LATE HOLOCENE ENVIRONMENTAL VARIABILITY AS RECORDED IN THE
SEDIMENT OF A NORTHEASTERN OHIO KETTLE LAKE

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ABSTRACT

Lake sediment can provide records of past changes in climate, water budget and lake level, ecosystems, and human impacts to the environment. This study uses the sediment from Brady Lake, a kettle lake in northeastern Ohio, to determine Late Holocene natural and anthropogenic environmental variability. Because no bathymetric map of the lake was available, one was created in ArcMap by collecting 7,507 latitude, longitude, and water depth measurements with a Garmen 125 fathometer and GPS unit. Sediment dispersal processes were studied by collecting surface samples throughout Brady Lake. Dense, sandy sediment, having low organic content ($<5\%$), were present in water less than 1.5 m deep where wind-wave orbital motion prevents muds from accumulating. Low density, porous muds, having high organic content (30%), accumulate below 1.5 m due to sediment focusing. A 4.13-m-long Livingston piston core was collected from the central deep-water basin to evaluate 2840 Cal yr of environmental change. Age control was determined through radiocarbon dating and correlating event stratigraphy datums to other dated Ohio kettle lake sediment records. Between 4.13 and 1.9 m core depth (2840-210 Cal yr BP), low density gyttja having 70% organic content and a C/N ratio of ~ 13.7 is present. These sediment characteristics are interpreted as the pre-Euro American settlement period when the watershed was forested and sediment yield was low. Within this interval, five lows in organic content, having increased sediment density, suggests a decrease in vegetation and increased watershed erosion. These changing watershed conditions may reflect fluctuations in atmospheric circulation and moisture balance during the Late Holocene. Furthermore, these lows agree with the timing of

globally distributed rapid climate change occurring between 3500-2500; 1200-1000; and 600-150 Cal yr BP identified by Mayewski et al. (2004). At 1.9 m core depth, the gyttja abruptly changes to bedded mud having increased concentrations of Pb, Cu, Zn, and Cr interpreted as the onset of Euro-American settlement in 1805. The Pre-settlement sedimentation rate was 0.080 cm/yr which increases 11-fold to 0.905 cm/yr following land clearance and watershed disturbance by settlers. Further anthropogenic impacts accompanied the construction of the Pennsylvania and Ohio Canal in 1840 when the level of Brady Lake was raised 3-4.6 m in order to provide a source of canal water. Between 1.9 and 1.4 m (1805-1868 AD) core depth, high density bedded mud is interpreted to reflect increased influx of watershed mineral erosion following deforestation (1805 AD) and high water levels during the time of the canal (1840-1868 AD). Between 1.4 and 1.12 m (1868-1891 AD) core depth, a change from bedded mud to lower density brown mud is inferred to represent a decrease in lake level following the draining of the canal in 1868 and continued watershed erosion. Between 1.12 and 0.20 m (1891-1980 AD) core depth, black mud having high ferrimagnetic content and heavy metal concentrations reflects increased anthropogenic impacts associated with the presence of a major lakeside amusement park from 1891 to 1960. In the uppermost 0.2 m (1980-2015 AD), Pb, Cu, Zn, and Cr concentrations decline likely due to the closure of the amusement park and the effectiveness of environmental regulations.

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CHAPTER I

INTRODUCTION

1.1 Overview

Lake sediment provides detailed records of past changes to lake and watershed systems including changes in climate, water budget and lake level, ecosystems, and human impacts (Cohen, 2003; Smol, 2008). The environment of northeastern Ohio has been dramatically altered from glacial activity traced back to pre-Wisconsinan glaciations (Szabo and Totten, 1995). Not only has the landscape been impacted by glacial activity, but it has also undergone numerous shifts in climate throughout the Holocene (Mayewski et al., 2004). Remaining relatively undisturbed during Native American occupation, northeastern Ohio was heavily impacted by anthropogenic activity during and post Euro-American settlement (Enders, 2011).

Throughout the Holocene, there have been changes to the moisture balance in the northern hemisphere, including in the US Midwest region (Mayewski et al., 2004). Multi-proxy analysis of lake sediment cores can be used to reconstruct paleoenvironments. For example, sediments from Elk Lake, Minnesota, record Holocene climate change (Dean et al., 1996; Dean, 1997). In the last 4000 years, increases in quartz and feldspar abundance and magnetic susceptibility are interpreted as increased eolian activity delivering more detrital sediment to Elk Lake during arid periods. During the Little Ice Age and the Dust Bowl of the 1930's, Elk Lake sediment also shows increased eolian activity and aridity (Dean, 1997).

Major anthropogenic activity in Ohio began approximately 1800 AD with the arrival of Euro-American settlers. Previous lake sediment studies in northeastern Ohio have documented European settlement by an abrupt decline in organic content, increased magnetic susceptibility and heavy metal concentrations, high sediment density, and low carbon to nitrogen ratios (C/N) within the sediment record (Haney, 2004; Shaw, 2013; Mitchell, 2015; Lally, 2016). Mitchell (2015) interpreted the increase in dry bulk density and magnetic susceptibility as increased soil erosion and sediment yield from deforestation. Shaw (2013) interpreted the lower carbon to nitrogen ratios of sedimentary organic matter as a decrease in terrestrial vegetation from land clearance. Sediment changes such as increased heavy metal concentration is often due to pollution in the watersheds (Haney, 2004; Shaw, 2013; Mitchell, 2015).

This study uses the sediment record from Brady Lake (Figure 1), a kettle lake in northeastern Ohio, to determine past natural and anthropogenic environmental variability. Because no bathymetric map was available to the public prior to this study, one was created. Sediment focusing processes were studied by analyzing surficial sediment samples and wave climate interaction. Multiple sediment cores were collected from the deep-water basin to compile a complete composite sediment record spanning the Late Holocene. Terrigenous sediment input to Brady Lake was hypothesized to increase during past dry conditions when the shoreline regressed. In addition, heavy metal concentration was hypothesized to increase during the time of the lakeside Brady Lake Electric Amusement Park. Anthropogenic impacts to Brady Lake are interpreted by correlating downcore sedimentological and geochemical properties with historical documentation. The significance of this study is that it provides greater spatial coverage of Late Holocene environmental change in the US Midwest as climate varied and Euro-Americans altered the landscape. Furthermore, this study provides insight on environmental conditions when the region's Native American occupants, the Hopewell, began to rapidly decline

Figure 1. (Top) Inset map showing the location of Brady Lake in northeastern, Ohio. (Bottom) Brady Lake is located in Portage County south of Lake Pippen and Lake Rockwell. Aerial photographs were obtained from ArcMap (2016).

at approximately 1600 cal yr B.P. (“Hopewell Culture,” n.d.). Furthermore, this study clarifies how the arrival of Euro-American settlers in northeast Ohio is reflected in the lake sediment. Results from this study can also be used as a reference for future lake management decisions.

1.2 Glacial History and Geology

Brady Lake is located in Franklin Township of Portage County, Ohio, just east of the city of Kent. Pennsylvanian age bedrock underlies Brady Lake (Coogan, 1996). Evidence of glacial activity in northeastern Ohio (Figure 2) can be traced back to pre-Wisconsinan glaciations (Szabo and Totten, 1995). Brady Lake is situated in the region associated with the Grand River Lobe, which was responsible for glaciating part of northeastern Ohio and northwestern Pennsylvania (Szabo, 1987). Throughout the Late Wisconsinan, the Grand River Lobe deposited the Kent, Lavery, Hiram, and Ashtabula Tills (Szabo and Totten, 1995). Based on radiocarbon dating, Kent ice advanced southward out of the Erie basin about 23,000 yr BP (Szabo et al., 2006). The Kent ice then retreated into Canada during the Erie Interstade about 16,500 yr BP (Szabo et al., 2006). Next came the Lavery ice advance and retreat at 15,500 to 15,100 years ago (Kushner, 2006). Following the retreat of the Lavery ice came the Hiram ice, which reached its greatest extent approximately 14,800 yr BP and retreated approximately 14,500 yr BP (Szabo et al., 2006 and 2013). Throughout the Lavery and Hiram glaciations, Brady Lake remained in the interlobate region of the Grand River and Cuyahoga Lobes (White, 1979; Szabo et al., 2006). The youngest ice advance at 14,000 yr BP, the Ashtabula, did not extend south to Portage County, Ohio (White, 1979; Szabo et al., 2006).

Brady Lake is a kettle lake with a surface area of approximately 0.3 km² and a maximum depth of 13.5 meters. As a closed lake, the lake receives water from precipitation on its surface, runoff from the slopes around the lake, and groundwater

GLACIAL MAP OF OHIO

Figure 2. Glacial deposit map of Ohio modified after Ohio Division of Geological Survey (2005). The red dot indicates the approximate location of Brady Lake.

(“Traditional Navigable Waterways,” 2012). The lake is located in a glacial outwash plain of permeable sand and gravel deposits that fill a deep buried bedrock valley (Walker, 1979). These characteristics make the area surrounding Brady Lake an excellent groundwater source (Walker, 1979). Today, ground water wells, which supply the city of Kent, result in water level fluctuations in Brady Lake (Brady Lake v. Kent, 2006-Ohio-1693).

1.3 Anthropogenic Activities in the Study Area

Early records of human activity in northeastern Ohio trace back to the Hopewell tribe about 2,100 years ago (“Ohio Hopewell Culture National Historic Park,” n.d.). The Hopewell were famous for building large earthworks and mounds of piled-up soil, specifically in mid-southern Ohio (“Ohio Hopewell Culture National Historic Park,” n.d.). For unknown reasons, the Hopewell began to rapidly decline at approximately 1600 cal yr B.P. (“Hopewell Culture,” n.d.). More recent Native American activity from the Seneca, Onandagas, Ottawas and Chippewas took place at three main sites in the Portage County area; the Brady Lake-Franklin Township area, Shalersville-Mantua drainage system, and the Hiram Rapids-Welshfield low cut (Enders, 2011). At the time of the American Revolutionary War, northeast Ohio contained relatively undisturbed hardwood forests and swamps (Enders, 2011). Brady Lake derived its name from a soldier, Captain Samuel Brady, whose mission was to monitor Native American movement throughout the American Frontier (Enders, 2011). Legend is that in 1780 Captain Samuel Brady was being chased by Native Americans. To escape, he leaped across a gorge of the Cuyahoga River near present day Kent, Ohio and hid in a lake (Brady Lake) breathing through a reed (Enders, et al., 2007; Enders, 2011). This suggests that Brady Lake contained a fringing marsh prior to Euro-American settlement. Today, there is virtually no fringing marsh present at Brady Lake.

Prior to the arrival of Euro-American settlers to northeast Ohio, mature forests with trees to 2 m in diameter and a forest floor with leaf litter up to 45 cm thick were present (Enders, 2011). In 1802, Franklin Township became the first township in the Western Reserve (Enders, 2011). Following the war of 1812, the British and Native Americans left the area and settlers from New England moved to the region in large numbers (Enders, 2011). The first task performed by the settlers was clearing the forest for agricultural purposes (Figure 3). The fallen trees were left for two to three years to dry before they were burned (Enders, 2011).

Between 1827-1832, the Ohio-Erie Canal was built between Cleveland and Akron and then later extended to the Ohio River (Enders, 2011). An east to west canal, the Pennsylvania and Ohio Canal, was completed in 1840 to connect Akron, Ohio to Beaver, Pennsylvania (Enders, 2011). The level of Brady Lake and nearby Lake Pippen were increased by 3 to 4.6 m to provide a water supply to the Pennsylvania and Ohio Canal (Enders, 2011). In 1851, the Cleveland and Pittsburgh Railroad was built through Portage County near Brady Lake (Enders, 2011). Accompanying the change in transportation from canals to railroads, the water level of Brady Lake and Lake Pippen was lowered by about 4.3 m when the Pennsylvania and Ohio Canal was drained (Enders, 2011).

In 1891, the Brady Lake Electric Amusement Park was built by A. G. Kent on 0.6 km² of lakefront property (“Brady Lake Electric Park,” n.d.). The park included a dance pavilion, summer theatre, swimming and bath houses, 75-passenger steamboat, 40 row boats, figure-8 roller coaster, miniature railroad, picnic area, midway, and pony track (Figure 4; “Brady Lake Electric Park,” n.d.). Visitors arrived at the park by the Pennsylvania and Erie railroad. Park ownership changed to the Cleveland Mob in the early 1940s, and the park turned into a gambling scene which ultimately lead to its demise in 1944 (“Brady Lake Electric Park,” n.d.). In 1960, structures which were not removed from the Brady Lake Park were burned to dispose of them (Enders, n.d.). Since

Figure 3. Timeline (nonlinear scale) of the major anthropogenic events that have impacted Brady Lake, Ohio. Brady Lake Park located on the eastern shore is circled in yellow on the photograph. Timeline events from Enders (2011), Enders et al. (2007), Enders F. (n.d.), and the Brady Lake File at the Portage County Historical Society. Photograph from the Portage County Historical Society.

(Kent Historical Society)

(Portage County Historical Society)

Figure 4. (Upper and lower left) Images of attractions at the Brady Lake Amusement Park obtained from the Kent Historical Society. (Middle right) A postcard from the Portage County Historical Society of the beach at the Brady Lake Amusement Park heavily occupied by people.

the closure of the amusement park, Brady Lake's shoreline and watershed have developed with residential homes and roads (Figure 5).

1.4 Climate

Following deglaciation, Holocene climate in northern mid latitudes has been influenced by variability in atmospheric conditions (Mayewski et al., 2004). Mayewski et al. (2004) identifies six major time periods of Holocene climate change directly linked to polar cooling, tropical aridity, and shifts in atmospheric circulation (Mayewski et al., 2004). The most recent of these climatic events occurred at intervals from 4200 – 3800, 3500 – 2500, 1200 – 1000, and 600 – 150 (Little Ice Age) cal yr B.P (Mayewski et al., 2004). In Ohio, both Yifru (2002) and Lally (2016) found well-defined changes in kettle lake sedimentary organic matter they interpreted to reflect past climate variability.

Climate in Ohio today is dominated by the tropical maritime, polar continental, arctic, polar maritime, and tropical continental air masses ("Ohio Floods and Droughts," 1990). The main source of moisture for the state comes from tropical maritime airmasses, which form over the Gulf of Mexico and the western Atlantic Ocean ("Ohio Floods and Droughts," 1990). The tropical continental airmasses that form over the southwest result in hot and dry periods in Ohio ("Ohio Floods and Droughts," 1990). In the 20th century, moisture balance varied in northeast Ohio as recorded by low flows of the Cuyahoga River and lower water levels in Lake Erie during the droughts of the 1930s and 1960s (Guy and Moore, 2010). Today's 30-year annual temperature and precipitation averages for northeast Ohio are 9.7° C and 104.5 cm (NOAA, 2016).

Figure 5. Photographs of Brady Lake taken from the southeastern shore in September, 2015. Roads and residential homes surround the shoreline.

CHAPTER II

METHODS

2.1 Field Methods

In November, 2015, and March, 2016, Brady Lake bathymetry was mapped by collecting latitude, longitude, and water depth measurements throughout the basin. In September, 2015, surficial sediment samples were collected in order to determine modern sediment dispersal and sediment focusing processes in the lake. Sediment cores were collected in December, 2015, from a shallow and deep-water core site to further assess sediment focusing and interpret Late Holocene environmental change.

2.1.1 Bathymetry Mapping

In order to create a bathymetric map of Brady Lake, water depth, latitude, and longitude data were collected by using a Garmin 125 Fathometer and GPS unit. Appendix A provides a detailed description of the procedures used to create the bathymetry map. 7,507 measurements were made on 11/24/2015 and 03/26/2016 along numerous transects (Figure A-1). Because lake level fluctuates throughout the seasons, the lake level was surveyed relative a fixed object on both days of data collection. Due to the difficulty of obtaining shoreline data, a field photograph of a distinctive dock that also showed the shoreline was used to find an aerial photograph that matched the position of the shoreline in the field photograph (Figure A-2). The shoreline in the aerial photograph was then georeferenced and used to digitize the shoreline (Figure A-2). The total water depth for each measurement was determined by adding the depth of the transducer in the

water to recorded water depth. Furthermore, the surveyed reference marker was used to make account for the change in lake level between survey days. The final bathymetric map was made by importing the field data into ArcMap as a table containing only the latitude, longitude, and water depth measurements as X, Y, and Z values. Contour intervals are in feet so the map could be used by the public.

2.1.2 Surface Sediment Samples

Surface sediment samples were collected on 09/15/2015 with a Wildco grab sampler to determine modern sediment dispersal processes in the lake (Figure 6; Table 1). The upper 2 cm of sediment was saved from the grab sampler for analyses. A Garmin GPS was used to record the latitude and longitude, and water depth was measured using a weighted rope.

2.1.3 Sediment Cores

A total of six sediment cores were recovered from Brady Lake in order to assess the environmental history (Table 2; Figure 7). Two short cores, about 20 cm long, were obtained from the Wildco Grab Sampler. A Livingston Piston Corer was used to collect 4 longer cores. Cores were obtained from the central deep water (11.78 m) basin as well as from a shallow water (5.39 m) site (Figure 7; Table 2). The core 2 barrel broke while coring, therefore it is shorter than cores 3 and 4. Core 4 was intentionally begun beneath the sediment-water interface to obtain a longer composite sediment record when joined with core 3. In the field, cores were split lengthwise and preliminary lithologic descriptions were made.

Figure 6. Aerial photograph of Brady Lake showing the locations of 31 surface sediment samples (Photo from ArcMap, 2016).

Table 1. Locations of surface sediment samples taken from Brady Lake, Ohio on 09/15/2015.

Sample	Latitude	Longitude	Water Depth (m)
G1	41.1630	81.3145	5.00
G2	41.1635	81.3141	3.75
G3	41.1621	81.3160	2.96
G4	41.1614	81.3169	3.06
G5	41.1609	81.3183	1.60
G6	41.1631	81.3178	6.00
G7	41.1635	81.3169	11.00
G8	41.1638	81.3161	8.01
G9	41.1639	81.3148	3.12
G10	41.1640	81.3144	0.95
G11	41.1659	81.3145	4.08
G12	41.1655	81.3155	11.54
G13	41.1652	81.3160	13.20
G14	41.1652	81.3169	5.00
G15	41.1654	81.3176	2.96
G16	41.1677	81.3195	0.10
G17	41.1677	81.3192	2.00
G18	41.1682	81.3190	3.90
G19	41.1676	81.3185	2.80
G20	41.1661	81.3183	1.60
G21	41.1664	81.3177	3.30
G22	41.1667	81.3167	3.50
G23	41.1672	81.3153	3.80
G24	41.1662	81.3162	1.00
G25	41.1656	81.3162	6.20
G26	41.1648	81.3160	12.50
G27	41.1642	81.3161	3.97
G28	41.1630	81.3159	7.30
G29	41.1617	81.3153	0.60
G30	41.1627	81.3144	0.50
G31	41.1628	81.3144	0.50

Table 2. Locations of sediment cores taken from Brady Lake, Ohio on 12/12/2015.

Core #	Latitude	Longitude	Water Depth (m)	Core Length (m)	Description
C1	41.1646	81.31633	11.78	0.177	Surface Core
C3	41.1646	81.31633	11.78	2.650	Piston Core
C4	41.1646	81.31633	11.78	2.570	Piston Core
C2	41.1646	81.31633	11.78	1.601	Piston Core
C5	41.1626	81.31598	5.39	0.216	Surface Core
C6	41.1626	81.31598	5.39	2.190	Piston Core

Figure 7. Aerial photograph of Brady Lake showing the location of the deep-water core site (yellow square) and the shallow water core site (green square). The aerial photograph was obtained from ArcMap (2016).

2.2 Laboratory Methods

The following laboratory methods were conducted on surficial sediment samples and sediment cores. Sedimentological and geochemical properties were analyzed using equipment at The University of Akron and radiocarbon dating was performed by Beta Analytic Inc.

2.2.1 Lithology Analysis

Split cores were photographed and visual descriptions of sediment color, grain size, and composition were noted. Whole core magnetic susceptibility (K) was measured at 3 cm intervals using a Bartington MS2 magnetic susceptibility meter. Magnetic susceptibility is a magnetic concentration parameter (Evans and Heller, 2003).

Loss-on-ignition (LOI) was measured on most surficial samples and at 1 cm intervals in all cores. The wet and dry bulk density as well as the water, organic matter and carbonate content of each sample was determined using the method described by Dean (1974). Briefly, 1 cubic centimeter of sediment is weighed, dried for 24 hours at 100° C, and reweighed to determine wet bulk density, dry bulk density, and water content. Next, the sample is placed into a furnace at 550° C for two hours to combust the organic matter. Finally, the carbonate content is estimated after heating the sample at 1000° C for one hour. Because of the length of time between core collection and LOI analyses, pore water had evaporated from the cores so the wet bulk density and water content values are not reliable for the cores. Loss-on-ignition measurements were not made on sample G27 because it consisted of pebbles. Although organic content was measured for samples G16 and G24, wet bulk density, dry bulk density, and porosity were not measured due to the limited amount of sediment.

2.2.2 Trace Metal Analysis

The concentrations of Cu, Pb, Zn, and Cr, were measured from 34 horizons in the sediment section from the deep-water site (Cores 3 and 4). Four replicated samples were also measured. The total digestion method of Lacey et al. (2001) was used to prepare the samples. Approximately 0.2 g of air-dried sediment was treated with trace metal grade hydrochloric, nitric, and hydrofluoric acids and placed in a hot water bath for approximately 48 hours. After cooling to room temperature, samples were neutralized and diluted to 50 mL with Milli Q water. Trace element concentrations were measured with a Perkin Elmer AAnalyst 700 Atomic Absorption Spectrometer (AA). Two acid blanks and two Buffalo River Sediment Reference Material #8704 standards were also measured (Table 3). Acid blanks were below detection level for Pb, Cu, and Cr, and were very low for Zn (average 0.027 mg/L) indicating no contamination. The Buffalo River Sediment values were within 12% of reported values indicating good recovery (Table 3).

2.2.3 Grain Size Analysis

To assess grain size effects on trace metal concentrations, representative sediment samples from Core 2 were measured for grain size. In addition, four surficial sediment samples were also measured for grain size. 30% hydrogen peroxide (H_2O_2) was applied to each sample multiple times over a week to remove organic matter. Grain size analysis of sandy sediment samples was done with a Rotap following the sieve method of Folk (1966). The pipette method of Folk (1966) was used to measure the grain size distribution of mud samples.

2.2.4 Carbon to Nitrogen Ratios

The carbon to nitrogen ratios (C/N) of 31 samples and 3 replicates were measured on a Perkin Elmer Series II CHS/O Analysis 2400. Sample preparation consisted of freeze-

Table 3. A comparison of the reported Buffalo River Standard #8704 trace metal concentrations to values measured at The University of Akron. (A) Two Buffalo River Standards #8704 were measured. (B) Reported values from the National Institute of Standards and Technology (2000). (C) Percentage of the reported value.

A.						
Sample	Sediment weight (g)	Pb (µg/g)	Cu (µg/g)	Zn (µg/g)	Cr (µg/g)	
Buffalo River Standard 1	0.206	141.019	102.427	401.456	108.495	
Buffalo River Standard 2	0.202	140.347	99.257	394.307	107.673	
B.						
	Pb (µg/g)	Cu (µg/g)	Zn (µg/g)	Cr (µg/g)		
Buffalo River Standard	150 +/- 17	-	405 +/- 15	121.9 +/- 3.8		
C.						
	Pb (%)	Cu (%)	Zn (%)	Cr (%)		
Buffalo River Standard 1	94.01	-	99.12	89.00		
Buffalo River Standard 2	93.56	-	97.36	88.33		
Average	93.79	-	98.24	88.67		

drying and placing approximately 2 mg of sediment in tin capsules. The samples were combusted so that the thermal conductivity of carbon, nitrogen, and hydrogen could be measured. Four MESS-4 standards from the National Research Center Canada were also measured after every ~12 samples to assess accuracy of data. The C/N of the MESS-4 samples remained around 10 +/- 1.5.

2.2.5 Sediment Composition

In addition to visual descriptions of the split core, representative lithologies were further analyzed for sediment composition. Smear slides were observed through a petrographic microscope for sediment components. A Phillips X-Ray Diffractor 3500 (XRD) was used to identify minerals in 31 samples and 2 replicates. Sample preparation for XRD analysis consists of freeze drying the sediment, pulverizing it with a mortar and pestle, and packing the powder into a sample holder. Mineral phases present in the sample were identified by comparing the sample diffractions to reference XRD patterns. The peak height ratio of quartz to mica present in each sample was determined. At 2θ , quartz peak at approximately 26.737° and mica peak at approximately 19.88° were used for the ratio values.

2.2.6 Magnetism

Magnetic concentration, grain size and mineralogy parameters were measured following the methods of Evans and Heller (2003) on representative surficial and downcore sediment samples. Samples were first air-dried, then homogenized with a mortar and pestle. Each sample was then packed tightly into 5.28-cm³ plastic boxes to immobilize the grains. Low frequency susceptibility (X_{lf}) was measured with a Bartington susceptibility meter. ARM (anhysteretic remanence magnetization) was imparted through a D-Tech AF demagnetizer and IRM (isothermal remanence magnetization) was imparted

with an ASC Impulse Magnetizer. All magnetic remanence was measured on a Molspin Spinner Magnetizer. X_{lf} was used as a magnetic concentration parameter. Diamagnetic and paramagnetic materials contribute to X_{lf} measurements however, higher measured values indicate greater quantities of ferrimagnetic material. X_{Arm}/X was used as a magnetic grain size parameter. Although superparamagnetic grains affect X_{lf} , X_{Arm} is not affected because it is biased towards fine grains less than 1 mm in size. In general, higher X_{Arm}/X values indicate finer magnetic grain sizes. The mineralogical parameter, S-Ratio, was used to determine the relative proportion of low to high coercivity minerals within each sample. S-Ratio values greater than 0.9 indicate an abundance of low coercivity minerals, whereas high coercivity minerals are present in significant amounts when the S-Ratio is less than 0.9.

2.2.7 ESEM Analysis

An FEI Quanta 2000 Environmental Scanning Electron Microscope (ESEM) equipped with an energy dispersive X-ray spectroscope (EDAX) was used to assess the morphology and composition of magnetic particles. Downcore magnetic susceptibility profiles were used to select 3 sample depths having varying magnetic concentration. 1 cm-thick sediment sections were sampled and dispersed in deionized water. A rare-earth-element magnet was used to extract ferrimagnetic particles from the sediment slurry. The rare-earth-magnet was applied with equal effort to each sample in an effort to assess magnetic particle abundance between samples. The extracts were photographed and then mounted on ESEM stubs. Combustion particles were identified based on their spheroidal shape and composition (Evans and Heller, 2003).

2.2.8 Radiocarbon Dating

Terrigenous macrofossils are rare in the deep-water cores. Sediment was sieved in order to recover plant macrofossils. A small piece of terrestrial leaf was recovered as well as fibrous aquatic plant matter. However, none of these samples yielded enough material for AMS dating. However, a large terrigenous leaf, confirmed by C/N analysis, was recovered from 60.5 cm deep in core 4. This leaf is possibly from an oak or maple. Bulk sediment from 61.5 cm and from the base of the core (235.5 cm) were also sampled for AMS dating. The leaf was rinsed in Milli Q water, dried in an oven at approximately 80° C, and wrapped in aluminum foil. Bulk sediment samples were placed in aluminum foil and refrigerated to avoid molding. Samples were sent to Beta Analytic in Miami, Florida for AMS dating. Pre-treatment of bulk samples consisted of passing the sediment through a 180-micron sieve and treating it with acid to remove any carbonates. The leaf was treated with acid and alkali to remove any carbonates or humic acids. Beta Analytic converted the ^{14}C age to calendar years using the INTCAL 13 calibration curve.

CHAPTER III

RESULTS

3.1 Lake Bathymetry

Prior to this study, the shape of the Brady Lake basin was unknown because no bathymetric map was available to the public. Lake bathymetry and geographical position data were collected and processed in ArcMap to create a bathymetric map (Appendix A). Brady Lake contains two deep water basins; one to the north and the other to the south (Figure 8). The deepest point in the lake at 44 feet is located in the northern basin. In addition to the two deep-water basins there are other shallower depressions within the lake.

3.2 Surface Samples

Surface sediment was collected throughout Brady Lake to assess sediment focusing and dispersal processes (Figure 6, Tables 1 and 4). Samples were visually classified as sand, gravel, gravelly mud, and mud. The grain size of four samples was quantitatively determined in order to confirm the visual grain size classification (Appendix B). Samples G12 and G13 were described as mud, and in fact, have D50 values of 6.74 and 7.26 ϕ , respectively. Furthermore, samples G10 and G29 were described as sand and have D50 values of 0.13 and 1.66 ϕ , respectively. Dense sand and gravel having low organic content is found in water less than 1.5 m deep (Figure 9). Organic-rich, low density mud is present in water depths greater than 1.5 m (Figure 9). There is an increase in the organic content of the mud between 1.5 to 6 m water depth and then organic content

Brady Lake

Portage County, Ohio

Figure 8. Bathymetric map of Brady Lake.

Table 4. Loss-on-ignition data for sediment samples taken at various depths in Brady Lake, OH. Samples are categorized as sand and gravel, gravelly mud, and mud.

Sample	Water Depth (m)	Percent Water (%)	WBD (g/cm ³)	DBD (g/cm ³)	Organic Matter (%)	Lithology
G16	0.1	-	-	-	4.37	Sand and Gravel
G30	0.5	17.62	2.01	1.66	3.84	Sand and Gravel
G31	0.5	17.45	1.93	1.59	2.57	Sand and Gravel
G29	0.6	16.60	2.02	1.69	0.55	Sand and Gravel
G10	0.95	13.12	2.08	1.81	0.44	Sand and Gravel
G24	1	-	-	-	2.38	Sand and Gravel
G20	1.6	71.25	1.14	0.33	13.11	Gravelly Mud
G5	1.6	84.27	1.09	0.17	21.07	Mud
G17	2	74.62	1.16	0.30	15.54	Mud
G19	2.8	85.15	1.08	0.16	23.57	Mud
G15	2.96	88.77	1.06	0.12	26.39	Mud
G3	2.96	87.72	1.05	0.13	19.48	Mud
G4	3.06	86.66	1.08	0.14	26.72	Mud
G9	3.12	15.12	2.07	1.76	1.48	Sand and Gravel
G21	3.3	86.86	1.07	0.14	24.43	Mud
G22	3.5	87.47	1.05	0.13	23.65	Mud
G2	3.75	55.73	1.30	0.58	7.98	Gravelly Mud
G23	3.8	87.98	1.04	0.13	26.12	Mud
G18	3.9	85.25	1.07	0.16	24.72	Mud
G11	4.08	18.13	1.97	1.61	0.48	Sand and Gravel
G1	5	81.26	1.07	0.20	16.66	Mud
G14	5	38.31	1.57	0.97	2.22	Sand and Gravel
G6	6	89.06	1.03	0.11	28.77	Mud
G25	6.2	89.54	1.04	0.11	30.20	Mud
G28	7.3	90.01	1.02	0.10	29.69	Mud
G8	8.01	91.33	1.01	0.09	32.24	Mud
G7	11	91.21	1.02	0.09	31.80	Mud
G12	11.54	90.72	1.01	0.09	32.11	Mud
G26	12.5	91.30	1.02	0.09	32.24	Mud
G13	13.2	91.41	0.99	0.09	33.46	Mud

Figure 9. Wet bulk density (WBD), dry bulk density (DBD), percent water (i.e., porosity), and organic matter content of Brady Lake, Ohio, surface sediment. Shallow water sediment is characterized by dense, sand and gravels with low organic content. In water greater than 1.5 m, low density muds having high organic content are present. The orange line indicates the estimated depth of wave base. Off trend samples are circled.

remains high at about 30% in water deeper than 6 m (Figure 9). The gravelly mud samples (G2 and G20) contain less organic matter than the mud samples, but more than the sand and gravel samples. Four samples (G2, G9, G11, and G14) are sand, gravel, or gravelly mud and are located in deeper water dominated by a mud lithology (Figure 9).

Magnetic concentration, grain size and mineralogy parameters were measured to further characterize the surficial sediment (Appendix C; Figure 10). No magnetic measurements were conducted on sample G27 because it was composed of pebbles. In general, samples with the greatest magnetic concentration were located in less than 5 m of water (Figure 10). Finer magnetic grain sizes are present in mud from deeper water than in sand and gravel from shallow water (Figure 10). However, three sand and gravel samples contain fine magnetic grain sizes and two of these samples are from water deeper than 1.5 m. The S-Ratio of most samples was above 0.9 indicating a low coercivity magnetic mineralogy (e.g., magnetite, greigite). However, five samples had S-ratio values less than 0.9 suggesting a significant presence of high coercivity minerals such as hematite or goethite (Figure 10).

3.3 Sediment Cores

A composite sediment record was constructed for both shallow and deep water core sites by correlating down core lithological properties. The composite sediment record made from cores 3 and 4 from the deep-water core site was further investigated for geochemical and additional lithological properties.

3.3.1 Core Correlation

Sediment cores were collected from shallow and deep water sites on 12/12/2015 (Figure 7; Table 2). At each site, a short core of surficial sediment was collected with a Wildco Grab Sampler (Cores 1 and 5). Three piston cores were recovered from the

Figure 10. Magnetic susceptibility (X_f), a ferrimagnetic concentration parameter, X_{ARM}/X , ratio a magnetic grain size parameter, and the S-Ratio a magnetic mineralogy parameter for Brady Lake, Ohio surficial sediment samples.

deep-water site (Cores 2, 3, and 4), and one from the shallow water site (Core 6). Whole core magnetic susceptibility profiles and preliminary lithology descriptions were used to estimate initial correlation tie lines between cores for each site (Figure 11; Appendix D). Once the core lithology was described in detail and LOI measurements were made at 1 cm intervals, a detailed core correlation was attained (Figures 12 and 13). Distinct changes in lithological properties were used to create a composite sediment record from individual cores at each site (Figures 12 and 13).

Initial magnetic susceptibility measurements of shallow water Cores 5 and 6 revealed a possible gap in the sediment record (Figure 11). Cores 5 and 6 did not contain the same sediment, therefore, a 2-cm gap was estimated from field notes and LOI measurements (Figure 12). Although a 2-cm gap was estimated, the gap could be slightly greater. A 239-cm long composite record was constructed by adding 22 cm to Core 6 based on the LOI correlation (Figure 12). In Core 5, organic content increases from about 30% to 60% between 15.5 and 20.5 cm core depth (Figure 12; Appendix E). This increase in organic content lies above the organic-rich sediment at the top of Core 6 (Figure 12).

Individual deep-water sediment cores were also correlated to create a 413-cm-long composite sediment section (Figure 13). Based on magnetic susceptibility and LOI measurements (Appendix D; Appendix E), piston Core 3 recovered intact surficial sediment because Core 3 contained sediment similar to that recovered in the grab sampler Core 1 (Figure 11; Figure 13). However, lithological properties of piston Core 2 indicate possible core-top disturbance when the core handles broke during coring (Figure 11; Figure 13). Core 2 was adjusted downward by 25 cm in order to correlate Core 2 LOI profiles with Cores 3 and 4 (Figure 13). Both Cores 3 and 4 contained an interval where organic content abruptly decreased by more than 40% (Figure 13). The depth of this lithological feature was correlated by adding 156 cm to Core 4. Because Cores 3 and 4

Figure 11. Magnetic Susceptibility (K) profiles of sediment cores taken from Brady Lake, Ohio on 12/12/2015. Lines indicate correlative sediment between cores. Cores 1, 2, 3, and 4 from the deep-water site and Cores 5 and 6 from the shallow-water site.

Figure 12. Lithology log and organic content profiles of sediment cores from a shallow water site at Brady Lake, Ohio. Correlation of sediment between cores is indicated by tie-lines.

Figure 13. Lithology log and organic content profiles of sediment cores from the deep-water basin of Brady Lake, OH. Core 4 was intentionally begun beneath the sediment-water interface in order to obtain a longer composite sediment record. Tie-lines correlate distinctive lithological features between cores.

correlated well, they were used to construct a complete composite sediment section that is 4.13 m in length (Figure 13).

3.3.2 Lithology

The composite sediment record of the shallow water core site is divided into five intervals containing distinct lithological characteristics (Figure 14). Beginning from the bottom of the core, the lower most 19.5 cm (239-219.5 cm core depth) consists of a gray to light brown clay having an average dry bulk density (DBD) of 1.25 g/cm³. This interval contains low organic content (average 3.3%) and high magnetic concentration which gradually decreases towards the top of the interval. The second interval from 219.5 to 205.5 cm core depth consists of a dark brown gyttja having high organic content (average 42.9 %) and an average DBD of 0.27 g/cm³ (Figure 14). The third interval from 205.5 to 114.5 cm core depth consists of different colored gyttja having low magnetic concentration. From the bottom to the top of this interval, organic matter content increases from 15.6% to 46% and DBD decreases from 0.486 to 0.113 g/cm³. Within the fourth interval, from 114.5 to 22.5 cm core depth, there is a 19-cm thick section containing an abundance of roots. Throughout the fourth interval, organic matter content continues to increase from 46.1% to 69.9%. However, centered at 36.5 cm core depth, there is a 2 cm thick layer where organic content decreases to 51.4% (Figure 14). Increased organic content results in erroneous high carbonate values because the weight of the sample after 1000° C is so small that weighing errors result in incorrect carbonate values. The average DBD for this interval is 0.088 g/cm³. The fifth interval comprises the uppermost 20.5 cm core depth. At the base of this interval, organic content declines markedly. This interval consists of low density (average DBD 0.151 g/cm³) black mud having low organic content (average 33%) and increased magnetic concentration.

Figure 14. Lithology log and magnetic susceptibility, wet bulk density (WBD), dry bulk density (DBD), organic matter and carbonate content profiles for the shallow water core site. A 2 cm gap in the sediment record is present between Cores 5 and 6 as indicated by the arrow.

Carbonate content is lower in the black mud (average 2.48 g/cm³) than in the gyttja and comparable to that in the basal gray clay.

The composite sediment record from the deep-water site is divided into four intervals having distinctive lithological properties (Figure 15). The lowermost interval (413 to 190 cm core depth) consists of gyttja (average organics 69%) having low bulk density (average DBD 0.1 g/cm³) and magnetic concentration. Throughout this interval carbonate content varies between 0 and 12% because the small weight loss at 1000° C yields questionable carbonate content results (Figure 15). There is a change from dark brown to light brown gyttja between 350 and 332 cm core depth. Five lows in organic matter content corresponding with increased DBD occur at approximately 399.5, 383.5, 277.5, 231.5, and 204.5 cm core depth (Figure 15). At 190 cm core depth there is an abrupt contact between lithologic interval 1 and the overlying interval 2. Lithic interval two spans 190 to 140 cm core depth and is characterized by bedded yellow-brown mud (Figure 15). These beds were readily visible when the core was first split and then became less apparent as the sediment oxidized. Within lithologic interval 2 organic content is low (average 25.1%) and magnetic concentration and DBD (average DBD 0.24 g/cm³) both increase. At 140 cm core depth there is a gradual contact between lithology interval 2 and the overlying interval 3 (Figure 15). Lithic interval 3 spans 140 to 85 cm core depth and is characterized by brown mud having moderate organic content (average 33.4%). In lithology interval 3, DBD gradually decreases from the high values of interval 2 whereas magnetic concentration and carbonate content remain similar to those in interval 2. At 85 cm core depth there is a graduate contact between lithologic interval 2 and the overlying interval 1 (Figure 15). Interval 1 is a black mud having low organic content (average 29.2%) and higher carbonate content and DBD than interval 2. Within lithologic interval 1, between 45 and 25 cm core depth, magnetic concentration and carbonate content are at a maximum of 12.1 (10⁻⁵ relative SI units) and 10.4% respectively.

Figure 15. Lithology log and magnetic susceptibility, wet bulk density (WBD), dry bulk density (DBD), organic and carbonate content profiles for the deep-water core site.

3.3.3 Heavy Metals

Heavy metal concentrations of anthropogenic origin (Pb, Cu, Zn, and Cr) were measured on the composite sediment record from the deep-water site (Table 5; Figure 16). Two Buffalo River Standards #8704 were also measured to assess accuracy of measurements (Table 3). The measured values of Pb, Zn, and Cr for the standard were within +/- 12% of the reported values indicating an efficient digestion and good recovery (Table 3). The acid blanks were below detection limit indicating no contamination during sample processing. Between 413 cm and 190 cm core depth in lithologic interval one, concentrations of Pb (average 14.8 µg/g), Cu (average 15.3 µg/g), Zn (average 88.18 µg/g), and Cr (average 17.4 µg/g) are low (Figure 16). Within lithologic interval 2 of the yellow-brown bedded mud (190 and 85 cm), concentrations of Pb and Zn show a slight increase whereas Cr and Cu nearly double in concentration compared to interval 1 (Figure 16). At 80 cm core depth there are increases in the Pb and Zn concentration corresponding to the base of the black mud interval 4. Between 25 and 50 cm depth in the black mud interval, the concentrations of Pb, Cu, Zn, and Cr reach their maximum values of 416.4, 137.3, 475.1, and 50.5 µg/g respectively (Table 5; Figure 16). In the uppermost 25 cm of the core the heavy metal concentrations decrease toward the top of the core (Figure 16).

Potential variation in grain size affecting the heavy metal concentration was assessed by measuring the grain size of 3 representative lithologies (Table 6; Figure 17). The sand content increases as the concentration of heavy metals increases and the clay content is highest where metal concentrations are lowest (Figure 17). Because heavy metals tend to adsorb to finer grained sediment (i.e., clay) it is unlikely that the small grain size variation in the core has any influence on the variation in heavy metal concentration.

Table 5. Trace metal concentration data from sediment cores taken from Brady Lake, Ohio.

Sample	Depth (cm)	Composite Depth (cm)	Sediment Weight (g)	Lead (Pb) (ug/g)	Copper (Cu) (ug/g)	Zinc (Zn) (ug/g)	Chromium (Cr) (ug/g)
Blank 1	-	-	-	-	-	-	-
Blank 2	-	-	-	-	-	-	-
Standard 1	-	-	0.206	141.02	102.43	401.46	108.50
Standard 2	-	-	0.202	140.35	99.26	394.31	107.67
Core 3	0.5	0.5	0.202	235.89	103.47	381.93	44.31
Core 3	5.5	5.5	0.201	270.15	109.20	366.17	36.57
Core 3	10.5	10.5	0.208	267.07	98.32	446.39	36.78
Core 3	15.5	15.5	0.201	286.32	101.99	398.51	35.32
Core 3	20.5	20.5	0.201	391.04	137.31	452.24	50.50
Core 3	25.5	25.5	0.203	399.26	129.56	448.03	46.80
Core 3	35.5	35.5	0.201	416.42	89.05	475.12	47.01
Core 3	40.5	40.5	0.204	365.20	62.99	413.97	43.87
Core 3	45.5	45.5	0.203	342.12	56.16	363.79	44.58
Core 3	45.5	45.5	0.208	336.06	52.64	358.65	40.38
Core 3	55.5	55.5	0.208	128.13	26.92	227.88	38.46
Core 3	65.5	65.5	0.204	107.35	21.32	140.93	41.42
Core 3	75.5	75.5	0.204	120.59	33.82	157.35	40.20
Core 3	85.5	85.5	0.208	58.17	29.81	115.38	42.55
Core 3	95.5	95.5	0.205	47.07	27.32	115.85	36.59
Core 3	95.5	95.5	0.203	54.93	25.86	116.50	39.16
Core 3	105.5	105.5	0.202	41.83	23.76	115.10	37.62
Core 3	115.5	115.5	0.203	22.66	27.34	117.24	32.02
Core 3	125.5	125.5	0.203	30.05	29.56	122.17	35.96
Core 3	135.5	135.5	0.210	22.38	24.29	130.95	40.48
Core 3	145.5	145.5	0.209	5.98	27.27	117.94	39.47
Core 3	150.5	150.5	0.209	17.22	27.03	111.72	44.02
Core 3	154.5	154.5	0.203	43.10	25.37	121.67	36.70
Core 3	158.5	158.5	0.203	4.93	29.80	105.17	35.96
Core 3	162.5	162.5	0.206	36.41	29.85	112.38	38.11
Core 3	166.5	166.5	0.210	13.57	31.67	118.33	41.19
Core 3	170.5	170.5	0.200	30.50	31.50	123.75	43.25
Core 3	170.5	170.5	0.200	25.50	31.25	124.50	44.50
Core 3	174.5	174.5	0.201	12.94	33.33	117.41	42.29
Core 3	178.5	178.5	0.203	22.66	48.03	126.35	42.12
Core 3	180.5	180.5	0.201	23.63	36.57	118.91	42.79
Core 3	190.5	190.5	0.200	18.25	26.75	103.50	24.00
Core 3	196.5	196.5	0.208	26.20	13.94	75.24	18.75
Core 4	50.5	206.5	0.202	18.32	18.81	89.85	20.05
Core 4	110.5	266.5	0.204	3.43	13.73	84.56	16.67
Core 4	180.5	336.5	0.203	11.08	11.58	92.12	11.82
Core 4	180.5	336.5	0.201	15.17	10.95	89.30	14.43
Core 4	250.5	406.5	0.202	11.14	11.39	82.67	16.09

Figure 16. Sedimentary heavy metal concentration profiles for the deep-water core site from Brady Lake, Ohio. Orange dots indicate replicated samples.

Table 6. Grain Size data from a deep-water sediment core from Brady Lake, OH.

Sample	Depth (cm)	Composite Depth (cm)	D ₅₀ (φ)	Sand (%)	Silt (%)	Clay (%)
Core 2	10-20	35-45	6.86	18.61	42.23	39.16
Core 2	65-75	90-100	6.94	10.31	55.97	33.72
Core 2	125-135	150-160	8.94	0.83	49.95	49.22

Figure 17. Percentages of sand, silt and clay for representative lithologies in comparison to Pb concentration. Grain size was analyzed on three 10-cm thick sediment sections. Orange dots on the Pb concentration profile indicate replicated samples.

3.3.4 Carbon to Nitrogen Ratios

Changes in the carbon to nitrogen ratio profile generally correspond to the different lithologic intervals (Figure 18). Between 4.13 and 1.9 m core depth, the gyttja (average organic content 69.1%) has an average C/N ratio of 13.7 (Figure 18). Within this interval there is an increase in C/N ratio to 17.4 corresponding to an 18-cm thick layer of light brown gyttja (Figure 18). The abrupt lithologic change from gyttja to bedded mud at 1.9 m core depth also corresponds to a sharp decrease in the C/N ratio to approximately 9. Within the brown and black mud above 140 cm core depth, the C/N ratio has moderate values between 10.5 and 12.5 and displays variation similar to the organic content profile (Figure 18).

3.3.5 Sediment Composition

Mineralogical analysis by XRD was conducted on 31 representative samples (Figure 19). The minerals quartz and “mica” were identified by their characteristic XRD peaks (Figure 19). “Mica” is defined as the combined XRD peaks of clay minerals illite, kaolinite, and mica. With increasing core depth, the quartz and mica diffraction peaks become wider due to the presence of increased organic matter in those samples (Figure 19). However, at 277.5 cm core depth, the quartz and mica peaks are sharp because organic content decreases in that samples (Figure 19). At 20.5 cm core depth, additional diffraction peaks at 11° and 29° 2θ were identified by the XRD software as magnesium oxide and lead silicate, respectively (Figure 19). These phases are unlikely to be present in Brady Lake sediment, but searches for expected minerals such as albite, orthoclase, siderite, dolomite, ankerite, and clinocllore did not match these unusual peaks. Furthermore, the 11° and 29° peaks are only found in interval 1 where heavy metal concentration is high. Therefore, the 11° and 29° peaks are referred to as “anthropogenic material” (Figure 19).

Figure 18. Lithology, carbon to nitrogen ratios (C/N), and organic matter content from the deep-water core site in Brady Lake, Ohio. Orange dots on the C/N plot indicate replicated samples.

Figure 19. (Left) XRD diffractograms for representative core lithologies, (middle) quartz to mica ratio, and (right) organic matter profiles from the deep-water core site in Brady Lake, Ohio. XRD diffractograms plotted by consecutively adding 25000 to each overlying sample. Orange points on the Quartz/Mica plot indicate replicated samples.

The ratio between quartz to mica (Q/M) was used to assess downcore mineral variability. Variations in organic matter content will influence the peak heights of a mineral on the diffractogram. Therefore, it is not possible to just use a single mineral's peak height to estimate a mineral's abundance. The Q/M ratio is generally less than 17.5 in the organic-rich gyttja (Figure 19). The Q/M ratio is generally greater than 17.5 in the low organic content muds above 190 cm core depth (Figure 19). In addition, at 277.5 cm core depth organic content decreases to 56% and the Q/M ratio peaks at 30.28 (Figure 19). The Q/M ratio measures changes in the relative proportions of quartz and mica minerals delivered to Brady Lake. The Q/M ratio is used to assess changes in the watershed as weathering and erosion varied throughout the Late Holocene.

3.3.6 Magnetic Measurements

Magnetic concentration, grain size, and mineralogy parameters were measured on 48 subsamples from the deep-water core site (Figure 20). Between 413 and 190 cm core depth the gyttja lithology contains low magnetic concentration. In the yellow-brown bedded mud and brown mud lithology between 190 and 85 cm core depth, magnetic concentration increases. In the upper 85-cm thick interval of black mud, magnetic concentration greatly increases to maximum concentrations between 25 to 50 cm and then declines toward the core top (Figure 20). The magnetic grain size parameter X_{ARM}/X suggests that magnetic grain size is coarse below 275 cm, becomes finer between 275 and 80 cm, and then coarsens in the upper 80 cm of the core (Figure 20). Below 350 cm core depth, the S-Ratio is less than 0.9 indicating an increased abundance of high coercivity minerals such as hematite or goethite (Figure 20). Between 300 and 80 cm core depth, the S-Ratio averages 0.97 signifying a magnetic assemblage dominated by low coercivity minerals such as magnetite or greigite. Above 80 cm core depth the S-Ratio declines from 0.95 to about 0.91 suggesting the mixture of both low and high coercivity minerals

Figure 20. Downcore lithology and magnetic concentration (X_{ip}), grain size (X_{ARM}/X), and mineralogy (S-Ratio) profiles for the deep-water core site from Brady Lake, Ohio.

in the black mud lithology. Between 350 and 300 cm core depth S-ratio values reach a maximum of 1, however, below about 250 cm magnetic remanence is so low that S-ratio calculations are not reliable.

3.3.7 ESEM Analysis

In order to confirm that magnetic susceptibility is predominantly a magnetic concentration parameter, remanence-bearing magnetic particles were extracted from the sediment with a rare-earth-magnet (Figure 21). As the magnetic susceptibility values decreased, the qualitative visual abundance of extracted particles also decreased (Figure 21). No visible remanence-bearing particles were recovered from 240.5 cm core depth suggesting that paramagnetic particles contribute to the low susceptibility values. The extracted particles from 44.5 and 183.5 cm core depth were analyzed by ESEM-EDAX. At 44.5 cm core depth, spheroidal particles having both smooth and granular surfaces were identified (Figures 22 and 23). Based on EDAX scans, both types of spheroidal particles contain Fe, O, Si, Al, Ti, K, and Ca (Figures 22 and 23). Although not as abundant, spheroidal particles were also identified at 183.5 cm core depth (Figure 24). The spheroidal particle at 183.5 cm core depth contained Fe, O, Si, and Ti, but no K or Ca (Figure 24). In addition to spheroidal particle, cubo-octahedral ferrimagnetic particles were also present in the 183.5 cm extract.

3.3.8 Radiocarbon Dates

An age model was constructed for the deep-water sediment core from three ^{14}C dates and two event stratigraphy horizons (Table 7; Figure 25). Beta Analytic Inc. converted the measured ^{14}C age to calendar years using the INTCAL 13 calibration curve (Beta Analytic written communication, 2017). The conversion of the ^{14}C age to calendar years results in maximum, midpoint, and minimum ages (Table 7). The maximum and

Figure 21. Magnetic susceptibility profile qualitatively compared to magnetic particles extracted from the sediment. Samples were taken from 44.5 cm (top), 183.5 cm (middle), and 240.5 cm (bottom) composite core depth.

Figure 22. (Top) ESEM photograph of spheroidal particles at 44.5 cm core depth. (Bottom) EDAX elemental profile of the spheroidal particle.

Figure 23. (Top) ESEM photograph of a spheroidal particle with a different morphology at 44.5 cm core depth. (Bottom) EDAX elemental profile of the spheroidal particle.

Figure 24. (Top) ESEM photograph of a spheroidal particle found at 183.5 cm core depth. (Bottom) EDAX elemental profile of the spheroidal particle.

Table 7. Radiocarbon and event stratigraphy ages for the composite sediment record from the deep-water site at Brady Lake, Ohio.

Lab #	Core #	Core		Composite Core Depth (cm)	Sample Type	Conventional Radiocarbon Age BP	Max Cal yr BP*	Midpoint Cal yr BP*	Min Cal yr BP*	Corrected		
		Depth (cm)								Max Cal yr BP	Midpoint Cal yr BP	Min Cal yr BP
Beta-457582	4	60.5	216.5	Bulk		620 +/- 30	660	602.5	545	452.5	395	337.5
Beta-457583	4	61.5	217.5	Leaf		330 +/- 30	485	395	305	485	395	305
Beta-457584	4	232.5	388.5	Bulk		2600 +/- 30	2760	2740	2720	2552.5	2532.5	2512.5
-	4	0	0	Core-top		-	-	-	-	0	0	0
-	4	34	190	Settlement		-	-	-	-	210	210	210

* = 2-sigma Cal yr BP

Figure 25. Age-depth model for the deep-water core from Brady Lake, Ohio. Blue dots indicate calibrated radiocarbon ages and orange dots represent event stratigraphy age control points.

minimum age ranges differ between samples because the INTCAL 13 calibration curve has regions of varying slopes. Complications arise when ^{14}C dating bulk sediment because multiple sources of organic matter (i.e., terrigenous and aquatic) each having different ^{14}C reservoir effects are incorporated into the bulk sediment (Philippsen, 2013). Because terrigenous plants are most likely to be in equilibrium with the atmospheric ^{14}C budget, terrigenous organic matter is considered the most reliable dating material (Marty et al., 2014). At about 217 cm in the core both a terrigenous leaf (Oak or Maple) and bulk sediment sample were dated to determine the bulk sediment age offset (Table 7). The age of the leaf and adjacent bulk sediment were 395 and 602.5 Cal yr BP respectively, therefore, an age difference of 207.5 Cal yr BP was subtracted from all bulk sediment ages (Table 7).

The age model is divided into three intervals of varying sedimentation rates (Figure 25). The two ^{14}C dates at 217.5 and 388.5 cm core depth yield a sedimentation rate of 0.080 cm/yr. Because similar lithologies are present below 388.5 cm core depth, the sedimentation rate of 0.080 cm/yr was extrapolated to the core base at 413 cm (Figure 25). The basal age of the deep-water composite core is 2840 cal yr BP.

Difficulties arise when calibrating ^{14}C dates to calendar years in the recent past due to plateaus in the INTCAL 13 calibration curve occurring between 50 and 250 cal BP (<http://www.radiocarbon.org/IntCal13.htm>). A single ^{14}C date within a plateau region would yield a large calendar age range which would not be useful for dating the sediment. Furthermore, increases in anthropogenic pollutants containing carbon (i.e., coal) during the last 2 centuries result in ancient radioactively “dead” carbon present in bulk sediment samples. Therefore, event stratigraphy was used to better constrain the ages of sediment above the uppermost ^{14}C date. At 190 cm core depth, an abrupt change from gyttja to yellow-brown bedded mud with decreased organic content and increased heavy metal concentration is presumed to represent Euro-American settlement in 1805 (210 Cal yr

BP). This assumption is supported by similar increases in heavy metal concentrations and decreases in organic matter in other dated Ohio kettle lake sediment cores (Yifru, 2002; Haney, 2004). Further support comes from extending the sedimentation rate (0.084 cm/yr) between the minimum age of the deep 14C sample and the maximum age of the leaf up to 190 cm core depth. This exercise dates the lithologic change at 190 cm to 1857 AD which is relatively close to 1805 AD and supports the assumption that settlement corresponds to the lithology change at 190 cm. The 14C date of the leaf (395 Cal yr BP) at 217.5 cm and the assumed settlement horizon at 190 cm core depth (210 Cal yr BP) yielded a sedimentation rate of 0.146 cm/yr.

The excellent lithologic agreement between the grab sample and piston core top indicates that the piston core recovered intact surficial sediment. Therefore, the core top (0 cm core depth) was set equal to year 2015 (0 Cal yr BP). Between the settlement horizon at 190 cm core depth (210 Cal yr BP) and the core top (0 Cal yr BP) the sedimentation increased to 0.905 cm/yr. Although linear sedimentation rates are assumed for the age model, the sedimentation rates likely varied within each interval. A linear sedimentation rate may result in slight uncertainty to the age of down core lithologic changes.

CHAPTER IV

DISCUSSION

4.1 Sediment Focusing Analysis

In order to better interpret the lake sediment cores, it was first necessary to understand modern-day sediment transport processes in the lake. Surficial sediment was analyzed for lithological properties to assess current sediment dispersal throughout Brady Lake. Downcore lithological properties were compared from both shallow and deep water core sites to assess variability in the sediment record at different locations in the Brady Lake basin.

Sediment focusing in lakes describes the process of greater sediment accumulation in deeper portions of a lake than in the shallower parts (Hilton, 1985). The four main processes that will redistribute sediment and cause sediment focusing in lakes are organic degradation, sliding and slumping on slopes, intermittent complete mixing, and peripheral wave action (Hilton, 1985). Of these four processes, wave action is a primary process of sediment dispersal. When a wave breaks, sediment in the littoral zone will be resuspended and deposited in deeper water (Larsen and MacDonald, 1994). The size of the particle that can be suspended is dependent upon the wave height (i.e., wave energy), which is in turn dependent on the fetch and wind speed (Hakanson, 1981). Wave base, calculated as half the wavelength, is the depth at which wave orbital motion ceases. Where wave base reaches the lake bed, a distinct pattern of coarser grains (i.e., sand or gravel) are found in shallower water and finer grains (i.e., muds) in deeper water below wave base. Wave base at Brady Lake was estimated using the following procedure: A fetch of 1.2 km and an

average daily wind velocity (fastest 2-minute) of 8 m/s (NOAA, 2015) results in a wave height of approximately 0.15 m at Brady Lake when the monographs of Hakanson (1981) are used. Furthermore, by comparing the relationship between wave height and water depth (Hakanson, 1981), a wave height of 0.15 m results in sediment movement in water less than 1.5 m deep.

The estimated wave base of 1.5 m agrees well with a pronounced change in surface sediment properties at 1.5 m depth (Figure 9). Dense, sand and gravel having low organic content is present in water less than 1.5 m deep whereas, organic-rich muds accumulate in water greater than 1.5 m deep. However, four samples containing sand and gravel were found at water depth greater than 1.5 m (Figures 9 and 26). Three of these samples were located along the eastern shoreline of Brady Lake where a major lakeside amusement park was present from 1891 to 1960 (Figure 26). During this period, the shoreline was built out to construct an artificial beach. The presence of the sand and gravel in deeper water is likely due to the construction of the beach. A gravelly mud sample from 5 m water depth is located near the western edge of the lake's central basin. The presence of sand and gravel may be the result of shallow water sediment slumping down the steep basin side into deep water.

A relationship between water depth and fetch can be used to estimate zones of erosion, transportation, and accumulation in lakes based on sediment porosity (Hakanson, 1981). With fetch of 1.2 km at Brady Lake, porous sediment (>75% water content) is expected to accumulate in water deeper than approximately 1 m (Hakanson, 1981). Porosity measurements of Brady Lake surface sediment agree with the estimated zone-of-accumulation depth of 1 m or greater (Figure 9). The majority of fine-grained surface sediment samples with 75% or greater water content were located in water deeper than 1 m (Table 4; Figure 9). Given the wind and wave climate at Brady Lake, sediment focusing processes are eroding fine grained sediment from water depth less than 1.5 m

Figure 26. Aerial photograph of Brady Lake showing locations of the 31 surface sediment samples (Photo from ArcMap, 2016). Red circles indicate samples having anomalous sediment properties for their water depth.

and transporting it to deeper water. Furthermore, sediment magnetic properties reveal the shallow water coarse grained sediment coarser magnetic grain sizes and higher ferromagnetic grain content (Figure 10).

To further examine sediment focusing effects on the distribution of different sediment types, sediment cores were collected from both deep water and shallow water sites (Figure 7). Lithology descriptions and organic matter content profiles were used to correlate the shallow and deep water core sites (Figure 27). The uppermost sediment in Brady Lake and other kettle lakes in Ohio has low organic matter content as a result of human disturbance to the lake system (Yifru, 2002; Haney, 2004; Shaw, 2013, Mitchell, 2015; Lally, 2016). In Brady Lake, the uppermost low organic content mud is 21.5 cm thick at the shallow water site and 190 cm thick at the deep-water site (Figure 27). The thickness of this low organic content sediment increases with water depth as a result of sediment focusing processes described previously. The shallow-water core ended in a dense clay which is similar to early glacial lacustrine sedimentation soon after deglaciation at approximately 16,500 to 14,500 yr BP (Szabo et al., 2006; Kushner, 2006; Lally, 2016). Above this dense clay, only ~220 cm of organic-rich lacustrine muds accumulated. Throughout the Holocene as lake level fluctuated, the shallow water core site is more often in the zone of transportation than in the zone of accumulation. The deep-water core was 4.13 m long and it is likely that organic-rich lacustrine muds extend down to 11-12 m deep because other Ohio kettle lakes have about 11-12 m of organic-rich lacustrine mud (Yifru, 2002; Lally, 2016).

Because of sediment focusing the thickest lacustrine deposits are found in the deep-water basin. The highest resolution sediment record comes from the deep-water site having the greatest sedimentation rate. Furthermore, as lake level decreases wave base extends into formerly deep waters and subjects the sediment to greater erosional action.

Figure 27. Organic content profiles from shallow and deep water coring sites in Brady Lake. Tie lines correlate distinctive lithologic properties between coring sites. Water depth not to scale.

Thus, shallow-water sites are more likely to have unconformities whereas, deep-water sites are more likely to preserve a continuous sediment record.

In addition to differences in temporal resolution and completeness of the stratigraphic record, shallow water sites record different environmental conditions than deep water sites. Between 114.5 and 95.5 cm core depth at the shallow water site, peat with abundant roots is present. This rooted peat suggests that a fringing marsh was present at the shallow water site at that time. A fringing marsh begins to form during the transformation process of a kettle lake to a bog (National Geographic, 2012). Rooted peat has not been recovered in the deep-water site from Brady Lake nor in much longer deep-water cores from Silver Lake (Lally, 2016). Therefore, a lateral facies pinchout must occur between the two coring sites at Brady Lake. Because of the greater temporal resolution and completeness of the stratigraphic record, the deep-water core was studied in detail to provide the Late Holocene environmental history discussed in the next section.

4.2 Paleoenvironment of Brady Lake

The paleoenvironment history of Brady Lake is broken down into the following five periods; Early to Late Holocene; Pre-Settlement, Settlement, Brady Lake Park, and the Environmental Regulations. The first period, spanning the Early to Late Holocene, was studied by correlating the 239-cm-long shallow-water core with sediment records from other Ohio kettle lakes (Yifru, 2002; Lally, 2016). The other four periods were studied by analyzing lithological and geochemical properties of the 413-cm-long sediment core from the deep-water site.

4.2.1 Early to Late Holocene Period (219.5-23.5 cm; 11,500-210 Cal yr BP)

Environmental conditions spanning the Early to Late Holocene at Brady Lake were studied by analyzing the sediment record from the shallow-water site. The Brady Lake

shallow water sediment core displays a remarkable degree of correlation to long cores from kettle lakes in Summit County (Lally, 2016) and Logan County (Yifru, 2002) Ohio (Figure 28). In Brady Lake, dense glacial lake clay is present between 239 to 219.5 cm core depth, similar to a glacial lake clay present between 1300 to 1188 cm core depth in Silver Lake (Lally, 2016). Lally (2016) dates this clay at 17,560-13,600 Cal yr BP and relates it to cold and dry conditions following deglaciation (Lally, 2016). In order for the lacustrine clay to be deposited, calm environmental conditions must have been present for a prolonged period of time allowing clay sized particles to settle. Above the clay in both Brady Lake and Silver Lake, Summit County, there is an interval where organic content abruptly increases and then declines (Figure 28). This increase in organic content is also seen in a Logan County kettle lake, however, the increase in organic content is slightly more gradual in the Logan County core (Figure 28). Lally (2016) dates this deep organic rich mud at 11,500-10,600 Cal yr BP and relates it to warm and moist climate following the Younger Dryas interval (Lally, 2016). Warm and moist conditions would promote vegetation growth, thus, increasing influx of organic matter to lake basins. Above 175 cm core depth in the shallow water core, organic content gradually increases by about 20% (Figure 28). The Silver Lake, Summit County, sediment displays a similar gradual increase in organic content. Lally (2016) dates the start of this interval to 7,450 Cal yr BP and relates it to warmer and wetter climate promoting vegetation growth (Lally, 2016). Within this organic-rich mud, pronounced lows in organic content occur. Based on an age model for Silver Lake sediment, Lally (2016) suggests that some of these lows in organic content correspond to ice rafting events in the North Atlantic (Lally, 2016). Between 95 and 25 cm core depth in the Brady Lake shallow-water core, organic content remains high at approximately 70% (Figure 28). Correlation of kettle lake sediment records from both Summit and Logan County date this interval at approximately 2500-200 Cal yr BP (Yifru, 2002; Lally, 2016). The consistency in organic content throughout this interval

Figure 28. Organic content profiles for the shallow water core site at Brady Lake, OH (left), and deep water core sites at Silver Lake of Summit County, OH (middle) modified after Lally (2016), and Silver Lake of Logan County, OH (right) modified after Yifru (2002). Shallow water core from Brady Lake plotted by composite core depth. Deep water cores from Silver Lake (Summit County) and Silver Lake (Logan County) are plotted on age. Tie lines correlate similar lithological characteristics between core sites.

suggests a warm and stable climate with increased lake productivity. The uppermost sediment from Brady Lake is further investigated using the deep-water sediment core because the temporal resolution of the deep-water sediment is greater than that of the shallow water sediment.

4.2.2 Pre-settlement Period (413-190 cm; 2840-210 Cal yr BP)

Late Holocene kettle lake sediment in Ohio is generally characterized by high organic content which suggests a warming climate with increased productivity (Yifru, 2002; Lally, 2016). In the Late Holocene prior to Euro-American settlement of northeast Ohio, the sediment accumulating Brady Lake was a low density, organic-rich gyttja with low concentrations of heavy metals and ferrimagnetic particles. In the deep-water core site this sediment is present between 413 and 190 cm and dates at 2840 to 210 Cal yr BP (Figures 29 and 30). This interval is characterized by high C/N ratio (average 13.7) and low Q/M ratio (below 17.5). C/N ratios of sedimentary organic matter are used to differentiate aquatic and terrigenous sources (Lerman et al., 1995). Low C/N ratios between 4 and 10 reflect nonvascular aquatic plants, whereas, vascular land plants have high C/N ratios greater than 20 (Lerman et al., 1995). High C/N ratios seen throughout this interval suggests greater inputs of terrigenous plant matter possibly from a forested watershed. Q/M is used to assess the relative proportions of quartz and mica minerals delivered to Brady Lake. Q/M ratios below 17.5 suggests that quartz input was relatively low throughout this interval. These lithological properties are interpreted to represent a forested watershed with low sediment yield (Figures 19, 29, and 30). Thick accumulations of leaf litter in the watershed was most likely the primary source of sediment input into Brady Lake. Furthermore, low Q/M ratio implies limited erosion of sediment in the watershed. One interval between 350 and 332 cm core depth, contains a

Figure 29. Downcore profiles of lithology, organic matter content, low frequency magnetic susceptibility (Xlf), chromium and copper concentrations, and carbon to nitrogen ratio (C/N) from the deep-water site at Brady Lake, Ohio. Orange points in the Pb, Cu, Cr, and C/N plots indicate replicated samples. Grey highlighted sections (Zones 1-5) indicate intervals with decreased organic content and increased sediment density.

Figure 30. Downcore age profiles of lithology, organic matter content, low frequency magnetic susceptibility (Xlf), chromium and copper concentrations, and carbon to nitrogen ratio (C/N) from the deep-water site at Brady Lake, Ohio. Orange points in the Pb, Cu, Cr, and C/N plots indicate replicated samples. Grey highlighted sections (Zones 1-5) indicate intervals with decreased organic content and increased sediment density.

peak in C/N ratio of 17.4 (Figures 29 and 30). This peak in C/N that dates to 1895 Cal yr BP may represent the time when the Brady Lake watershed was the most forested.

During periods of arid climate, vegetation in the watershed is expected to decrease thereby reducing vegetation screening of sediment and allowing increased erosion. Within the Pre-settlement period there are five zones where organic content decreases and sediment density increases (Figures 29 and 30). These five zones occur at approximately 399.5, 383.5, 277.5, 231.5, and 204.5 cm core depths and possibly represent a decrease in vegetation and increased erosion in the watershed. The timing of these five zones generally fall in globally distributed climate change intervals between 3500-2500, 1200-1000, and 600-150 Cal yr BP as identified by Mayewski et al. (2004). During each of these intervals of climatic change, advances in North American alpine glaciers occur (Mayewski et al., 2004). Mayewski et al. (2004) suggests that these intervals of climate change are driven by variability in solar output (Mayewski et al., 2004). However, the onset of the most recent interval between 600-150 Cal yr BP may also be influenced by an abundance of volcanic aerosols (Mayewski et al., 2004). A pronounced feature of the climatic interval between 3500-2500 Cal yr BP included a North Atlantic Ice Rafting event dated at 2800 years ago (Bond et al., 1997). Both intervals between 3500-2500 and 1200-1000 Cal yr BP are characterized by weak westerly winds over North America, cooling trends in high latitudes, and aridity in lower latitudes (Mayewski et al., 2004). The timing of Zone 1 (2670 Cal yr BP) and Zone 2 (2470 Cal yr BP) may correspond to high latitude cooling between 3500-2500 Cal yr BP (Mayewski et al., 2004). In Zone 3 (1145 Cal yr BP), organic content decreases by about 25% and the Q/M ratio peaks at about 30 (Figures 19, 29, and 30). The increase in quartz content suggests greater input of terrigenous sediment from greater watershed erosion. The timing of Zone 3 falls within the interval of rapid climate change between 1200-1000 Cal yr BP and may be due to cool and arid conditions in North America. The varved sediment from Elk Lake,

Minnesota, contains greater Al and Na concentrations and mass accumulation rates at this time interpreted to reflect increased eolian activity from regional aridity (Dean, 1997). Silver Lake, Ohio, sediment contains a similar interval of decreased organic content and increased sediment density that dates to approximately 1245 Cal yr BP (Lally, 2016). Lally (2016) suggests that this interval may correspond to hemisphere-wide climate change during an ice rafting event dated to 1400 years ago (Bond et al., 1997; Lally, 2016). Between 600 and 150 Cal yr BP, a period generally referred to as the Little Ice Age is defined as relatively cold and windy in polar regions (Mayewski et al., 2004). During the Little Ice Age, sediment from Elk Lake, Minnesota, contains an increased influx of detrital clastic material defined by peaks in Al and Na concentrations and mass accumulation rates (Dean, 1997). Dean (1997) suggests that this influx of clastic material results from increased eolian activity during the Little Ice Age (Dean, 1997). In Brady Lake, Zones 4 and 5 date to 520 and 300 Cal yr BP respectively, and may represent decreased productivity and greater watershed erosion during arid climate of the Little Ice Age.

Prior to Euro-American settlement in northeast Ohio, the environment was likely impacted from Native American activities such as agriculture and fire. Changes in climate such as warming during the Medieval Climatic Optimum (1000-1300 AD) and cooling during the Little Ice Age influenced Native American culture in different ways across the US (Ruddiman, 2001; Bird et al., 2017). Studies on the Mississippian inhabitants using Martin Lake, Indiana, sediment cores found an increase in maize agriculture during the Medieval Climate Optimum when warm seasons lengthened and rainfall increased in the midcontinental US (Bird et al., 2017). However, as conditions became more arid during the Little Ice Age, the Natives began to leave sites in southern Ohio and central Mississippi River Valley's (Bird et al., 2017). In the US southwest, prolonged conditions of drought during the Medieval Climate Optimum resulted in declines in agriculture

which led to the collapse of Native cultures there (Bird et al., 2017). In Ohio, some of the earliest occupants, the Hopewell, began to decline at approximately 1600 cal yr BP (“Hopewell Culture” n.d.). Archaeologists suggest cultural change and advances in technologies may be the primary reason for their decline (“Hopewell Culture” n.d.). The Brady Lake record shows a highly forested watershed during this time between about 2300-1400 Cal yr BP (Figure 30). The zones interpreted to indicate pronounced hydrological and sedimentological changes at Brady Lake pre-date or post-date this time interval (Figure 30). Future studies to further investigate the interaction between Native American’s and the environment of northeast Ohio could be determined through pollen and macroscopic charcoal analyses.

4.2.3 European Settlement Period (190-112 cm; 1805-1891 AD)

At 190 cm core depth, organic-rich gyttja abruptly changes into yellow-brown bedded mud (Figures 29 and 30). The bedded mud is characterized by an increase in magnetic susceptibility, trace metal concentration, and dry bulk density, and a 40% decrease in organic content and C/N ratios (Figures 29 and 30). The concentrations of Pb and Zn increase slightly, whereas, the Cr and Cu concentrations double (Figures 16, 29, and 30). Corresponding to the decrease in organic content is an increase in the Q/M ratio to values above 17.5 (Figure 19). This abrupt lithologic contact is inferred to mark the onset of Euro-American settlement of the Brady Lake watershed at 210 Cal yr BP (1805 AD). Prior to settlement, the Brady Lake watershed was heavily forested with thick accumulations of leaf litter (Enders, 2011). However, settlers clear cut the hardwood forests for agricultural purposes, thus decreasing the influx of terrigenous organic matter into Brady Lake as represented by low C/N ratio (Figures 29 and 30). Increased watershed erosion following deforestation would account for the increase in sediment density and Q/M ratio (Figures 29 and 30). Furthermore, the pre-settlement sedimentation

rate of 0.080 cm/yr increased 11-fold to 0.905 cm/yr following land clearance, watershed disturbance, and inferred removal of the Brady Lake fringing marsh by settlers (Figure 31). In addition, the pre-settlement mass accumulation rate of 0.008 g/cm²/yr increased to 0.168 g/cm²/yr after settlement (Figure 31). The increase in both linear sedimentation rate and mass accumulation rate correspond to increased sediment influx from the watershed and are not an artifact of sediment compaction. Shortly after settlement, numerous saw mills were being built along the Cuyahoga River in the nearby city of Kent (Enders et al., 2007). Agricultural tilling, combustion activities, and early industrial activities by the settlers leads to an increase in sedimentation rate (Figures 29 and 30). The increased erosion from land clearance and also burning downed trees changed the sediment source type resulting in increases in magnetic susceptibility and heavy metal concentrations above 190 cm core depth (Figures 29 and 30).

The most prominent lithological characteristic that marks Euro-American settlement in northeast Ohio is a decrease in organic content found in lake sediment cores (Figure 32). As settlement began around nearby Silver Lake, Rex Lake, and Summit Lake, organic content decreased and the gyttja lithology was overlain by a more dense mud lithology (Figure 32; Haney, 2004; Mitchell, 2015; Lally, 2016). The decrease in organic content occurs at different core depths in each lake due to differences in sedimentation rates (Figure 32). Furthermore, the length of core over which this decrease occurs varies. In Summit Lake the decrease occurs over 55 cm whereas, at Brady Lake the decrease occurs in 10 cm, the shortest interval of all the lakes (Figure 32). The Rex and Silver Lake organic matter decrease occurs in a distinct two-step fashion, whereas at Brady Lake the decrease occurs in a large step. The variation in the decline may be the result of differences in watershed activities during settlement.

In 1840, the lake level of Brady Lake was increased by 3 to 4.6 m in order to provide a water source to the newly constructed Pennsylvania and Ohio Canal (Enders, 2011).

Figure 31. Lithology, sediment accumulation rate (SAR), and mass accumulation rate (MAR) plotted on age for the deep-water site at Brady Lake, Ohio.

Figure 32. Down core organic content profiles of composite sediment records from kettle lakes in northeast Ohio. (From left to right) Summit Lake modified after Haney (2004), Brady Lake, Rex Lake modified after Mitchell (2015), and Silver Lake modified after Lally (2016). A decrease in sedimentary organic matter marks the onset of European settlement in northeast Ohio.

Between 190-140 cm (1805-1868 AD) yellow-brown bedded mud with highest DBD and the lowest C/N ratio is present (Figures 29 and 30). This interval of bedded mud may correspond to an increased influx of watershed mineral erosion following deforestation and high water levels during the time of the canal. Furthermore, this interval of bedded mud likely reflects the loss of a fringing marsh that was present prior to settlement at Brady Lake. The alternating thickness of each bedded mud appears to represent sediment influx pulses which may have variable sedimentation rates. Therefore, the abrupt change in lithology at 140 cm core depth likely dates to 1868 AD when the canal was drained and lake level lowered. Between 140-112 (1868 -1891 AD), brown mud with slightly lower density and increased organic content is present. The absence of bedded mud throughout this interval suggests further changes in watershed conditions after lake level lowered. Erosion in the watershed may have decreased throughout this interval as reflected by increasing organic content and decreasing sediment density. Transportation by railroad was also booming in the 1850's and likely contributes to the increase in heavy metal concentration seen in Brady Lake sediment (Enders, 2011).

4.2.4 Brady Lake Park Period (112-20 cm; 1891-1980 AD)

Between 112 and 20 cm core depth (1891-1980 AD), brown to black mud containing high ferrimagnetic and heavy metal concentration is present (Figures 29 and 30). Throughout this interval of mud, magnetic susceptibility nearly doubles and Pb concentration increases by about 300 µg/g (Figures 29 and 30). Concentrations of Cu and Cr reach consensus-based threshold effect concentration (TEC) levels, whereas concentrations of Pb and Zn exceed consensus-based probable effect concentration (PEC) levels (MacDonald et al., 2000). When heavy metal concentration exceeds the TEC level, adverse effects to “freshwater ecosystems” may begin to be detected (MacDonald et al., 2000). However, once heavy metal concentration surpasses the PEC level, adverse effects

to “freshwater ecosystems” are expected to occur (MacDonald et al., 2000). This core interval of increased heavy metal concentration is interpreted as the result of substantial anthropogenic activity when an amusement park was present and is called the Brady Lake Park Period (Figures 3 and 4). Visitors arrived at the park by a streetcar service which consistently made stops at the park entrance (Enders et al., 2007). The Park’s major attractions included a 75-passenger steamboat, 40 row boats, figure-8 roller coaster, a miniature railroad, and a pony track (Figures 3 and 4; “Brady Lake Electric Park,” n.d.). Abundant ferrimagnetic and spheroidal carbonaceous particles (i.e., combustion particles) were also identified throughout this interval (Figures 21, 22, and 23). The abundant of combustion particles come from varieties of anthropogenic activities including the steamboat, vehicles on land, and heating for buildings. Much like Brady Lake, nearby Silver Lake sediment contained an interval of black mud (117.5 to 79 cm core depth) with increased heavy metal concentration (Figures 33 and 34). Shaw (2013) interpreted these geochemical changes as increased anthropogenic activity during the time of a major lakeside amusement park at Silver Lake. Although the Brady Lake Park closed sometime around 1944, many structures still remained (Enders, 2011). In 1960, all unremoved structures were then burned to get rid of them. The removal of the park is likely reflected by the peak in magnetic susceptibility and heavy metal concentrations in the black mud interval between about 25-50 cm (Figures 16, 29, and 30).

4.2.5 Environmental Regulations Period (20-0 cm; 1980-2015 AD)

The uppermost 20 cm of sediment (1980-2015 AD) is characterized by decreasing magnetic susceptibility, dry bulk density, heavy metal concentration, C/N ratio, and increasing organic content (Figures 29 and 30). Cr and Cu concentration decreases by about 15 and 35 $\mu\text{g/g}$ respectively, whereas Pb concentration decreases by about 120 $\mu\text{g/g}$. At this point in time, the Brady Lake Park has been removed and the Clean Air and

Figure 33. Down-core concentrations of lead (Pb) from lakes in northeast Ohio. (From left to right) Summit Lake modified after Haney (2004), Brady Lake modified after Shaw (2013), and Rex Lake modified after Mitchell (2015). Summit Lake and Brady Lake plot indicate replicated samples. Vertical gold lines represent Threshold Effect Concentration levels and vertical orange lines represent Probable Effect Concentration levels from MacDonald et al. (2000).

Figure 34. Down core concentrations of Chromium (Cr) for Summit Lake modified after Haney (2004), Brady Lake, and Silver Lake modified after Shaw (2013). Summit Lake and Brady Lake plotted by age. Silver Lake plotted by depth. Orange points on the Brady Lake plot indicate replicated samples. Vertical gold lines represent Probable Effect Concentration levels and vertical orange lines represent Probable Effect Concentration levels from MacDonald et al. (2000).

Clean Water Acts of the 1970s have been put into effect. The goal of the Clean Air and Water Acts was to monitor and reduce the inputs of pollutants into the atmosphere and lake systems (Laws & Regulations, 2017). Studies of pollution in Cuyahoga River dam pool sediment have shown the effectiveness of environmental regulations in decreasing heavy metals in the environment since the 1980's (Mann et al., 2013). Decreasing Pb concentrations in the uppermost sediment of Rex, Summit, and Silver Lakes also reflect the effectiveness of environmental regulations (Figure 33; Haney, 2004; Shaw, 2013; Mitchell, 2015). The significant decline in Pb concentration is likely due in large part to decreases in the use of leaded gasoline. Although Pb concentration decreased by about half, present day Pb concentrations remain above PEC level in Brady Lake (Table 5; MacDonald et al., 2000). Although the Brady Lake watershed is located in a more rural setting much like Silver and Rex lakes, Brady Lake Pb concentrations resemble those of Summit Lake in an urban environment. During the time of the Brady Lake Park Period (1891-1980 AD), heavy metal pollution to Brady Lake was clearly the most intense in recorded history. Based on the declining Pb concentration since 1980, Pb concentration at Brady Lake is projected to decline to PEC level in approximately 20 years.

CHAPTER V

CONCLUSIONS

The goal of this study was to use the sediment record from Brady Lake, a kettle lake in northeastern Ohio, to determine past natural and anthropogenic environmental variability. Surficial sediment was analyzed for lithological properties to assess current sediment dispersal throughout Brady Lake. Sediment cores were collected from both shallow and deep water sites to assess variability in the sediment record at different locations in the Brady Lake basin. A 4.13-m-long deep-water sediment core was analyzed for lithological and geochemical properties to evaluate 2840 Cal yr of environmental change. This thesis research found the following:

- Sediment focusing processes in Brady Lake results in the accumulation of dense sandy sediment having low organic content (<5%) in water less than 1.5 m deep and low density, porous muds having high organic content (30%) in water greater than 1.5 m deep. Using wind speed and fetch, the estimated wave base of 1.5 m agrees well with a pronounced change in surface sediment properties at 1.5 m depth.
- The thickest lacustrine deposits having the greatest temporal resolution are found in the deep-water basin due to sediment focusing. In addition to having a condensed stratigraphic record, the shallow-water core site also contains sediments (i.e., rooted peat) representing different environmental conditions than the deep-water core site.

- Down core lithological properties record the paleoenvironmental history since 2840 Cal yr BP in the Brady Lake watershed-lake system. High C/N ratios (average 13.7) and organic content prior to Euro-American settlement (2840-210 Cal yr BP) suggest low watershed erosion and more terrigenous plant matter influx from a forested watershed. However, five lows in organic content with increased density and quartz content correspond to published rapid climate change intervals between 3500-2500, 1200-1000, and 600-150 Cal yr BP possibly reflecting atmospheric circulation changes leading to greater watershed erosion.
- Radiocarbon dates and event stratigraphy correlation yielded a Pre-settlement sedimentation rate of 0.080 cm/yr which increased 11-fold to 0.905 cm/yr after Euro-American settlement in 1805. This sedimentation rate increase results from land clearance and increased human activity in the Brady Lake watershed.
- Between 190-140 cm (1805-1868 AD) yellow-brown bedded mud with highest drybulk density and the lowest C/N ratio corresponds to an increased influx of watershed mineral erosion following deforestation and high water levels during the time of the Pennsylvania and Ohio Canal (1840-1868 AD). Furthermore, this interval of bedded mud likely reflects the loss of a fringing marsh that was present prior to settlement at Brady Lake. Between 140-112 (1868 -1891 AD), brown mud with slightly lower density and increased organic content suggests further changes in watershed conditions after lake level lowered.
- Between 112 and 20 cm core depth (1891-1980 AD), brown to black mud containing the highest ferrimagnetic and heavy metal concentration corresponds to the time when a major lakeside amusement park was present in the Brady Lake watershed between 1891-1960 AD.

- The uppermost 20 cm of sediment (1980-2015 AD) is characterized by decreasing ferrimagnetic and heavy metal concentrations. This interval is inferred to reflect the effectiveness of environmental regulations since 1980.

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APPENDICES

APPENDIX A

BRADY LAKE BATHYMETRY MAPPING

A Garmin 125 Fathometer and GPS unit were attached to a boat to collect latitude, longitude, and water depth measurements. The fathometer and GPS were powered by a car battery and connected to a laptop. On November 24, 2015 the lake was surveyed and the data was stored on the HyperTerminal computer program. Due to the limited data storage capability of HyperTerminal, only a small number of measurements at the end of each track line were saved. Therefore, a new survey was made on March 26, 2016 and the data was logged using the Putty computer program. A total of 7,507 data points were measured along numerous transects throughout the lake (Figure A-1). Because lake level fluctuates, the water level was measured from a fixed reference marker on both survey days. Thus the change in lake level between the survey dates could be accounted for. Furthermore, the depth of the transducer in the water was added to the transducer water depth measurements to obtain the total water depth. By following the general methods of Yifru and Peck (2002), the data points were incorporated into ArcMap as a table containing latitude, longitude, and water depth measurements. Limited shoreline data was collected by walking along the shoreline with the GPS unit. A field photograph of a distinctive dock that also showed the shoreline was used to find an aerial photograph that matched the position of the shoreline in the field photograph (Figure A-2). This aerial photograph, from Google Earth Pro (Google Earth Pro, 2016), was georeferenced and used to digitize the shoreline (Figure A-2). The shoreline polyline was then converted into points which were given a value of 0 for water depth, and merged together with

the field-data points layer. A Triangulated Irregular Network (TIN) was created from the bathymetry data point layer (Figure A-3). The TIN was then transformed into a raster because more analyses can be done with a raster than with a TIN (Figure A-4). Bathymetric contours were created from the raster at a 3-foot contour interval. The output contours from the raster had a jagged appearance (Figure A-5), so the contours were smoothed with the use of the Smooth Line Cartography tool (Figure A-6). To provide a three-dimensional view of the Brady Lake basin, the TIN in Figure A-3 was imported into ArcScene and given a vertical exaggeration of 10X (Figure A-7). The bathymetry map (Figure A-6), along with a basemap containing surrounding roads, was imported into Microsoft PowerPoint where the contours were further smoothed by hand and roads outlined to produce the final map (Figure A-8). This map is the final product delivered to the Brady Lake Township officials. Because Brady Lake's water level will fluctuate in the future, the water depths on the map correspond to 3' 5" below the base of a reference telephone pole located at the lake's southeastern beach along Lakeview Dr.

Figure A-1. The 7,507 points showing the transects along which the data were collected. The long track lines were collected with the Putty program. The short track lines were all the data that were saved in the HyperTerminal program.

Figure A-2. A georeferenced aerial photograph of Brady Lake obtained from Google Earth Pro (Google Earth Pro, 2016) was used to digitize the shoreline. The position of the shoreline shown in the aerial photograph corresponded to the shoreline position at the dock on the second survey day (March 26, 2016).

Figure A-3. The TIN of the Brady Lake basin.

Figure A-4. The raster file of Brady Lake bathymetry.

Figure A-5. The bathymetric contours created from the raster have a jagged appearance.

Figure A-6. The output contours were smoothed with the use of the Smooth Line Cartography tool.

Figure A-7. The 3-dimentional view of Brady Lake's basin in ArcScene. The TIN was given a vertical exaggeration of 10X to enhance the image of the lake's basin structure.

Brady Lake

Portage County, Ohio

Figure A-8. The final bathymetric map of Brady Lake. The contours and basemap showing surrounding roads were exported from ArcMap as an image and imported into Microsoft PowerPoint. Roads were then traced and contours were again outlined to further smooth them out.

APPENDIX B

GRAIN SIZE DATA FOR SURFACE SEDIMENT SAMPLES

Table B-1. Grain size data for surface sediment samples from Brady Lake, Ohio.

Sample G12

Start weight (g) = 10.444

Total Mud (g) = 9.331

D₅₀ = 6.7418

Phi (φ)	Beaker (g)	Beaker + Sediment (g)	Sediment Weight (g)	Sediment weight - dispersant (g)	*50	Individual weight (%)	Cumulative weight Coarser than (%)	Comments
4 (wet)	85.367	86.48	1.113	-	-	10.66	10.66	-
5	84.063	84.318	0.255	0.1634	8.17	1.79	12.44	Lost a drop
6	85.153	85.375	0.222	0.1304	6.52	17.68	30.13	Lost a drop
7	85.881	86.053	0.172	0.0804	4.02	26.79	56.92	Lost a drop
8	86.812	86.963	0.151	0.0594	2.97	14.64	71.56	-
9	87.456	87.607	0.151	0.0594	2.97	0.00	71.56	-

Table B-2. Grain size data for surface sediment samples from Brady Lake, Ohio.

Sample G13									
Start weight (g) = 9.233									
Total Mud (g) = 8.4006									
D ₅₀ = 7.2629									
Phi (φ)	Beaker (g)	Beaker + Sediment (g)	Sediment Weight (g)	Sediment weight - dispersant (g)	*50	Individual weight (%)	Cumulative weight Coarser than (%)	Comments	
4 (wet sieve)	83.691	84.615	0.924	-	-	10.01	10.01	-	-
5	87.609	87.854	0.245	0.1534	7.67	-2.32	7.69	-	-
6	83.268	83.482	0.214	0.1224	6.12	18.65	26.34	-	-
7	85.863	86.044	0.181	0.0894	4.47	19.86	46.20	Lost a drop	-
8	84.055	84.212	0.157	0.0654	3.27	14.44	60.65	-	-
9	86.954	87.104	0.15	0.0584	2.92	4.21	64.86	-	-

Table B-3. Grain size data for surface sediment samples from Brady Lake, Ohio.

Sample G10				
Initial Weight (g) = 30.758				
End weight (g) = 30.497				
Percent Error (%) = 0.849				
D ₅₀ = 0.1289				
Phi (φ)	mm	Sample Weight (g)	Individual Weight (%)	Cumulative Weight (%)
-3	8	4.002	13.12	13.12
-2.5	6.3	2.119	6.95	20.07
-2	4	0.916	3.00	23.07
-1.5	2.83	3.104	10.18	33.25
-1	2	1.794	5.88	39.13
-0.5	1.41	1.542	5.06	44.19
0	1	1.387	4.55	48.74
0.5	0.71	1.491	4.89	53.63
1	0.5	1.29	4.23	57.86
1.5	0.35	2.631	8.63	66.49
2	0.25	4.811	15.78	82.26
2.5	0.177	3.698	12.13	94.39
3	0.125	1.309	4.29	98.68
3.5	0.088	0.322	1.06	99.73
4	0.0625	0.056	0.18	99.92
> 4	> 0.0625	0.025	0.08	100.00

Table B-4. Grain size data for surface sediment samples from Brady Lake, Ohio.

Sample G29				
Initial Weight (g) = 30.574				
End weight (g) = 30.173				
Percent Error (%) = 1.312				
D ₅₀ = 1.6635				
Phi (φ)	mm	Sample Weight (g)	Individual Weight (%)	Cumulative Weight (%)
-3	8	1.827	6.06	6.06
-2.5	6.3	0	0.00	6.06
-2	4	0.87	2.88	8.94
-1.5	2.83	0.83	2.75	11.69
-1	2	0.593	1.97	13.65
-0.5	1.41	0.718	2.38	16.03
0	1	1.057	3.50	19.54
0.5	0.71	1.472	4.88	24.42
1	0.5	1.993	6.61	31.02
1.5	0.35	3.681	12.20	43.22
2	0.25	6.255	20.73	63.95
2.5	0.177	6.063	20.09	84.05
3	0.125	3.104	10.29	94.33
3.5	0.088	1.219	4.04	98.37
4	0.0625	0.346	1.15	99.52
> 4	> 0.0625	0.145	0.48	100.00

APPENDIX C

MAGNETIC CONCENTRATION (X_{LF}), GRAIN SIZE (X_{ARM}/X), AND
MINERALOGY (S-RATIO) DATA FOR SURFACE SEDIMENT SAMPLES

Table C-1. Magnetic concentration (X_{if}), grain size (X_{ARM}/X), and mineralogy (S-Ratio) parameters for surface sediment samples from Brady Lake, Ohio.

Sample	Sample Depth (m)	X_{if} ($10^{-8} \text{ m}^3 \text{ kg}^{-1}$)	X_{ARM}/X ($10^{-6} \text{ m}^3 \text{ kg}^{-1}$)	S-Ratio	Lithology
G16	0.10	284.9	5.17	0.98	Sand and Gravel
G30	0.50	145.6	2.69	0.93	Sand and Gravel
G31	0.50	61.2	1.20	0.95	Sand and Gravel
G29	0.60	22.5	0.49	0.93	Sand and Gravel
G10	0.95	5.3	0.24	0.86	Sand and Gravel
G24	1.00	5.6	0.51	0.85	Sand and Gravel
G20	1.60	43.7	3.32	0.93	Gravelly Mud
G5	1.60	61.7	4.56	0.93	Mud
G17	2.00	139.5	7.10	0.88	Mud
G19	2.80	108.2	9.12	0.92	Mud
G15	2.96	48.6	4.78	0.93	Mud
G3	2.96	34.4	3.50	0.93	Mud
G4	3.06	47.2	3.84	0.92	Mud
G9	3.12	3.7	0.50	0.89	Sand and Gravel
G21	3.30	69.9	6.32	0.92	Mud
G22	3.50	57.2	4.87	0.92	Mud
G2	3.75	64	1.95	0.91	Gravelly Mud
G23	3.80	79.5	6.26	0.93	Mud
G18	3.90	104.2	10.78	0.91	Mud
G11	4.08	71	1.48	0.98	Sand and Gravel
G1	5.00	87.3	6.39	0.93	Mud
G14	5.00	2.6	0.24	0.84	Sand and Gravel
G6	6.00	62.7	5.23	0.91	Mud
G25	6.20	51.1	4.65	0.92	Mud
G28	7.30	62.1	6.02	0.92	Mud
G8	8.01	46	3.81	0.92	Mud
G7	11.00	43.5	4.33	0.92	Mud
G12	11.54	40.2	2.75	0.92	Mud
G26	12.50	41.9	3.34	0.91	Mud
G13	13.20	31.7	2.83	0.92	Mud

APPENDIX D
WHOLE-CORE MAGNETIC SUSCEPTIBILITY DATA

Table D-1. Whole core magnetic susceptibility for Core 1.

Core Depth (cm)	Composite Core Depth (cm)	K (10^{-5} Relative SI Units)
0	0	0.8
3	3	1.5
6	6	1.6
9	9	1.6
12	12	1.7
15	15	1.7

Table D-2. Whole core magnetic susceptibility for Core 2.

Core Depth (cm)	Composite Core Depth (cm)	K (10^{-5} Relative SI Units)
0	25	2.9
3	28	6.2
6	31	9.1
9	34	11.1
12	37	9.9
15	40	8.9
18	43	10.6
21	46	10.1
24	49	7.8
27	52	6.2
30	55	5.3
33	58	5.3
36	61	5.4
39	64	5.4
42	67	6.0
45	70	5.8
48	73	5.4
51	76	5.3
54	79	4.6
57	82	5.5
60	85	5.3
63	88	4.8
66	91	3.8
69	94	3.7
72	97	4.1
75	100	4.4
78	103	4.0
81	106	3.6
84	109	3.7
87	112	3.6
90	115	4.1
93	118	3.8
96	121	4.0
99	124	3.7
102	127	3.8
105	130	4.2
108	133	4.2
111	136	4.4
114	139	5.7
117	142	5.7

Table D-2 continued. Whole core magnetic susceptibility for Core 2.

Core Depth (cm)	Composite Core Depth (cm)	K (10 ⁻⁵ Relative SI Units)
120	145	5.9
123	148	5.8
126	151	5.2
129	154	5.2
132	157	5.4
135	160	5.2
138	163	5.1
141	166	5.5
144	169	5.2
147	172	3.5
150	175	4.2
153	178	4.2
156	181	4.8
159	184	3.7

Table D-3. Whole core magnetic susceptibility for Core 3.

Core Depth (cm)	Composite Core Depth (cm)	K (10^{-5} Relative SI Units)
0	0	1.3
3	3	2.4
6	6	2.7
9	9	3.4
12	12	4.2
15	15	4.7
18	18	5.6
21	21	7.3
24	24	8.2
27	27	8.3
30	30	8.4
33	33	7.8
36	36	8.6
39	39	10.9
42	42	11.9
45	45	12.1
48	48	10.6
51	51	8.5
54	54	5.9
57	57	5.7
60	60	5.0
63	63	5.3
66	66	5.8
69	69	5.9
72	72	6.2
75	75	6.2
78	78	6.1
81	81	5.1
84	84	4.3
87	87	4.3
90	90	4.1
93	93	4.0
96	96	3.7
99	99	3.6
102	102	5.9
105	105	7.9
108	108	9.1
111	111	8.6
114	114	7.1
117	117	6.1

Table D-3 continued. Whole core magnetic susceptibility for Core 3.

Core Depth (cm)	Composite Core Depth (cm)	K (10-5 Relative SI Units)
120	120	7.5
123	123	8.4
126	126	8.0
129	129	9.5
132	132	8.6
135	135	7.3
138	138	6.4
141	141	5.5
144	144	7.4
147	147	5.4
150	150	5.5
153	153	5.4
156	156	5.3
159	159	5.9
162	162	6.2
165	165	6.3
168	168	6.6
171	171	5.8
174	174	7.5
177	177	7.5
180	180	8.6
183	183	7.0
186	186	6.6
189	189	4.5
192	192	3.0
195	195	2.9
198	198	2.6
201	201	2.6
204	204	3.7
207	207	2.4
210	210	2.9
213	213	2.4
216	216	2.6
219	219	2.6
222	222	2.7
225	225	1.9
228	228	2.3
231	231	2.2
234	234	2.2

Table D-3 continued. Whole core magnetic susceptibility for Core 3.

Core Depth (cm)	Composite Core Depth (cm)	K (10 ⁻⁵ Relative SI Units)
237	237	1.9
240	240	1.8
243	243	1.4
246	246	1.3
249	249	0.9
252	252	0.9
255	255	1.0
258	258	0.8
261	261	0.5
264	264	0.9

Table D-4. Whole core magnetic susceptibility for Core 4.

Core Depth (cm)	Composite Core Depth (cm)	K (10^{-5} Relative SI Units)
0	156	1.5
3	159	2.6
6	162	2.8
9	165	3.0
12	168	3.0
15	171	3.1
18	174	3.3
21	177	3.6
24	180	3.9
27	183	3.8
30	186	2.4
33	189	0.9
36	192	0.4
39	195	1.9
42	198	1.0
45	201	0.6
48	204	1.1
51	207	0.9
54	210	1.1
57	213	0.8
60	216	1.0
63	219	1.0
66	222	0.8
69	225	0.8
72	228	1.6
75	231	0.9
78	234	1.3
81	237	1.6
84	240	1.6
87	243	1.6
90	246	1.7
93	249	1.3
96	252	1.1
99	255	1.2
102	258	1.1
105	261	1.4
108	264	1.0
111	267	0.4
114	270	1.1
117	273	1.3

Table D-4 continued. Whole core magnetic susceptibility for Core 4.

Core Depth (cm)	Composite Core Depth (cm)	K (10 ⁻⁵ Relative SI Units)
120	276	1.1
123	279	1.1
126	282	1.2
129	285	1.1
132	288	1.1
135	291	0.9
138	294	0.8
141	297	0.4
144	300	0.5
147	303	0.6
150	306	0.7
153	309	0.9
156	312	0.5
159	315	0.5
162	318	0.2
165	321	0.3
168	324	0.3
171	327	0.5
174	330	0.4
177	333	0.2
180	336	-0.2
183	339	-0.3
186	342	-0.3
189	345	-0.3
192	348	-0.2
195	351	-0.2
198	354	-0.2
201	357	-0.3
204	360	-0.2
207	363	-0.3
210	366	-0.4
213	369	-0.3
216	372	-0.3
219	375	-0.3
222	378	-0.3
225	381	-0.3
228	384	-0.3
231	387	-0.4
234	390	-0.3

Table D-4 continued. Whole core magnetic susceptibility for Core 4.

Core Depth (cm)	Composite Core Depth (cm)	K (10 ⁻⁵ Relative SI Units)
237	393	-0.3
240	396	-0.3
243	399	-0.3
246	402	-0.4
249	405	-0.3
252	408	-0.3
255	411	-0.1

Table D-5. Whole core magnetic susceptibility for Core 5.

Core Depth (cm)	Composite Core Depth (cm)	K (10^{-5} Relative SI Units)
0	0	0.8
3	3	2.2
6	6	2.8
9	9	3.3
12	12	3.5
15	15	2.9
18	18	1.2
21	21	0.4

Table D-6. Whole core magnetic susceptibility for Core 6.

Core Depth (cm)	Composite Core Depth (cm)	K (10^{-5} Relative SI Units)
0	22	0.4
3	25	-0.1
6	28	-0.6
9	31	-0.6
12	34	-0.8
15	37	-0.7
18	40	-0.6
21	43	-0.5
24	46	-0.3
27	49	-0.6
30	52	-0.1
33	55	-0.2
36	58	-0.5
39	61	-0.2
42	64	-0.4
45	67	-0.3
48	70	-0.3
51	73	-0.4
54	76	-0.4
57	79	-0.5
60	82	-0.5
63	85	-0.4
66	88	-0.4
69	91	-0.4
72	94	-0.4
75	97	-0.4
78	100	-0.5
81	103	-0.4
84	106	-0.4
87	109	-0.4
90	112	-0.5
93	115	-0.4
96	118	-0.4
99	121	-0.4
102	124	-0.4
105	127	-0.4
108	130	-0.4
111	133	-0.3
114	136	-0.4
117	139	-0.4

Table D-6 continued. Whole core magnetic susceptibility for Core 6.

Core Depth (cm)	Composite Core Depth (cm)	K (10^{-5} Relative SI Units)
120	142	-0.4
123	145	-0.4
126	148	-0.3
129	151	-0.4
132	154	-0.3
135	157	-0.4
138	160	-0.3
141	163	-0.3
144	166	-0.3
147	169	-0.3
150	172	-0.3
153	175	-0.2
156	178	-0.2
159	181	-0.1
162	184	0.0
165	187	0.0
168	190	0.0
171	193	0.0
174	196	0.0
177	199	0.0
180	202	0.1
183	205	0.2
186	208	0.1
189	211	0.0
192	214	0.0
195	217	0.3
198	220	0.8
201	223	2.0
204	226	3.9
207	229	6.0
210	232	9.6
213	235	13.6
216	238	15.9
219	241	15.8

APPENDIX E

LOSS-ON-IGNITION (LOI) MEASUREMENTS FOR POROSITY, WET BULK DENSITY (WBD), DRY BULK DENSITY (DBD), ORGANIC MATTER, AND CARBONATE CONTENT. POROSITY AND WBD MEASUREMENTS ARE INACCURATE DUE TO PORE WATER EVAPORATING BETWEEN THE TIME OF CORE SPLITTING AND LOI SAMPLING

Table E-1. Loss-on-ignition data for Core 1 from Brady Lake, Ohio.

Depth (cm)	Composite Depth (cm)	Water (%)	WBD (g/cm ³)	DBD (g/cm ³)	Organic (%)	Carbonate (%)
0.5	0.5	17.23	0.972	0.124	32.26	3.24
1.5	1.5	14.76	0.939	0.123	33.33	4.98
2.5	2.5	14.28	0.948	0.127	30.71	7.73
3.5	3.5	14.94	0.903	0.110	31.82	7.25
4.5	4.5	14.73	0.906	0.115	33.04	3.53
5.5	5.5	14.88	0.935	0.109	33.94	5.67
6.5	6.5	15.01	0.956	0.124	31.45	6.40
7.5	7.5	15.03	0.951	0.117	32.48	5.16
8.5	8.5	14.03	0.948	0.121	30.58	4.86
9.5	9.5	16.75	0.940	0.141	25.53	5.18
10.5	10.5	14.98	0.966	0.116	31.90	5.16
11.5	11.5	14.63	0.971	0.121	31.40	6.55
12.5	12.5	14.64	0.962	0.124	29.84	7.82
13.5	13.5	15.69	0.928	0.126	30.16	6.18
14.5	14.5	14.77	0.958	0.154	23.38	5.76
15.5	15.5	13.29	0.930	0.126	30.95	4.69
16.5	16.5	14.74	0.955	0.137	29.20	8.41
17.5	17.5	15.29	0.984	0.144	29.86	5.39

Table E-2. Loss-on-ignition data for Core 2 from Brady Lake, Ohio.

Depth (cm)	Composite Depth (cm)	Water (%)	WBD (g/cm ³)	DBD (g/cm ³)	Organic (%)	Carbonate (%)
0.5	25.5	15.82	1.000	0.167	24.55	6.48
1.5	26.5	17.83	0.913	0.115	33.04	7.06
2.5	27.5	15.73	0.950	0.120	31.67	8.29
3.5	28.5	14.41	1.014	0.183	23.50	6.80
4.5	29.5	13.83	0.990	0.217	17.97	5.35
5.5	30.5	12.55	0.993	0.179	22.35	5.87
6.5	31.5	18.38	0.961	0.157	26.11	7.03
7.5	32.5	14.60	0.981	0.163	26.38	6.80
8.5	33.5	12.48	0.983	0.171	24.56	6.33
9.5	34.5	15.90	1.008	0.181	24.31	6.95
10.5	35.5	16.69	1.030	0.232	19.40	5.82
11.5	36.5	15.20	0.974	0.160	28.75	5.96
12.5	37.5	15.79	0.959	0.157	28.66	7.29
13.5	38.5	14.99	0.944	0.144	31.94	4.16
14.5	39.5	15.12	0.944	0.148	30.41	6.60
15.5	40.5	13.14	0.954	0.148	30.41	7.92
16.5	41.5	16.94	0.979	0.171	30.41	5.71
17.5	42.5	16.36	0.994	0.176	30.11	6.63
18.5	43.5	19.02	1.156	0.155	29.68	6.24
19.5	44.5	12.39	0.981	0.175	29.71	6.63
20.5	45.5	15.39	0.957	0.170	29.41	6.80
21.5	46.5	15.99	1.032	0.176	29.55	5.48
22.5	47.5	16.77	1.016	0.165	30.91	7.16
23.5	48.5	18.23	0.947	0.159	30.82	6.18
24.5	49.5	13.78	1.014	0.169	30.18	6.92
25.5	50.5	15.25	1.013	0.166	30.72	5.91
26.5	51.5	17.65	1.010	0.166	30.12	7.03
27.5	52.5	13.38	0.938	0.152	32.89	5.33
28.5	53.5	15.38	0.987	0.159	32.70	6.36
29.5	54.5	14.58	0.982	0.155	32.90	5.23
30.5	55.5	16.24	0.992	0.156	32.69	6.48
31.5	56.5	14.48	0.978	0.156	32.69	5.18
32.5	57.5	14.79	1.003	0.161	33.54	5.08
33.5	58.5	15.10	1.006	0.168	31.55	4.73
34.5	59.5	14.39	0.986	0.160	31.25	6.18
35.5	60.5	14.65	1.000	0.162	32.72	6.24
36.5	61.5	16.05	1.009	0.164	33.54	4.99
37.5	62.5	14.74	0.977	0.159	33.33	5.13

Table E-2 continued. Loss-on-ignition data for Core 2 from Brady Lake, Ohio.

Depth (cm)	Composite Depth (cm)	Water (%)	WBD (g/cm ³)	DBD (g/cm ³)	Organic (%)	Carbonate (%)
38.5	63.5	15.63	0.993	0.163	33.74	5.04
39.5	64.5	14.41	0.960	0.161	34.16	3.85
40.5	65.5	14.28	0.962	0.162	32.72	6.24
41.5	66.5	14.88	0.971	0.161	33.54	3.81
42.5	67.5	15.16	0.983	0.169	32.54	3.58
43.5	68.5	14.96	1.008	0.180	31.11	4.39
44.5	69.5	17.95	0.995	0.168	32.74	6.02
45.5	70.5	14.39	0.980	0.159	32.70	5.08
46.5	71.5	15.45	0.969	0.153	33.99	5.39
47.5	72.5	12.82	0.902	0.147	33.33	5.55
48.5	73.5	14.47	0.992	0.164	34.15	3.78
49.5	74.5	13.74	0.993	0.172	33.72	3.58
50.5	75.5	13.61	0.975	0.163	31.90	6.13
51.5	76.5	16.88	0.980	0.172	30.23	6.80
52.5	77.5	16.71	1.005	0.163	33.13	6.24
53.5	78.5	13.26	1.004	0.159	33.33	5.13
54.5	79.5	13.98	0.984	0.160	33.75	5.13
55.5	80.5	14.90	0.994	0.161	33.54	5.08
56.5	81.5	15.75	0.989	0.154	32.47	6.54
57.5	82.5	15.35	0.988	0.161	32.92	5.04
58.5	83.5	15.46	0.991	0.162	32.72	6.24
59.5	84.5	15.03	0.937	0.146	33.56	5.61
60.5	85.5	15.86	1.008	0.172	33.14	3.55
61.5	86.5	13.31	0.964	0.164	32.32	4.90
62.5	87.5	13.77	0.932	0.153	32.68	5.28
63.5	88.5	14.60	0.965	0.158	33.54	5.18
64.5	89.5	14.90	1.004	0.164	34.15	6.30
65.5	90.5	15.07	1.003	0.164	34.15	3.78
66.5	91.5	15.28	0.976	0.159	34.59	3.92
67.5	92.5	14.92	0.988	0.161	34.78	3.89
68.5	93.5	14.97	0.982	0.161	34.78	5.18
69.5	94.5	14.40	0.965	0.158	34.81	5.28
70.5	95.5	14.79	0.988	0.162	33.95	5.08
71.5	96.5	14.33	0.970	0.164	33.54	3.74
72.5	97.5	14.32	0.953	0.167	31.74	4.77
73.5	98.5	14.24	0.974	0.181	29.83	5.35
74.5	99.5	14.84	0.995	0.180	30.00	4.32
75.5	100.5	13.85	0.954	0.169	31.95	4.73
76.5	101.5	14.48	0.950	0.180	29.44	4.28

Table E-2 continued. Loss-on-ignition data for Core 2 from Brady Lake, Ohio.

Depth (cm)	Composite Depth (cm)	Water (%)	WBD (g/cm ³)	DBD (g/cm ³)	Organic (%)	Carbonate (%)
77.5	102.5	15.76	1.011	0.158	34.81	5.28
78.5	103.5	14.05	0.965	0.168	33.93	3.68
79.5	104.5	15.55	0.986	0.181	29.83	5.35
80.5	105.5	14.45	1.016	0.175	33.14	3.49
81.5	106.5	15.03	0.988	0.176	31.25	5.62
82.5	107.5	14.84	0.984	0.168	33.33	4.86
83.5	108.5	14.59	0.982	0.171	33.92	3.61
84.5	109.5	14.89	0.989	0.170	33.53	3.61
85.5	110.5	13.88	0.980	0.174	32.18	4.61
86.5	111.5	16.76	1.019	0.182	32.97	4.46
87.5	112.5	15.24	1.003	0.173	34.68	4.81
88.5	113.5	15.37	1.008	0.174	34.48	3.58
89.5	114.5	15.39	1.008	0.182	32.42	4.42
90.5	115.5	14.23	1.015	0.192	29.69	4.03
91.5	116.5	14.22	1.006	0.188	30.32	5.19
92.5	117.5	15.12	1.028	0.201	29.35	4.79
93.5	118.5	16.75	1.010	0.193	30.57	4.06
94.5	119.5	15.75	1.021	0.195	30.77	4.03
95.5	120.5	14.68	1.003	0.195	28.72	3.91
96.5	121.5	17.25	0.997	0.181	29.83	5.35
97.5	122.5	15.34	1.034	0.193	29.53	5.00
98.5	123.5	16.53	1.000	0.186	29.57	5.19
99.5	124.5	14.59	1.032	0.192	29.17	4.00
100.5	125.5	17.48	1.002	0.185	29.73	4.18
101.5	126.5	15.11	1.027	0.196	28.57	3.89
102.5	127.5	14.31	0.966	0.175	30.86	4.50
103.5	128.5	18.92	1.042	0.194	30.41	4.03
104.5	129.5	17.78	1.014	0.187	30.48	4.18
105.5	130.5	15.73	1.026	0.196	29.08	3.91
106.5	131.5	15.58	1.047	0.206	28.64	3.70
107.5	132.5	13.67	1.002	0.193	28.50	4.93
108.5	133.5	15.28	1.029	0.199	29.15	3.86
109.5	134.5	19.18	1.024	0.201	28.86	3.80
110.5	135.5	15.64	1.038	0.205	27.80	4.59
111.5	136.5	18.49	1.029	0.194	29.38	3.97
112.5	137.5	16.06	1.034	0.213	26.76	4.36
113.5	138.5	16.58	1.041	0.211	27.01	4.42
114.5	139.5	18.31	1.045	0.217	25.81	4.22

Table E-2 continued. Loss-on-ignition data for Core 2 from Brady Lake, Ohio.

Depth (cm)	Composite Depth (cm)	Water (%)	WBD (g/cm ³)	DBD (g/cm ³)	Organic (%)	Carbonate (%)
115.5	140.5	16.92	1.038	0.218	25.69	4.20
116.5	141.5	17.71	1.070	0.228	25.88	4.02
117.5	142.5	17.94	1.049	0.213	26.76	3.49
118.5	143.5	13.31	1.020	0.215	25.58	4.25
119.5	144.5	13.08	1.054	0.222	25.23	4.92
120.5	145.5	18.54	1.030	0.220	25.91	4.17
121.5	146.5	14.09	1.038	0.225	25.33	4.05
122.5	147.5	14.20	1.041	0.226	24.78	4.00
123.5	148.5	16.29	1.062	0.236	24.15	3.80
124.5	149.5	18.66	1.062	0.233	22.75	3.78
125.5	150.5	18.56	1.045	0.220	24.55	4.92
126.5	151.5	17.33	1.073	0.230	24.35	3.91
127.5	152.5	13.13	1.065	0.236	24.58	3.82
128.5	153.5	19.16	1.043	0.232	24.57	4.66
129.5	154.5	18.64	1.061	0.239	24.27	3.76
130.5	155.5	15.03	1.064	0.238	24.37	4.53
131.5	156.5	13.96	1.047	0.236	24.15	4.56
132.5	157.5	18.35	1.051	0.230	24.78	3.93
133.5	158.5	19.35	1.041	0.225	24.44	5.60
134.5	159.5	12.89	1.072	0.236	25.00	3.84
135.5	160.5	15.55	1.064	0.240	24.58	3.76
136.5	161.5	15.78	1.047	0.233	24.03	3.84
137.5	162.5	18.96	1.054	0.225	26.22	2.46
138.5	163.5	16.98	1.058	0.239	23.43	3.72
139.5	164.5	18.35	1.078	0.242	23.55	4.41
140.5	165.5	18.16	1.067	0.254	22.05	4.12
141.5	166.5	16.90	1.060	0.254	22.05	3.43
142.5	167.5	12.74	1.065	0.253	22.13	4.14
143.5	168.5	15.42	1.067	0.250	22.40	4.21
144.5	169.5	16.51	1.088	0.254	22.83	3.47
145.5	170.5	15.48	1.047	0.240	22.08	5.09
146.5	171.5	16.28	1.083	0.256	22.27	3.42
147.5	172.5	13.94	1.070	0.254	21.65	4.78
148.5	173.5	14.09	1.092	0.263	21.67	3.96
149.5	174.5	17.91	1.063	0.265	20.75	3.89
150.5	175.5	15.67	1.078	0.270	20.00	4.41
151.5	176.5	18.22	1.095	0.298	18.79	3.93
152.5	177.5	17.01	1.123	0.312	18.27	3.73

Table E-2 continued. Loss-on-ignition data for Core 2 from Brady Lake, Ohio.

Depth (cm)	Composite Depth (cm)	Water (%)	WBD (g/cm ³)	DBD (g/cm ³)	Organic (%)	Carbonate (%)
153.5	178.5	14.74	1.094	0.303	18.15	3.84
154.5	179.5	15.13	1.100	0.301	17.61	4.94
155.5	180.5	15.34	1.110	0.316	17.09	2.08
156.5	181.5	16.18	1.176	0.385	13.77	4.10
157.5	182.5	16.34	1.194	0.427	13.35	3.31
158.5	183.5	16.87	1.197	0.429	13.52	2.93
159.5	184.5	14.92	1.147	0.407	14.74	3.53

Table E-3. Loss-on-ignition data for Core 3 from Brady Lake, Ohio.

Depth (cm)	Composite Depth (cm)	Water (%)	WBD (g/cm ³)	DBD (g/cm ³)	Organic (%)	Carbonate (%)
0.5	0.5	18.27	0.973	0.156	30.13	7.49
1.5	1.5	16.03	1.009	0.152	30.92	7.77
2.5	2.5	16.18	1.001	0.141	32.62	8.59
3.5	3.5	18.01	0.985	0.146	32.19	8.24
4.5	4.5	16.38	1.011	0.147	31.29	8.08
5.5	5.5	20.59	1.037	0.166	30.12	7.03
6.5	6.5	15.58	1.028	0.155	29.68	8.73
7.5	7.5	15.89	1.038	0.164	28.05	6.92
8.5	8.5	15.97	1.028	0.161	27.95	7.03
9.5	9.5	15.86	1.050	0.179	24.58	7.05
10.5	10.5	15.25	1.034	0.170	27.06	7.68
11.5	11.5	15.10	1.035	0.168	27.38	8.92
12.5	12.5	18.28	1.035	0.166	28.31	6.86
13.5	13.5	15.50	1.032	0.169	28.40	8.99
14.5	14.5	15.28	1.024	0.173	25.43	8.43
15.5	15.5	16.62	1.026	0.166	27.11	7.87
16.5	16.5	15.53	1.055	0.194	24.74	6.52
17.5	17.5	15.17	1.032	0.189	24.87	7.66
18.5	18.5	15.43	1.038	0.170	28.82	7.87
19.5	19.5	15.09	1.039	0.176	27.84	7.50
20.5	20.5	14.94	1.011	0.182	25.82	8.06
21.5	21.5	15.10	1.060	0.217	21.20	5.57
22.5	22.5	14.28	1.018	0.176	25.00	10.30
23.5	23.5	19.09	1.017	0.169	27.81	8.92
24.5	24.5	14.19	1.014	0.167	29.34	9.22
25.5	25.5	16.92	1.046	0.188	26.60	8.87
26.5	26.5	15.42	1.029	0.174	25.29	9.42
27.5	27.5	15.72	1.031	0.175	25.14	9.34
28.5	28.5	15.23	1.019	0.181	25.41	9.07
29.5	29.5	16.29	1.055	0.181	25.41	9.07
30.5	30.5	15.76	1.047	0.183	26.23	8.06
31.5	31.5	14.90	1.034	0.177	25.99	9.34
32.5	32.5	13.88	1.018	0.184	24.46	9.78
33.5	33.5	14.70	1.038	0.173	28.32	8.77
34.5	34.5	15.31	1.052	0.194	24.23	7.40
35.5	35.5	15.53	1.018	0.169	26.04	8.70
36.5	36.5	16.25	1.047	0.189	23.81	10.39
37.5	37.5	15.78	1.054	0.188	28.19	9.07

Table E-3 continued. Loss-on-ignition data for Core 3 from Brady Lake, Ohio.

Depth (cm)	Composite Depth (cm)	Water (%)	WBD (g/cm ³)	DBD (g/cm ³)	Organic (%)	Carbonate (%)
38.5	38.5	14.40	1.019	0.173	28.90	7.74
39.5	39.5	14.81	1.007	0.167	30.54	7.03
40.5	40.5	15.30	1.051	0.183	30.60	6.43
41.5	41.5	18.86	1.033	0.180	30.00	6.48
42.5	42.5	18.10	1.026	0.180	29.44	8.57
43.5	43.5	18.28	1.009	0.177	30.51	6.63
44.5	44.5	14.62	1.038	0.182	29.67	6.38
45.5	45.5	17.17	1.027	0.175	31.43	6.80
46.5	46.5	16.36	1.052	0.185	30.27	5.27
47.5	47.5	16.84	1.033	0.178	30.34	5.48
48.5	48.5	18.03	1.036	0.176	30.68	6.69
49.5	49.5	16.42	1.040	0.179	30.17	5.44
50.5	50.5	13.86	1.026	0.176	29.55	6.58
51.5	51.5	15.88	1.017	0.164	31.71	6.07
52.5	52.5	14.67	1.006	0.164	32.32	6.13
53.5	53.5	17.88	1.021	0.167	33.53	3.68
54.5	54.5	15.23	0.993	0.155	32.90	6.54
55.5	55.5	19.31	1.011	0.167	32.34	4.81
56.5	56.5	15.34	0.990	0.167	31.74	5.96
57.5	57.5	17.47	1.018	0.166	33.73	7.42
58.5	58.5	17.06	0.981	0.158	33.54	6.48
59.5	59.5	15.58	0.979	0.156	33.33	5.23
60.5	60.5	15.13	0.993	0.163	32.52	7.42
61.5	61.5	15.03	0.988	0.157	33.76	5.23
62.5	62.5	15.16	0.977	0.158	33.54	6.48
63.5	63.5	15.63	1.005	0.157	34.39	5.28
64.5	64.5	15.07	0.993	0.163	33.74	5.04
65.5	65.5	14.95	1.003	0.157	33.76	2.62
66.5	66.5	16.30	1.037	0.179	31.28	4.42
67.5	67.5	14.51	1.004	0.165	32.73	6.13
68.5	68.5	15.14	1.000	0.159	33.96	3.89
69.5	69.5	14.72	1.006	0.164	33.54	4.99
70.5	70.5	16.00	1.007	0.164	32.93	4.95
71.5	71.5	13.44	0.964	0.161	34.16	3.85
72.5	72.5	15.25	1.014	0.170	32.35	4.73
73.5	73.5	15.30	0.983	0.160	33.12	5.08
74.5	74.5	17.90	1.027	0.170	32.94	4.77
75.5	75.5	15.57	1.005	0.162	32.72	4.99
76.5	76.5	14.49	1.006	0.172	32.56	4.69

Table E-3 continued. Loss-on-ignition data for Core 3 from Brady Lake, Ohio.

Depth (cm)	Composite Depth (cm)	Water (%)	WBD (g/cm ³)	DBD (g/cm ³)	Organic (%)	Carbonate (%)
77.5	77.5	14.34	1.008	0.164	32.93	4.95
78.5	78.5	15.56	0.990	0.152	31.58	6.54
79.5	79.5	16.07	1.013	0.167	31.74	4.77
80.5	80.5	15.93	0.998	0.160	33.12	5.08
81.5	81.5	15.88	1.035	0.171	32.16	4.69
82.5	82.5	18.34	1.004	0.159	33.33	3.85
83.5	83.5	15.66	1.004	0.173	30.06	4.50
84.5	84.5	14.55	1.012	0.173	30.06	3.37
85.5	85.5	18.01	1.019	0.167	32.93	3.64
86.5	86.5	17.31	1.006	0.168	32.14	4.77
87.5	87.5	16.42	1.013	0.174	32.76	4.65
88.5	88.5	14.66	0.975	0.163	33.13	4.99
89.5	89.5	14.78	1.000	0.167	32.93	4.86
90.5	90.5	14.86	0.987	0.166	33.13	3.68
91.5	91.5	14.60	0.998	0.167	33.53	3.68
92.5	92.5	12.98	0.992	0.165	33.94	4.99
93.5	93.5	15.17	1.002	0.168	33.33	4.86
94.5	94.5	15.73	0.990	0.170	32.94	4.77
95.5	95.5	16.33	0.973	0.144	35.42	5.85
96.5	96.5	19.21	0.991	0.161	36.02	5.28
97.5	97.5	15.76	0.985	0.165	35.76	6.42
98.5	98.5	14.14	0.980	0.159	35.85	5.33
99.5	99.5	15.86	0.995	0.155	36.13	4.12
100.5	100.5	18.91	0.998	0.158	36.71	4.08
101.5	101.5	18.13	1.008	0.157	36.94	5.49
102.5	102.5	14.26	0.990	0.160	36.88	5.39
103.5	103.5	18.06	0.979	0.164	36.59	6.54
104.5	104.5	16.47	0.988	0.158	35.44	6.67
105.5	105.5	14.98	0.973	0.155	36.77	5.55
106.5	106.5	17.48	0.992	0.158	36.71	4.08
107.5	107.5	18.70	0.971	0.154	36.36	1.39
108.5	108.5	19.06	0.996	0.162	37.04	5.33
109.5	109.5	16.47	1.015	0.166	34.94	3.78
110.5	110.5	16.52	0.981	0.168	33.33	4.86
111.5	111.5	13.20	1.006	0.172	34.30	3.61
112.5	112.5	17.38	1.018	0.173	34.10	4.77
113.5	113.5	18.38	1.005	0.175	32.57	5.76
114.5	114.5	18.04	0.980	0.172	31.98	4.65

Table E-3 continued. Loss-on-ignition data for Core 3 from Brady Lake, Ohio.

Depth (cm)	Composite Depth (cm)	Water (%)	WBD (g/cm ³)	DBD (g/cm ³)	Organic (%)	Carbonate (%)
115.5	115.5	16.74	0.995	0.158	36.08	5.39
116.5	116.5	12.88	0.974	0.155	37.42	5.61
117.5	117.5	15.55	0.990	0.157	37.58	6.94
118.5	118.5	15.90	1.002	0.159	38.99	5.61
119.5	119.5	15.25	1.005	0.159	37.74	4.12
120.5	120.5	16.24	1.002	0.154	37.66	5.67
121.5	121.5	15.30	1.005	0.185	30.27	5.27
122.5	122.5	18.47	1.002	0.179	31.28	2.21
123.5	123.5	17.67	1.005	0.183	30.05	5.31
124.5	124.5	14.82	1.033	0.187	29.95	3.11
125.5	125.5	15.37	1.013	0.183	31.15	4.32
126.5	126.5	15.09	1.005	0.177	30.51	4.42
127.5	127.5	13.47	0.993	0.178	30.90	3.32
128.5	128.5	16.98	1.026	0.178	30.90	3.32
129.5	129.5	13.58	0.992	0.176	30.68	4.46
130.5	130.5	15.18	1.017	0.183	30.60	3.21
131.5	131.5	18.34	1.000	0.185	31.35	3.21
132.5	132.5	14.17	1.019	0.196	30.10	5.96
133.5	133.5	14.61	1.017	0.188	28.19	4.03
134.5	134.5	12.54	1.003	0.187	30.48	4.18
135.5	135.5	15.65	1.021	0.198	29.29	4.86
136.5	136.5	18.06	1.002	0.179	30.17	4.35
137.5	137.5	17.94	1.017	0.189	31.22	4.18
138.5	138.5	15.86	1.008	0.197	29.95	2.96
139.5	139.5	19.00	1.019	0.201	29.85	4.82
140.5	140.5	14.09	1.006	0.207	29.47	4.66
141.5	141.5	15.23	1.004	0.187	31.02	5.27
142.5	142.5	14.61	1.014	0.192	31.25	4.12
143.5	143.5	15.74	1.052	0.195	29.74	4.96
144.5	144.5	14.67	1.040	0.198	27.27	4.72
145.5	145.5	15.52	1.023	0.204	26.47	4.53
146.5	146.5	15.62	1.033	0.208	26.92	4.47
147.5	147.5	16.29	1.033	0.207	26.57	5.37
148.5	148.5	15.41	1.039	0.212	26.89	4.39
149.5	149.5	15.95	1.048	0.200	27.00	3.73
150.5	150.5	14.48	1.052	0.219	26.94	3.40
151.5	151.5	14.42	1.038	0.221	25.34	4.12
152.5	152.5	14.55	1.031	0.221	25.34	4.12

Table E-3 continued. Loss-on-ignition data for Core 3 from Brady Lake, Ohio.

Depth (cm)	Composite Depth (cm)	Water (%)	WBD (g/cm ³)	DBD (g/cm ³)	Organic (%)	Carbonate (%)
153.5	153.5	15.95	1.045	0.209	26.79	3.56
154.5	154.5	15.07	1.055	0.216	26.85	3.44
155.5	155.5	15.15	0.997	0.194	26.80	4.79
156.5	156.5	15.29	1.034	0.208	25.00	5.23
157.5	157.5	17.28	1.049	0.225	26.22	4.10
158.5	158.5	13.86	1.035	0.221	24.89	4.10
159.5	159.5	15.30	1.055	0.237	23.63	4.51
160.5	160.5	14.77	1.035	0.222	25.23	4.92
161.5	161.5	18.02	1.039	0.224	25.45	4.89
162.5	162.5	15.34	1.024	0.230	24.35	3.91
163.5	163.5	14.86	1.050	0.232	25.00	3.13
164.5	164.5	14.52	1.028	0.234	23.93	3.82
165.5	165.5	14.27	1.019	0.227	23.79	3.93
166.5	166.5	17.79	1.052	0.242	23.55	3.68
167.5	167.5	14.02	1.050	0.245	23.27	3.62
168.5	168.5	14.90	1.045	0.245	22.86	3.60
169.5	169.5	14.58	1.066	0.258	22.48	4.08
170.5	170.5	14.33	1.061	0.258	22.87	3.42
171.5	171.5	14.61	1.056	0.248	22.98	3.56
172.5	172.5	13.72	1.036	0.251	22.71	3.51
173.5	173.5	14.60	1.069	0.266	22.18	3.29
174.5	174.5	14.45	1.060	0.259	22.01	3.37
175.5	175.5	14.80	1.086	0.273	20.51	3.76
176.5	176.5	14.15	1.070	0.280	19.64	3.63
177.5	177.5	14.43	1.078	0.287	18.82	3.50
178.5	178.5	17.62	1.088	0.300	18.67	3.90
179.5	179.5	13.40	1.099	0.309	18.12	3.76
180.5	180.5	19.66	1.129	0.305	17.70	3.25
181.5	181.5	17.23	1.126	0.295	17.29	3.90
182.5	182.5	16.19	1.143	0.321	16.82	3.57
183.5	183.5	13.36	1.177	0.387	14.47	3.29
184.5	184.5	18.88	1.154	0.355	16.06	3.19
185.5	185.5	17.13	1.161	0.363	15.98	4.01
186.5	186.5	15.39	1.087	0.251	25.10	3.62
187.5	187.5	14.97	1.050	0.201	33.83	3.07
188.5	188.5	15.21	0.998	0.164	41.46	5.67
189.5	189.5	16.71	0.995	0.166	42.77	4.29
190.5	190.5	17.12	0.985	0.150	48.00	5.23

Table E-3 continued. Loss-on-ignition data for Core 3 from Brady Lake, Ohio.

Depth (cm)	Composite Depth (cm)	Water (%)	WBD (g/cm ³)	DBD (g/cm ³)	Organic (%)	Carbonate (%)
191.5	191.5	17.64	0.955	0.112	64.29	10.20
192.5	192.5	14.04	0.949	0.111	66.67	0.00
193.5	193.5	16.99	0.970	0.112	66.07	3.58
194.5	194.5	17.58	0.973	0.114	64.91	6.80
195.5	195.5	17.85	0.962	0.111	63.96	3.40
196.5	196.5	14.80	0.978	0.112	66.07	7.16
197.5	197.5	14.60	0.972	0.113	64.60	6.80
198.5	198.5	19.21	0.975	0.115	64.35	9.95
199.5	199.5	19.12	0.974	0.115	65.22	6.80
200.5	200.5	16.66	0.976	0.114	64.91	3.40
201.5	201.5	14.59	0.977	0.118	63.56	6.33
202.5	202.5	15.93	0.972	0.126	60.32	5.44
203.5	203.5	15.74	0.972	0.124	59.68	5.44
204.5	204.5	16.28	0.985	0.128	59.37	7.85
205.5	205.5	15.95	0.967	0.121	59.50	5.55
206.5	206.5	19.48	0.974	0.122	61.48	2.89
207.5	207.5	16.32	0.979	0.120	63.33	3.09
208.5	208.5	14.72	0.965	0.114	64.91	3.40
209.5	209.5	13.36	0.963	0.112	66.07	3.58
210.5	210.5	16.81	0.967	0.114	65.79	6.97
211.5	211.5	17.01	0.997	0.112	66.96	7.35
212.5	212.5	14.99	0.973	0.110	68.18	3.89
213.5	213.5	16.28	0.961	0.111	67.57	7.56
214.5	214.5	16.70	0.974	0.113	68.14	7.56
215.5	215.5	15.13	0.965	0.112	70.54	4.12
216.5	216.5	13.03	0.953	0.108	69.44	4.12
217.5	217.5	15.95	0.961	0.107	69.16	4.12
218.5	218.5	16.20	0.963	0.109	69.72	4.12
219.5	219.5	15.96	0.973	0.107	69.16	8.24
220.5	220.5	15.88	0.969	0.109	69.72	4.12
221.5	221.5	19.52	0.990	0.109	69.72	8.24
222.5	222.5	18.05	0.957	0.103	69.90	4.39
223.5	223.5	15.64	0.970	0.106	68.87	4.12
224.5	224.5	15.31	0.970	0.104	70.19	0.00
225.5	225.5	15.56	0.969	0.105	69.52	-
226.5	226.5	13.67	0.974	0.105	69.52	0.00
227.5	227.5	15.62	0.974	0.109	67.89	3.89
228.5	228.5	15.83	0.995	0.117	64.96	9.95

Table E-3 continued. Loss-on-ignition data for Core 3 from Brady Lake, Ohio.

Depth (cm)	Composite Depth (cm)	Water (%)	WBD (g/cm ³)	DBD (g/cm ³)	Organic (%)	Carbonate (%)
229.5	229.5	14.39	0.971	0.111	63.96	3.40
230.5	230.5	16.08	0.975	0.113	65.49	3.49
231.5	231.5	14.67	0.960	0.108	66.67	11.33
232.5	232.5	14.83	0.974	0.111	68.47	7.77
233.5	233.5	15.56	0.971	0.110	70.00	4.12
234.5	234.5	17.49	0.955	0.108	69.44	8.24
235.5	235.5	19.26	0.959	0.103	70.87	9.07
236.5	236.5	13.70	0.971	0.106	68.87	8.24
237.5	237.5	16.28	0.963	0.106	68.87	8.24
238.5	238.5	15.78	0.976	0.107	70.09	4.25
239.5	239.5	15.53	0.956	0.102	70.59	4.53
240.5	240.5	15.71	0.960	0.102	70.59	9.07
241.5	241.5	15.02	0.957	0.102	71.57	4.69
242.5	242.5	14.91	0.966	0.106	69.81	8.50
243.5	243.5	16.38	0.971	0.106	69.81	8.50
244.5	244.5	15.31	0.985	0.109	69.72	8.24
245.5	245.5	17.89	0.964	0.108	69.44	8.24
246.5	246.5	15.78	0.987	0.110	70.00	4.12
247.5	247.5	19.16	0.948	0.103	70.87	4.53
248.5	248.5	16.73	0.960	0.105	70.48	8.77
249.5	249.5	15.44	0.943	0.103	70.87	9.07
250.5	250.5	18.09	0.963	0.103	70.87	9.07
251.5	251.5	19.19	0.964	0.104	71.15	9.07
252.5	252.5	16.14	0.962	0.106	70.75	4.39
253.5	253.5	18.26	0.962	0.105	69.52	8.50
254.5	254.5	19.84	0.940	0.103	70.87	4.53
255.5	255.5	19.65	0.953	0.104	70.19	8.77
256.5	256.5	18.83	0.955	0.105	70.48	8.77
257.5	257.5	17.45	0.953	0.104	69.23	8.50
258.5	258.5	16.48	0.954	0.104	69.23	4.25
259.5	259.5	16.49	0.965	0.105	68.57	8.24
260.5	260.5	18.37	0.964	0.105	69.52	8.50
261.5	261.5	16.06	0.964	0.107	68.22	8.00
262.5	262.5	15.08	0.952	0.109	68.81	4.00

Table E-4. Loss-on-ignition data for Core 4 from Brady Lake, Ohio.

Depth (cm)	Composite Depth (cm)	Water (%)	WBD (g/cm ³)	DBD (g/cm ³)	Organic (%)	Carbonate (%)
0.5	156.5	15.32	1.047	0.204	26.47	3.63
1.5	157.5	15.26	1.055	0.209	26.32	5.30
2.5	158.5	14.74	1.044	0.209	25.84	4.39
3.5	159.5	15.39	1.037	0.214	25.70	3.42
4.5	160.5	15.23	1.054	0.221	24.89	4.10
5.5	161.5	16.81	1.055	0.221	25.79	4.15
6.5	162.5	16.96	1.051	0.222	25.23	4.10
7.5	163.5	16.53	1.053	0.215	24.65	5.88
8.5	164.5	15.58	1.063	0.221	24.89	4.10
9.5	165.5	16.11	1.072	0.238	23.95	3.76
10.5	166.5	14.09	1.035	0.236	22.88	3.74
11.5	167.5	13.57	1.057	0.242	21.90	5.04
12.5	168.5	14.60	1.046	0.233	22.75	4.53
13.5	169.5	14.85	1.053	0.239	22.59	3.68
14.5	170.5	14.40	1.049	0.242	22.73	4.36
15.5	171.5	15.34	1.069	0.246	21.95	4.25
16.5	172.5	14.88	1.038	0.239	22.59	2.94
17.5	173.5	14.44	1.085	0.261	20.69	4.60
18.5	174.5	13.66	1.097	0.271	19.56	4.37
19.5	175.5	15.49	1.094	0.273	19.05	4.31
20.5	176.5	15.18	1.112	0.279	18.64	3.59
21.5	177.5	14.70	1.110	0.294	17.35	3.92
22.5	178.5	15.45	1.124	0.303	17.49	3.81
23.5	179.5	15.06	1.129	0.311	15.76	4.67
24.5	180.5	14.61	1.162	0.358	14.53	4.00
25.5	181.5	14.22	1.100	0.306	16.34	4.25
26.5	182.5	17.56	1.188	0.394	13.71	3.60
27.5	183.5	16.62	1.127	0.353	14.16	3.59
28.5	184.5	14.15	1.146	0.343	15.45	4.69
29.5	185.5	16.35	1.035	0.178	36.52	4.81
30.5	186.5	14.71	1.014	0.150	43.33	4.80
31.5	187.5	15.20	0.997	0.135	45.93	7.45
32.5	188.5	13.64	0.974	0.105	61.90	10.20
33.5	189.5	19.39	0.975	0.104	65.38	7.56
34.5	190.5	17.25	0.961	0.100	66.00	8.00
35.5	191.5	16.37	0.964	0.097	67.01	4.25
36.5	192.5	19.24	0.955	0.098	66.33	12.36
37.5	193.5	17.31	0.987	0.102	65.69	3.89

Table E-4 continued. Loss-on-ignition data for Core 4 from Brady Lake, Ohio.

Depth (cm)	Composite Depth (cm)	Water (%)	WBD (g/cm ³)	DBD (g/cm ³)	Organic (%)	Carbonate (%)
38.5	194.5	18.94	0.980	0.106	63.21	6.97
39.5	195.5	18.56	0.967	0.104	64.42	11.03
40.5	196.5	18.00	0.978	0.110	64.55	3.49
41.5	197.5	20.01	0.964	0.105	65.71	7.56
42.5	198.5	19.54	0.981	0.107	63.55	10.46
43.5	199.5	15.00	0.988	0.110	61.82	3.24
44.5	200.5	18.24	0.982	0.112	61.61	6.33
45.5	201.5	19.01	0.980	0.115	60.87	6.04
46.5	202.5	17.02	0.991	0.115	59.13	5.79
47.5	203.5	19.92	0.987	0.117	57.26	5.44
48.5	204.5	17.44	0.999	0.118	58.47	2.78
49.5	205.5	17.11	0.971	0.109	57.80	8.87
50.5	206.5	17.10	0.957	0.101	59.41	6.63
51.5	207.5	15.31	0.949	0.103	61.17	3.40
52.5	208.5	15.49	0.946	0.094	63.83	8.00
53.5	209.5	15.57	0.963	0.101	64.36	7.56
54.5	210.5	15.19	0.954	0.098	66.33	8.24
55.5	211.5	14.58	0.947	0.098	68.37	4.39
56.5	212.5	15.39	0.951	0.100	68.00	8.50
57.5	213.5	15.88	0.953	0.093	67.74	4.53
58.5	214.5	14.77	0.958	0.100	71.00	0.00
59.5	215.5	16.89	0.960	0.097	68.04	4.39
60.5	216.5	15.64	0.965	0.099	70.71	9.38
61.5	217.5	16.45	0.969	0.097	68.04	8.77
62.5	218.5	15.44	0.975	0.096	69.79	4.69
63.5	219.5	16.18	0.984	0.094	70.21	4.86
64.5	220.5	15.89	0.955	0.093	69.89	4.86
65.5	221.5	16.64	0.969	0.092	69.57	9.71
66.5	222.5	15.71	0.946	0.091	69.23	4.86
67.5	223.5	15.80	0.961	0.091	71.43	5.23
68.5	224.5	13.84	0.968	0.094	69.15	9.38
69.5	225.5	15.31	0.958	0.092	68.48	4.69
70.5	226.5	15.26	0.969	0.096	67.71	8.77
71.5	227.5	16.34	0.959	0.096	66.67	8.50
72.5	228.5	18.18	0.947	0.094	65.96	0.00
73.5	229.5	16.60	0.972	0.098	66.33	4.12
74.5	230.5	14.96	0.980	0.099	63.64	7.56
75.5	231.5	20.55	0.987	0.100	64.00	7.56
76.5	232.5	14.28	0.951	0.098	66.33	4.12

Table E-4 continued. Loss-on-ignition data for Core 4 from Brady Lake, Ohio.

Depth (cm)	Composite Depth (cm)	Water (%)	WBD (g/cm ³)	DBD (g/cm ³)	Organic (%)	Carbonate (%)
77.5	233.5	15.08	0.966	0.096	68.75	4.53
78.5	234.5	15.99	0.954	0.094	68.09	13.60
79.5	235.5	16.61	0.971	0.097	70.10	9.38
80.5	236.5	18.40	0.961	0.091	69.23	9.71
81.5	237.5	16.40	0.962	0.091	69.23	4.86
82.5	238.5	15.49	0.950	0.090	70.00	5.04
83.5	239.5	15.18	0.969	0.091	71.43	5.23
84.5	240.5	16.41	0.955	0.092	70.65	5.04
85.5	241.5	15.09	0.958	0.089	71.91	5.44
86.5	242.5	15.20	0.964	0.094	70.21	9.71
87.5	243.5	15.53	0.951	0.088	71.59	10.88
88.5	244.5	19.83	0.958	0.091	71.43	10.46
89.5	245.5	13.24	0.951	0.093	69.89	4.86
90.5	246.5	15.52	0.951	0.090	71.11	5.23
91.5	247.5	17.56	0.943	0.096	70.83	9.71
92.5	248.5	15.20	0.941	0.095	70.53	4.86
93.5	249.5	15.40	0.949	0.098	69.39	4.53
94.5	250.5	14.65	0.942	0.095	70.53	4.86
95.5	251.5	14.31	0.936	0.113	74.34	9.38
96.5	252.5	14.38	0.928	0.093	70.97	5.04
97.5	253.5	14.86	0.946	0.096	70.83	9.71
98.5	254.5	14.63	0.931	0.094	70.21	4.86
99.5	255.5	13.75	0.939	0.096	69.79	4.69
100.5	256.5	14.50	0.930	0.094	69.15	9.38
101.5	257.5	16.75	0.947	0.097	69.07	9.07
102.5	258.5	19.35	0.962	0.093	72.04	5.23
103.5	259.5	15.09	0.952	0.097	70.10	4.69
104.5	260.5	14.40	0.929	0.093	69.89	9.71
105.5	261.5	15.53	0.945	0.093	69.89	4.86
106.5	262.5	14.16	0.941	0.095	69.47	0.00
107.5	263.5	19.46	0.945	0.094	69.15	9.38
108.5	264.5	18.37	0.949	0.095	68.42	4.53
109.5	265.5	15.77	0.949	0.097	69.07	4.53
110.5	266.5	15.08	0.949	0.099	67.68	4.25
111.5	267.5	19.63	0.942	0.097	68.04	8.77
112.5	268.5	17.72	0.936	0.098	67.35	8.50
113.5	269.5	14.98	0.947	0.097	69.07	0.00
114.5	270.5	17.36	0.941	0.101	67.33	8.24

Table E-4 continued. Loss-on-ignition data for Core 4 from Brady Lake, Ohio.

Depth (cm)	Composite Depth (cm)	Water (%)	WBD (g/cm ³)	DBD (g/cm ³)	Organic (%)	Carbonate (%)
115.5	271.5	15.39	0.956	0.104	66.35	3.89
116.5	272.5	18.62	0.951	0.104	65.38	7.56
117.5	273.5	15.88	0.958	0.105	64.76	7.35
118.5	274.5	14.61	0.968	0.107	64.49	3.58
119.5	275.5	16.06	0.961	0.110	63.64	6.80
120.5	276.5	15.56	0.953	0.111	63.96	6.80
121.5	277.5	17.15	0.961	0.123	56.10	5.04
122.5	278.5	15.34	0.964	0.110	61.82	6.48
123.5	279.5	17.96	0.969	0.113	61.06	3.09
124.5	280.5	14.97	0.952	0.110	62.73	6.63
125.5	281.5	18.15	0.948	0.112	62.50	6.48
126.5	282.5	17.68	0.956	0.113	62.83	9.71
127.5	283.5	15.68	0.934	0.106	64.15	10.74
128.5	284.5	14.03	0.920	0.094	65.96	8.50
129.5	285.5	15.17	0.951	0.101	67.33	4.12
130.5	286.5	16.43	0.957	0.101	68.32	4.25
131.5	287.5	16.09	0.957	0.102	68.63	4.25
132.5	288.5	13.09	0.950	0.099	70.71	0.00
133.5	289.5	19.86	0.935	0.098	69.39	9.07
134.5	290.5	15.04	0.951	0.098	70.41	9.38
135.5	291.5	15.82	0.941	0.095	69.47	9.38
136.5	292.5	15.36	0.942	0.097	71.13	9.71
137.5	293.5	15.20	0.940	0.096	72.92	10.46
138.5	294.5	14.10	0.943	0.096	71.87	5.04
139.5	295.5	15.77	0.942	0.096	72.92	0.00
140.5	296.5	18.41	0.955	0.098	72.45	10.07
141.5	297.5	15.07	0.940	0.099	71.72	9.71
142.5	298.5	15.89	0.950	0.103	71.84	9.38
143.5	299.5	19.27	0.973	0.103	69.90	8.77
144.5	300.5	17.40	0.945	0.099	71.72	9.71
145.5	301.5	16.29	0.953	0.099	69.70	9.07
146.5	302.5	15.96	0.946	0.100	69.00	8.77
147.5	303.5	16.85	0.950	0.099	69.70	9.07
148.5	304.5	15.78	0.938	0.100	69.00	4.39
149.5	305.5	15.42	0.958	0.103	67.96	8.24
150.5	306.5	18.85	0.945	0.102	69.61	4.39
151.5	307.5	17.56	0.935	0.101	70.30	4.53
152.5	308.5	15.39	0.950	0.103	70.87	9.07

Table E-4 continued. Loss-on-ignition data for Core 4 from Brady Lake, Ohio.

Depth (cm)	Composite Depth (cm)	Water (%)	WBD (g/cm ³)	DBD (g/cm ³)	Organic (%)	Carbonate (%)
153.5	309.5	15.56	0.957	0.104	75.00	5.23
154.5	310.5	14.94	0.964	0.104	70.19	4.39
155.5	311.5	16.57	0.950	0.104	70.19	4.39
156.5	312.5	14.40	0.956	0.105	69.52	8.50
157.5	313.5	16.10	0.956	0.109	71.56	0.00
158.5	314.5	15.12	0.949	0.110	71.82	4.39
159.5	315.5	15.18	0.941	0.102	71.57	4.69
160.5	316.5	17.56	0.924	0.100	71.00	4.69
161.5	317.5	17.28	0.962	0.105	72.38	4.69
162.5	318.5	16.88	0.946	0.102	70.59	9.07
163.5	319.5	15.68	0.959	0.106	73.58	4.86
164.5	320.5	15.15	0.943	0.102	73.53	5.04
165.5	321.5	14.17	0.933	0.101	73.27	5.04
166.5	322.5	15.04	0.953	0.102	74.51	0.00
167.5	323.5	16.71	0.939	0.103	72.82	4.86
168.5	324.5	19.48	0.963	0.104	72.12	4.69
169.5	325.5	15.61	0.937	0.100	73.00	0.00
170.5	326.5	16.59	0.942	0.100	73.00	0.00
171.5	327.5	15.23	0.942	0.098	72.45	5.04
172.5	328.5	15.44	0.947	0.098	74.49	0.00
173.5	329.5	15.31	0.949	0.102	73.53	5.04
174.5	330.5	15.50	0.946	0.102	74.51	0.00
175.5	331.5	16.11	0.938	0.104	75.00	5.23
176.5	332.5	14.00	0.954	0.107	73.83	4.86
177.5	333.5	15.69	0.944	0.102	75.49	5.44
178.5	334.5	16.11	0.954	0.101	73.27	5.04
179.5	335.5	14.30	0.957	0.104	73.08	9.71
180.5	336.5	15.87	0.976	0.103	73.79	5.04
181.5	337.5	20.42	0.961	0.105	75.24	10.46
182.5	338.5	17.91	0.938	0.101	74.26	5.23
183.5	339.5	14.83	0.951	0.105	73.33	9.71
184.5	340.5	15.47	0.942	0.103	74.76	10.46
185.5	341.5	15.56	0.955	0.103	74.76	10.46
186.5	342.5	16.63	0.958	0.101	74.26	10.46
187.5	343.5	14.84	0.942	0.100	75.00	10.88
188.5	344.5	17.69	0.946	0.102	73.53	10.07
189.5	345.5	15.74	0.947	0.099	74.75	5.44
190.5	346.5	15.52	0.942	0.099	71.72	9.71

Table E-4 continued. Loss-on-ignition data for Core 4 from Brady Lake, Ohio.

Depth (cm)	Composite Depth (cm)	Water (%)	WBD (g/cm ³)	DBD (g/cm ³)	Organic (%)	Carbonate (%)
191.5	347.5	15.40	0.950	0.102	71.57	9.38
192.5	348.5	13.33	0.949	0.100	71.00	9.38
193.5	349.5	15.26	0.949	0.101	70.30	4.53
194.5	350.5	15.65	0.953	0.097	72.16	10.07
195.5	351.5	15.97	0.951	0.096	71.88	10.07
196.5	352.5	14.99	0.960	0.100	72.00	9.71
197.5	353.5	15.33	0.938	0.096	72.92	5.23
198.5	354.5	17.99	0.960	0.099	72.73	5.04
199.5	355.5	15.80	0.963	0.096	70.83	9.71
200.5	356.5	16.17	0.945	0.093	72.04	5.23
201.5	357.5	16.75	0.969	0.098	69.39	9.07
202.5	358.5	18.79	0.950	0.094	72.34	5.23
203.5	359.5	18.13	0.959	0.095	71.58	10.07
204.5	360.5	16.06	0.942	0.094	72.34	0.00
205.5	361.5	13.17	0.931	0.093	72.04	10.46
206.5	362.5	19.08	0.945	0.095	70.53	4.86
207.5	363.5	13.41	0.945	0.093	70.97	0.00
208.5	364.5	18.89	0.948	0.094	72.34	5.23
209.5	365.5	19.49	0.943	0.092	75.00	0.00
210.5	366.5	17.50	0.953	0.092	73.91	0.00
211.5	367.5	20.11	0.955	0.092	72.83	5.44
212.5	368.5	18.57	0.951	0.094	72.34	5.23
213.5	369.5	19.33	0.952	0.093	72.04	5.23
214.5	370.5	17.33	0.973	0.095	69.47	9.38
215.5	371.5	15.01	0.945	0.091	71.43	10.46
216.5	372.5	13.67	0.958	0.095	69.47	4.69
217.5	373.5	20.31	0.956	0.097	72.16	10.07
218.5	374.5	14.70	0.953	0.093	73.12	10.88
219.5	375.5	16.63	0.939	0.095	72.63	10.46
220.5	376.5	19.21	0.946	0.093	72.04	5.23
221.5	377.5	15.82	0.943	0.092	71.74	10.46
222.5	378.5	14.55	0.938	0.091	71.43	10.46
223.5	379.5	15.22	0.944	0.094	70.21	14.57
224.5	380.5	16.99	0.942	0.094	71.28	15.11
225.5	381.5	13.17	0.946	0.093	72.04	5.23
226.5	382.5	14.74	0.941	0.095	69.47	4.69
227.5	383.5	19.54	0.944	0.103	63.11	7.16
228.5	384.5	16.18	0.948	0.097	68.04	8.77

Table E-4 continued. Loss-on-ignition data for Core 4 from Brady Lake, Ohio.

Depth (cm)	Composite Depth (cm)	Water (%)	WBD (g/cm ³)	DBD (g/cm ³)	Organic (%)	Carbonate (%)
229.5	385.5	16.36	0.960	0.099	64.65	7.77
230.5	386.5	16.13	0.943	0.094	65.96	12.75
231.5	387.5	19.35	0.962	0.095	66.32	4.25
232.5	388.5	16.23	0.957	0.093	66.67	8.77
233.5	389.5	16.60	0.951	0.092	69.57	9.71
234.5	390.5	17.90	0.966	0.093	70.97	10.07
235.5	391.5	19.71	0.951	0.090	70.00	10.07
236.5	392.5	16.40	0.940	0.096	68.75	4.53
237.5	393.5	14.50	0.955	0.102	67.65	4.12
238.5	394.5	15.46	0.941	0.097	70.10	4.69
239.5	395.5	15.95	0.942	0.098	67.35	4.25
240.5	396.5	16.40	0.948	0.103	68.93	0.00
241.5	397.5	18.43	0.956	0.106	60.38	9.71
242.5	398.5	15.85	0.962	0.107	58.88	6.18
243.5	399.5	18.80	0.951	0.103	59.22	6.48
244.5	400.5	16.25	0.963	0.106	62.26	6.80
245.5	401.5	16.85	0.968	0.107	64.49	3.58
246.5	402.5	15.10	0.949	0.103	65.05	7.56
247.5	403.5	16.97	0.959	0.104	66.35	7.77
248.5	404.5	16.40	0.960	0.104	67.31	4.00
249.5	405.5	14.95	0.947	0.100	69.00	4.39
250.5	406.5	14.88	0.959	0.103	68.93	8.50
251.5	407.5	15.56	0.962	0.106	71.70	4.53
252.5	408.5	14.91	0.967	0.101	67.33	12.36
253.5	409.5	16.13	0.993	0.102	63.73	7.35
254.5	410.5	16.07	0.961	0.102	67.65	8.24

Table E-5. Loss-on-ignition data for Core 5 from Brady Lake, Ohio.

Depth (cm)	Composite Depth (cm)	Water (%)	WBD (g/cm ³)	DBD (g/cm ³)	Organic (%)	Carbonate (%)
0.5	0.5	16.13	0.961	0.156	27.56	3.49
1.5	1.5	14.07	0.971	0.161	26.71	2.53
2.5	2.5	13.97	0.950	0.148	30.41	2.76
3.5	3.5	14.67	0.960	0.156	28.21	3.49
4.5	4.5	13.67	1.005	0.200	22.50	1.36
5.5	5.5	14.12	0.953	0.168	26.19	2.43
6.5	6.5	17.13	0.983	0.166	27.71	2.46
7.5	7.5	17.17	0.970	0.164	26.83	2.49
8.5	8.5	18.17	0.969	0.155	29.68	1.75
9.5	9.5	17.45	0.965	0.161	28.57	3.38
10.5	10.5	16.13	0.987	0.168	27.98	1.62
11.5	11.5	16.26	0.991	0.178	25.28	3.06
12.5	12.5	12.43	0.919	0.257	14.40	1.59
13.5	13.5	17.77	0.957	0.126	36.51	3.24
14.5	14.5	19.34	0.972	0.136	35.29	3.00
15.5	15.5	14.47	0.963	0.182	25.27	2.99
16.5	16.5	14.15	0.962	0.125	38.40	2.18
17.5	17.5	19.04	0.962	0.116	43.10	3.52
18.5	18.5	15.41	0.941	0.093	52.69	1.46
19.5	19.5	14.24	0.935	0.084	58.33	1.62
20.5	20.5	14.91	0.936	0.080	61.25	1.70

Table E-6. Loss-on-ignition data for Core 6 from Brady Lake, Ohio.

Depth (cm)	Composite Depth (cm)	Water (%)	WBD (g/cm ³)	DBD (g/cm ³)	Organic (%)	Carbonate (%)
0.5	22.5	16.01	0.955	0.083	69.88	5.44
1.5	23.5	15.83	0.963	0.079	72.15	6.18
2.5	24.5	16.59	0.954	0.078	69.23	11.33
3.5	25.5	17.91	0.949	0.078	73.08	6.48
4.5	26.5	15.21	0.956	0.079	72.15	6.18
5.5	27.5	17.66	0.969	0.077	71.43	12.36
6.5	28.5	16.11	0.965	0.079	72.15	6.18
7.5	29.5	15.08	0.980	0.080	72.50	0.00
8.5	30.5	15.48	0.980	0.081	71.60	11.83
9.5	31.5	14.79	0.960	0.076	71.05	12.36
10.5	32.5	16.20	0.970	0.082	69.51	5.44
11.5	33.5	18.64	0.981	0.082	70.73	5.67
12.5	34.5	17.08	0.981	0.083	71.08	5.67
13.5	35.5	17.06	0.980	0.080	72.50	6.18
14.5	36.5	16.02	0.978	0.111	51.35	2.52
15.5	37.5	17.01	0.987	0.084	69.05	10.46
16.5	38.5	14.65	0.969	0.083	68.67	5.23
17.5	39.5	18.09	0.968	0.084	67.86	10.07
18.5	40.5	15.91	0.975	0.094	61.70	7.56
19.5	41.5	16.62	0.966	0.085	70.59	0.00
20.5	42.5	16.71	0.977	0.086	67.44	4.86
21.5	43.5	16.28	0.986	0.086	68.60	5.04
22.5	44.5	15.69	0.974	0.086	68.60	10.07
23.5	45.5	16.31	0.984	0.086	69.77	5.23
24.5	46.5	20.29	0.972	0.085	68.24	10.07
25.5	47.5	14.81	0.976	0.086	68.60	5.04
26.5	48.5	15.48	0.972	0.081	71.60	5.91
27.5	49.5	15.97	0.969	0.083	71.08	5.67
28.5	50.5	18.82	0.975	0.081	70.37	11.33
29.5	51.5	17.54	0.974	0.084	70.24	5.44
30.5	52.5	17.23	0.975	0.087	68.97	5.04
31.5	53.5	17.52	0.962	0.086	67.44	4.86
32.5	54.5	15.57	0.970	0.087	67.82	9.71
33.5	55.5	16.46	0.976	0.085	68.24	5.04
34.5	56.5	16.82	0.979	0.085	64.71	9.07
35.5	57.5	19.86	0.979	0.087	65.52	4.53
36.5	58.5	15.90	0.976	0.085	68.24	0.00
37.5	59.5	15.61	0.981	0.088	62.50	4.12

Table E-6 continued. Loss-on-ignition data for Core 6 from Brady Lake, Ohio.

Depth (cm)	Composite Depth (cm)	Water (%)	WBD (g/cm ³)	DBD (g/cm ³)	Organic (%)	Carbonate (%)
38.5	60.5	15.92	0.973	0.089	59.55	3.78
39.5	61.5	15.67	0.971	0.088	61.36	4.00
40.5	62.5	15.89	0.970	0.088	60.23	3.89
41.5	63.5	16.80	0.966	0.082	64.63	4.69
42.5	64.5	15.77	0.969	0.082	64.63	9.38
43.5	65.5	16.42	0.967	0.085	65.88	4.69
44.5	66.5	15.01	0.972	0.085	64.71	4.53
45.5	67.5	16.69	0.971	0.086	66.28	0.00
46.5	68.5	14.01	0.974	0.082	63.41	4.53
47.5	69.5	20.66	0.947	0.081	61.73	8.77
48.5	70.5	16.48	0.975	0.085	58.82	3.89
49.5	71.5	15.23	0.983	0.086	59.30	3.89
50.5	72.5	17.47	0.990	0.086	60.47	0.00
51.5	73.5	16.39	0.992	0.085	61.18	4.12
52.5	74.5	16.04	0.962	0.082	60.98	0.00
53.5	75.5	16.86	0.995	0.087	58.62	0.00
54.5	76.5	15.60	0.972	0.082	59.76	0.00
55.5	77.5	15.86	0.979	0.079	59.49	0.00
56.5	78.5	18.76	0.982	0.087	58.62	7.56
57.5	79.5	16.69	0.980	0.086	60.47	4.00
58.5	80.5	18.79	0.967	0.085	61.18	0.00
59.5	81.5	14.91	0.964	0.085	60.00	0.00
60.5	82.5	19.87	0.989	0.085	60.00	4.00
61.5	83.5	19.19	0.975	0.083	62.65	4.39
62.5	84.5	16.11	0.980	0.087	59.77	3.89
63.5	85.5	16.70	0.987	0.091	60.44	0.00
64.5	86.5	15.17	0.978	0.087	59.77	3.89
65.5	87.5	16.07	0.958	0.086	59.30	3.89
66.5	88.5	16.50	0.990	0.088	60.23	3.89
67.5	89.5	16.58	0.977	0.088	61.36	0.00
68.5	90.5	16.39	0.991	0.089	59.55	0.00
69.5	91.5	16.21	0.992	0.090	55.56	3.40
70.5	92.5	16.02	0.975	0.088	56.82	3.58
71.5	93.5	15.13	0.963	0.088	55.68	3.49
72.5	94.5	20.45	0.948	0.086	50.00	3.16
73.5	95.5	16.38	0.992	0.080	58.75	4.12
74.5	96.5	18.83	0.963	0.083	55.42	3.68
75.5	97.5	16.16	0.969	0.091	54.95	6.63
76.5	98.5	15.93	0.959	0.084	55.95	7.35

Table E-6 continued. Loss-on-ignition data for Core 6 from Brady Lake, Ohio.

Depth (cm)	Composite Depth (cm)	Water (%)	WBD (g/cm ³)	DBD (g/cm ³)	Organic (%)	Carbonate (%)
77.5	99.5	15.55	0.954	0.083	60.24	0.00
78.5	100.5	17.28	0.969	0.086	58.14	3.78
79.5	101.5	13.59	0.957	0.099	51.52	8.50
80.5	102.5	16.42	0.970	0.105	50.48	2.62
81.5	103.5	16.56	0.969	0.097	55.67	6.33
82.5	104.5	18.84	0.963	0.095	53.68	3.09
83.5	105.5	15.34	0.979	0.110	50.00	0.00
84.5	106.5	20.55	0.996	0.114	47.37	4.53
85.5	107.5	16.29	0.983	0.112	49.11	2.39
86.5	108.5	15.91	0.981	0.112	50.89	2.47
87.5	109.5	14.99	0.957	0.104	50.96	2.67
88.5	110.5	16.90	0.976	0.105	51.43	2.67
89.5	111.5	20.21	0.978	0.108	48.15	4.86
90.5	112.5	14.70	0.982	0.117	46.15	2.16
91.5	113.5	14.87	0.970	0.115	46.09	2.19
92.5	114.5	17.16	0.984	0.113	46.02	4.46
93.5	115.5	16.20	1.011	0.116	45.69	4.32
94.5	116.5	16.20	1.005	0.118	44.92	4.18
95.5	117.5	19.24	0.997	0.121	43.80	4.00
96.5	118.5	15.19	1.005	0.123	43.90	1.97
97.5	119.5	19.62	0.995	0.123	43.90	5.91
98.5	120.5	19.46	1.004	0.124	43.55	5.83
99.5	121.5	19.60	0.995	0.122	43.44	3.94
100.5	122.5	15.74	0.994	0.128	41.41	3.63
101.5	123.5	17.81	0.991	0.129	40.31	1.77
102.5	124.5	17.72	1.001	0.137	39.42	3.28
103.5	125.5	16.25	0.997	0.139	39.57	4.86
104.5	126.5	13.57	1.006	0.127	41.73	3.68
105.5	127.5	15.99	0.999	0.119	43.70	6.09
106.5	128.5	15.64	1.016	0.118	44.92	2.09
107.5	129.5	19.32	0.992	0.120	44.17	4.06
108.5	130.5	16.27	0.995	0.122	43.44	3.94
109.5	131.5	16.53	0.998	0.123	43.90	3.94
110.5	132.5	15.43	1.005	0.122	43.44	3.94
111.5	133.5	15.38	1.022	0.127	43.31	3.78
112.5	134.5	15.34	1.012	0.132	41.67	3.53
113.5	135.5	15.76	1.015	0.150	32.67	4.04
114.5	136.5	20.57	1.012	0.142	36.62	4.53

Table E-6 continued. Loss-on-ignition data for Core 6 from Brady Lake, Ohio.

Depth (cm)	Composite Depth (cm)	Water (%)	WBD (g/cm ³)	DBD (g/cm ³)	Organic (%)	Carbonate (%)
115.5	137.5	15.46	0.993	0.137	36.50	4.69
116.5	138.5	16.04	0.999	0.133	39.85	3.40
117.5	139.5	16.17	0.997	0.120	43.33	4.00
118.5	140.5	15.92	1.009	0.133	40.60	0.00
119.5	141.5	15.49	0.985	0.114	48.25	2.31
120.5	142.5	14.38	1.000	0.136	38.97	3.28
121.5	143.5	15.63	0.987	0.136	37.50	3.20
122.5	144.5	15.66	0.984	0.116	42.24	4.06
123.5	145.5	15.87	0.982	0.127	40.94	3.63
124.5	146.5	18.52	0.977	0.108	45.37	4.61
125.5	147.5	15.40	0.993	0.106	49.06	2.52
126.5	148.5	15.41	1.012	0.121	45.45	2.06
127.5	149.5	13.52	0.975	0.114	43.86	2.13
128.5	150.5	15.30	1.027	0.178	28.65	2.14
129.5	151.5	15.48	1.010	0.154	34.42	1.35
130.5	152.5	14.98	1.016	0.159	32.08	5.04
131.5	153.5	18.66	1.025	0.153	36.60	0.00
132.5	154.5	15.39	1.015	0.162	32.10	2.47
133.5	155.5	15.75	1.029	0.165	31.52	3.61
134.5	156.5	16.52	1.018	0.163	32.52	3.71
135.5	157.5	19.21	1.007	0.160	34.37	3.89
136.5	158.5	14.43	1.023	0.150	36.00	2.83
137.5	159.5	14.59	1.010	0.150	37.33	2.89
138.5	160.5	15.36	1.010	0.149	36.91	4.34
139.5	161.5	15.55	1.009	0.154	35.71	4.12
140.5	162.5	16.23	1.005	0.133	44.36	1.84
141.5	163.5	16.79	0.995	0.147	38.10	2.99
142.5	164.5	18.53	0.993	0.150	38.67	0.00
143.5	165.5	15.12	1.016	0.172	32.56	2.34
144.5	166.5	15.76	1.000	0.147	40.82	3.13
145.5	167.5	14.42	0.993	0.141	43.97	1.72
146.5	168.5	15.13	1.018	0.160	38.75	4.16
147.5	169.5	15.90	1.016	0.173	35.84	2.45
148.5	170.5	14.21	1.030	0.181	33.70	2.27
149.5	171.5	17.22	1.045	0.184	33.15	3.32
150.5	172.5	15.20	1.024	0.178	35.96	3.58
151.5	173.5	15.77	1.035	0.177	36.16	3.61
152.5	174.5	15.94	1.030	0.180	36.11	3.55

Table E-6 continued. Loss-on-ignition data for Core 6 from Brady Lake, Ohio.

Depth (cm)	Composite Depth (cm)	Water (%)	WBD (g/cm ³)	DBD (g/cm ³)	Organic (%)	Carbonate (%)
153.5	175.5	20.45	1.050	0.188	35.64	2.25
154.5	176.5	20.52	1.043	0.183	36.07	5.81
155.5	177.5	15.41	1.034	0.181	37.02	2.39
156.5	178.5	16.67	1.046	0.187	36.90	3.46
157.5	179.5	15.17	1.047	0.205	32.20	3.91
158.5	180.5	18.09	1.041	0.200	34.00	3.09
159.5	181.5	14.20	1.058	0.222	29.73	3.49
160.5	182.5	14.79	1.054	0.231	29.00	2.49
161.5	183.5	14.01	1.093	0.257	26.07	2.86
162.5	184.5	15.54	1.093	0.261	25.29	3.49
163.5	185.5	15.65	1.091	0.260	26.15	1.42
164.5	186.5	15.56	1.086	0.259	25.87	2.13
165.5	187.5	14.66	1.068	0.242	27.69	2.33
166.5	188.5	12.86	1.065	0.248	28.23	2.29
167.5	189.5	15.06	1.103	0.311	21.54	2.23
168.5	190.5	16.88	1.093	0.272	25.37	3.35
169.5	191.5	15.28	1.117	0.298	24.16	3.01
170.5	192.5	14.13	1.118	0.318	22.96	2.22
171.5	193.5	14.00	1.137	0.359	19.50	1.88
172.5	194.5	17.84	1.150	0.370	18.38	1.35
173.5	195.5	14.21	1.089	0.283	25.80	1.94
174.5	196.5	18.86	1.113	0.302	24.50	2.98
175.5	197.5	14.48	1.092	0.295	26.10	2.50
176.5	198.5	15.16	1.091	0.260	30.38	3.76
177.5	199.5	14.88	1.070	0.243	32.51	4.15
178.5	200.5	16.53	1.176	0.442	16.74	1.48
179.5	201.5	14.49	1.190	0.426	16.90	2.31
180.5	202.5	14.38	1.155	0.393	18.83	2.56
181.5	203.5	15.10	1.155	0.417	18.71	1.60
182.5	204.5	13.50	1.212	0.486	15.64	1.66
183.5	205.5	16.13	0.969	0.191	52.88	6.04
184.5	206.5	14.46	1.007	0.231	41.99	4.06
185.5	207.5	14.22	1.079	0.259	35.91	3.28
186.5	208.5	15.00	1.062	0.242	38.02	2.72
187.5	209.5	16.45	1.082	0.316	29.75	3.06
188.5	210.5	17.14	1.057	0.240	40.00	1.89
189.5	211.5	17.24	1.003	0.188	53.72	4.69
190.5	212.5	17.28	1.008	0.181	59.67	5.59

Table E-6 continued. Loss-on-ignition data for Core 6 from Brady Lake, Ohio.

Depth (cm)	Composite Depth (cm)	Water (%)	WBD (g/cm ³)	DBD (g/cm ³)	Organic (%)	Carbonate (%)
191.5	213.5	14.33	1.024	0.182	60.44	3.78
192.5	214.5	17.75	1.023	0.177	62.71	4.12
193.5	215.5	15.92	1.023	0.195	57.44	3.28
194.5	216.5	18.13	1.074	0.260	46.54	3.91
195.5	217.5	18.28	1.111	0.313	35.14	4.02
196.5	218.5	14.82	1.219	0.455	19.12	1.85
197.5	219.5	12.37	1.323	0.627	10.05	2.41
198.5	220.5	11.70	1.378	0.734	7.49	1.60
199.5	221.5	11.19	1.386	0.772	6.09	1.88
200.5	222.5	10.49	1.444	0.856	4.79	1.84
201.5	223.5	10.68	1.486	0.915	4.04	2.01
202.5	224.5	8.77	1.625	1.162	2.93	2.05
203.5	225.5	7.75	1.717	1.278	2.50	2.07
204.5	226.5	8.21	1.689	1.234	2.59	2.26
205.5	227.5	8.11	1.718	1.272	2.52	2.19
206.5	228.5	7.28	1.758	1.358	2.36	1.74
207.5	229.5	7.06	1.824	1.433	2.09	1.65
208.5	230.5	6.03	1.842	1.461	1.98	1.61
209.5	231.5	7.96	1.841	1.437	1.95	1.93
210.5	232.5	7.35	1.812	1.416	2.05	1.67
211.5	233.5	7.16	1.733	1.303	2.53	2.78
212.5	234.5	7.14	1.831	1.436	2.30	2.81
213.5	235.5	6.89	1.913	1.534	2.28	3.90
214.5	236.5	6.94	1.972	1.587	2.39	5.00
215.5	237.5	6.28	1.967	1.620	1.91	3.85
216.5	238.5	6.03	1.980	1.653	2.00	4.20