,3
	PPSC-SED22	04	Meyer's Branch	1,2,3
	PPSC-SED22	05	Meyer's Branch	1,2,3
Mill Creek	PPSC-SED23	01	Mill Creek	1,2,3
	PPSC-SED23	02	Mill Creek	1,2,3
	PPSC-SED23	03	Mill Creek	1,2,3
	PPSC-SED23	04	Mill Creek	1,2,3
	PPSC-SED23	05	Mill Creek	1,2,3
Tinker Creek	PPSC-SED24	01	Tinker Creek	1,2,3
	PPSC SED24	02	Tinker Creek	1,2,3
	PPSC-SED24	03	Tinker Creek	1,2,3
	PPSC-SED24	04	Tinker Creek	1,2,3
	PPSC- SED24	05	Tinker Creek	1,2,3
Lake Marion	PPSC-SED25	01	Lake Marion	1,2,3
	PPSC-SED25	02	Lake Marion	1,2,3
	PPSC-SED25	03	Lake Marion	1,2,3
	PPSC-SED25	04	Lake Marion	1,2,3
	PPSC-SED25	05	Lake Marion	1,2,3

[1] Analyte codes are:

0 - Target Analyte List metals.

1 - Specified analyses (nitrate/nitrite, total organic carbons, organic nitrogen, orthophosphate, total phosphate, chloride, particle size distribution, sulfide, cation exchange capacity).

2 - Radionuclides (gross alpha, nonvolatile beta, gamma pulse height analysis, strontium-90, plutonium series).

3 - Target Compound List with tentatively identified compounds.