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Deep Creek Lake Sediment Study: Physical and Chemical Characteristics of Lake Sediments

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EXECUTIVE SUMMARY

The State of Maryland, Department of Natural Resources (DNR) recently added Deep Creek Lake to its public land holdings. Increased development of the surrounding land and a growing public concern over lake sedimentation has prompted a detailed examination of this resource. While Deep Creek Lake appears generally healthy based on existing water quality data, there are gaps in data, particularly with regard to sediments. Additional information is needed on the bottom sediments contained within this system, capacity of the lake itself, and identification, where possible, of the impacts of changing land use patterns on sedimentation and sediment character within the lake

In order to characterize the bottom sediments in Deep Creek Lake, the Maryland Geological Survey (MGS), a program within DNR's Resource Assessment Service, collected surficial sediments at 50 locations throughout the lake. The sediments were analyzed for textural properties, total nitrogen (N), total carbon (C), reactive carbon (C_R), total phosphorus (P), and 48 additional elements including arsenic (As), antimony (Sb), cadmium (Cd), cobalt (Co), chromium (Cr), copper (Cu), iron (Fe), mercury (Hg), nickel (Ni), lead (Pb), sulfur (S), zinc (Zn). These data provide baseline information on the bottom sediments.

Based on the textural analyses of the 50 surficial sediment samples (representing the top 5 cm of the sediment column), the majority of the samples collected are fine-grained sediments, with an average textural content of 18% sand, 39% silt and 43% clay. Clay represents a major component of the collected sediments, which is not unexpected given the abundance of shale in the underlying formations within the watershed. Sediments with the highest clay content were collected in the deepest part of the lake. Sand is a relatively minor component with only four samples classified as sand and silty-sand. The sand sample is the only sample to contain appreciable amounts of gravel (i.e., particles with diameter> 2mm). This sample was collected in the upstream reach of Cherry Branch.

Average N, C, and P in Deep Creek Lake sediments fall within the range of those measured in other Maryland freshwater lakes. On average, 70% of the total C contained in Deep Creek Lake sediment is reactive, readily available to the biological community. Coarser sediments (*i.e.*, low clay content) tend to contain a lower portion of reactive C. Sediments in the northern portion of the lake contain overall higher C content (both total and reactive C) compared to the southern end. There is less variation in the non-reactive C content with regard to distribution.

Total C has little correlation with grain size; the poor correlation due to inclusion of non-reactive C which has no association with any particular sediment type. However, reactive C has higher correlation with clay as well as with N and P (compared to total C), indicating that a significant portion of the reactive carbon in the sediment comes from primary productivity (plankton and algae blooms). Total N has the highest correlation with reactive C indicating that most N is associated with organic material, most likely from primary productivity (algae). Total P is associated with the clay content of the sediment as well as many of the metals and S. When comparing the relative amounts of C, N and P in the Deep Creek Lake sediments to those of dried algae, P appears to be the limiting nutrient. In other words, mean C:P and N:P ratios are greater than those ratios of dried algae.

Compared to other freshwater lakes, S is significantly higher in most of the Deep Creek Lake sediments, particularly those collected in the deepest area at the downstream end (north end). The very dark color (black and dark grey) of some sediments collected indicated the presence of S, in the form of mono-sulfides (as FeS). Sources of S include sulfates from acid mine drainage, and atmospheric deposition in the watershed. Reduced S and sulfate (SO_4^{-2}) concentration is an extremely important variable controlling P release from sediments. The increased P release from sediments at higher sulfate concentrations may help explain why primary production in freshwater systems (with relatively low S concentrations) tends to be P limited, whereas in many saline systems (with high sulfate concentrations) production is often P sufficient. Sulfur also plays an important role in arsenic cycling, which explains the high correlations between S, As, and Fe seen in this study.

Concentration and enrichment of most metals in Deep Creek Lake sediments are within normal range given the geology of the watershed. However, the sediments are significantly enriched in As, Cd, Cs, Hf, Pb, Sb, and Zn, with respect to average continental crust rock. The enrichments are higher than those reported for New Germany Lake, which is located in the same physiographic and atmospheric deposition regions and, thus is expected to be similar in geochemistry. The higher enrichments, particularly As, Cr, and Sb, in Deep Creek Lake sediments are attributed to contribution from coal deposits within the lake’s watershed. Coal deposits are generally enriched with these metals as well as other rare earth elements. Acid mine drainage processes most likely mobilized these elements, resulting in higher concentration compared to New Germany sediments. It should be noted that sediments are enriched in Pb in all of the freshwater lakes studied in Maryland, illustrating the widespread anthropogenic sources for Pb. Nevertheless, Pb concentrations in Deep Creek Lake sediments are low as to not be a threat to the benthic community.

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INTRODUCTION

The State of Maryland, Department of Natural Resources (DNR) recently added Deep Creek Lake to its public land holdings. Increased development of the surrounding land and a growing public concern over lake sedimentation has prompted a detailed examination of this resource. While Deep Creek Lake appears generally healthy based on existing water quality data, there are gaps in data, particularly with regard to sediments (Kesley and Powell, 2011). Additional information is needed on the bottom sediments contained within this system, capacity of the lake itself, and identification, where possible, of the impacts of changing land use patterns on sedimentation and sediment character within the lake

Sediments accumulating on the lake bottom act as reservoir for nutrients and contaminants, including toxic metals and organic pollutants. The physical and chemical properties of sediments are a controlling factor in the absorption and release of nutrients and contaminants. Documentation of these characteristic and the concentrations of any existing contaminants are necessary for the effective management of Deep Creek Lake.

Objectives

In order to characterize the bottom sediment in Deep Creek Lake, the Maryland Geological Survey (MGS), a program within DNR's Resource Assessment Service, collected sediments within the lake and analyzed them for physical and chemical properties. The results of these analyses are presented in this report.

Study Area

Deep Creek Lake is located in Garrett County. The lake was formed in 1925 when the Youghiogheny Hydroelectric Company constructed a dam across Deep Creek. The lake is presently owned and managed by Maryland Department of Natural Resources.

The Deep Creek Lake watershed is located within the Appalachian Plateau Physiographic Region of Maryland. The bedrock of this region consists principally of gently folded sedimentary rock comprised of shale, siltstone, and sandstone of mixed marine and non-marine origins. Folding has produced elongated arches, or anticlines, trending NE to SW across the region that expose the oldest formations at the surface. In the intervening synclinal basins, coal-bearing strata of Pennsylvanian and Permian ages are preserved. The northern half of Deep Creek Lake is located on broad syncline, called the Casselman Basin. Meadow Mountain is the eastern border of this structure. The lake perimeter is steep within this structure. The rock exposed here are brown colored sandstones and shales of a Mississippian age formation called the Mauch Chunk. Within the State Park, the 200 to 300-foot thick Greenbrier Limestone underlies the lake, contributing calcium carbonate to the water. Calcium carbonate may buffer the lake from acidic runoff from adjacent coal deposits. The Cherry Branch tributary drains the coal bearing formations and is thought to contribute a significant portion of the acidity to the lake (MDE, 2002).

The dam and immediately adjacent areas lie within the Upper Youghiogheny coal basin. Here sandstones and shales of the Allegheny /Pottsville formation of Lower Pennsylvanian age (325 million years old) are exposed. Some lower coal beds may also be exposed.

The southern half of the lake lies within the Deer Park Anticline composed of the (1) brown colored sandstones and shales of the Pocono Formation of Lower Mississippian age (350 million years old) then (2) further southeast, red to reddish brown sandstones and shales of the Hampshire Formation of Upper Devonian age (365 million years old) and finally (3) Devonian series of formations, comprise of predominately greywacke, siltstone and shale, sandstones and conglomerates. Unlike the northern half of the lake, the topography along the perimeter of the lake within the anticline structure is flatter and gentler.

Other Studies

In 2007 and 2008, the United States Geological Survey (USGS) collected 34 sediment cores from Deep Creek Lake to determine the amount of sediment accumulation since the lake was established. The cores were collected in areas where sediment accumulation was expected to be the highest: in coves and mouths of streams draining into the lake. However, the USGS did not collect any cores in the deepist areas of the lake due to limitation of their coring equipment. The USGS analyzed seven cores for grain size and five cores for ^{137}Cs activity to determine sedimentation rates. USGS results showed variable sedimentation rates over the the 83 year history of Deep Creek Lake, with the higher average sedimentation rates occurring early after the lake was contructed (between 1925 and 1963). (Banks et al., 2010).

Concurrent with this study, a reconnaissance study of sediment accumulation in ten selected coves within Deep Creek Lake was conducted. The results of that study are presented in a separate report (Ortt and Manship, 2011).

METHODS

Field Collection of Sediment Sample

MGS collected 50 surficial sediment grab samples for this study. Sampling sites were selected to achieve spatial coverage; some sites were co-located at existing Maryland DNR water quality (WQ) and sub-aquatic vegetation (SAV) monitoring stations and Garret County Health Department (GCHD) stations (Figure 1).

Samples were collected in October 19 and 20, 2010. Locations of the sediment samples were document using a Lowrance GlobalNav 212 GPS interfaced to a Lowrance DGPS beacon receiver. Location coordinates were recorded in UTM, NAD83, meters. Location coordinates and water depths for the sediment locations are listed in Appendix I (Table 11).

Sediment samples were collected using a hand-operated LaMotte stainless-steel dredge which sampled a bottom surface area of 19 cm x 14 cm and a mean sediment depth of 10 cm.

Upon collection, the samples were placed in Whirl-Pak™ bags and kept cool until delivery to the MGS laboratory where they were refrigerated at 4˚ C. until analyses.

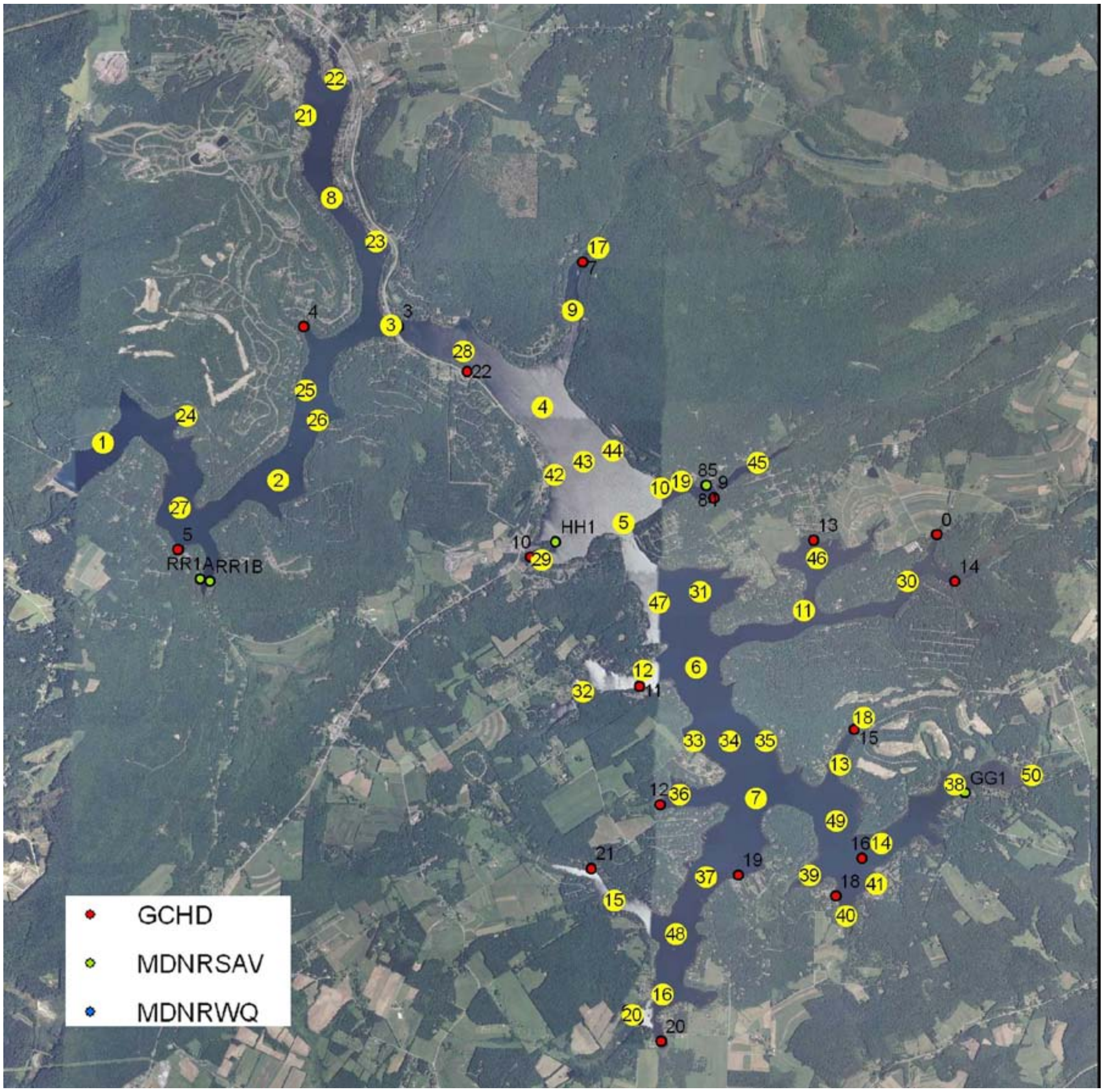


Figure 1. Sample locations. MGS sampling sites are represented by yellow circles, labeled with Site number. Also shown are existing Maryland DNR water quality (WQ) and sub-aquatic vegetation (SAV) monitoring stations and Garret County Health Department (GCHD) stations.

Laboratory Analyses

Textural Analyses

All 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.

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

where: $\boldsymbol{W_w}$ is the weight of water; and
$\boldsymbol{W_t}$ 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 chemical analyses (see **Chemical Analyses** section).

Bulk density (ρ_B) was calculated from water content utilizing equation (2) by assuming an average grain density (ρ_s) of 2.72 g/cm^3 and saturation of voids with water of density $\rho_w = 1.0$ g/cm^3. This method was adopted from the work of Bennett and Lambert (1971):

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

where $\boldsymbol{W_d}$ 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 consisted 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 were then treated with a 0.26 percent solution of the dispersant sodium hexametaphosphate ($(NaPO_3)_6$) to ensure that individual grains did not re-aggregate during analysis.

The separation of sand and silt-clay portions of the sample was accomplished by wet-sieving through a 4-phi mesh sieve (0.0625 mm, U.S. Standard Sieve #230). The sand fraction was dried and weighed. The finer silt and clay-sized particles were suspended in a 1000 ml cylinder in a solution of 0.26 percent sodium hexametaphosphate. The suspension was agitated and, at specified times thereafter; 20 ml pipette withdrawals were made (Carver, 1971; Folk, 1974). The rationale behind this process was 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 were calculated to permit the determination of the amount of silt (4 phi) and clay sized (8 phi) particles in the suspension. Withdrawn samples were dried at 65°C and weighed. From these data the percentages by dry weight of sand, silt, and clay were calculated for each sample and classified according to Shepard's (1954) nomenclature (Figure 2). Results of textural analyses are presented in Appendix II (Table 12).

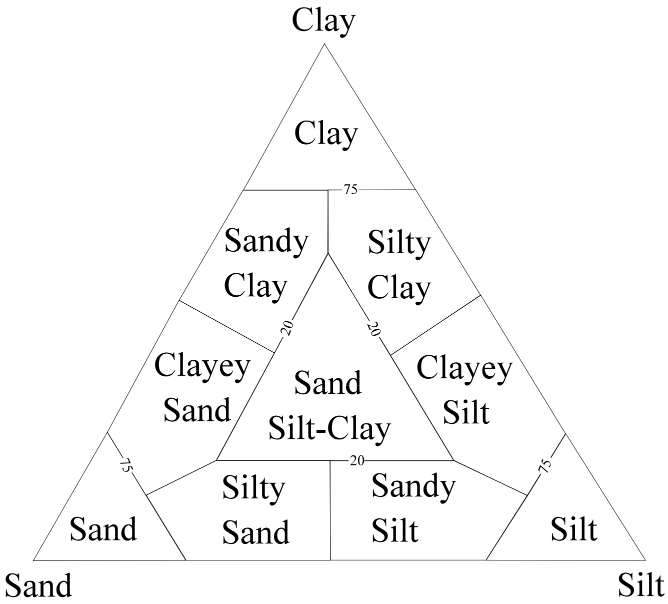


Figure 2. Shepard's (1954) classification of sediment types

Chemical Analyses

Sediments dried for water content determination were saved for elemental analyses. The dried sediments were pulverized in tungsten-carbide vials using a ball mill, then placed in Whirl-Pak^{TM} bags and stored in a desiccator.

Nitrogen, Carbon and Sulfur Analyses

The sediments were analyzed for total nitrogen (N), total carbon I, non-reactive C and total sulfur (S) using a Carlo Erba NA1500 analyzer. Untreated dried sediments were analyzed for total nitrogen, carbon and sulfur (NCS) contents. A split of dried sample was treated with15% hydrogen peroxide (H_2O_2) to remove "reactive" C (*i.e.*, carbon associated with labile or biologically active organic matter). This peroxide- treated sample was analyzed for non-reactive C which consists of inorganic or mineral C and non-labile C (Hennessee and others, 1986). Reactive C was calculated as the difference between total C and non-reactive C.

Approximately 10-15 mg of dried sediment (treated and untreated) was weighed into a tin capsule. The exact weight (to the nearest µg) of the sample was recorded. To ensure complete combustion during the analysis, 15-20 mg of vanadium pentoxide (V_2O_5) was added to the sediment. The tin capsule containing the sediment and vanadium pentoxide mixture was then crimped to seal and stored in air-tight vial until analysis.

The sediment sample, contained in a tin capsule, was dropped into a combustion chamber where the sample was oxidized in pure oxygen. The resulting combustion gases (N, C, H, and S), along with pure helium used as a carrier gas, were passed through a reduction furnace to remove free oxygen and then through a sorption trap to remove water. Separation of the gas components was achieved by passing the gas mixture through a chromatographic column. A thermal conductivity detector was used to measure the relative concentrations of the gases.

The NA1500 Analyzer was configured for NCS analysis using the manufactu'er's recommended settings. As a primary standard, Sulfanilamide was used. Blanks (tin capsules containing only vanadium pentoxide) were run at the beginning and end of sample set. Replicates of every fifth sample were run. As secondary standards, one or more reference materials (NIST SRM #164–a - Estuarine Sediment and NIST SRM #87–4 - Buffalo River Sediment) were run every 5 samples. Comparisons of results of SRMs to their certified values are presented in Appendix I. Results of the NCS analyses are presented in Appendix II.

Elemental Analyses

Two to three-gram splits of the dried sediments were shipped to Activation Laboratories, Ltd. (Actlabs) in Ontario, Canada, to be analyzed for 48 elements including total phosphorus (P) (Table 1). Sediments were analyzed either by neutron activation technique (INAA) or using a four-acid, "near total" digestion process, followed by analysis of the digestate by inductively coupled plasma emission spectroscopy (ICP-OES). The four-acid digestion employed perchloric ($HClO_4$), hydrochloric (HCl), nitric (HNO_3), and hydrofluoric (HF) acids. Forty-three (43) of the 50 sediment samples were also analyzed for mercury using cold vapor extraction followed by Fluid-Injection Mercury System (FIMS). However, the recommended protocols for handling samples prior to the mercury analyses were not followed (*i.e.*, sediment samples were dried in open containers and holding time prior to analyses exceeded 14 days). Therefore, the reported Hg concentrations represent a portion of the total Hg originally contained in the sediments.

SRM NIST #8704 and #1646a were included as double- blind samples with the lake sediments submitted to Actlabs. The Actlabs' results of the analyses of the SRMs are listed in Appendix I (Table 10). Elemental analysis results for the surficial samples are listed in Appendix II (Table 14).

Table 1. List of the elements analyzed by Actlabs, Inc. along with units reported and laboratory detection limits.

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

RESULTS AND DISCUSSION

Physical Characteristics

Based on the textural analyses of the 50 surficial sediment samples (representing the top 5 cm of the sediment column), the majority of the samples collected are fine-grained sediments, with an average textural content of 18% sand, 39% silt and 43% clay. Thirty-two samples fall within the clayey-silt and silt-clay classifications (Table 2). Fourteen samples are classified as sand-silt-clay. Clay represents a major component of the collected sediments, which is not unexpected given the abundance of shale in the underlying formations within the watershed. Sand is a relatively minor component with only four samples classified as sand and silty-sand. The sand sample is the only sample to contain appreciable amounts of gravel (i.e., particles with diameter> 2mm). This sample was collected in the upstream reach of Cherry Branch (Figure 3) and contained abundant leaf litter, and organic matter which contributed to the higher water content. Typically, the water content of sand sized sediments averages around 20%. Water content increases with decreasing sediment size, with clayey sediments having water contents greater than 70%.

Table 2. Summary of sediment types for samples collected in Deep Creek Lake for this study.

Shepard's Classification	**No. of Samples**	**Average (%)**					
		Water	**Nitrogen**	**Total Carbon**	**Reactive Carbon**	**Sulfur**	**Phosphorus**
Sand	1	53.17	0.126	4.066	2.089	0.112	0.018
Silty-Sand	3	45.24	0.160	2.391	1.120	0.056	0.021
Sand-Silt-Clay	14	61.81	0.258	3.504	2.240	0.175	0.041
Clayey-Silt	8	68.42	0.379	5.120	3.471	0.276	0.055
Silty-Clay	24	72.87	0.385	4.336	2.962	0.331	0.073

The physical and chemical behavior of sediment is reflected in its texture. Particle diameter reflects the energy environment in which the sediment was deposited. Generally, coarse grained sediments (*i.e.*, sand and gravel) are found in higher energy environments, such as areas subjected to wave activity or high water currents, which tend to winnow out any fine grained sediment. Fine-grained sediments, which are transported further from the source and take a long time to settle, are usually found in areas that are not subjected to high waves or winds, or below deep of wave motion, such as deeper areas in the central area of the lake, or coves that are sheltered from high waves and winds. In Deep Creek Lake, the sediment distribution follows this pattern. The finest-grained sediments (i.e., sediment with highest clay content) are in the deepest part of the lake, whereas sandier sediments are found in shallower depths and in the up-stream areas.

Size also reflects the mineral composition of the sediments, which, in turn, is a product of the parent rock. The Deep Creek Lake watershed lies within sedimentary rock comprised of mixed marine and non-marine shale, siltstone, and sandstone. The gravel- and sand- sized particles deposited in the lake consist primarily of quartz minerals, sand and gravel sized pieces of unweathered (intact) parent rock, large micas, feldspar, heavy minerals and sand sized coal particles. The quartz is a stable mineral and generally chemically inert. Clay minerals are abundant in the lake since shale is a common parent rock. Shales are lithified mud deposits, composed of silt sized particles (mainly quartz) and clay minerals which are the end product of weathering of other minerals. Clay particles are small, in the sub-micron range, platelike particles with a relatively large surface area. Thus, clay minerals comprise a significant portion of the clay size component of sediments. Depending on the crystalline lattice, clays have an enormous capacity to incorporate both organic and metal cations onto the lattice surface, and water and organic compounds within lattice layers. These bound substances, in turn, contribute to the cohesiveness of the clays. Organic rich clays, in turn, support active benthic bacteria and plankton communities.

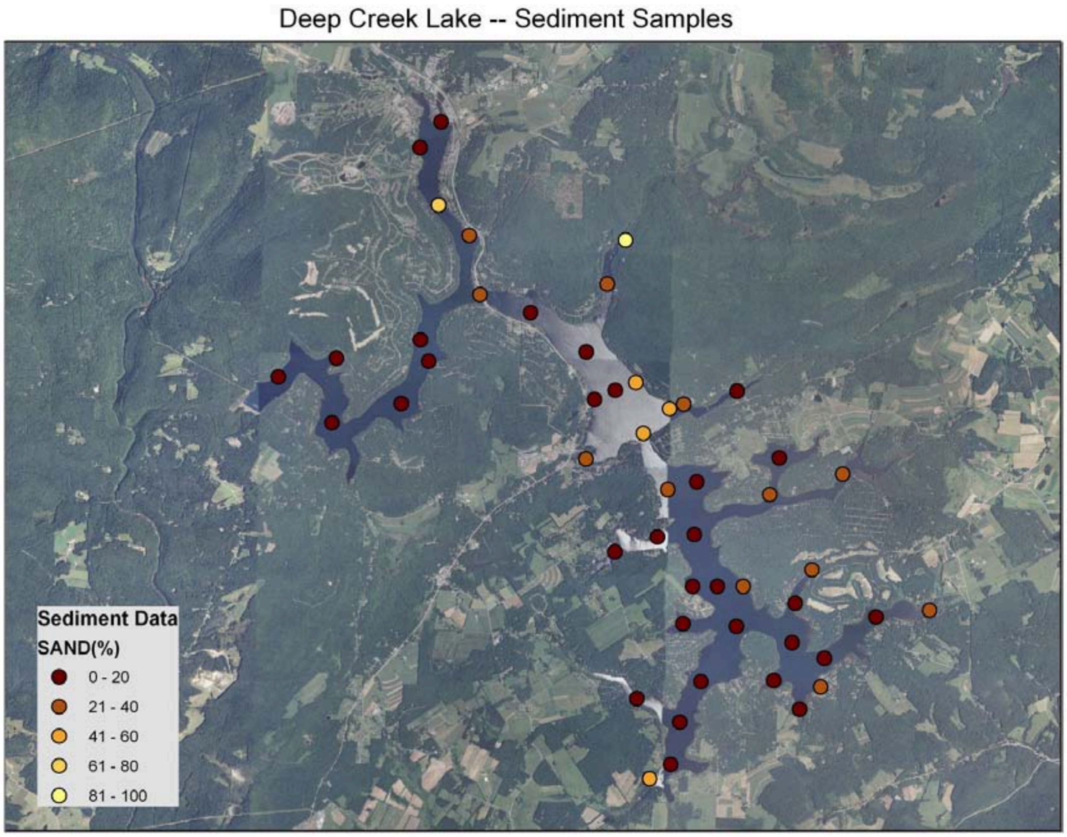


Figure 3. Sediment distribution by sand content.

Nitrogen, Carbon, Sulfur and Phosphorus

Total C contents measured in Deep Creek Lake sediments range from 1.5% to 9.6% (dry weight), with a mean of 4.1%. These values are lower than the average C reported for New

Germany Lake but higher than other fresh water reservoirs located in Central Maryland (Table 3). The total C in Deep Creek Lake consists of both reactive and non-reactive components. The non-reactive component is comprised of coal fragments, inorganic C contained in mineral such as limestone, and organic C containing high cellulose content such as woody debris associated with terrigenous (allochthonous) material. Reactive C contents average 2.7%, with values ranging from 0.6 % to 5.2%. Reactive C consists of aqueous algal matter as well as the more labile component of terrigenous carbon such as fresh leaf litter, decomposing animal and plant debris. On average, 70% of the total carbon contained in Deep Creek Lake sediment is reactive, readily available to the biological community. Coarser sediments (*i.e.*, low clay content) tend to contain a lower portion of reactive C (Figure 4).

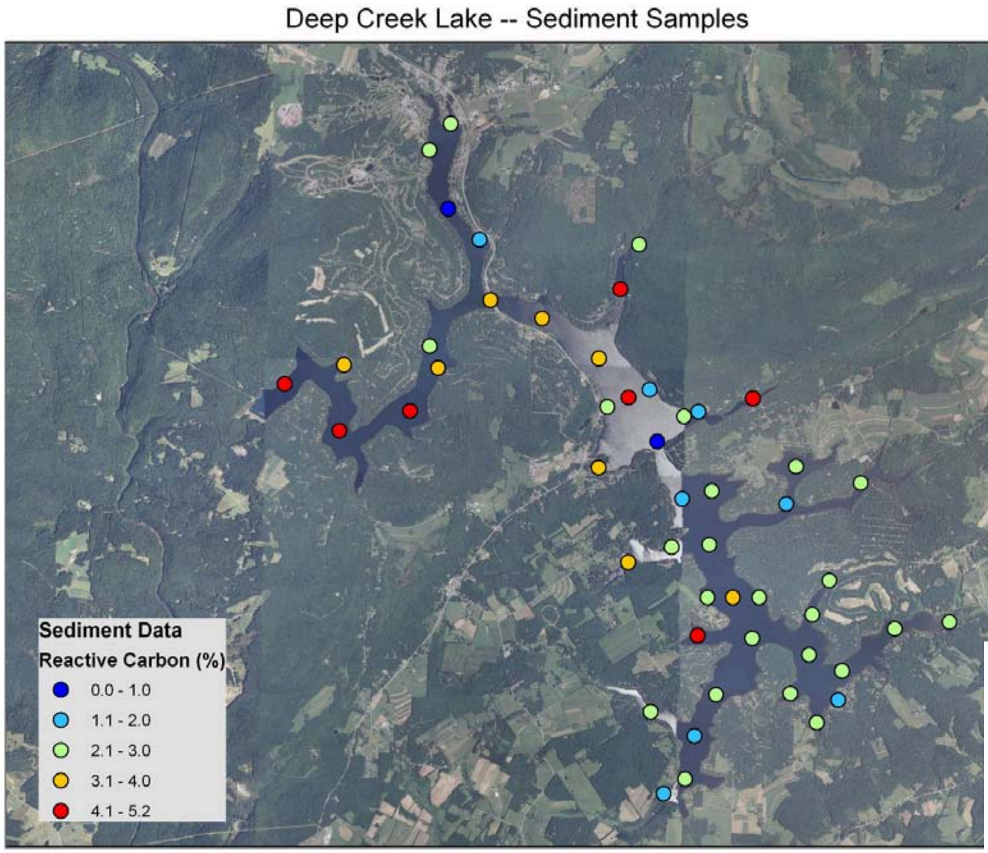
Sediments in the northern portion of the lake contain overall higher carbon content (both total and reactive carbon) compared to the southern end (Figure 4). There is less variation in the non-reactive carbon content with regard to distribution.

Total carbon has little correlation with grain size; the poor correlation due to inclusion of non-reactive carbon which has no association with any particular sediment type (Table 4). However, reactive carbon has higher correlation (r = 0.4) with clay as well as with N and P (compared to total C), indicating a significant portion of the reactive carbon in the sediment comes from primary productivity within the lake (plankton and algae blooms).

Table 3. Comparison of total N, C. and P in surface sediment in Maryland fresh water reservoirs. Values given are % dry sediment weight.

	% N		**% C**		**% P**		**%S**	
Reservoir/Lake	**Ave.**	**Range**	**Ave.**	**Range**	**Ave.**	**Range**	**Ave.**	**Range**
Loch Raven (Ortt et al, 1999)	0.32	0.24-0.40	3.17	2.53-3.94	0.16	0.12-0.19	0.057	0.0-0.15
Little Seneca Lake (Ortt et al., 2011)	0.29	0.18-0.34	3.25	2.07-5.06	0.08	0.06-0.14	0.11	0.04-0.15
Triadelphia Reservoir (Wells et al, 2007)	0.26	0.11-0.48	2.77	1.48-4.12	0.10	0.04-0.17	0.074	0.027-0.28
Rocky Gorge Reservoir (Wells et al, 2007)	0.22	0.05-0.41	2.67	0.83-4.17	0.09	0.03-0.16	0.08	0.02-0.17
New Germany Lake (Ortt and Wells, 2009)	0.51	0.09-0.81	6.20	2.02-7.54	0.06	0.01-0.10	0.08	0.01-0.21
Deep Creek Lake (This Study)	**0.33**	**0.12-0.62**	**4.11**	**1.55-9.60**	**0.06**	**0.01-0.13**	**0.26**	**0-0.98**

Total N measured in Deep Creek Lake sediments average 0.33%, with values ranging from 0.12% to 0.62%. Total N has the highest correlation with reactive C (Figure 5) indicating most N is associated with organic material, most likely from primary productivity (algae). Sources of N include atmospheric input, septic flow and fertilizers. As organic matter is “cycled through the natural system”, relative proportions of P and, to a lesser degree, N increase as C decreases. Table 5 lists the Redfield ratios for N, C, and P for different sources and in sediment from several Maryland fresh and marine environments. The Deep Creek Lake ratios listed in Table 5 are calculated using total C. Ratios are smaller using reactive C: C:N=8.3; C:P=54.3, closer to the ideal Redfield ratio endpoint.



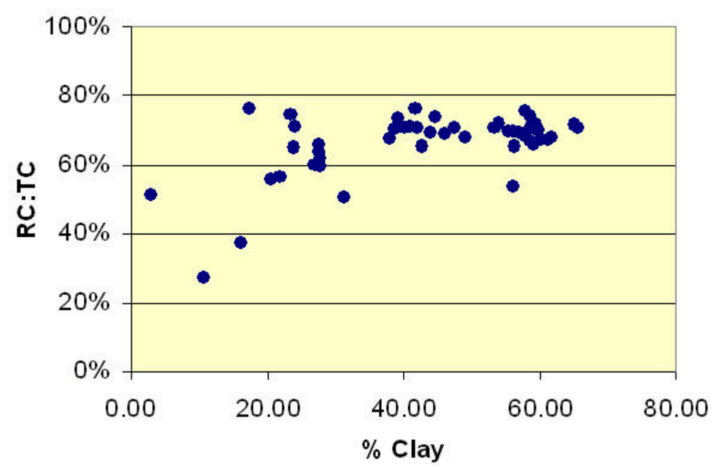


Figure 4. Reactive carbon (% dry weight) distribution in sediments. Reactive carbon accounts for 60% to 80% of the total carbon measured in most of the sediment samples.

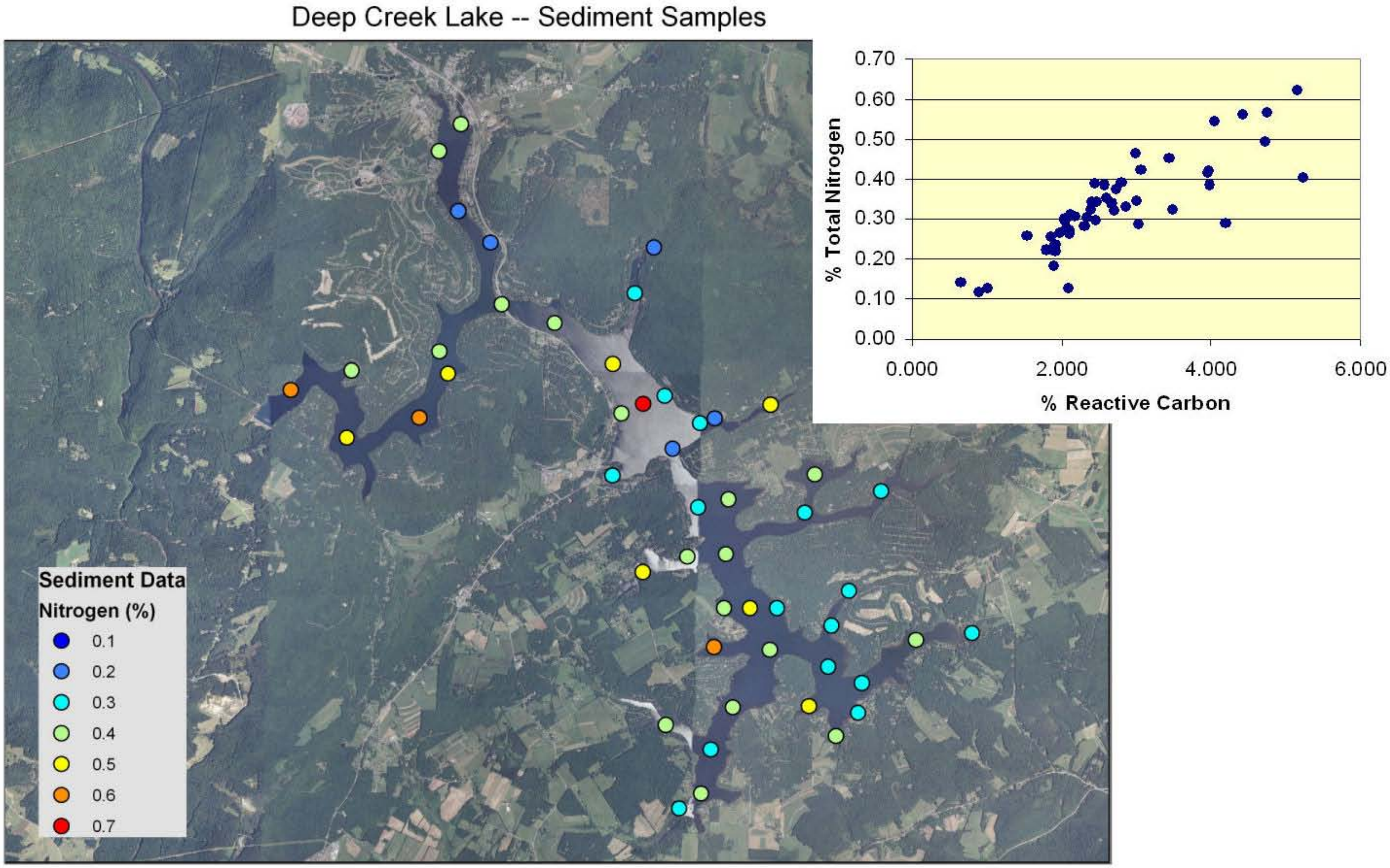


Figure 5. Nitrogen (% dry weight) distribution in sediments. Nitrogen is strongly associated with reactive carbon ($R^2 = 0.72$), suggesting that the nitrogen is organic in nature, a significant portion likely from algae.

Table 4. Correlation matrix for textural, nutrient, and selected metals data based on 50 surficial sediment samples collected in Deep Creek Lake. C_T and C_R denote total carbon and reactive carbon contents, respectively. The correlations were done using Pearson product-moment technique (Johnson and Wichern, 1982). Values listed in the table are Pearson product-moment correlation coefficienI(r). Values shown in regular type are significant at the 95% confidence level ($p < 0.05$); values in red are not significant ($p > 0.05$). The strongest correlations ($r > 0.8$) are highlighted in **bold**

	Water	**Sand**	**Silt**	**Clay**	**N**	**C_T**	**C_R**	**S**	**P**	**Cd**	**Cu**	**Cr**	**Fe**	**Mn**	**Ni**	**Pb**	**Zn**	**As**
Water		-0.73	0.28	0.79	0.74	0.41	0.63	0.63	0.77	0.58	0.78	0.55	**0.81**	0.17	0.75	0.72	0.75	0.75
Sand	-0.73		-0.68	**-0.92**	-0.68	-0.28	-0.44	-0.42	-0.69	-0.34	**-0.80**	-0.63	-0.65	-0.01	-0.56	-0.61	-0.51	-0.54
Silt	0.28	-0.68		0.33	0.35	0.22	0.29	0.06	0.16	0.21	0.33	0.52	0.24	0.20	0.30	0.20	0.23	0.11
Clay	0.79	**-0.92**	0.33		0.68	0.23	0.40	0.51	0.79	0.32	**0.85**	0.53	0.70	-0.10	0.56	0.67	0.53	0.64
N	0.74	-0.68	0.35	0.68		0.74	**0.85**	0.72	0.63	0.60	0.52	0.34	0.53	0.07	0.52	0.45	0.57	0.61
C_T	0.41	-0.28	0.22	0.23	0.74		**0.94**	0.45	0.26	0.44	0.02	-0.01	0.08	0.13	0.18	0.10	0.28	0.29
C_R	0.63	-0.44	0.29	0.40	**0.85**	**0.94**		0.60	0.46	0.63	0.25	0.17	0.34	0.17	0.44	0.33	0.50	0.51
S	0.63	-0.42	0.06	0.51	0.72	0.45	0.60		0.72	0.65	0.53	0.31	0.70	0.01	0.57	0.60	0.69	0.70
P	0.77	-0.69	0.16	0.79	0.63	0.26	0.46	0.72		0.52	**0.81**	0.48	**0.86**	-0.04	0.66	**0.80**	0.72	0.75
Cd	0.58	-0.34	0.21	0.32	0.60	0.44	0.63	0.65	0.52		0.47	0.43	0.61	0.27	**0.82**	0.62	**0.88**	0.58
Cu	0.78	**-0.80**	0.33	**0.85**	0.52	0.02	0.25	0.53	**0.81**	0.47		0.68	**0.84**	0.02	0.76	**0.85**	0.71	0.70
Cr	0.55	-0.63	0.52	0.53	0.34	-0.01	0.17	0.31	0.48	0.43	0.68		0.65	0.36	0.68	0.59	0.61	0.49
Fe	**0.81**	-0.65	0.24	0.70	0.53	0.08	0.34	0.70	**0.86**	0.61	**0.84**	0.65		0.11	**0.80**	**0.87**	**0.84**	0.77
Mn	0.17	-0.01	0.20	-0.10	0.07	0.13	0.17	0.01	-0.04	0.27	0.02	0.36	0.11		0.45	0.07	0.24	0.13
Ni	0.75	-0.56	0.30	0.56	0.52	0.18	0.44	0.57	0.66	**0.82**	0.76	0.68	**0.80**	0.45		0.79	**0.90**	0.72
Pb	0.72	-0.61	0.20	0.67	0.45	0.10	0.33	0.60	**0.80**	0.62	**0.85**	0.59	**0.87**	0.07	0.79		**0.84**	0.72
Zn	0.75	-0.51	0.23	0.53	0.57	0.28	0.50	0.69	0.72	**0.88**	0.71	0.61	**0.84**	0.24	**0.90**	**0.84**		0.69
As	0.75	-0.54	0.11	0.64	0.61	0.29	0.51	0.70	0.75	0.58	0.70	0.49	0.77	0.13	0.72	0.72	0.69	

Table 5. Comparison of mass ratios of C, N, and P observed in different samples (sources).

	C:N	**C:P**	**N:P**
Global forest litter (McGroddy *et al.*, 2004)	57.3	1166.1	20.4
Global forest foliage (McGroddy *et al.*, 2004)	37.1	470.0	12.7
Dried marsh plant (Wells *et al*., 2002)	32.3	711.2	21.7
Marsh sediments (Wells *et al*., 2002)	18.1	243.6	13
New Germany (Ortt *et al.*, 2009)	13.5	109.2	8.1
Dried algae (Wetzel, 1983)	13.3	40.0	3.0
Deep Creek Lake sediments (This Study)	**12.9**	**87.5**	**6.5**
Rocky Gorge Reservoir (Wells *et a.l*, 2007)	12.5	31.2	2.5
Triadelphia Reservoir (Wells *et a.l*, 2007)	11.1	29.2	2.6
Loch Raven (Ortt *et al.*, 1999)	10.1	19.9	2.0
Coastal Bays bottom sediments (Wells *et al.*, 1994)	7.0	65.1	9.3
Plankton (Redfield *et al.*, 1963)	5.7	41	7.2

Although total P does not directly undergo reduction-oxidation processes in sediments, its cycling within the lake is controlled, in part, by the redox state of certain metals, particularly S and Fe, and by the concentration of organic matIal (C). Sources of P include weathering of natural soils and rocks, runoff from agricultural land and seepage from septic systems. Phosphate (PO_4^{-3}) from fertilizers binds to soils, which erode during storm events adding suspended phosphate to streams that drain into the lake. Septic seepage may contribute phosphate in the form of orthophosphate and organic phosphorus. Unlike N and C, P has no gaseous form. Therefore, P does not cycle out of the system like N by way of denitrification or C by respiration. Thus P tends to accumulate in the sediments. Once in the sediments, P is slowly released into the interstitial water as organic material is oxidized. Free phosphate is rapidly bound to ferric oxyhydroxides and oxidized manganese which are found in the upper, oxidized layer of the sediments (i.e., oxidized flocculant layer on sediment surface). Deeper in the sediment column where anoxic conditions prevail and metals oxides have been reduced, P is released into the interstitial water and, if sulfide is low or absent, reacts with reduced forms of metals, particularly Fe, forming hydrous phosphates. However, if present, free sulfide will bind more readily to the reduced Fe and the phosphate remains free to diffuse upward to the oxidized layer whe“e it is ”captured" by excess ferric oxyhydroxides (FeOOH) and manganese oxides found in the upper sediment layer. If the overlying water column becomes anoxic, the “captured” P may be released in the overlying water column where it can contribute to increased algae/plankton production. The portion of total P active in this cycle includes the loosely sorbed phosphate, fresh, leachable, organic P, and iron-bound phosphate. These available forms of P make up 40% to 50% of the total P in the upper 1 cm of sediments and are largely depleted below 3 cm in the sediment column (Jorgensen, 1996). Any P below this depth usually consists of the more stable forms, bound to clay minerals, or associated with apatite or calcium carbonate minerals, and become permanently buried in the sediments.

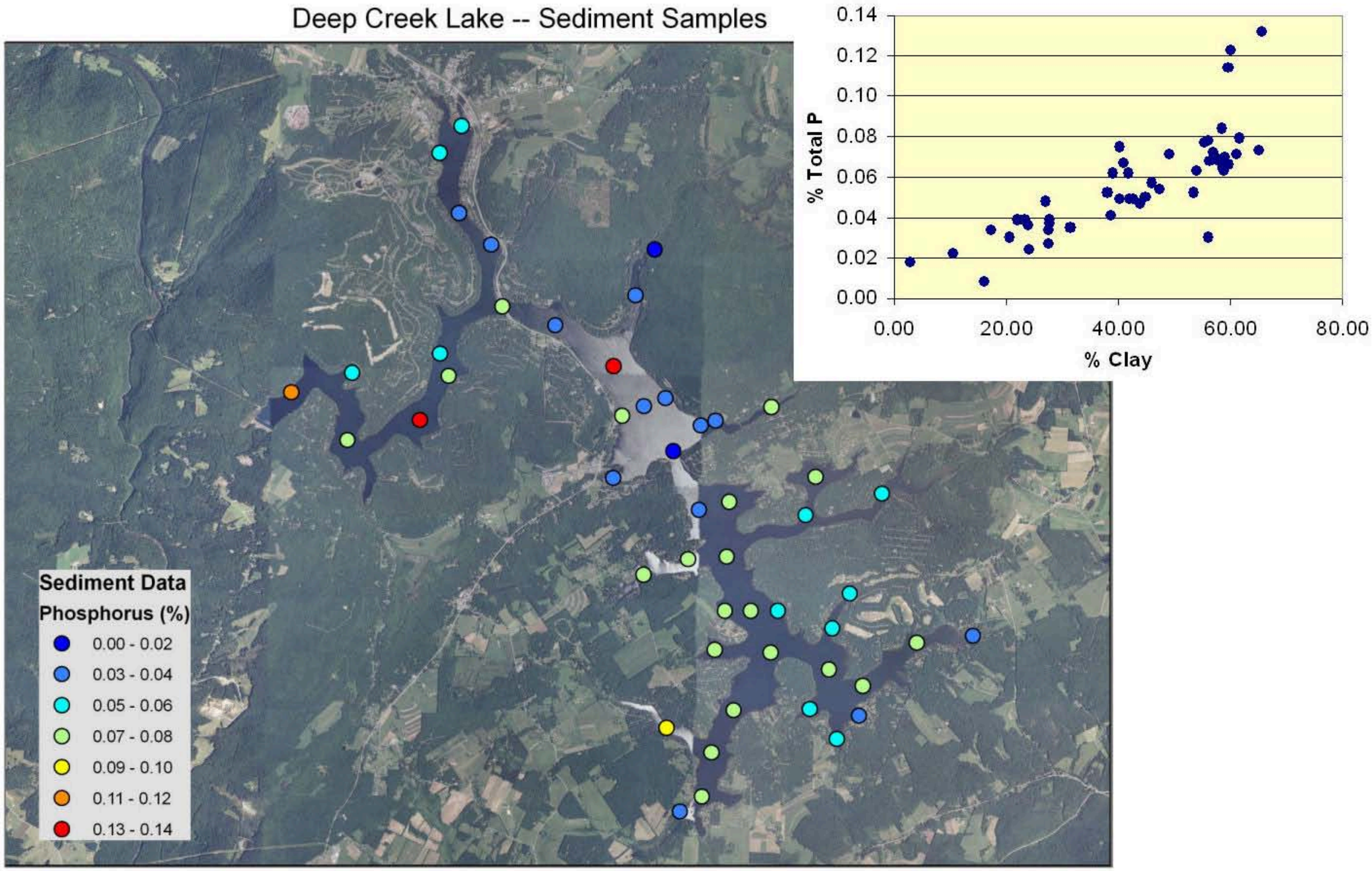


Figure 6. Total P (% dry weight) distribution in sediments. P is strongly associated with sediment clay content (R^2=0.63). The three highest P contents were measured in sediments collected from the deepest part of the lake (depth > 15 m).

Total P measured in the sediments average 0.06%, with values ranging from 0.01% to 0.13%. These values are similar to those found in New Germany Lake (Table 3). Total P is associated with the sediment clay content (Figure 6). P also shows a high correlation with many of the metals as well as S (Table 4). When comparing the relative amounts of C, N and P in the Deep Creek Lake sediments to those of dried algae, P appears to be the limiting nutrient. In other words, mean C:P and N:P ratios are greater than those of dried algae.

Sulfur measured in the sediments average 0.26% with values ranging from trace to 1%. S is significantly higher in some of the Deep Creek Lake sediments, particularly those collected in the downstream end (north end) (Figure 7). The very dark color (black and dark grey) of some sediments collected indicated the presence of S, in the form of mono-sulfides (FeS). Sources of S include sulfates from acid mine drainage and sulfide bearing minerals (pyrites) in the marine shales and siltstones, and atmospheric deposition within the watershed. Another source could be from slow release fertilizer (granules) that use sulfur coatings.

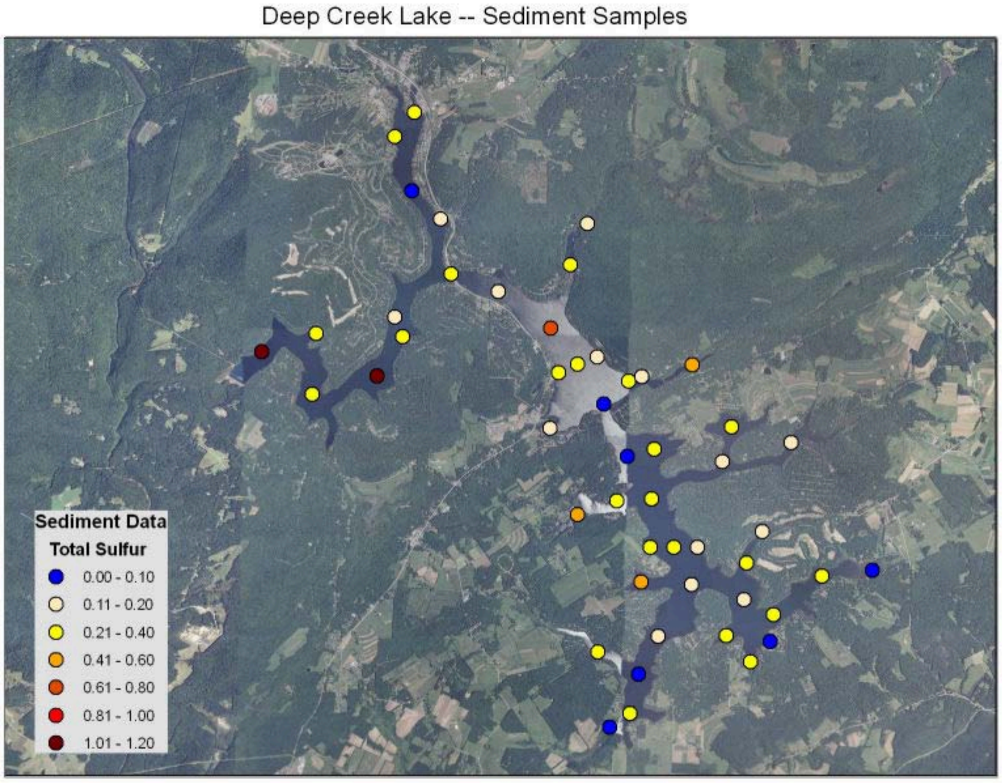


Figure 7. Total S (% dry weight) distribution in sediments.

Reduced S and sulfate (SO_4^{-2}) concentration is an extremely important variable controlling P release from sediments (Caraco *et al.* 1989; Wetzel, 1983). The increased P release from sediments at higher sulfate concentrations may help explain why primary production in freshwater systems (with relatively low S concentrations) tends to be P limited, whereas in many saline systems (with high sulfate concentrations) production is often P sufficient. Sulfur also plays an important role in arsenic cycling (Fisher et al., 2008), which explains the high correlations between S, As, and Fe (Table 4).

Metals

Table 6 lists summary statistics for those metals having reported threshold limits listing in NOAA Screening Quick Reference Tables (Buchman, 2008). Most elements listed in Table 6 are above background levels. Because the Deep Creek Lake samples were analyzed using a near total decomposition method (four-acid digestion), caution is warranted when comparing the resulting concentration values for some metals to threshold limits given in the NOAA tables. The values listed in the NOAA tables are based on EPA methods which allow partial decomposition of sediment samples and thus reflects that portion of any element that may become biologically available/mobile under extreme environmental conditions. For example, the NOAA tables list background levels in soil/sediments for Al as 0.26% which reflects the average Al biologically available. However, Actlabs' results for Al range from 1.06% to 7.33%, reflecting total recovery of the element by the digestions method used. Al is a major component of most minerals found in native rock and soils. Likewise, average concentrations of Fe and Mn exceed the NOAA background levels for the same reasons given for Al.

Table 6. Summary statistics of select metal concentration measured in Deep Creek sediments. All values are ppm unless otherwise indicated. For comparison, benchmark levels for freshwater sediments are included along with the number of lake samples exceeding the respective limit values. These benchmarks for freshwater sediments are based upon chronic, long-term impacts of contamination to benthic organisms (Buchman, 2008). The Lowest Effect Level (LEL) is a level of sediment contamination that can be tolerated by the majority of benthic organisms. The Severe Effect Level (SEL) is that at which pronounced disturbance of the sediment-dwelling community can be expected. This is the concentration that would be detrimental to the majority of the benthic community.

	As	**Cd**	**Cr**	**Cu**	**Hg (ppb)**	**Fe (%)**	**Mn**	**Ni**	**Pb**	**Zn**
Average	19.4	1.3	80.2	24.2	87.7	4.1	593.4	48.6	48.3	209.9
Std. Dev.	6.0	0.7	23.19	8.1	39.7	1.5	604.1	17.0	20.7	94.4
min	5.2	0.4	25	4	30	1.14	71	13	8	38
max	32.8	3.1	139	37	282	7.94	4280	95	99	462
Background	1.1	0.3	13	25	51	1.8	400	9.9	17	35
LEL	6	0.6	26	16	200	2	460	16	31	120
SEL	33	10	110	110	2000	4	1100	75	250	820
#>Background	50	48	50	27	39	45	34	50	46	50
#>LEL	49	42	49	39	1	45	26	48	39	41
#>SEL	0	0	4	0	0	31	2	2	0	0

Hg, on the other hand, may be compared to the NOAA tables. Hg, was analyzed using cold vapor extraction followed by FIMS method. However, because standard handing protocols for Hg sample analyses were not followed; maximum recoveries most likely were not achieved. Nevertheless, reported Hg concentrations for many of the Deep Creek Lake sediments exceeded the upper background level for fresh water sediments. Hg concentration reported for one sample, Sta. #2, exceeded the LEL threshold value. Generally, reported Hg concentrations increased with clay content (Figure 8). The levels of Hg concentration in the sediments are not unexpected and probably are higher than reported.

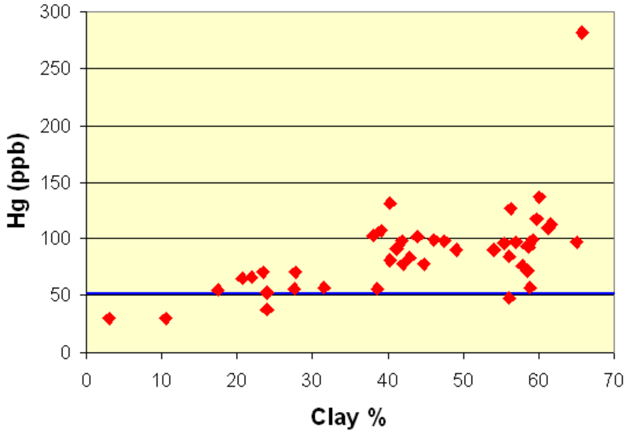


Figure 8. Plot of Hg concentration versus clay content. The blue line is the background level for freshwater sediments (51 ppb) (Buchman, 2008).

While, most metals of concern (As, Cd, Cr, Cu, Hg, Ni, Pb, Zn) are above the LEL in most sediments (Table 6), very few exceeded the SEL value. Most sediments containing metals above the LEL correspond the fine-grained sediments in the deepest part of the lake. Many of the metals show a significant correlations with clay content and nutrient content (N and P) as well as with other metals (Table 4).

Enrichment Factors

Because of the wide range of sediment types analyzed, comparisons of absolute metal concentrations between the surficial sediments are difficult. Therefore, metal concentrations are discussed in terms of enrichment factors (EF). The use of enrichment factors also allows for comparisons of sediments from different environments and the comparisons of sediments whose trace metal contents were obtained by different analytical techniques (Cantillo, 1982; Hill *et al.*, 1990; Sinex and Helz, 1981). However, the use of enrichment factors to assess metal data does not entirely eliminate the influence of textural variation.

Enrichment factor is defined as:

$$EF_{(x)} = X/Fe_{(sample)} \; / \; X/Fe_{(reference)} \qquad \text{Equation 3}$$

where: $EF_{(x)}$ is the enrichment factor for the metal X;

$X/Fe_{(reference)}$ is the ratio of the concentrations of metal X to Fe in a reference material, such as an average continental crust rock.

Fe is chosen as the element for normalizing because anthropogenic sources for Fe are small compared to natural sources (Helz, 1976). Taylor's (1964) average continental crust is used as the reference material. Average crustal abundance data may not be representative of Deep Creek Lake sediments because there is a higher proportion of clay and silt in the sediments compared to the average crustal rock. However, abundance data is useful as a relative indicator when comparing the data with other studies.

The average EF values for most metals are within those values obtained for other freshwater lakes and reservoirs (Table 7). The sediments in Deep Creek Lake are significantly enriched (*i.e.*, EF>3) in As, Cd, Cs, Hf, Pb, Sb, and Zn, with respect to average continental crust rock. The EF values are higher than those reported for New Germany Lake, which is located in the same physiographic and atmospheric deposition regions and, thus is expected to be similar in geochemistry. The higher enrichments, particularly As, Cd, and Sb, in Deep Creek Lake sediments are attributed to contribution from coal deposits within the lake's watershed. Coal deposits are generally enriched with these metals. Issues with documented acid mine drainage processes most likely further mobilized these elements. However, when EF values are plotted on a map, there appears to be not general pattern as to the distribution of the highest EF values. This may be due to several factors. There may be more than one source of the elements. The elements may have different geochemical behaviors during and after deposition in the lake. It should be noted that EF values for Pb are significantly high for all of the lakes listed illustrating the widespread anthropogenic sources for Pb.

Table 7. Comparisons of average enrichment factors in several Maryland fresh water lakes and reservoirs. Enrichment factors are relative to the average earth's crust (Taylor, 1964).

Element	**Loch Raven (Ortt *et al.*, 1999)**	**Triadelphia Reservoir (Wells *et al.* 2007)**	**Rocky Gorge Reservoir (Wells *et al.*, 2007)**	**New Germany Lake (Ortt *et al.*, 2009)**	**Deep Creek Lake (this study)**
Cd	0.28	4.93	1.89	0.9	8.90
Cr	1.62		0.93	1.05	1.19
Cu	0.85	0.83	0.95	0.52	0.62
Mn	1.25	1.09	1.45	0.50	0.94
Ni	0.86	0.80	0.77	0.69	0.91
Pb	4.35	4.26	3.83	3.46	5.24
Zn	2.87	1.98	1.92	2.62	4.09
Al		0.78	1.27	1.24	0.94
As			3.61	9.13	15.61
Ce			2.41	1.88	2.21
Co		1.74	1.17	0.87	2.13
Cs			1.87	2.99	3.54
Eu			2.56	1.83	2.16
Hf			3.79	6.77	7.48
Sb			3.19	10.64	24.41
Th		0.08	1.64	1.91	1.78
Ti			1.21	0.94	1.05
U			1.64	3.10	2.32
V		1.09	1.00	0.78	0.85
Y		2.25	2.29	1.48	1.39

SUMMARY AND CONCLUSIONS

Deep Creek Lake bottom sediment reflect the geology of the watershed. In general, the surficial sediments sampled in Deep Creek Lake are primarily fine-grained, ranging from silty clays to clayey silts. The predominance of clay size sediments is not unexpected given the abundance of shale in the underlying formations within the watershed.

Total C, N and P concentrations measured in Deep Creek Lake sediments are within the range of those reported for other Maryland freshwater lakes. Reactive carbon accounts for 70% of total carbon. Comparisons of total and reactive C content with N and P in terms of Redfield ratios for plankton and algae suggest that a significant portion of the reactive carbon is from primary productivity. Also, P appears to be the limiting nutrient in Deep Creek Lake sediments.

Unlike other Maryland freshwater lakes, total S content is high in some of the lake sediments. Sources of S include sulfates from acid mine drainage and sulfide bearing minerals (pyrites) in the marine shales and siltstones, and atmospheric deposition within the watershed. Under anoxic conditions, sulfur may contribute to the increased release of P from sediments, which, in turn, may increase primary productivity (i.e., algae blooms).

Concentration and enrichment of most metals in Deep Creek Lake sediments are within normal range given the geology of the watershed. The sediments are significantly enriched in As, Cd, Cs, Hf, Pb, Sb, and Zn, with respect to average continental crust rock. The EF values are higher than those reported for New Germany Lake, which is located in the same physiographic and atmospheric deposition regions and, thus is expected to be similar in geochemistry. The higher enrichments, particularly As, Cr, and Sb, in Deep Creek Lake sediments are attributed to contribution from coal deposits within the lake's watershed. Coal deposits are generally enriched with these metals as well as other rare earth elements. Documented acid mine drainage processes most likely mobilized these elements, resulting in higher concentrations compared to New Germany, where acid mine drainage may not be an issue. It should be noted that EF values for Pb are significantly high for all of the lakes listed, illustrating the widespread anthropogenic sources for Pb. Nevertheless, Pb levels in Deep Creek Lake sediments are well below the SEL benchmark threshold for freshwater sediments.

Reported Hg concentrations for many of the Deep Creek Lake sediments exceeded the upper background level for fresh water sediments. Generally, reported Hg concentrations increased with clay content. The levels of Hg concentration in the sediments are not unexpected and probably are higher than reported.

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Appendix I
QA/QC

Textural Analyses

Although the techniques used to determine grain size are based on traditional analytical methods developed for the sedimentology laboratory, 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

Table 8. Results of nitrogen, carbon, and sulfur analyses of the standard reference materials (SRMs) compared to the certified or known values. MGS values were obtained by averaging the results of all SRM analyses run during this study.

	NIST SRM 2704- Buffalo River			NIST SRM 1646a- Estuarine Sediments			NIST SRM 2702- Inorganics in Marine Sediment		
Element	NIST Values [1]	MGS Results	% Recovery	NIST Values [2]	MGS Results	% Recovery	NIST Values [2]	MGS Results	% Recovery
Total Nitrogen (% dry weight)	0.19 +/- 0.001	0.191 +/- 0.011	101.7	0.0583+/- 0.008	0.055 +/-0.008	93.9	0.251	0.255	101.6
Carbon (% dry weight)	3.348 +/- 0.016	3.443 +/- 0.078	102.8	0.583	0.581 +/-0.015	99.7	3.36	3.287	97.8
Sulfur (% dry weight)	0.37 +/- 0.004	0.283 +/- 0.034	50.9	0.352 +/- 0.004	0.317 +/-0.049	90.0	1.5	1.385	92.3

[1] For NIST 2704, the value for carbon is certified by NIST. The sulfur value is the non-certified value reported by NIST. The value of nitrogen was obtained from repeated analyses in-house and by other laboratories (Haake Buchler Labs and U.S. Dept. of Agriculture).

[2] For SRM the value for sulfur are certified values reported by NIST; nitrogen and carbon values were obtained from repeated analyses in-house and by Actlabs

Table 9. Results of analyses of Standard Reference Material (NIST SRM #8704 - Buffalo River Sediment) submitted as blind unknowns with the Deep Creek Lake surficial samples. Also given are the method detection limits for each element reported by Actlabs, Inc..

Analyte	Symbol	Unit	Detection Limit	Certified value	Std dev	Actlabs Results		
						Average	Std dev	% recovery
Silver	Ag	ppm	0.3			0.45	0.07	
Gold	Au	ppb	2			6		
Aluminum	Al	%	0.01	6.1	0.18	5.00	0.10	82.0
Arsenic	As	ppm	0.5	17		19.9	1.1	116.9
Barium	Ba	ppm	50	413	13	367	67	88.8
Beryllium	Be	ppm	1			2	0.0	
Bismuth	Bi	ppm	2			< 2		
Bromide	Br	ppm	0.5			6.6	1.2	
Calcium	Ca	%	0.01	2.641	0.083	2.92	0.02	110.6
Cadmium	Cd	ppm	0.3	2.94	0.29	3.2	0.1	108.8
Cerium	Ce	ppm	3	66.5	2	74.7	6.5	112.3
Cobalt	Co	ppm	1	13.57	0.43	15	2	110.5
Chromium	Cr	ppm	2	121.9	3.8	142	16	116.5
Cesium	Cs	ppm	1	5.83	0.12	7.67	0.58	131.5
Copper	Cu	ppm	1			91.33	5.03	
Europium	Eu	ppm	0.2	1.31	0.038	1.77	0.21	134.9
Iron	Fe	%	0.01	3.97	0.1	4.28	0.19	107.8
Hafnium	Hf	ppm	1	8.4	1.5	10	1.000	119.0
Mercury	Hg	ppb	1			901	4	
Iridium	Ir	ppb	5			< 5		
Potassium	K	%	0.01	2.001	0.041	2.05	0.03	102.6
Lanthanum	La	ppm	0.5			35.83	1.16	
Lutetium	Lu	ppm	0.05			0.47	0.06	
Magnesium	Mg	%	0.01	1.2	0.018	1.1	0.0	95.0
Manganese	Mn	ppm	1	544	21	563	10	103.5
Molybdenum	Mo	ppm	1			2.33	0.58	
Sodium	Na	%	0.01	0.553	0.015	0.617	0.015	111.5
Neodymium	Nd	ppm	5			29.7	10.0	
Nickel	Ni	ppm	1	42.9	3.7	43.7	0.6	101.8
Phosphorus	P	%	0.001			0.086	0.005	
Lead	Pb	ppm	3	150	17	134.3	3.5	89.6
Rubidium	Rb	ppm	15			91.7	9.7	
Sulfur	S	%	0.01			0.36	0.01	
Antimony	Sb	ppm	0.1	3.07	0.32	5.8	1.6	187.8
Scandium	Sc	ppm	0.1	11.26	0.19	12.97	0.75	115.2
Samarium	Sm	ppm	0.1			6.7	0.2	
Tin	Sn	%	0.01			< 0.01		
Strontium	Sr	ppm	1			125	2.0	
Tantatum	Ta	ppm	0.5			1.8		
Terbium	Tb	ppm	0.5			1.35	0.07	
Thorium	Th	ppm	0.2	9.07	0.16	9.57	1.08	105.5
Titanium	Ti	%	0.01	0.457	0.02	0.410	0.020	89.7
Uranium	U	ppm	0.5	3.09	0.13	3.13	0.99	101.4

Table 9. Results of analyses of Standard Reference Material (NIST SRM #8704 - Buffalo River Sediment) submitted as blind unknowns with the Deep Creek Lake surficial samples. Also given are the method detection limits for each element reported by Actlabs, Inc..

						Actlabs Results		
Analyte	**Symbol**	**Unit**	**Detection Limit**	**Certified value**	**Std dev**	**Average**	**Std dev**	**% recovery**
Vanadium	V	ppm	2	94.6	4	83.7	7.0	88.4
Tungsten	W	ppm	1			< 1		
Yttrium	Y	ppm	1			23.3	0.6	
Ytterbium	Yb	ppm	0.2			3.5	0.2	
Zinc	Zn	ppm	1	408	15	373	7	91.5

Table 10. Results of analyses of Standard Reference Material (NIST SRM #1646a- Estuarine Sediment) submitted as blind unknowns with the Deep Creek Lake surficial samples. Also given are the method detection limits for each element reported by Actlabs, Inc..

						Actlabs Results		
Analyte	**Symbol**	**Unit**	**Detection Limit**	**Certified value**	**Std dev**	**Average**	**Std dev**	**% recovery**
Silver	Ag	ppm	0.3			< 0.3		
Gold	Au	ppb	2			10		
Aluminum	Al	%	0.01	2.297	0.018	1.95	0.05	84.9
Arsenic	As	ppm	0.5	6.23	0.21	10.07	2.15	161.6
Barium	Ba	ppm	50			243	59	
Beryllium	Be	ppm	1			< 1		
Bismuth	Bi	ppm	2			< 2		
Bromide	Br	ppm	0.5			40.47	1.46	
Calcium	Ca	%	0.01	0.519	0.02	0.62	0.02	120.1
Cadmium	Cd	ppm	0.3	0.148	0.007	< 0.3		
Cerium	Ce	ppm	3			44	1.7	
Cobalt	Co	ppm	1			5	0.0	
Chromium	Cr	ppm	2	40.9	1.9	45	5.3	110.0
Cesium	Cs	ppm	1			< 1		
Copper	Cu	ppm	1	10.01	0.34	10	0.0	99.9
Europium	Eu	ppm	0.2			0.95	0.07	
Iron	Fe	%	0.01	2.008	0.039	2.28	0.03	113.7
Hafnium	Hf	ppm	1			15	1.0	
Mercury	Hg	ppb	1	40		29	0.6	73.3
Iridium	Ir	ppb	5			< 5		
Potassium	K	%	0.01	0.864	0.016	0.9	0.01	104.2
Lanthanum	La	ppm	0.5			22.4	0.4	
Lutetium	Lu	ppm	0.05			0.27	0.02	
Magnesium	Mg	%	0.01	0.388	0.009	0.383	0.01	98.8
Manganese	Mn	ppm	1	234.5	2.8	249	13	106.0
Molybdenum	Mo	ppm	1			1		
Sodium	Na	%	0.01	0.741	0.017	0.78	0.02	105.3

Table 10. Results of analyses of Standard Reference Material (NIST SRM #1646a- Estuarine Sediment) submitted as blind unknowns with the Deep Creek Lake surficial samples. Also given are the method detection limits for each element reported by Actlabs, Inc..

						Actlabs Results		
Analyte	**Symbol**	**Unit**	**Detection Limit**	**Certified value**	**Std dev**	**Average**	**Std dev**	**% recovery**
Neodymium	Nd	ppm	5			17.67	2.89	
Nickel	Ni	ppm	1			25	1.0	
Phosphorus	P	%	0.001	0.027	0.001	0.027	0.001	101.2
Lead	Pb	ppm	3	11.7	1.2	10.3	0.6	88.3
Rubidium	Rb	ppm	15			54	5	
Sulfur	S	%	0.01	0.352	0.004	0.367	0.006	104.2
Antimony	Sb	ppm	0.1			1.4	1.3	
Scandium	Sc	ppm	0.1			5.17	0.15	
Samarium	Sm	ppm	0.1			3.53	0.06	
Tin	Sn	%	0.01			< 0.01		
Strontium	Sr	ppm	1			68.33	0.58	
Tantatum	Ta	ppm	0.5			< 0.5		
Terbium	Tb	ppm	0.5			< 0.5		
Thorium	Th	ppm	0.2			5.93	0.21	
Titanium	Ti	%	0.01	0.456	0.021	0.463	0.06	101.6
Uranium	U	ppm	0.5			2.63	0.31	
Vanadium	V	ppm	2	44.84	0.76	38.33	13.32	85.5
Tungsten	W	ppm	1			< 1		
Yttrium	Y	ppm	1			9.33	0.58	
Ytterbium	Yb	ppm	0.2			1.7	0.2	
Zinc	Zn	ppm	1	48.9	1.6	46.7	0.6	95.4

Appendix II
Textural and Chemical Data

Table 11. Deep Creek Lake sediment sample locations, depths and field descriptions collected on October 19 and 20, 2010.

	MSPCS, m, NAD83		**UTM, Zone 18, m, NAD83**		**Depth**	**Field Descriptions**			
Station	**Northing**	**Easting**	**Northing**	**Easting**	**(m)**	**Sediment Type**	**Sediment Color**	**SAV/ Algae**	**Comments**
DCL-01	207796	194895	4374849	638758	20.3	mud	black	none	soft, smooth, gelatinous mud
DCL-02	207338	197028	4374751	640955	15.5	mud	black	none	smooth, slimy
DCL-03	209229	198400	4376698	642242	14.4	mud	graphite black	none	watery, soft, plant material, very smooth
DCL-04	208231	200244	4375783	644133	15	mud	dark olive grey	none	gelatinous, watery, soft
DCL-05	206821	201235	4374410	645180	12.8	clayey mud		none	firm clay
DCL-06	205061	202120	4372691	646145	10.5	mud		none	cohesive
DCL-07	203468	202851	4371138	646945	9.8	mud	olive brown	none	very smooth, gelatinous, soft
DCL-08	210779	197678	4378209	641454	8.7	mud	muddy sand	none	very firm, plant matter/sticks
DCL-09	209409	200610	4376975	644437	8.7	gritty mud	dark olive gray	none	plant material, mostly organics, fisheries on site
DCL-10	207247	201692	4374860	645618	2.9	mud	black (N2)	SAV	gelatinous, slightly gritty
DCL-11	205754	203429	4373448	647421	7.4	mud	black	none	reddish floc, leaf litter
DCL-12	205022	201478	4372127	645497	7.3	mud		none	olive gray to brown, gray little bit of black
DCL-13	203877	203873	4371587	647945	4.5	mud	dark olive gray to black	none	2 cm oxidized flock, soft gelatinous, very smooth
DCL-14	202919	204374	4370660	648491	6.4	mud		none	reddish oxidized floc, very smooth, soft mud
DCL-15	202222	201120	4369810	645213	3.5	mud	dark olive gray	none	very thin (1mm) rusty floc, soft smooth
DCL-16	201077	201709	4368695	645910	3.4	mud	dark olive gray	lots of SAV	shallow slope edges, very smooth, plant matter
DCL-17	210174	200930	4377501	644530	1.5	muddy sand		none	lots of gas, lots of organic material, sample downstream
DCL-18	204449	204162	4371982	648086	0.5	mud		SAV	lots of plant material and roots, sampled below road
DCL-19	207326	201934	4374949	645855	3.3	mud		algae	smooth, watery, reddish algae mat

Table 11. Deep Creek Lake sediment sample locations, depths and field descriptions collected on October 19 and 20, 2010.

	MSPCS, m, NAD83		UTM, Zone 18, m, NAD83		Depth	Field Descriptions			
Station	**Northing**	**Easting**	**Northing**	**Easting**	**(m)**	**Sediment Type**	**Sediment Color**	**SAV/ Algae**	**Comments**
DCL-20	200829	201344	4368436	645550	1.7	mud		rooted SAV	lots of roots
DCL-21	211780	197358	4379195	641036	2.3	mud	dark brownish gray	Lots of SAV	reddish floc over soft, smooth mud, rooted SAV
DCL-22	212227	197725	4379659	641434	3.8	mud		SAV	reddish floc, soft, smooth, gelatinous mud
DCL-23	210248	198214	4377702	642008	6	mud	olive brown	none	rust floc over 5cm, soft, fluffy mud over consolidated clay, same leaf litter
DCL-24	208125	195907	4375467	639792	3.2	mud		none	plant material, soft, gelatinous, leaf litter layer on structure
DCL-25	208437	197362	4375857	641241	11.7	mud	greenish gray	none	watery, smooth, sticks, plant material, black streaks
DCL-26	208072	197508	4375503	641400	11.2	mud		none	smooth mud
DCL-27	207004	195828	4374350	639778	7.4	mud		none	smooth, soft
DCL-28	208912	199280	4376416	643132	12.3	sandy, mud	brownish gray	none	plant material, gritty, clay balls
DCL-29	206373	200239	4373925	644210	3.1	mud		algae mat	plant material, sticks
DCL-30	206108	204697	4373859	648664	3.9	soupy mud		none	reddish algae floc, slightly gritty mud, very watery, plant matter
DCL-31	205980	202168	4373616	646150	8.4	mud	brownish gray	none	watery, soft, very fine gritty mud
DCL-32	204765	200742	4372337	644784	3.9	mud	olive gray	Filament-like SAV	firm, very slightly gritty
DCL-33	204162	202093	4371793	646159	4.8	clayey mud	dark olive brown	few strands	firm, cohesive, very smooth
DCL-34	204162	202524	4371811	646586	10.4	mud		none	reddish brown floc, plant material, watery, smooth/clayey lumps
DCL-35	204162	202970	4371840	647034	5.3	slimy mud	olive brown	none	rust colored surface, slightly gritty mud, gelatinous, sticky
DCL-36	203514	201920	4371140	646015	2.4	mud	olive gray	SAV	watery, lumpy, small clay lumps throughout
DCL-37	202510	202239	4370150	646377	7.9	mud	olive gray	none	gelatinous
DCL-38	203632	205273	4371403	649357	3.4	mud		none	reddish floc, gelatinous mud, smooth, soft
DCL-39	202528	203500	4370190	647627	1.5	mud	dark gray	SAV	smooth, gelatinous, rooted SAV

Table 11. Deep Creek Lake sediment sample locations, depths and field descriptions collected on October 19 and 20, 2010.

	MSPCS, m, NAD83		UTM, Zone 18, m, NAD83		Depth	Field Descriptions			
Station	**Northing**	**Easting**	**Northing**	**Easting**	**(m)**	**Sediment Type**	**Sediment Color**	**SAV/ Algae**	**Comments**
DCL-40	202034	203947	4369752	648098	1	mud	olive gray	SAV	smooth mud, rooted SAV, plant material
DCL-41	202418	204313	4370150	648452	1.4	gritty sandy		rooted SAV	tons of SAV
DCL-42	207406	200388	4374956	644303	10	mud		none	smooth (not gritty)
DCL-43	207564	200745	4375135	644664	14.8	gritty mud		none	organic/leaf litter, sticks
DCL-44	207698	201103	4375291	645015	3.8	gritty mud		SAV	algae floc
DCL-45	207553	202864	4375211	646762	1	soft mud		SAV	layer of leaf litter
DCL-46	206391	203592	4374086	647561	4.8	mud		none	very smooth, cohesive
DCL-47	205846	201661	4373455	645648	11.4	mud	olive gray	none	smooth, cohesive
DCL-48	201809	201870	4369434	646036	6.4	mud	olive brown/black	none	rusty floc, gelatinous, soft, watery
DCL-49	203190	203822	4370899	647927	8	mud	olive brown	none	smooth, soft, gelatinous, slightly oxidized pockets
DCL-50	203744	206206	4371483	650089	0.5	mud	light brown over olive gray	SAV & algal mat	slightly gritty, clay lumps

Table 12. Physical characteristics of the surficial sediment sample collected in Deep Creek Lake.

Station	**Water content % wet weight**	**Bulk Density g/cm^3**	**Size component (% dry weight)**				**Shepard's Classification**
			Gravel	**Sand**	**Silt**	**Clay**	
DCL-01	82.40	1.13	0.00	0.46	39.98	59.56	Silty-Clay
DCL-02	82.08	1.13	0.00	0.41	33.92	65.67	Silty-Clay
DCL-03	74.76	1.19	0.00	24.75	34.20	41.05	Sand-Silt-Clay
DCL-04	79.20	1.15	0.00	1.38	38.58	60.05	Silty-Clay
DCL-05	40.03	1.61	0.00	45.39	38.43	16.18	Silty-Sand
DCL-06	71.05	1.22	0.00	1.50	36.91	61.59	Silty-Clay
DCL-07	70.31	1.23	0.00	1.48	39.40	59.12	Silty-Clay
DCL-08	36.21	1.68	0.00	66.90	22.52	10.57	Silty-Sand
DCL-09	66.34	1.27	0.13	38.23	33.92	27.72	Sand-Silt-Clay
DCL-10	64.20	1.29	0.00	55.46	21.15	23.40	Sand-Silt-Clay
DCL-11	64.08	1.29	0.00	24.08	33.17	42.74	Sand-Silt-Clay
DCL-12	72.78	1.21	0.00	2.82	37.47	59.70	Silty-Clay
DCL-13	69.12	1.24	0.00	12.95	42.26	44.80	Silty-Clay
DCL-14	71.31	1.22	0.00	0.46	41.02	58.52	Silty-Clay
DCL-15	69.22	1.24	0.00	0.46	41.01	58.53	Silty-Clay
DCL-16	71.35	1.22	0.00	3.12	39.02	57.86	Silty-Clay
DCL-17	53.17	1.42	3.10	88.80	5.14	2.96	Sand
DCL-18	64.48	1.29	0.00	35.58	37.37	27.05	Sand-Silt-Clay
DCL-19	62.36	1.31	0.00	33.85	42.17	23.98	Sand-Silt-Clay
DCL-20	55.77	1.39	0.00	42.93	33.19	23.88	Sand-Silt-Clay
DCL-21	73.27	1.20	0.00	2.52	50.06	47.42	Clayey-Silt
DCL-22	69.21	1.24	0.00	4.04	49.95	46.01	Clayey-Silt
DCL-23	48.21	1.49	0.38	35.64	36.43	27.56	Sand-Silt-Clay
DCL-24	73.46	1.20	0.00	5.05	56.92	38.03	Clayey-Silt
DCL-25	76.95	1.17	0.00	17.29	38.77	43.94	Silty-Clay
DCL-26	81.02	1.14	0.00	1.11	40.93	57.96	Silty-Clay
DCL-27	72.79	1.21	0.00	18.11	41.69	40.20	Clayey-Silt
DCL-28	55.97	1.39	0.00	17.84	50.77	31.39	Clayey-Silt

Table 12. Physical characteristics of the surficial sediment sample collected in Deep Creek Lake.

Station	Water content % wet weight	Bulk Density g/cm^3	Size component (% dry weight)				Shepard's Classification
			Gravel	Sand	Silt	Clay	
DCL-29	58.55	1.36	0.00	36.09	42.04	21.88	Sand-Silt-Clay
DCL-30	65.96	1.27	0.00	20.38	37.63	41.98	Sand-Silt-Clay
DCL-31	72.59	1.21	0.00	2.08	41.63	56.28	Silty-Clay
DCL-32	69.14	1.24	0.00	3.72	35.03	61.26	Silty-Clay
DCL-33	65.22	1.28	0.00	3.19	42.82	53.99	Silty-Clay
DCL-34	74.00	1.20	0.00	12.41	38.55	49.04	Silty-Clay
DCL-35	68.59	1.25	0.00	30.29	29.47	40.23	Sand-Silt-Clay
DCL-36	72.77	1.21	0.00	1.22	33.78	65.00	Silty-Clay
DCL-37	75.34	1.18	0.00	4.65	38.50	56.85	Silty-Clay
DCL-38	71.48	1.22	0.00	0.66	40.59	58.75	Silty-Clay
DCL-39	74.59	1.19	0.00	1.25	45.38	53.37	Silty-Clay
DCL-40	62.54	1.31	0.00	7.75	53.65	38.61	Clayey-Silt
DCL-41	67.44	1.26	0.00	33.14	39.02	27.84	Sand-Silt-Clay
DCL-42	66.40	1.27	0.00	5.33	55.55	39.12	Clayey-Silt
DCL-43	69.39	1.24	0.00	1.72	42.14	56.14	Silty-Clay
DCL-44	59.47	1.34	0.00	58.95	23.72	17.33	Silty-Sand
DCL-45	73.70	1.20	0.00	5.14	53.06	41.81	Clayey-Silt
DCL-46	68.78	1.25	0.00	1.09	40.30	58.61	Silty-Clay
DCL-47	51.15	1.45	0.00	33.62	38.88	27.51	Sand-Silt-Clay
DCL-48	68.25	1.25	0.00	1.22	42.65	56.14	Silty-Clay
DCL-49	70.60	1.23	0.00	0.90	43.76	55.34	Silty-Clay
DCL-50	53.38	1.42	0.00	29.51	49.92	20.56	Sand-Silt-Clay

Table 13. Nutrient content for Deep Creek Lake sediment samples.

Station	Nutrient elements (% dry weight)				
	Nitrogen	**Total carbon**	**Reactive carbon**	**Sulfur**	**Phosphorus**
DCL-01	0.566	6.642	4.748	0.973	0.114
DCL-02	0.547	5.737	4.058	0.980	0.132
DCL-03	0.346	4.232	3.013	0.347	0.067
DCL-04	0.453	5.128	3.443	0.521	0.123
DCL-05	0.117	2.415	0.906	0.037	0.008
DCL-06	0.323	3.513	2.391	0.252	0.079
DCL-07	0.306	3.317	2.183	0.125	0.07
DCL-08	0.140	2.394	0.650	0.000	0.022
DCL-09	0.289	7.053	4.197	0.326	0.039
DCL-10	0.271	2.750	2.056	0.393	0.039
DCL-11	0.220	2.925	1.915	0.139	0.049
DCL-12	0.305	3.349	2.345	0.228	0.066
DCL-13	0.271	2.853	2.108	0.397	0.05
DCL-14	0.278	2.915	2.056	0.264	0.066
DCL-15	0.353	3.504	2.598	0.254	0.084
DCL-16	0.385	3.405	2.575	0.398	0.069
DCL-17	0.126	4.066	2.089	0.112	0.018
DCL-18	0.296	4.108	2.455	0.193	0.048
DCL-19	0.181	2.673	1.900	0.141	0.024
DCL-20	0.235	2.953	1.914	0.098	0.036
DCL-21	0.389	3.450	2.444	0.366	0.054
DCL-22	0.374	3.960	2.729	0.324	0.057
DCL-23	0.128	1.545	1.013	0.116	0.027
DCL-24	0.386	5.879	3.985	0.254	0.052
DCL-25	0.330	4.136	2.864	0.180	0.047
DCL-26	0.415	5.770	3.951	0.377	0.068
DCL-27	0.405	7.408	5.234	0.292	0.075
DCL-28	0.323	6.870	3.484	0.142	0.035
DCL-29	0.288	5.391	3.039	0.176	0.039
DCL-30	0.264	2.972	2.105	0.147	0.049
DCL-31	0.343	3.684	2.410	0.213	0.068
DCL-32	0.422	4.549	3.066	0.418	0.071
DCL-33	0.302	2.843	2.050	0.301	0.063
DCL-34	0.420	5.829	3.972	0.231	0.071
DCL-35	0.296	2.894	2.045	0.170	0.049

Table 13. Nutrient content for Deep Creek Lake sediment samples.

Station	Nutrient elements (% dry weight)				
	Nitrogen	**Total carbon**	**Reactive carbon**	**Sulfur**	**Phosphorus**
DCL-36	0.561	6.196	4.425	0.467	0.073
DCL-37	0.338	3.864	2.671	0.102	0.072
DCL-38	0.390	3.930	2.800	0.253	0.063
DCL-39	0.464	4.244	3.000	0.319	0.052
DCL-40	0.342	3.512	2.472	0.194	0.041
DCL-41	0.258	2.488	1.535	0.038	0.037
DCL-42	0.319	3.690	2.708	0.247	0.062
DCL-43	0.621	9.599	5.151	0.257	0.03
DCL-44	0.222	2.365	1.803	0.131	0.034
DCL-45	0.494	6.195	4.715	0.387	0.062
DCL-46	0.313	3.180	2.124	0.265	0.064
DCL-47	0.255	2.915	1.859	0.085	0.034
DCL-48	0.265	2.851	1.981	0.062	0.078
DCL-49	0.269	3.026	2.110	0.112	0.077
DCL-50	0.282	4.162	2.313	0.086	0.03

Table 14. Deep Creek Lake sediment elemental data. All values are ppm (ug/g) unless indicated otherwise.

Station	**Ag**	**Al%**	**As**	**Au**	**Ba**	**Be**	**Bi**	**Br**	**Ca%**	**Cd**	**Ce**	**Co**	**Cr**	**Cs**	**Cu**	**Eu**
DCL-01	0.3	6.07	30.9	< 2	430	4	< 2	16.1	0.25	2.5	83	63	101	8	33	1.8
DCL-02	0.3	6.44	32.8	< 2	450	5	< 2	19.4	0.18	2.1	96	66	93	8	37	1.9
DCL-03	< 0.3	5	21.4	5	< 50	3	< 2	10.1	0.2	1.4	86	45	78	5	27	1.8
DCL-04	0.4	6.93	24.7	8	500	5	< 2	12.3	0.21	2.3	105	76	100	10	36	1.9
DCL-05	< 0.3	3.43	5.2	< 2	330	2	< 2	2	0.19	0.6	66	16	68	5	10	1.5
DCL-06	< 0.3	7.25	23.9	5	580	3	< 2	7.9	0.23	1.3	109	38	70	11	34	1.9
DCL-07	< 0.3	7.04	21.5	< 2	510	3	< 2	6.5	0.22	0.9	105	28	85	11	29	1.9
DCL-08	0.5	2.14	8.5	< 2	190	< 1	< 2	2.5	0.2	< 0.3	51	9	44	1	7	1
DCL-09	0.3	2.79	16.4	< 2	280	2	< 2	6.5	0.19	1.2	60	49	46	4	11	1.4
DCL-10	< 0.3	3.44	22.9	< 2	< 50	3	< 2	5.6	0.08	2.1	65	74	56	4	20	1.3
DCL-11	< 0.3	5.58	18.1	10	450	2	< 2	6.6	0.18	0.8	83	20	80	6	29	1.6
DCL-12	< 0.3	6.76	21	< 2	550	3	< 2	7.8	0.2	1.5	95	36	85	11	32	1.5
DCL-13	< 0.3	5.88	24.5	< 2	290	3	< 2	6.6	0.13	0.8	84	28	75	8	26	1.8
DCL-14	< 0.3	7.33	21	< 2	560	3	< 2	7.4	0.17	0.9	101	31	85	11	30	2
DCL-15	< 0.3	7.15	20.9	8	660	3	< 2	9.8	0.2	0.9	106	21	83	10	26	2
DCL-16	0.3	6.89	19.4	< 2	640	3	< 2	8.6	0.21	1.2	100	29	79	11	28	1.5
DCL-17	1.6	1.06	6.8	< 2	120	< 1	< 2	2.9	0.17	0.5	34	51	25	< 1	4	< 0.2
DCL-18	< 0.3	4.77	17	< 2	280	3	< 2	6.1	0.21	0.9	74	19	69	9	21	1.6
DCL-19	< 0.3	3.19	18.5	10	300	2	< 2	4.3	0.1	0.8	78	35	59	4	16	1.6
DCL-20	< 0.3	3.72	15.1	< 2	310	2	< 2	5.9	0.13	0.4	74	13	53	6	12	1.5
DCL-21	< 0.3	6.15	22.5	12	520	3	< 2	8.1	0.23	2	95	55	131	7	29	1.8
DCL-22	< 0.3	5.78	19.8	< 2	520	3	< 2	8.1	0.21	2.1	92	42	124	8	29	1.8
DCL-23	< 0.3	4.5	14.3	< 2	530	2	< 2	2.9	0.11	0.7	96	29	101	5	16	1.7
DCL-24	< 0.3	6.15	21.5	7	490	4	< 2	10.9	0.19	2.5	112	95	139	5	27	2.1
DCL-25	< 0.3	5.59	20.5	< 2	550	3	< 2	7.5	0.19	1.4	85	47	127	5	25	1.8

Table 14. Deep Creek Lake sediment elemental data. All values are ppm (ug/g) unless indicated otherwise.

Station	**Ag**	**Al%**	**As**	**Au**	**Ba**	**Be**	**Bi**	**Br**	**Ca%**	**Cd**	**Ce**	**Co**	**Cr**	**Cs**	**Cu**	**Eu**
DCL-26	0.4	3.79	24.2	10	470	3	< 2	11.8	0.19	1.8	95	68	107	8	31	1.4
DCL-27	0.4	5.1	28.6	15	490	3	< 2	10.7	0.28	2.9	85	81	79	5	25	2
DCL-28	< 0.3	3.91	13.1	< 2	310	1	< 2	3.6	0.32	0.5	70	12	64	7	11	1.4
DCL-29	< 0.3	3.72	17.8	< 2	260	2	< 2	4.9	0.51	1.3	74	17	73	5	22	1.7
DCL-30	< 0.3	5.68	18.4	< 2	530	3	< 2	8.6	0.19	0.9	85	22	65	8	25	1.7
DCL-31	< 0.3	6.87	16.1	< 2	640	3	< 2	9.5	0.22	1.5	108	38	99	9	34	1.4
DCL-32	0.3	6.66	31.1	< 2	660	3	< 2	9	0.24	2.3	111	46	83	9	32	2
DCL-33	0.4	6.67	24.1	22	470	3	< 2	6.1	0.17	1.2	101	34	87	9	27	1.8
DCL-34	0.3	5.44	31.5	< 2	520	3	< 2	6.8	0.23	1	91	30	87	7	25	1.4
DCL-35	< 0.3	5.45	16.9	13	600	3	< 2	6.6	0.15	1.2	86	29	66	8	25	2
DCL-36	< 0.3	6.98	29.3	< 2	600	4	< 2	10.3	0.27	1.8	108	38	94	9	31	2
DCL-37	0.3	6.92	18	< 2	600	3	< 2	7.8	0.21	0.8	100	26	95	13	28	1.8
DCL-38	< 0.3	6.89	18.8	< 2	650	3	< 2	8.1	0.22	0.7	104	25	87	12	27	1.8
DCL-39	< 0.3	6.6	19.9	< 2	640	3	< 2	11.6	0.22	1.5	104	30	92	10	30	2.1
DCL-40	< 0.3	5.77	14.2	< 2	580	3	< 2	9	0.22	0.8	100	23	84	8	23	2
DCL-41	< 0.3	4.6	19.7	< 2	490	2	< 2	9.2	0.26	0.4	84	20	73	7	18	1.8
DCL-42	< 0.3	5.5	17	< 2	690	3	< 2	6.5	0.19	1.7	95	61	80	7	29	1.9
DCL-43	0.7	2.22	12.1	< 2	200	1	< 2	4.2	0.22	0.9	47	19	31	3	12	1.1
DCL-44	< 0.3	3.1	17.4	< 2	350	2	< 2	5	0.1	1.1	62	47	55	4	16	1.4
DCL-45	< 0.3	5.22	17.4	< 2	550	5	< 2	13	0.23	3.1	97	65	69	4	21	1.9
DCL-46	< 0.3	6.76	15.9	9	680	3	< 2	7.8	0.23	1.1	104	24	84	9	37	1.9
DCL-47	< 0.3	4.07	11.5	< 2	260	1	< 2	3.4	0.17	< 0.3	78	14	62	5	14	1.4
DCL-48	< 0.3	7.22	18.8	< 2	500	3	< 2	8.2	0.21	0.7	105	22	92	9	27	1.8
DCL-49	0.3	7.28	18	8	780	3	< 2	7.8	0.19	1.1	111	31	88	11	30	1.9
DCL-50	< 0.3	3.71	11.5	< 2	350	2	< 2	4.8	0.19	0.5	63	17	59	4	17	1.4

Table 14 (cont.). Deep Creek Lake sediment elemental data. All values are ppm (ug/g) unless indicated otherwise.

Station	Fe%	Hf	Hg (ppb)	Ir	%K	La	Lu	Mg%	Mn	Mo	Na%	Nd	Ni	Pb	Rb	S%
DCL-01	7.94	9		< 5	1.43	45.9	0.47	0.36	509	5	0.17	31	64	76	119	1.12
DCL-02	7.47	6	282	< 5	1.76	46.9	0.55	0.45	525	4	0.16	25	71	99	143	1.16
DCL-03	5.71	13	91	< 5	1.33	41	0.59	0.37	477	2	0.16	25	53	84	101	0.37
DCL-04	6.7	9	137	< 5	2.02	50.4	0.65	0.49	436	3	0.17	59	71	83	141	0.61
DCL-05	1.45	18		< 5	1.18	30.4	0.55	0.24	280	< 1	0.16	19	22	16	68	0.03
DCL-06	5.07	8	113	< 5	2.15	51.3	0.55	0.55	370	< 1	0.16	53	56	77	163	0.31
DCL-07	4.61	10	99	< 5	2.46	50.5	0.63	0.53	379	< 1	0.19	40	50	55	196	0.15
DCL-08	1.14	14	30	< 5	0.67	25.3	0.4	0.15	71	< 1	0.08	23	13	10	26	0.03
DCL-09	2.13	18	71	< 5	0.61	28.4	0.44	0.15	315	2	0.08	31	34	27	< 15	0.33
DCL-10	4.16	16	71	< 5	1.05	32.8	0.39	0.25	662	1	0.09	33	64	45	78	0.39
DCL-11	3.3	13	83	< 5	1.76	41.5	0.47	0.41	356	< 1	0.14	23	38	53	115	0.14
DCL-12	4.97	10	117	< 5	2.22	49.6	0.57	0.5	535	< 1	0.16	46	60	71	155	0.22
DCL-13	4.47	13	78	< 5	2.24	42.1	0.56	0.43	499	< 1	0.15	41	48	51	140	0.38
DCL-14	4.5	10	94	< 5	2.59	52.1	0.64	0.55	371	< 1	0.19	38	51	62	153	0.24
DCL-15	4.76	9	72	< 5	2.49	52.5	0.59	0.52	466	1	0.17	43	49	35	145	0.23
DCL-16	4.13	8	76	< 5	2.48	50.4	0.66	0.48	470	1	0.17	43	53	41	123	0.36
DCL-17	1.41	26	30	< 5	0.17	15.6	0.24	0.05	1040	1	0.03	10	23	8	< 15	0.11
DCL-18	2.84	11		< 5	2.08	39.6	0.51	0.4	356	< 1	0.16	29	41	29	100	0.18
DCL-19	3.6	23	52	< 5	1.07	36.8	0.64	0.25	537	1	0.11	29	41	28	45	0.13
DCL-20	2.14	13	38	< 5	1.32	33.6	0.57	0.24	226	< 1	0.1	23	27	19	81	0.1
DCL-21	6.24	10	98	< 5	2.02	47.2	0.56	0.56	960	< 1	0.19	38	67	55	129	0.39
DCL-22	4.97	12	99	< 5	1.94	45.6	0.57	0.46	543	< 1	0.17	39	60	57	130	0.35
DCL-23	3.46	13		< 5	1.43	44.6	0.51	0.34	644	< 1	0.16	31	33	44	109	0.12
DCL-24	4.43	12	103	< 5	1.53	58.4	0.64	0.34	4280	< 1	0.17	44	95	58	100	0.29
DCL-25	4.41	12	101	< 5	1.58	42.5	0.49	0.38	577	< 1	0.16	31	54	58	98	0.19

Table 14 (cont.). Deep Creek Lake sediment elemental data. All values are ppm (ug/g) unless indicated otherwise.

Station	Fe%	Hf	Hg (ppb)	Ir	%K	La	Lu	Mg%	Mn	Mo	Na%	Nd	Ni	Pb	Rb	S%
DCL-26	5.12	9		< 5	1.44	46.3	0.6	0.32	599	2	0.17	40	63	66	96	0.34
DCL-27	5.32	10	131	< 5	1.2	41.7	0.51	0.32	1020	2	0.13	22	81	77	78	0.3
DCL-28	1.74	13	57	< 5	1.18	35.2	0.6	0.25	450	1	0.14	30	16	22	95	0.15
DCL-29	2.57	18	66	< 5	1.26	39.1	0.57	0.33	283	2	0.16	31	32	34	82	0.19
DCL-30	3.67	13	78	< 5	2.03	43.9	0.46	0.44	330	< 1	0.16	33	44	57	124	0.16
DCL-31	4.54	10	127	< 5	2.03	52	0.52	0.5	438	< 1	0.17	46	58	76	152	0.24
DCL-32	4.39	9	110	< 5	2.24	49.9	0.48	0.49	488	2	0.14	43	65	69	143	0.45
DCL-33	4.59	9	90	< 5	2.13	49.1	0.69	0.49	506	2	0.17	44	49	52	121	0.31
DCL-34	4.16	10	90	< 5	1.47	46.9	0.62	0.4	409	1	0.16	39	42	45	120	0.24
DCL-35	4.37	16	81	< 5	2.02	43.8	0.61	0.41	506	< 1	0.13	38	45	48	100	0.19
DCL-36	4.07	8	97	< 5	2.31	50.7	0.56	0.49	682	1	0.16	36	65	50	174	0.49
DCL-37	4.69	9	97	< 5	2.39	54	0.62	0.51	416	< 1	0.18	46	49	49	144	0.11
DCL-38	4.63	8	57	< 5	1.96	51.6	0.65	0.51	532	< 1	0.18	40	47	40	174	0.28
DCL-39	3.76	9		< 5	1.97	48.9	0.53	0.49	447	< 1	0.21	39	58	49	160	0.37
DCL-40	3.7	12	56	< 5	2.16	49.1	0.66	0.45	429	< 1	0.23	49	44	34	127	0.21
DCL-41	3.78	16		< 5	1.94	41.6	0.68	0.37	2040	< 1	0.18	34	38	27	105	0.04
DCL-42	5.1	14	107	< 5	1.75	49.5	0.59	0.46	505	< 1	0.19	36	67	73	105	0.26
DCL-43	1.78	20	48	< 5	0.69	23.2	0.32	0.16	370	3	0.05	27	20	16	55	0.27
DCL-44	3.66	15	55	< 5	0.92	30.9	0.46	0.22	836	2	0.08	19	49	38	61	0.14
DCL-45	4.4	11	98	< 5	1.45	46.4	0.58	0.33	635	2	0.18	41	61	42	113	0.41
DCL-46	4.47	9	92	< 5	1.97	51	0.62	0.5	389	< 1	0.18	31	51	51	149	0.28
DCL-47	2.3	16	56	< 5	1.39	37.4	0.53	0.29	295	< 1	0.16	26	20	34	74	0.09
DCL-48	4.67	9	84	< 5	2.51	55.6	0.62	0.52	420	< 1	0.19	47	47	48	166	0.06
DCL-49	5.1	9	96	< 5	2.59	55.1	0.66	0.54	400	< 1	0.2	49	50	56	176	0.12
DCL-50	2.03	15	65	< 5	1.47	33.1	0.54	0.27	360	< 1	0.14	36	29	23	63	0.09

Table 14 (cont.). Deep Creek Lake sediment elemental data. All values are ppm (ug/g) unless indicated otherwise.

Station	Sb	Sc	Se	Sm	Sn%	Sr	Ta	Tb	Th	Ti%	U	V	W	Y	Yb	Zn
DCL-01	6.9	13.8	< 3	6.8	< 0.01	73	2	< 0.5	11.8	0.48	5	111	< 1	30	3.6	366
DCL-02	7.4	14.8	< 3	7.3	< 0.01	82	4.3	< 0.5	11.4	0.46	5.1	117	< 1	33	3.4	372
DCL-03	7.6	11.9	< 3	6.6	< 0.01	72	< 0.5	1.1	10	0.43	4.9	82	6	29	3.3	283
DCL-04	7.6	15.5	< 3	8	< 0.01	87	< 0.5	< 0.5	12.6	0.52	6.6	125	< 1	36	3.9	462
DCL-05	11	8.5	< 3	5.1	< 0.01	59	< 0.5	1.5	9	0.07	3.4	14	< 1	24	3.5	67
DCL-06	2.6	16.5	< 3	7.9	< 0.01	103	2.4	1.3	13.6	0.37	5.3	83	< 1	28	4.1	262
DCL-07	2.8	16.6	< 3	7.8	< 0.01	108	< 0.5	1.4	14	0.34	5	82	< 1	28	4.3	204
DCL-08	1	5.4	< 3	3.9	< 0.01	33	1.1	< 0.5	6.5	0.35	1.9	41	< 1	18	2.3	38
DCL-09	1.4	6.5	< 3	4.8	< 0.01	44	< 0.5	< 0.5	6.4	0.34	< 0.5	50	< 1	30	3	166
DCL-10	1.8	8.3	< 3	5.3	< 0.01	46	< 0.5	1.1	8.4	0.39	2.6	68	< 1	27	3.4	308
DCL-11	2	12.3	< 3	6	< 0.01	79	3.5	1	11.4	0.37	4.3	81	< 1	25	3.6	164
DCL-12	2.6	15.5	< 3	7.3	< 0.01	92	< 0.5	< 0.5	13.6	0.34	4.4	72	< 1	27	3.5	271
DCL-13	2.3	13.5	< 3	6.5	< 0.01	84	< 0.5	< 0.5	11.8	0.47	4.5	79	6	27	4	170
DCL-14	2.5	17.4	< 3	7.8	< 0.01	115	< 0.5	< 0.5	14.3	0.44	4.5	99	< 1	28	4.1	191
DCL-15	2.1	16.4	< 3	7.9	< 0.01	107	< 0.5	< 0.5	14.6	0.53	5.1	121	< 1	27	4.3	182
DCL-16	1.9	15.9	< 3	7.6	< 0.01	110	< 0.5	1.3	13.1	0.53	4.1	114	10	26	4	195
DCL-17	0.6	2.8	< 3	2.6	< 0.01	26	< 0.5	< 0.5	2.8	0.16	< 0.5	17	< 1	51	1.6	85
DCL-18	1.6	11.8	< 3	6.4	< 0.01	162	< 0.5	< 0.5	10.4	0.29	3.6	171	< 1	27	3.8	126
DCL-19	1.6	8.5	< 3	5.9	< 0.01	45	1.6	1.1	9.9	0.4	3.5	55	5	27	4.6	157
DCL-20	1.6	9.5	< 3	5.3	< 0.01	67	1.5	< 0.5	9.8	0.46	3.9	75	< 1	23	3.1	75
DCL-21	2.3	13.5	< 3	6.4	< 0.01	78	2.2	< 0.5	12.5	0.45	5.5	81	9	25	3.6	316
DCL-22	2.2	13	< 3	6.6	< 0.01	79	1.7	< 0.5	11.8	0.39	5.7	58	< 1	26	3.9	292
DCL-23	1.7	9.6	5	6.2	< 0.01	70	1.7	< 0.5	10.5	0.18	3	37	< 1	22	3.6	138
DCL-24	2.3	13.3	< 3	8.2	< 0.01	59	< 0.5	< 0.5	12	0.41	5.1	74	< 1	34	4.9	337
DCL-25	2.2	11.8	< 3	6.5	< 0.01	75	2.2	< 0.5	11.4	0.3	3.9	55	< 1	28	3.5	299

Table 14 (cont.). Deep Creek Lake sediment elemental data. All values are ppm (ug/g) unless indicated otherwise.

Station	Sb	Sc	Se	Sm	Sn%	Sr	Ta	Tb	Th	Ti%	U	V	W	Y	Yb	Zn
DCL-26	3.3	14.2	< 3	7.2	< 0.01	71	< 0.5	< 0.5	12.1	0.5	4	110	< 1	13	3.8	340
DCL-27	4.9	11.6	< 3	6.4	< 0.01	65	< 0.5	< 0.5	10.1	0.48	3.6	94	< 1	27	3.5	323
DCL-28	3.9	8.7	< 3	5.1	< 0.01	68	< 0.5	< 0.5	8.3	0.49	3.9	67	< 1	22	3.8	89
DCL-29	3.5	9.5	< 3	6.5	< 0.01	65	1.6	< 0.5	9.9	0.48	5.2	72	< 1	29	3.9	166
DCL-30	4	12.9	< 3	6.8	< 0.01	79	2.2	< 0.5	12.5	0.25	4	50	< 1	26	3.6	182
DCL-31	5.2	16.3	< 3	7.8	< 0.01	94	< 0.5	1.8	13.9	0.48	4.2	89	< 1	28	3.8	272
DCL-32	5.3	15.9	< 3	8.1	< 0.01	90	< 0.5	< 0.5	12.6	0.51	5.6	117	< 1	28	3.5	288
DCL-33	5.6	15.5	< 3	7.5	< 0.01	98	2.3	< 0.5	12.9	0.55	3.8	118	< 1	25	4.2	209
DCL-34	5.2	14.2	< 3	7.4	< 0.01	85	2.2	< 0.5	13	0.52	3.9	104	< 1	27	3.9	164
DCL-35	4.4	13	< 3	6.9	< 0.01	79	1.7	< 0.5	11.8	0.51	3.9	101	< 1	26	3.6	186
DCL-36	4.7	16.3	< 3	8.1	< 0.01	104	< 0.5	< 0.5	14	0.5	3.8	129	< 1	28	3.9	231
DCL-37	5.1	16.5	< 3	8.1	< 0.01	107	2.5	< 0.5	14.7	0.35	5.1	90	< 1	28	4	185
DCL-38	4	17	< 3	7.7	< 0.01	101	2.7	< 0.5	13.9	0.39	4.4	68	< 1	27	3.9	161
DCL-39	3.8	16	< 3	7.7	< 0.01	104	2.6	< 0.5	13.6	0.42	3.9	60	< 1	28	4.2	216
DCL-40	1.9	15.3	< 3	7.6	< 0.01	96	2.2	< 0.5	13.9	0.26	4.2	33	< 1	27	5.1	147
DCL-41	1.2	12.4	< 3	6.5	< 0.01	83	1.8	< 0.5	11.3	0.11	3.4	38	9	27	4.3	115
DCL-42	2	13.5	< 3	7.4	< 0.01	76	< 0.5	< 0.5	13.2	0.33	3.8	43	< 1	29	5	336
DCL-43	1.1	5.7	< 3	3.9	< 0.01	37	1.4	< 0.5	5.8	0.26	2.4	46	< 1	44	2.7	101
DCL-44	1.2	7.7	< 3	4.9	< 0.01	41	< 0.5	1.1	7.3	0.36	2.6	60	< 1	25	3.2	211
DCL-45	1.2	12	< 3	7.2	< 0.01	64	1.5	1.5	10.7	0.53	5.5	93	< 1	30	4.3	326
DCL-46	1.4	15.9	< 3	7.4	< 0.01	93	1.4	1.2	13.5	0.38	4.9	70	< 1	26	4.2	192
DCL-47	1.2	10.4	< 3	5.5	< 0.01	65	1.5	1.4	9.4	0.29	4.1	54	< 1	24	4.3	76
DCL-48	1.9	17.1	< 3	7.8	< 0.01	112	< 0.5	< 0.5	14.7	0.47	3	112	< 1	27	4.1	179
DCL-49	2.2	18	< 3	8	< 0.01	111	< 0.5	1.4	14.4	0.52	4.3	121	< 1	28	4.5	192
DCL-50	0.9	9	< 3	5.1	< 0.01	64	2.9	< 0.5	9.1	0.18	4.3	33	< 1	26	4.1	84