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MARYLAND GEOLOGICAL SURVEY  
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**Centreville Dam Sediments Study  
Queen Anne's County, Maryland**

**Reconnaissance Survey of Sediments  
At Centreville Dam, Corsica River**

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Prepared For  
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## **Acronyms and Abbreviations used in this report**

<i>Abbreviation</i>	<i>Description</i>
LOD	Limit of Detection
MGS	Maryland Geological Survey
NAD83	North America [Horizontal] Datum of 1983
ND	Not Detected
NIST	National Institute of Standards and Technology
RL	Reporting Limit
SBAS	Satellite Based Augmentation System (GPS)
SRM	Standard Reference Material
TCLP	Toxicity Characteristic Leaching Procedure
USGS	United States Geological Survey
UTM	Universal Transverse Mercator (coordinate system)

## EXECUTIVE SUMMARY

In response to a request by American Rivers, Maryland Geological Survey (MGS) was contracted to study the sediments within the Centreville Dam impoundment located in Queen Anne's County in the State of Maryland. The dam is located at the head of Gravel Run immediately to the southeast of the Rt. 213 bridge. The sediments required TCLP analysis to verify that the sediments meet the regulatory thresholds for TCLP metals for disposal at the Queen Anne's County landfill. Cores were collected at six locations to quantify the physical and chemical properties of the sediment, and to test for the presence of leachable metals above regulatory thresholds. The samples tested included sediments from five sites above the dam, a composite sample from these five sites, and a sample from a site below the dam for comparison. The fieldwork for this study occurred in September 2013.

The physical properties of the sediments accumulated behind Centreville Dam were dominated by sandy mud that was unconsolidated near the surface with increased consolidation at depth. The underlying sediments contained increased sand and gravel with episodic laminations indicative of the pre-dam streambed as well as peaty deposits indicative of the pre-dam marsh. The elemental analysis results were within the ranges expected for the sediments in the study area. The total background concentrations of arsenic, chromium and lead were all comparable to those recorded in similar studies with sample sites in Maryland (Vosnakis et al., 2009; Smith et al., 2013).

The TCLP analyses showed non-detectable concentrations of all TCLP metals for all samples tested. Due to non-detection, no differences in leachable metals concentrations were found between the sites above the dam and the site below the dam. The analysis of samples from five sites above the dam exceeds the mandate of four samples from various locations within the deposit. The composite sample tested to measure the average leachable metals from all sample sites above the dam also resulted in non-detection for all TCLP metals.

Based on the TCLP metals analyses of core samples collected for this study, the sediments located behind Centreville Dam do not contain any leachable metals concentrations above the regulatory thresholds. Therefore, the accumulated sediments behind the dam meet the regulatory requirements for placement in the Queen Anne's County landfill.

## INTRODUCTION

### *Background*

Centreville Dam is located on the headwaters of the Corsica River in downtown Centreville in Queen Anne’s County, Maryland. The deposits behind the dam vary in depth from ten feet to half of a foot over a spatial area approximated by sixty feet wide and two hundred fifty feet long. The estimated volume of sediment is 2200 cubic yards consisting of mostly silty clay and fine sand (Boardman, personal communication, 2013). The Queen Anne’s County landfill operated by R.Baker is authorized to accept this material upon passing regulatory thresholds for TCLP metals. A minimum of four samples taken from various locations in the material is required.

### *Previous Sediment Studies*

Sediments were collected and analyzed by J.D. Hynes in June 2012 (Table 1). The analysis performed by J.D. Hynes is not in accordance with the methodologies stated in the MDE regulatory guidance for routine landfill placement. J.D. Hynes analyzed the samples using a very strong acid (nitric acid; hydrogen peroxide; hydrochloric acid) digestion technique (EPA 3050B) rather than a very weak acid (acetic acid) leachate method (EPA 1311 and others) which is stipulated by regulations and required by the Queen Anne County landfill. The TCLP methods, in general, provide the concentration of elements which can generally be removed from the sediments due to natural conditions and filter through the landfill, and therefore is used for the determination of elemental regulatory guidance. The 3050B methods determine a near-total elemental makeup of the sediment using very strong and multiple acid digestions which is typically not seen in the environment except under extreme conditions.

**Table 1. Analysis results from J.D.Hynes in June 2012.**

Element	Regulatory Threshold TCLP (mg/L)	B1S6 mg/kg (ppm)	B2S1 mg/kg (ppm)	B3S1 mg/kg (ppm)	B4S1 mg/kg (ppm)	B5S1 mg/kg (ppm)
Arsenic	5	3.7	6.7	7	8.7	13
Barium	100	N. A.				
Cadmium	1	N. D.				
Chromium	5	22	25	51	36	47
Lead	5	N. D.	85	65	56	63
Mercury	0.2	N. D.	0.2	0.19	N. D.	N. D.
Selenium	1	N. D.				
Silver	5	N. D.				

Per MDE regulatory guidance and per the manager, Jon Baker, of the county landfill, the tested sediments would not have been allowed to be placed in the county landfill. This forces the sediments to be placed in a more constrained hazardous material placement site at a far greater

expense to the Town of Centreville.

It was anticipated that the TCLP analysis of the metals would detect levels below regulatory threshold levels allowing the Centreville Dam legacy sediments to be placed in the county landfill. Should the levels have remained above threshold concentrations, further collection and testing of the sediments would be needed, and the placement of the material would need to occur in a confined facility.

## **STUDY OBJECTIVES**

The objective of this study was to document the impounded sediments behind Centreville Dam and to conduct TCLP Metals analysis to assist in disposal of the sediment to include:

1. Collect 6 cores using vibracoring, push coring, and soil auger techniques (5 above the dam and 1 below the dam). A maximum penetration of 3 meters will be achieved using these techniques. Cores will show stratigraphy of the deposit and will provide *in-situ* sampling of sediments at depth for analysis.
2. Split, document, photograph, and sub-sample collected cores.
3. Analyze a sub-set of the sediments for physical properties (bulk density, water content, grain size) based on strata changes within the cores.
4. Process selected physical property samples for total elemental analysis (49 elements).
5. Analyze cores for TCLP Metals using homogenized channel samples from the identified sediment deposits within the collected core. The cores will be analyzed individually and also as a homogenized sample for all sites above the dam.

## **METHODS**

### ***Sediment Coring***

MGS collected six sediment cores for this study. Five cores were selected to document the sediment which is currently captured behind Centreville Dam. This exceeds the minimum requirements of four samples locations required by the Queen Anne's County Landfill. Core #2 was collected downstream of the dam as a control core in order to document if the dam was preventing any contaminated soils from moving downstream in the event any contaminated soils were detected above the dam (Figure 1).



**Figure 1.** Map of the sediment cores locations.

Sediment cores above the dam were collected in aluminum liners attached to a vibracore head supplemented with 113 kilograms [250 pounds] of added weight. The vibration speed was varied to obtain the greatest penetration. Cores were driven to refusal then capped, labeled, and retrieved. Horizontal control was provided through a Thales Navigation ProMark 3 GPS supplemented with satellite-based augmentation system (SBAS) differential corrections providing a real-time horizontal accuracy of 2-5 meters [6-15 feet]. Horizontal positions were recorded in the Universal Transverse Mercator (UTM) system based upon the North American Datum of 1983 (NAD83). Core locations and penetration depths are listed in Table 2.

**Table 2.** Collected core locations and depths.

<b>Core</b>	<b>Northing</b> (UTM-Meters)	<b>Easting</b> (UTM-Meters)	<b>Penetration</b> (Meters)	<b>Comment</b>
1	4322639	408107	2.48	Just above dam
2	4322679	408067	0.72	Below dam and bridge
3	4322628	408122	2.22	
4	4322618	408130	2.29	
5	4322617	408143	2.85	
6	4322607	408153	3.67	Farthest upstream

Core #2 was collected in a CAB liner which was driven to refusal using a 5 pound hammer. A BENTHOS valve was then attached to the top of the core tube to maintain suction during removal. The core was then capped, labeled, and retrieved. The core location was located

below the Rt. 213 bridge in order to reach an area where sediment had accumulated below the rip-rap and concrete immediately downstream of the dam.

### *Laboratory Analyses*

#### Core Processing

Upon collection, cores were stored in a sample refrigerator at four degrees centigrade until they were split. Cores were split and sediment was sampled within 48 hours of collection. Cores in aluminum liners were opened using a circular saw, the blade of which was set to cut the core liner only. Each coreliner was cut lengthwise on the front and back. Core #2 was extruded from the core liner. Using stainless steel spatulas, the core was carefully split to minimize any disturbance of sediment structure, dividing the sediment between the coreliner halves. Immediately upon splitting the core, the core was described, photographed, and sampled for analysis. The core description logs are included in Appendix A.

Samples to be tested for TCLP metals were collected from each core by taking a channel sample from the upper portion of the core to include all post dam sediments. A second channel sample from the same core portions was collected from the five cores collected above the dam and homogenized as a composite sample representative of all post dam sediments behind the dam. These samples were placed in sealed glass jars with Teflon lids, stored in ice, and transported to Phase Separation Science laboratories on the same day.

A second set of samples were taken from each core at specific intervals based on lithologic changes in sediments. These samples were analyzed for textural and elemental components.

#### TCLP Analysis

TCLP samples of unprepared sediment were taken to Phase Separation Science laboratories in Catonsville, MD to be analyzed for a suite of pollutant metals. The pollutant suite is identified below along with the EPA method utilized for the analysis.

**Table 3.** TCLP metals analyzed and reported in this study. Preparation and analytical methods for each metal are identified.

TCLP Metal	Preparation Method	Analytical Method
Arsenic	EPA 3010A	EPA SW-846 / 6020A
Barium	EPA 3010A	EPA SW-846 / 6020A
Cadmium	EPA 3010A	EPA SW-846 / 6020A
Chromium	EPA 3010A	EPA SW-846 / 6020A
Lead	EPA 3010A	EPA SW-846 / 6020A
Mercury	EPA 3010A	EPA SW-846 / 6020A
Selenium	EPA 3010A	EPA SW-846 / 6020A
Silver	EPA 3010A	EPA SW-846 / 6020A

Reported TCLP results, units, reporting limits, and regulatory threshold limit are summarized in Table 6. The laboratory certificate of analysis, chain of custody, and quality assurance documentation is included in Appendix B.

### Textural Analyses

Twenty sediment samples were analyzed for water content, bulk density, and grain size (sand, silt, clay contents, as well as gravel, when present). Two homogeneous splits of each sample are processed, one for bulk property analyses and the other for grain-size characterization. Analyses were performed as soon as possible after sample collection, and all samples were refrigerated in sealed Whirl-Pak™ plastic bags prior to analysis.

Water content was calculated as the percentage of water weight to the weight of the wet sediment using Equation 1.

$$\%Water = \frac{W_w}{W_t} * 100 \quad \text{Equation 1}$$

where:  $W_w$  is the weight of water; and  
 $W_t$  is the weight of wet sediment.

Water content was determined by weighing 20-30 g of sediment; the sediment was dried at 65°C, and then re-weighing the dried sediment. Dried sediments were saved for elemental analyses (see **Elemental Analyses** section).

Bulk density ( $\rho_B$ ) is calculated from water content utilizing Equation 2 by assuming an average grain density ( $\rho_s$ ) of 2.72 g/cm<sup>3</sup> and saturation of voids with water of density  $\rho_w = 1.0$  g/cm<sup>3</sup>. This method was adopted from the work of Bennett and Lambert (1971):

$$\rho_B = \frac{W_t}{W_d / 2.72 + W_w} \quad \text{Equation 2}$$

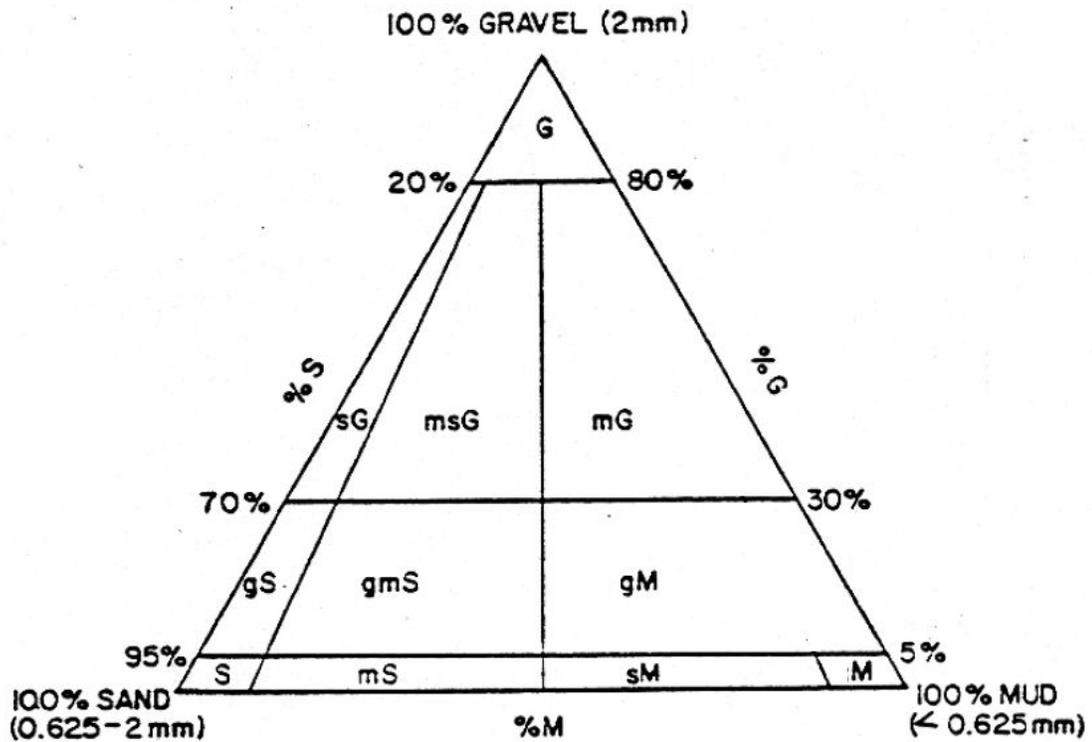
where  $W_d$  is the weight of dry sediment.

Sand, silt and clay contents were determined using the textural analysis detailed in Kerhin and others, (1988). Grain size analysis consists of cleaning the samples in solutions of 10 percent hydrochloric acid and 6 or 15 percent hydrogen peroxide (determined by water content) with subsequent rinsing with deionized water. This process removed soluble salts, carbonates, and organic matter that could interfere with the disaggregation of the individual grains. The samples are then treated with a 0.26 percent solution of the dispersant sodium

hexametaphosphate ((NaPO<sub>3</sub>)<sub>6</sub>) to ensure that individual grains did not re-aggregate during analysis.

The separation of the gravel-sand (coarse) fraction and the silty-clay or mud (fine) fraction of the sample was accomplished by wet-sieving through a 4-phi mesh sieve (0.0625 mm, U.S. Standard Sieve #230). The coarse fraction was dried, weighed, and dry-sieved through 2mm mesh sieve (U.S. Standard Sieve #10), separating gravel and sand-sized particles.

The finer silt and clay-sized particles are suspended in a 1000 ml cylinder in a solution of 0.26 percent sodium hexametaphosphate. The suspension is agitated and, at specified times thereafter; 20 ml pipette withdrawals are made (Carver, 1971; Folk, 1974). The rationale behind this process is that larger particles settle faster than smaller ones (Stoke's Law). By calculating the settling velocities for different sized particles, times for withdrawal can be determined at which all particles of a specified size will have settled past the point of withdrawal. Sampling times are calculated to permit the determination of the amount of silt (4 phi) and clay sized (8 phi) particles in the suspension. Withdrawn samples are dried at 65°C and weighed. From these data the percentages by dry weight of gravel, sand, and mud (silt and clay) are calculated for each sample and classified according to Folk's nomenclature (Figure 2).



**Figure 2.** Folk classification of sediment types

Although the techniques used to determine grain size are based on traditional analytical methods developed for the sedimentology lab, some analytical error is inherent to the techniques. For example, results can be affected by level of technician skill and/or changes in laboratory conditions (such as sudden temperature changes). Furthermore, there is no standard reference material available that includes the broad range of particle sizes and shapes contained in natural

sediment. To maximize consistency of textural analysis, several “checks” are used to monitor results. The calculated sand, silt, clay and gravel (when present) percentages are checked against 1) sample field descriptions; 2) calculated water contents; and 3) calculated weight loss of sample during processing. These comparisons are made to determine if the size components match the visual description of the sample and/or fall within an expected classification with respect to water content and weight loss. Any discrepancy is “flagged” and the results are reviewed further to determine if re-analysis is warranted.

### Elemental Analyses

Splits of ten dried sediment samples were shipped to Activation Laboratories, Ltd. (Actlabs) in Ontario, Canada to be analyzed for 49 elements. Prior to elemental analyses, Actlabs ground the samples to the point where 95% of the sample passed 200-mesh sieve (0.074 mm screen opening). Elemental concentrations were determined by one of two techniques depending on the particular element. Splits of the ground samples were digested using a four-acid “near total” digestion technique which employed perchloric (HClO<sub>4</sub>), hydrochloric (HCl), nitric (HNO<sub>3</sub>), and hydrofluoric (HF) acids. The digested samples were then analyzed using an Inductively Coupled Argon Plasma Spectrometer - Optical emission spectrometry (ICAP-OES), also referred to as inductively coupled plasma - atomic emission spectrometry (ICP-AES).

The four-acid digestion is considered the most vigorous digestion method using in geochemistry. However, certain refractory or resistant minerals, such as barite, chromite, and cassiterite, still may not be completely dissolved. Also, even with total dissolution, as with most silicates, some elements may be volatilized, including Si, As, Sb, Cr, U, Au and most rare earth elements (REEs). These elements are determined by a second method. Untreated splits of the ground samples were analyzed using Neutron Activation Analysis (INAA).

Detection limit and analytical method used for each element are listed in Appendix D Table D-1. As part of their QA/QC protocol, Actlabs analyzed a series of blanks, replicates and standard reference materials (SRM). Analytical results are presented in Appendix D Table D-2 of SRMs.

## **RESULTS AND DISCUSSION**

### TCLP Analysis

TCLP metals analyses were run on the post dam depositional sediment portion of all the collected cores. This included a sample of the deposited sediments from below the dam in Core#2 as well as a composite sample of the deposited sediments from Cores #1, #3, #4, #5, and #6 collected above the dam.

**Table 4.** TCLP results showing Non Detected for all metals on all samples analyzed. Values are mg/L and sample increments are in centimeters.

TCLP Metals	Reporting Limit	TCLP Limit	Core#2	Core#1	Core#3	Core#4	Core#5	Core#6	Comp.
			0-26	0-89	0-116	0-137	0-102	0-148	
			Result						
Arsenic	0.05	5	ND						
Barium	1	100	ND						
Cadmium	0.05	1	ND						
Chromium	0.05	5	ND						
Lead	0.05	5	ND						
Mercury	0.002	0.2	ND						
Selenium	0.05	1	ND						
Silver	0.05	5	ND						

All analyses yielded results that were below the reporting limits of the analysis method. Also, due to the non detection among all samples, no differences in leachable metals concentrations were found between the sites above the dam and the site below the dam. Based on these results, all depositional sediments confined behind Centreville Dam meet the eligibility requirements for disposal at the County landfill.

Physical Properties

Laboratory results are located in Appendix C.

The physical properties of the deposited sediment contained behind Centreville Dam are relatively consistent. Sandy mud and mud dominates the overlying sediments in all upstream cores. The core located downstream of the dam (Core #2) was slightly more sandy with a 42% sand but is still classified as sandy mud. The sediments contained behind the dam were very soft, unconsolidated, and gassy near the surface and became progressively firmer/more consolidated with depth. This is seen in the subsamples collected from both Core#3 and Core#4.

The top 38 cm in Core#3 contained 54% water with a bulk density of 1.42 g/cm<sup>3</sup> which dropped to 33% water with a bulk density of 1.73 g/cm<sup>3</sup> from 38-116 cm. The top 62 cm in Core#4 contained 44% water with a bulk density off 1.38 g/cm<sup>3</sup> which dropped to 28% water with a bulk density of 1.83 g/cm<sup>3</sup> from 63-137 cm. The cores located above the dam also had distinct transitions to the pre-dam sediments. The underlying sediments were coarser with increased sand and gravel indicative of the higher energy environment prior to the dam. These sediments also contained many laminates created from episodic changes in the stream flow. Cores #1, #3, and #4 also contained layers with peaty material related to the pre-dam marsh environment. Cores #5 and #6 penetrated through the streambed sediments at 199 and 231 cm respectively.

## Elemental Analysis

Laboratory results are located in Table 7.

In general, reported total concentrations of the elements for the core samples fell within the ranges expected for the type of sediments found in the study area. The total arsenic levels from all samples containing depositional sediments behind the dam ranged from 4.2 to 8.8 mg/kg with an average of 6.1 mg/kg. These concentrations are similar to the total concentrations reported by J.D Hynes which had an average of 7.8 mg/kg. A study on background arsenic levels in soils conducted in seven states contained 6 sample sites in Maryland with a range of arsenic from 1.8-13.7 mg/kg (Vosnakis et al., 2009). Recent work performed by the U. S. Geological Survey (USGS) included 17 sample sites in Maryland with an average arsenic concentration of 6.6 mg/kg (Smith et al., 2013).

Lead and chromium were also found in the previous studies on the sediments behind the dam. The average total concentrations of Lead from the 10 samples analyzed for this study was 38 mg/kg. This is comparable to the background concentrations measured by USGS with an average of 39 mg/kg (Smith et al., 2013). The average concentrations of chromium of the same 10 samples at Centreville was 70 mg/kg. This is below the average background concentrations reported by USGS with an average of 211 mg/kg.

**Table 5. Elemental Properties of Core Samples**

Core	Core Depth (cm)		FOLK CLASS	Ag	Al (%)	As	Au	Ba	Be	Bi	Br	Ca	Cd	Ce	Co	Cr	Cs	Cu	Eu	Fe	Hf	Hg	Ir	K	La	Li	Lu	Mg	Mn
	Top	Bottom		ppm	ppm	ppm	ppb	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	%	ppm	ppm	ppb	%	ppm	ppm	ppm	%
Core #1	0	189	Sandy Mud	0.6	4.39	4.7	< 2	400	2	2	< 0.5	0.29	0.5	78	9	72	4	17	1.5	2.14	15	< 1	< 5	1.27	39.7	24	0.19	0.27	396
Core #2	0	26	Sandy Mud	0.7	3.61	2.5	< 2	400	1	3	8.4	0.63	0.4	58	7	54	2	11	1.2	1.55	17	< 1	< 5	1.01	30.8	24	0.15	0.15	223
Core #3	0	116	Sandy Mud	< 0.3	5.76	6.1	< 2	520	2	< 2	4.6	0.36	0.7	101	11	63	3	21	2	2.75	12	< 1	< 5	1.35	48.6	27	0.22	0.3	447
Core #3	0	38	Sandy Mud	< 0.3	6.09	8.8	< 2	510	2	< 2	8.4	0.36	1.3	91	15	71	3	26	1.6	2.91	9	< 1	< 5	1.33	44.3	29	0.18	0.35	493
Core #3	38	116	Mud	< 0.3	6.41	4.2	< 2	570	2	< 2	< 0.5	0.35	< 0.3	110	10	69	3	15	1.9	2.06	12	< 1	< 5	1.48	52.6	28	0.22	0.32	285
Core #4	0	137	Sandy Mud	< 0.3	5.15	4.2	< 2	460	2	< 2	4.6	0.45	1.8	86	10	66	2	27	1.7	2.47	12	< 1	< 5	1.21	42.1	25	0.18	0.29	274
Core #5	0	102	Mud	0.5	5.96	6.7	< 2	580	2	< 2	6.5	0.58	1.9	103	12	77	4	31	1.7	3.13	9	1	< 5	1.33	47.5	31	0.2	0.35	271
Core #5	199	214	Muddy Sand	0.5	2.56	6.5	< 2	310	1	< 2	3.2	0.23	0.9	30	3	59	2	11	0.7	1.81	12	< 1	< 5	0.86	15.9	17	0.08	0.23	135
Core #6	0	148	Sandy Mud	< 0.3	5.27	8.5	< 2	570	2	< 2	5.1	0.48	1.9	77	11	72	4	25	1.5	2.99	11	< 1	< 5	1.2	36.8	27	0.16	0.3	322
Composite			Sandy Mud	< 0.3	5.22	5.9	2	470	2	< 2	4.2	0.41	1.3	86	10	72	2	25	1.9	2.7	13	< 1	< 5	1.2	40.7	26	0.2	0.28	303

Core	Core Depth (cm)		FOLK CLASS	Mo	Na	Nd	Ni	P	Pb	Rb	S	Sb	Sc	Se	Sm	Sn	Sr	Ta	Tb	Th	Ti	U	V	W	Y	Yb	Zn
	Top	Bottom		ppm	%	ppm	ppm	%	ppm	ppm	%	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm
Core #1	0	189	Sandy Mud	2	0.39	40	20	0.078	24	80	0.04	0.5	6.9	< 3	6.4	< 0.01	76	< 0.5	0.7	10	0.61	2.9	63	< 1	27	3.3	74
Core #2	0	26	Sandy Mud	1	0.29	38	13	0.024	10	71	0.36	0.3	4.7	< 3	4.8	< 0.01	96	< 0.5	0.7	7.5	0.56	2.7	40	< 1	23	2.7	46
Core #3	0	116	Sandy Mud	< 1	0.42	68	27	0.064	26	142	0.06	0.7	7.9	< 3	8.1	< 0.01	87	< 0.5	1	12	0.39	2.9	56	< 1	39	3.6	94
Core #3	0	38	Sandy Mud	2	0.4	57	29	0.083	41	76	0.09	0.6	8.3	< 3	7.1	< 0.01	88	< 0.5	1	10.5	0.36	4.2	60	< 1	34	3.6	165
Core #3	38	116	Mud	< 1	0.43	90	22	0.049	22	110	0.04	0.5	8.6	< 3	8.8	< 0.01	92	< 0.5	1	11.9	0.16	3.5	35	< 1	42	4.1	63
Core #4	0	137	Sandy Mud	< 1	0.36	47	23	0.056	35	89	0.05	0.5	7.3	< 3	7.2	< 0.01	85	< 0.5	1	9.6	0.27	3.5	40	< 1	36	3.4	123
Core #5	0	102	Mud	4	0.4	66	30	0.096	50	119	0.34	0.9	8.4	< 3	8.1	< 0.01	97	< 0.5	1.7	10.3	0.43	3.8	73	< 1	38	3.7	169
Core #5	199	214	Muddy Sand	5	0.21	22	18	0.007	6	28	0.74	0.4	3.6	< 3	2.4	< 0.01	58	< 0.5	< 0.5	5.9	0.44	2.1	37	< 1	12	1.4	50
Core #6	0	148	Sandy Mud	2	0.32	49	25	0.102	57	95	0.15	0.7	7.2	< 3	5.9	< 0.01	88	< 0.5	0.7	9.3	0.36	3	60	< 1	30	2.9	167
Composite			Sandy Mud	< 1	0.37	51	22	0.061	39	75	0.09	1	7.6	< 3	7.1	< 0.01	86	< 0.5	1	10.1	0.34	3.9	52	< 1	34	3.6	119

## CONCLUSION

The physical properties of the sediments accumulated behind Centreville Dam are dominated by sandy mud that is very unconsolidated near the surface with increased consolidation at depth. The underlying sediments contain increased sand and gravel with episodic laminations indicative of the pre dam streambed as well as peaty deposits indicative of the pre dam marsh.

The elemental analysis results are within the ranges expected for the sediments in the study area. The total background concentrations of arsenic, chromium and lead are all comparable to those recorded in similar studies with sample sites in Maryland. The averages for both arsenic and lead at Centreville were nearly identical to those reported in the recent USGS study.

The TCLP analyses shows non-detectable concentrations of all TCLP metals for all samples tested. Due to the non-detection, no differences in leachable metals concentrations were found between the sites above the dam and the site below the dam. The analysis of samples from five sites above the dam exceeds the mandate of four samples from various locations within the deposit. The composite sample tested to measure the average leachable metals from all sample sites above the dam also resulted in non-detection for all TCLP metals.

Based on the TCLP metals analyses of core samples collected for this study, the sediments located behind Centreville Dam do not contain any leachable metals concentrations above the regulatory thresholds. Therefore, the accumulated sediments behind the dam meet the regulatory requirements for placement in the Queen Anne's County landfill.

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## **Appendix A: Core Description Logs**

<b>Site: Core #1      Penetration Depth – 248 cm      Core Length – 208 cm</b> Notes: Just above dam in the middle bank to bank			
Photograph	Interval (cm)	Color (Munsell Color Standard, GSA, 1991)	Description
	0-27	5Y 4/1	Very soft, soupy, watery, high organics, slightly gassy, silty mud
	27-116	5Y 5/2  Grading  To  5Y 5/2 With 5Y 4/1	Firm to very firm clayey silt; firmer with depth
	116-189	5Y 3/1	Very slightly softer than above; more organics; large, rotten woody chunk at depth (~138 cm) Slightly sandier and firm below ~153 cm; still very silty
	189-205	5Y 6/1 With 5Y 4/1	Medium to coarse sand laminates; some peaty material at ~200 cm; large rooty material
	205-208	5Y4/1	Silty sand and gravel

<b>Site: Core #2      Penetration Depth – 72 cm      Core Length – 63 cm</b> Notes: Below dam and below Rt. 213 bridge between rocks; Push core/CAB liner			
Photograph	Interval (cm)	Color (Munsell Color Standard, GSA, 1991)	Description
	0-27	10YR 2/2	1 cm soft, dusky yellowish brown, soft surface layer over very firm, silty mud with organics throughout
	27-63	5Y 6/2 With 10YR 2/2 Laminates  10YR 2/2	Firm, light olive gray medium sand with darker laminates throughout  Slightly siltier and all 10YR 2/2 below ~54 cm

<b>Site: Core #3      Penetration Depth – 222 cm      Core Length – 146 cm</b> Notes: Water depth 2.5 cm			
Photograph	Interval (cm)	Color (Munsell Color Standard, GSA, 1991)	Description
	0-27	5Y 2/1	Very soft, soupy, watery, high organics throughout; gassy
	22-38	5Y 4/1	Similar texture as above; less gassy
	38-94	5Y 5/1	Very firm silty mud; firmer with depth
	94-116	5Y 4/1	Firm silty mud; more organics than above
	116-120	5Y 6/1 w/ 5Y 4/1	Silty sand with darker laminates; very firm
	120-140	10YR 2/2	Highly organic, peaty, silty mud; large root/stick at ~139 cm
	140-146	10YR 2/2 w/ 5Y 6/1	Similar to above with lighter colored sandy laminates

Site: Core #4      Penetration Depth – 229 cm      Core Length – 192cm			
Photograph	Interval (cm)	Color (Munsell Color Standard, GSA, 1991)	Description
	0-62	5Y 2/1 Grading To 5Y 4/1	Very soft, soupy, watery, organic, gassy, silty mud
	62-70	5Y 4/1	Very firm, silty/clayey mud with sandy laminates at 70-73 and 87-90 cm
	70-73		
	73-87		
	87-90		
	90-115	5Y 5/1	Very firm, silty mud
	115-137	5Y 3/1 With 5Y 5/1	Rock near top; Firm silty mud with lighter laminates
	137-144	5Y 5/1	Slightly silty, firm sand
	144-152		Peaty, slightly sandy silt
	152-158		Clean, medium to coarse sand
	158-167	5Y 4/1	Peaty silty mud
167-192	5Y 2/1	Peaty, dark, silty mud with Hydrogen sulfide odor; sandier with depth	

Site: Core #5      Penetration Depth – 285 cm      Core Length – 219 cm			
Photograph	Interval (cm)	Color (Munsell Color Standard, GSA, 1991)	Description
	0-86	5Y 4/1 Grading To 5Y 5/1	Soft, soupy, highly organic, gassy, silty mud
	86-102	10YR 4/2	Slightly firm, silty mud; more consolidated
	102-115	5Y 4/1 to 5Y 6/1	Medium to coarse, slightly silty mud
	115-160	5Y 4/1	Very firm, slightly silty, very fine sand
	160-166	5Y 5/2	Very firm, clean sand
	166-199	5Y 2/1	Silty sand with very gravelly layers at 175-183 and 191-199 cm
	199-219	5GY 4/1	Very firm, very fine silty sand

Site: Core #6      Penetration Depth – 367 cm      Core Length – 257 cm			
Photograph	Interval (cm)	Color (Munsell Color Standard, GSA, 1991)	Description
	0-148	Mixed 5Y 4/1 And 5Y 3/1	Soft, soupy, watery, organic, gassy, silty mud Slightly firmer with depth below 80 cm
	148-184	Mixed 5Y 8/1, 5Y 4/1, and 5Y 5/2	Sand and large gravel
	184-224	Mixed 5Y 4/1, N4, and 5Y 8/1	Gravelly sand and silty mud with varying amounts of gravel throughout; gravel gets larger with depth; peaty laminate layer 218-221; cobbles and gravel 221-224
	224-231	5Y 4/1	Muddy coarse sand
	231-257	5GY 4/1	Abrupt horizon; very firm, dry, gritty, fine silty sand

## **Appendix B: TCLP Laboratory Documents**



## **Appendix C: Physical Properties of Core Samples**

**Table C-1. Physical properties of core samples. Grain size is in % by weight. Core Depth is the actual interval measurement on the collected core.**

Core	Core Depth (cm)		Water %	Bulk Density g/cm <sup>3</sup>	Gravel %	Sand %	Silt %	Clay %	Mud %	Folk Classification
	Top	Bottom								
Core #1	0	189	39.92	1.60	0.22	22.88	52.94	23.96	76.90	Sandy Mud
Core #1	0	27	57.36	1.37	2.33	15.74	44.88	37.05	81.93	Sandy Mud
Core #1	27	116	31.52	1.76	0.00	2.28	68.58	29.14	97.72	Mud
Core #1	116	189	25.69	1.89	0.07	77.99	13.94	8.00	21.94	Muddy Sand
Core #2	0	26	48.02	1.48	0.00	41.91	42.62	15.47	58.09	Sandy Mud
Core #3	0	116	53.93	1.40	0.00	12.93	57.53	29.54	87.07	Sandy Mud
Core #3	0	38	53.61	1.42	0.23	10.51	54.22	35.05	89.26	Sandy Mud
Core #3	38	116	33.28	1.73	0.13	7.22	61.23	31.42	92.66	Mud
Core #3	116	146	45.57	1.52	0.12	70.98	18.14	10.76	28.90	Muddy Sand
Core #4	0	137	50.40	1.45	0.22	26.42	48.78	24.58	73.37	Sandy Mud
Core #4	0	62	56.35	1.38	2.26	6.50	56.32	34.92	91.23	Mud
Core #4	62	137	28.31	1.83	0.40	37.58	43.27	18.75	62.02	Sandy Mud
Core #4	137	158	28.54	1.82	0.00	92.17	5.09	2.75	7.83	Sand
Core #5	0	102	65.54	1.27	0.00	9.17	57.45	33.38	90.83	Mud
Core #5	102	115	18.45	2.06	0.18	95.20	3.28	1.34	4.61	Sand
Core #5	115	160	25.68	1.89	0.00	85.84	11.12	3.05	14.16	Muddy Sand
Core #5	199	214	28.43	1.83	0.00	76.17	14.93	8.90	23.83	Muddy Sand
Core #6	0	148	60.38	1.33	0.00	27.76	44.43	27.82	72.24	Sandy Mud
Core #6	224	257	30.56	1.78	0.00	67.48	21.80	10.73	32.52	Muddy Sand
Composite 1, 3, 4, 5, 6			45.49	1.53	0.37	18.61	54.70	26.31	81.01	Sandy Mud



## **Appendix D: Elemental Properties of Core Samples**

**Table D-1.** Elements (analytes) reported in this study include 49 elements analyzed by Actlabs. TAL metals are indicated by shading; Thallium (Tl) was not included in the Actlabs suite. Methods abbreviations: High Temp. Combustion-GC: High Temperature combustion, following by Gas Chromatography; TD-ICP: Total Digestion followed by Inductively Coupled Plasma Spectrometry; INAA: Instrumental Neutron Activation Analysis.

Element	Symbol	Reporting Unit	Detection Limit	Analysis Method	Element	Symbol	Reporting Unit	Detection Limit	Analysis Method
Aluminum	Al	%	0.01	TD-ICP	Molybdenum	Mo	ppm	1	TD-ICP
Antimony	Sb	ppm	0.1	INAA	Neodymium	Nd	ppm	5	INAA
Arsenic	As	ppm	0.5	INAA	Nickel	Ni	ppm	1	INAA / TD-ICP
Barium	Ba	ppm	50	INAA	Phosphorus	P	%	0.001	TD-ICP
Beryllium	Be	ppm	1	TD-ICP	Potassium	K	%	0.01	TD-ICP
Bismuth	Bi	ppm	2	TD-ICP	Rubidium	Rb	ppm	15	INAA
Bromine	Br	ppm	0.5	INAA	Samarium	Sm	ppm	0.1	INAA
Cadmium	Cd	ppm	0.3	TD-ICP	Scandium	Sc	ppm	0.1	INAA
Calcium	Ca	%	0.01	TD-ICP	Selenium	Se	ppm	3	INAA
Cerium	Ce	ppm	3	INAA	Silver	Ag	ppm	0.3	INAA / TD-ICP
Cesium	Cs	ppm	1	INAA	Sodium	Na	%	0.01	INAA
Chromium	Cr	ppm	2	INAA	Strontium	Sr	ppm	1	TD-ICP
Cobalt	Co	ppm	1	INAA	Sulfur	S	%	0.01	TD-ICP
Copper	Cu	ppm	1	TD-ICP	Tantalum	Ta	ppm	0.5	INAA
Europium	Eu	ppm	0.2	INAA	Terbium	Tb	ppm	0.5	INAA
Gold	Au	ppb	2	INAA	Thorium	Th	ppm	0.2	INAA
Hafnium	Hf	ppm	1	INAA	Tin	Sn	%	0.01	INAA
Iridium	Ir	ppb	5	INAA	Titanium	Ti	%	0.01	TD-ICP
Iron	Fe	%	0.01	INAA	Tungsten	W	ppm	1	INAA
Lanthanum	La	ppm	0.5	INAA	Uranium	U	ppm	0.5	INAA
Lead	Pb	ppm	3	TD-ICP	Vanadium	V	ppm	2	TD-ICP
Lutetium	Lu	ppm	0.05	INAA	Ytterbium	Yb	ppm	0.2	INAA
Magnesium	Mg	%	0.01	TD-ICP	Yttrium	Y	ppm	1	TD-ICP

**Table D-1.** Elements (analytes) reported in this study include 49 elements analyzed by Actlabs. TAL metals are indicated by shading; Thallium (Tl) was not included in the Actlabs suite. Methods abbreviations: High Temp. Combustion-GC: High Temperature combustion, following by Gas Chromatography; TD-ICP: Total Digestion followed by Inductively Coupled Plasma Spectrometry; INAA: Instrumental Neutron Activation Analysis.

<b>Element</b>	<b>Symbol</b>	<b>Reporting Unit</b>	<b>Detection Limit</b>	<b>Analysis Method</b>	<b>Element</b>	<b>Symbol</b>	<b>Reporting Unit</b>	<b>Detection Limit</b>	<b>Analysis Method</b>
Manganese	Mn	ppm	1	TD-ICP	Zinc	Zn	ppm	1	INAA / TD-ICP
Mercury	Hg	ppm	1	INAA					

**Table D-2.** Results of Actlabs analyses of Reference material for the TD-ICP method. Actlabs' measure values compared to the certified values. Reference materials include USGS geochemical exploration references and Canadian SRMs

Analyte Symbol	Unit Symbol	Detection Limit	USGS GXR -1: Jasperoid		USGS GXR-4: CopperMill Head		USGS SDC-1: Mica Schist		Method Blank
			Measured value	Certified value	Measured value	Certified value	Measured value	Certified value	
Ag	ppm	0.3	29	31	3.5	4	< 0.3	0.041	< 0.3
Cu	ppm	1	1100	1110	6440	6520	31	30	< 1
Cd	ppm	0.3	3.3	3.3	0.4	0.86	< 0.3	0.08	< 0.3
Mo	ppm	1	14	18	310	310	< 1	0.25	< 1
Pb	ppm	3	684	730	45	52	22	25	< 3
Ni	ppm	1	43	41	41	42	37	38	< 1
Zn	ppm	1	708	760	74	73	104	103	< 1
S	%	0.01	0.23	0.257	1.8	1.77	0.07	0.065	< 0.01
Al	%	0.01	3.48	3.52	4.7	7.2	5.93	8.34	< 0.01
Be	ppm	1	1	1.22	2	1.9	3	3	< 1
Bi	ppm	2	1280	1380	10	19	< 2	2.6	< 2
Ca	%	0.01	0.98	0.96	1.17	1.01	1.22	1	< 0.01
K	%	0.01	0.06	0.05	3.27	4.01	2.77	2.72	< 0.01
Li	ppm	1	12	8.2	11	11.1	36	34	< 1
Mg	%	0.01	0.33	0.217	1.75	1.66	1.04	1.02	< 0.01
Mn	ppm	1	900	852	147	155	926	880	13
P	%	0.001	0.055	0.065	0.133	0.12	0.053	0.069	< 0.001
Sr	ppm	1	286	275	218	221	182	180	< 1
Ti	%	0.01					0.27	0.606	< 0.01
V	ppm	2	84	80	91	87	61	102	< 2
Y	ppm	1	27	32	14	14	34	40	< 1

**Table D-2 (cont.).** Results of Actlabs analyses of reference material for the TD-ICP method. Actlabs' measure values compared to the certified values. Reference materials include USGS geochemical exploration references and Canadian SRMs.

Analyte Symbol	Unit Symbol	Detection Limit	USGS SCO-1: Shale		USGS GXR-6: Powdered Soil		USGS DNC-1a: Dolerite		Method Blank
			Measured value	Certified value	Measured value	Certified value	Measured value	Certified value	
Ag	ppm	0.3	< 0.3	0.134	0.4	1.3			< 0.3
Cu	ppm	1	31	29	68	66	100	100	< 1
Cd	ppm	0.3	< 0.3	0.14	0.7	1			< 0.3
Mo	ppm	1	< 1	1.4	2	2.4			< 1
Pb	ppm	3	31	31	76	101			< 3
Ni	ppm	1	29	27	22	27	260	247	< 1
Zn	ppm	1	103	100	115	118	60	70	< 1
S	%	0.01	0.07	0.063	0.02	0.016			< 0.01
Al	%	0.01	5.23	7.24	13.8	17.7			< 0.01
Be	ppm	1	2	1.8	1	1.4			< 1
Bi	ppm	2	< 2	0.37	< 2	0.29			< 2
Ca	%	0.01	2.28	1.87	0.31	0.18			< 0.01
K	%	0.01	2.33	2.3	1.81	1.87			< 0.01
Li	ppm	1	46	45	42	32	5	5.2	< 1
Mg	%	0.01	1.69	1.64	0.85	0.609			< 0.01
Mn	ppm	1	410	410	990	1010			6
P	%	0.001	0.086	0.09	0.043	0.035			< 0.001
Sr	ppm	1	169	170	57	35	139	144	< 1
Ti	%	0.01	0.36	0.38					< 0.01
V	ppm	2	141	130	188	186	152	148	< 2
Y	ppm	1	20	26	17	14	16	18	< 1

