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Impact of Lead Mining on Sediments in a Proximal Pond to the Mascot Mine in

Gorham, New Hampshire

A Senior Thesis

Presented to

The Faculty of the Department of Geology

Bates College

In partial fulfillment of the requirements for the

Degree of Bachelor of Science

By

Forrest Hamilton

Lewiston, Maine

December 10, 2019

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Abstract

Mascot Mine was opened in Gorham, New Hampshire in 1881 and closed in 1885. The lead mine was briefly opened for less than a year in 1906 marking the final closing of the mine. However the mining impacts can still be seen today. The purpose of this study was to investigate the environmental impacts the lead mine had on the surrounding environment. A sediment core as well as water samples were gathered in fall 2019 at Mascot Pond which sits directly below the mine in contact with the mines tailings piles. The sediment core gathered was 47 cm long, containing sediments correlating to pre-mine operation. From 47cm to 40cm the sediment had an average lead concentration value of 26.3 ± 20.05 mg/kg. Given the known baseline lead concentrations for the Appalachian region of 15.3 ± 17.5 mg/kg this section of the sediment core was classified as “pre-mining” (>1881). Following lead concentrations significantly increased to the maximum value of 3918 mg/kg at the 34 cm. Given the severity in the increase in concentrations it is clear that anthropogenic mining was involved. Water samples from Mascot Pond had an average pH value of 5.03 verses a nearby stream having a pH value of 6.70. Eight other metals were examined throughout the entirety of the sediment core. These metal concentrations all showed baseline levels at the bottom of the sediment core than a significant increase to non-natural levels around 35 ± 2 cm. The processes seen at Mascot Pond can be attributed to chemical weathering of the material associated with the mine. The relative acidic water of the pond as well as extremely high metal concentrations are indicative of a dissociation processes. The overall scale of mining at the Mascot Mine is relatively small compared to some mines across the world, however a clear impact can be seen on the local environment.

Introduction

1.1 Overview

For centuries, the use of lead has played a prominent role in human civilization. Lead is a soft ductile durable material. Lead is also a poor conductor and resistant to corrosion. Therefore lead is commonly seen in the manufacturing of batteries, ammunition, cable sheathing, older piping and older paint. Lead is also a byproduct of many sources of industrial techniques such as mining, coal burning and manufacturing processes. Unlike previous decades, it is relatively well known among a majority of the population that exposure to lead and lead products can cause serious health effects. Unfortunately humans are commonly unaware of exposure that exists within their daily lives. In the United States fourteen percent of children have troubling amounts of lead within their blood systems (Dennis, 2016). Other populations around the world experience similar negative effects from lead exposure. Locations near lead mining in particular are concerning. Living within close proximity to a lead mine can cause detrimental health effects (Lar et al., 2013).

Mascot Mine is an abandoned lead mine in New Hampshire. The mine is relatively small and was open for less than a decade. Currently no humans inhabit the area, however during mine operation a small cluster of buildings were located at the base of the mine in what looks like a relatively pristine wooded area. Mascot Pond is a small body of water that sits directly below the mine's tailings pile. This study aims to look at the effect of Mascot Mine on the surrounding environment. Though no humans currently live within close proximity of the study site, the area is a common destination of hikers, tourists and summer camps. This project aims to provide a report of the health of the area as well as explore the history of metal deposition from the adjacent mine.

1.2 Location of Study Site

The study location for this report, Mascot Pond and Mascot Mine, are located in Gorham New Hampshire (fig 1.1) in the Lead Mine State Forest. Mascot Pond is in close proximity to exposed bedrock immediately adjacent to the mine (fig 1.1). Mascot Mine is located on the side of Mount Hayes. Mount Hayes has a summit elevation of 2,555 ft and the surface water of

Mascot Pond sits at an altitude of 1,089 ft (fig 1.1). The base of the mine's tailings pile and ponds northeastern border have the coordinates of N 44.40097° W71.17899°.

Images taken of the mine are also included below (fig 1.2) (fig 1.3). These images were taken from the first day from field work on September 18 2019 as well as spring of 2019.

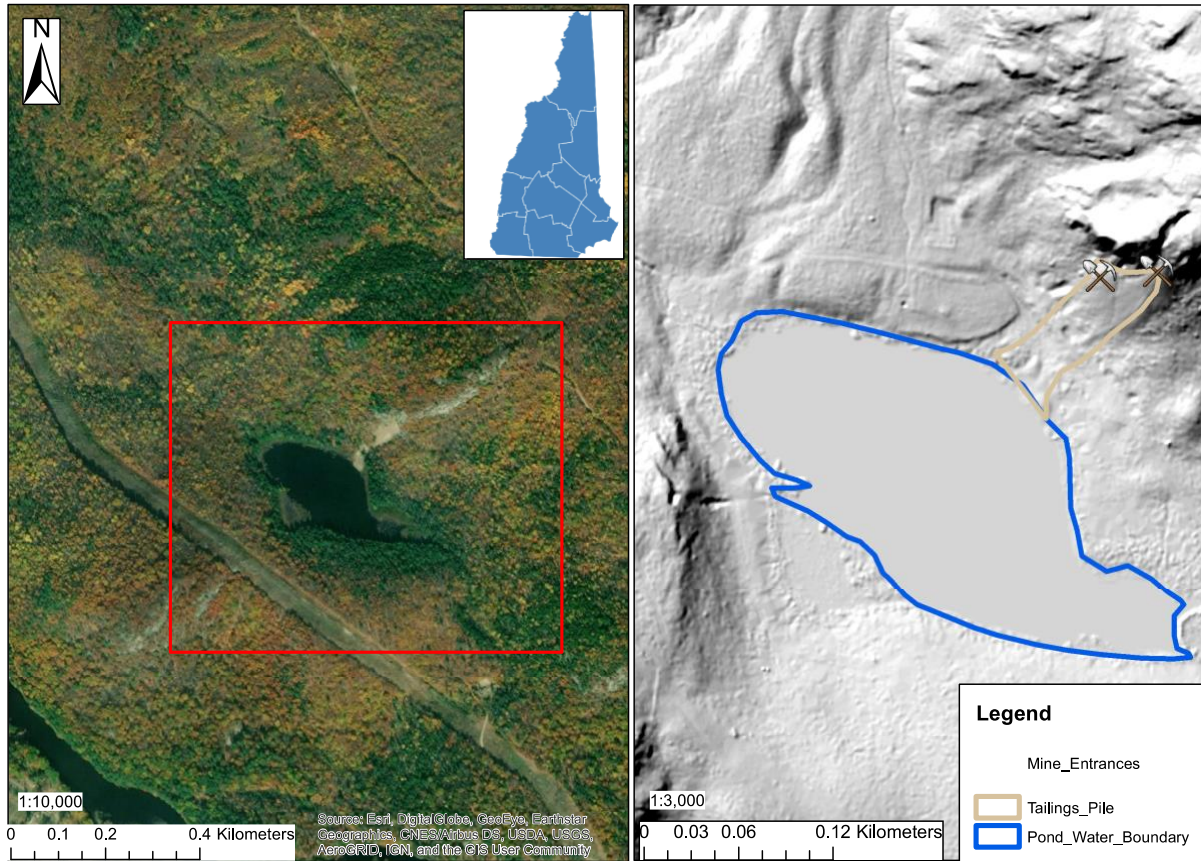


Figure 2.1: Study site location map. Left: aerial photo with the study site location in red. Right: Hill shade imagery of study site showing topographical features. Mascot Pond's water boundary, Mascot Mine's tailings pile and mine entrances are also displayed.



1.2 Image of Mascot Pond. This image was taken on the base of the tailings pile. This image displays nearly all of the pond. A backpack seen in the center of the image can be used for scale.



Figure 1.3: Images of Mascot Pond and Mascot Mine. Left Image taken from a canoe in the middle of Mascot Pond showing the mine and tailings pile on the side of Mount Hayes. Middle: Image taken from the mine entrance looking down on tailings pile. Left Image taken from base of tailings pile, looking up at mine entrance. This image is was taken at the same altitude as the ponds surface water

1.3 Regional Structural Geology

Bedrock geology consists of mainly schists from the Devonian and Silurian time period, that were metamorphized during the Acadian orogeny (Cox, 1970). Later the schist present was intruded by syntectonic granite rocks during the New Hampshire Plutonic series (Cox, 1970). The granitic rocks are from the White Mountain Plutonic Series of the Devonian. This plutonic series occurred at the climax of the Acadian period and can be characterized as cross cutting intrusions with dike like mannerism, which indicate that the formation was influenced by the flow and movement of magma (Billings, 1980 p. 146). The intrusion of these igneous rocks

likely occurred at the end of the Acadia orogeny, as uplift had occurred and open space was available for intrusion of the New Hampshire Plutonic material. Environments for mineral crystallization likely existed following the crystallization of the intrusive plutons from the White Mountain Plutonic Series (Cox, 1970). See figure 1.4 for complete bedrock map of region.

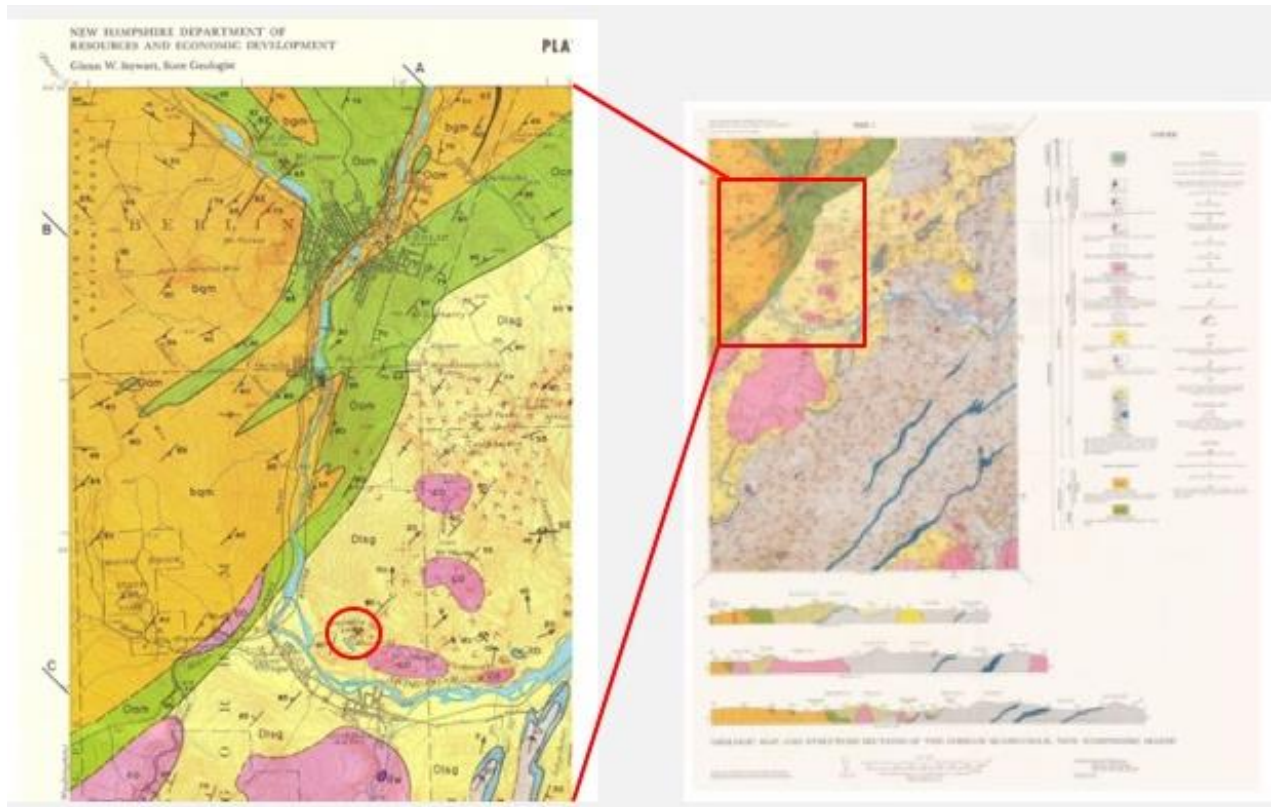


Figure 1.4: Bedrock Map of region from Billings, 1980. Left: Close up image of section in which Mascot Pond is located. Red circle highlights the ponds location. Right: Overall bedrock map.

1.4 Structural Geology of Mascot Mine

The Mascot Mine entrance is located on an exposed cliff approximately (fig 1.1). Mascot mine was developed on a breccia vein cutting through the surrounding rocks. The breccia vein strikes NE 40° and has a dip of 70° (fig 1.5). The vein ranges from 10 feet to 20 feet wide and contains granitic rocks and interstitial quartz as well as manganosiderite (Cox, 1970). There is also an visible aphanitic dike that has been shifted 24 feet by three faults broken into three individual sections (fig 1.5). The formation of highly valued minerals occurred within small sections of the overall vein. These minerals were subject to extraction for economic purposes.

A diagram (fig 1.5) below displays a geological sketch of the mine from a birds-eye cross section perspective. Worthy of note in the diagram is the scale. Also the aphanitic dike is

represented and faulting motion can be seen. The diagram produced by Cox, 1970 is the only know published geological work done on the site of the mine.

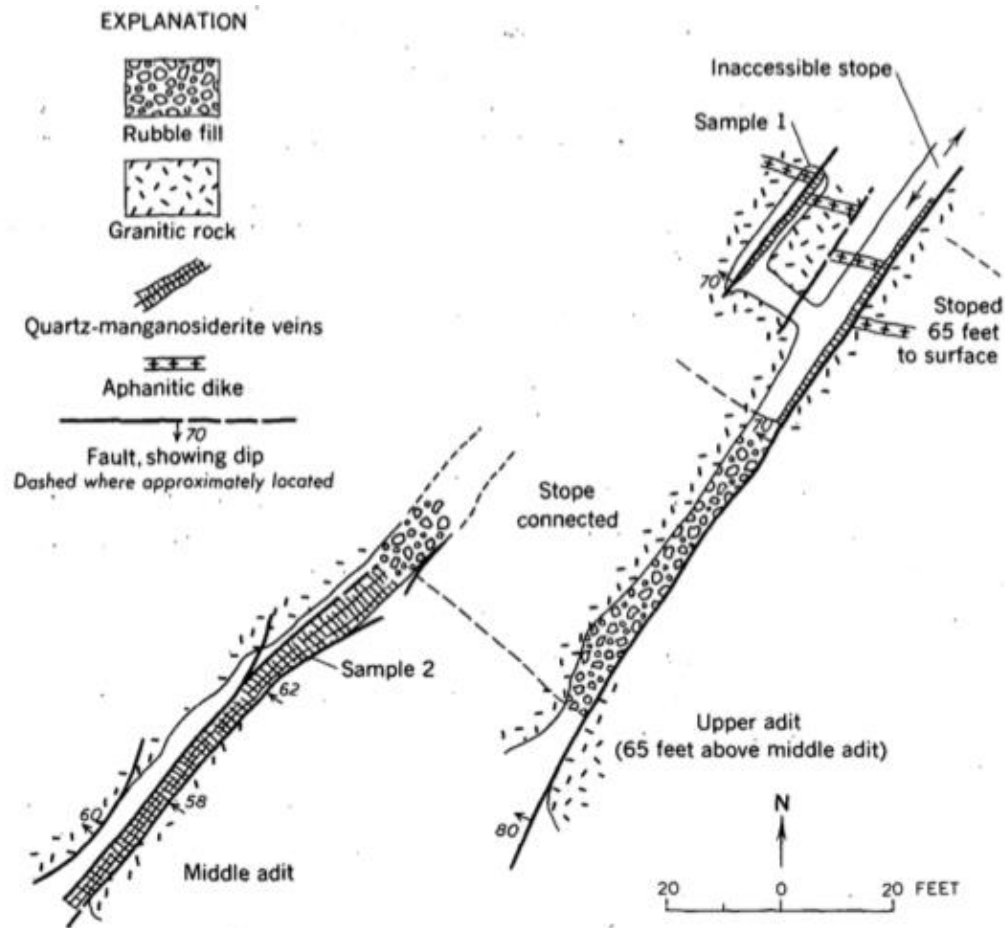


FIGURE 7.—Geologic sketch map, Mascot mine, Gorham, N.H. Note displacement of dike by faults in upper adit.

Figure 1.5: Geologic feature diagram of Mascot Mine and respective components present. Diagram from: Cox 1970.

1.5 Mineralogy of Mascot Mine

Two main types of rock exists at Mascot Mine and over 28 different minerals have been identified in the tailings pile (Janules, 2012). The first group is a mix massive sulfide ore minerals cemented together with quartz The second is group is dominated by the mineral siderite (FeCO_3) (Janules, 2012). Galena (PbS) is the main ore mineral present at Mascot Mine. It has been recorded that Mascot Mine also has a silver content ranging from 0.02 to 0.5 percent within minable ore (Cox, 1970).Sphalerite (Zn,Fe)S and chalcopyrite (CuFeS_2) have both been identified as a minor constuent of the ore present (Cox, 1970). The main gangue minerals that

can be commonly found in tailings are milky coarsely crystalline quartz, carbonate minerals manganosiderite and pyrite (Cox, 1970). The dike rocks present have been altered by sericite, chlorite and carbonite minerals but show signs of plagioclase and mafic minerals (Cox, 1970). The prized galena within the vein was present in four inch to ten inch bands. Three bands are reported to have been together forming a 22 inch thick section (Cox, 1970).

1.6 Operation History of Mascot Mine

The operation history of Mascot Mine is relatively short with respect to other mines around the world. Timothy Harden Hutchinson who was a successful millwright, engineer and businessman built a bridge crossing the Androscoggin River in 1877 later known as Lead Mine Bridge (Reuben, 2012). Dr. N. T Rowe used the established bridge to explore the side of Mount Hayes where he found lead ore near Mascot Pond. Thomas Culhane soon after found the large breccia vein and the Mascot Mining Co. was formed (Reuben, 2012.) From 1881 to 1885 adit-drift mining occurred on the breccia vein where 50,000 tons of vein material was extracted (Cox, 1970). The mine was processing 1.5-3.5 tons of mater concentrate per day. This processing rate resulted in 30 tons of concentrate (pulverized bedrock) containing 70-82 percent lead and 28 ounces of silver per ton to be extracted for commercialization (Cox, 1970). Later in 1906 the mine was briefly opened as an attempt to fully exhaust the financial opportunity the mine withholds. At this time 70, tons of lead and 174 ounces of silver per ton were extracted (Cox, 1970). Though the life of the mine was short-lived, at one point it was reported that there was enough wealth to be extracted to cure the national debt at the time being two million dollars (Reuben, 2012). This statement was false and the mine closed sooner than anticipated.

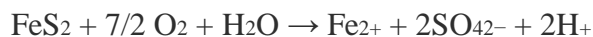
1.7 Mining of sulfide minerals

Galena mining for the production of lead materials existed regionally within New Hampshire, however also is present globally. Galena is commonly present in small bands such as the bands mined at Mascot Mine. To properly extract the thin bands of galena large amounts of waste piles are produced. Exposure to elements associated with lead mining such as arsenic, cadmium, copper, chromium, iron, magnesium, nickel, lead and zinc which are released from ores from mining and are of great concern to humans within close proximity (Lar et al., 2013). The extraction of lead from galena is as follows: galena ore is mined and crushed to a size of 0.1mm. The crushed ore is the added to water and a series of oils at different densities bring the

ore to the bottom of container. This process extracts light products associated with the heavier metals, ultimately increasing the quality of the ore. The ore is then heated to a temperature of 2500°F which oxidizes the impurities. Throughout this process there is room for significant amounts of contamination to the surrounding environment.

1.8 Acid Mine Drainage

Acid mine drainage is produced when sulfide bearing materials are exposed to oxygen and water (Akcil and Koldas, 2006). Acid mine drainage commonly occurs in iron sulfide-aggregated rocks. Acid mine drainage processes can occur naturally, however mining practices commonly promote the process (Akcil and Koldas, 2006). Sites where acid mine drainage has occurred are commonly characterized by having low pH, high specific conductivity and high metal concentrations (Akcil and Koldas, 2006). Pyrite is one of the most common sulfide minerals and is also present at Mascot Mine. The reaction for pyrite is the oxidation of the sulfide mineral into dissolved iron, sulfate and hydrogen.



Due to the oxidation process acidic waters are commonly a byproduct. The factors that control the rate of acid generation are pH, temperature, oxygen content, degree of saturation, surface area of exposed metal sulfide and bacterial activity (Akcil and Koldas, 2006). Waste piles associated with mines containing sulfides have the potential to lower the pH of surrounding waters to extreme lows; however, carbonate minerals may neutralize the low pH (Akcil and Koldas, 2006). It is important to recognize that Mascot Mine has sulfide minerals as well as carbonate minerals (Cox, 1970). The consequential effects of acid mine drainage can cause long-lasting damage. Sulfide-bearing rock from mines can contaminate the surrounding area for centuries after the mine has closed (Candeias et al., 2015).

Today, mining generates 5x10⁹ tons of tailings per year worldwide (Lu and Wang, 2012). Sulfide tailings are the main source of heavy metal contamination. Globally, developing countries are vulnerable to extreme metal contamination, because environmental remediation policies have not been implemented (Lu and Wang, 2012). It is important to recognize that heavy metal contamination is a threat to populations all around the world. It is also crucial to understand the consequences associated with mines.

1.9 Lead toxicity

It is well known that exposure to lead can cause negative consequences to humans, with increased severity in harmful effects to fetus's and youth. (Thomason et al. 2019). Until recent decades many populations were exposed to high levels of lead and were not aware. Living within close proximity to mining fields exposes residents to health issues that can alter bodily function forever (Lar et al., 2013). Through the physical process of extracting ore, lead poisoning can occur through atmospheric deposition, hand to mouth contact, contaminated drinking water and food sources. In June, 2010 in Zamfara, northwestern Nigeria ingestion of lead from mining caused the death of at least 400 people which consisted of mostly children between the ages of 5 and 11 years (Lar et al., 2013). Similar in Lavrio a Greek city, mining waste tailing piles and low-grade ore were deposited around where 10,000 residents inhabited. Lavrio later revealed that 95% of children had lead levels in blood exceed the tolerable limit of 100 mg l⁻¹ suggested by the World Health (Pappa et al., 2018). Lead contamination from mining exists globally and the impacts are detrimental. This report will explore the effects of lead mining on Mascot Mine to hopefully prevent any lead poisoning within the study area in the future.

Methods

2.1 Field Methods

Mascot Pond is located 1.71 miles north-east of Gorham New Hampshire (fig 1.1). There is no vehicle access to the study site. A canoe and coring equipment were carried in multiple phases to Mascot Pond to obtain sediment cores and other samples on September 18, 2019. On November 13, 2019 additional water samples were collected. In total from the two sampling days, three sediment cores, six water samples and 10 kg of rock samples were gathered.

The sediment cores location were targeted in two spot of the pond (fig 2.1). First the deepest section of the lake was targeted to obtain a maximum sediment record. Two cores were taken here (MP-01-19 and MP-02-19) (fig 2.1) to ensure maximum redundancy. The third sediment core (MP-03-19) was taken near the ponds outflow (fig 2.1). For the sake of this study MP-02-19 was analyzed, however the two other cores were archived for future analysis.

Five water samples were taken at Mascot Pond fully, extending along the length of the pond for a complete data set (fig 2.1). A sixth water sample (MPWS-06-19) was taken in a

nearby stream which has no input or output relation with Mascot Pond (fig 2.1). Tailings samples were taken on tailings pile throughout the full extent of the pile.

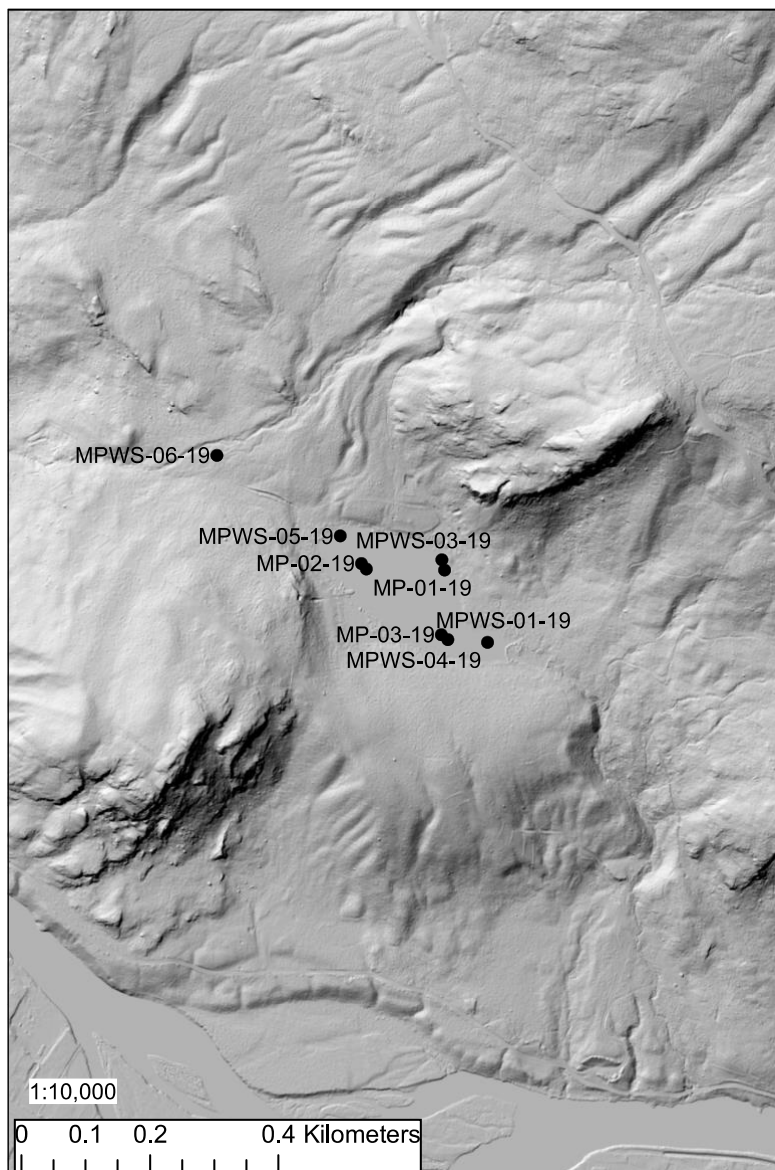


Figure 2.1: Sample location map of Mascot Pond showing water samples and core locations.

2.1.1 Sediment cores

The sediment cores were taken for content analysis of sediment and soil including metal concentrations. The sediment cores were taken using a universal coring apparatus provided by the Bates College Geology department. The universal coring device operates with a two-way valve at the top of a 5cm diameter 1.2 m long clear plastic tube. As the collection tube and coring

device are lowered to the sediment water flows through the two-way valve. The coring device is dropped to the sediment water interface and a weight was applied in a hammer motion which drives the collection tube into the sediment. When the collection tube and coring device are pulled out of the sediment, the two-way valve seals against gravity acting as a vacuum trapping the sediment and water within the collection tube. After collection the plastic tubes were cut just above the sediment water interface and capped for transportation. All three cores had positive sediment water interface, allowing for the sediment interface to not be disturbed. The tubes were held vertically during the process of transporting them to a car. They remained vertical in the car ride back to Bates College until they were opened in the laboratory. See table 2.1 for specific core location as well as core length.

Sample:	Date of Sampling:	Latitude:	Longitude:	Water Depth:	Core Length Wet:	Core Length Dry:
MP-01-19	9-18-19	N 44.40031°	W 71.18040°	5.4m	45cm	Not Opened
Mp-02-19	9-18-19	N 44.40035°	W 71.18048°	5.4m	53cm	47cm
MP-03-19	9-18-19	N 44.39954°	W 71.17922°	50cm	55cm	Not Opened

Table 2.1: Table of sediment core samples collected at Mascot Pond. Dates of sampling is displayed for all samples. Latitude, longitude water, core length wet and core length dry are included.

2.1.2 Water Samples:

Two water samples MPWS-01-19 and MPWS-02-19 were taken at Mascot Pond on September 18, 2019. The first was taken near coring location MP-03-19 and the second located near the beach below the tailings pile (fig 2.1). The water samples on were gathered in one liter bottles in undisturbed areas of the pond. Only water was collected. The one liter bottles were fully submerged but rather angled alongside the water interface. Therefore the water collected can be classified as surface water.

Four more water samples MPWS-03-19, MPWS-04-19, MPWS-05-19 and MPWS-06-19 were taken on November 13, 2019. Three of these samples were collect at Mascot Pond itself (fig 2.1). The fourth was collected at a proximal stream (fig 2.1). These samples were taken in 100 ml bottles. A hydrolab was used to record temperature, specific conductivity, dissolved oxygen and pH, at each sampling location for samples MPWS-03-19, MPWS-04-19, MPWS-05-19 and MPWS-06-19. An effort was made to avoid collecting organic material such as leaves or

pollen in the bottles. Water samples were taken for metal concentration analysis. See table 2.2 for date of sampling, specific location of each water sample and water depth at which the sample was taken.

Sample ID:	Date of Sampling:	Latitude:	Longitude:	Water Depth:
MPWS-01-19	9-18-19	N 44.39954°	W 71.17922°	50cm
MPWS-02-19	9-18-19	N 44.40057°	W 71.17869°	10cm
MPWS-03-19	11-13-19	N 44.40049°	W 71.17913°	40cm
MPWS-04-19	11-13-19	N 44.39946°	W 71.17776°	20cm
MPWS-05-19	11-13-19	N 44.40087	W 71.18100°	60cm
MPWS-06-19	11-13-19	N 44.40179°	W 71.18435°	10cm
(Tailings samples)Beach	9-18-19	N 44.40057°	W 71.17869°	N/A
(Tailings samples) Base of Tailings	9-18-19	N 44.40066°	W 71.17853°	N/A

Table 2.2: Table of water and tailings samples at Mascot Pond. Dates of sampling is displayed for all samples. Latitude and longitude are displayed for all samples. Water depth is displayed for where the water samples were taken. However water samples were taken at the surface.

2.1.3 Tailings Pile

For the last sampling phase, approximately 10 kg of rock samples were gathered ranging from fine grained sand to cobble size samples. One liter of beach sand was collected at the base of the tailings pile and pond boundary. Other rock samples were collected from the tailings pile. Rock samples ranged in size from a few millimeters to 75 centimeters (fig 2.2). An effort was made to collect a broad range of rock types. The collection of rock samples was done for potential future analysis of mineral content.



Figure 2.2: Tailings samples from Mascot Pond. Left two images display larger samples. Middle image displays tailings pile. Right image displays tailings from beach.

2.2 Core Analysis

Upon returning to the environmental geochemistry laboratory of Bates College, the cores were stored at four degrees Celsius for 3 days. All three cores obtained had very high amounts of water and therefore underwent a four day dewatering process so that the cores would maintain some integrity during the core opening, split and subsampling. For the dewatering process, the cores were placed vertically and paper towels were placed at the top of the core to act as a wicking device. Small slits were cut along the core tube approximately every eight centimeters. Sediment was not able to penetrate the slits. Initial wet core length was noted as well as the length post dewatering (table 2.1)

Core MP-02-19 was designated as the core to be sampled because it was located at the deepest known part of the pond and was the longest core obtained. A dremel tool was used to cut the plastic tube in half while trying to cause limited disturbance to the sediment. The core was split into two sections A and B, using wire. Observations of Munsell color and texture were made. Each split of the core was distinguished and used for different methods. MP-02-19B was used to gather data surrounding percent water, bulk density and loss on ignition. After methods were performed on MP-02-19B the samples were achieved for future isotopic analysis. Because

the samples were so organic rich, the entire split A (MP-02-19A) was subsampled into one centimeter semi-circle cut-outs for digestion and metal analysis.

2.2.1 Percent Water and Bulk Density Calculations

For percent water and bulk density calculations, the MP-02-19B core material was extracted using a one cubic centimeter sample size for every centimeter for the first 25 cm. From 25 cm to 37 cm the core was sampled every two centimeters. From 37 cm to 47 cm the core was sampled every one centimeter. The one cubic sediment samples were weighed (wet weight). The samples were then heated in an oven at 60°C for 24 hours. After cooling, the samples were reweighed to determine dry weight. Percent water and bulk density calculations can be seen below:

Percent water:

$$\left(\frac{\text{Mass wet} - \text{Mass dry}}{\text{mass Wet}} \right) * 100$$

Dry Bulk Density (percent):

$$\left(\frac{\text{Mass dry}}{\text{One cm}^3} \right) * 100$$

2.2.2 Loss on Ignition (LOI)

To determine LOI, the one cubic centimeter samples were heated to 550°C for four hours to volatilize organic matter. The samples were then cooled to room temperature and reweighed which yielded the ashed weight. Below are the specific calculations for LOI.

Loss on Ignition (percent):

$$\left(\frac{\text{Mass Dry} - \text{Mass Ashed Sed}}{\text{Mass Dry}} \right) * 100$$

2.2.3 Magnetic Susceptibility

Magnetic susceptibility analysis was performed on MP-02-19 in one centimeter increments for the entirety of the core. The first measurement was taken at the first centimeter from the top of the core. The analysis was done using a Bartington MS2E sensor in the sediment laboratory at Bates College. This sensor is a surface sensor, therefore a single layer of plastic

wrap was applied to the surface of the core to prevent contamination of the sediment material downcore. A calibration for drift was performed after analysis was complete. This process accounts for any disruptive aspects within the environment where testing was occurred. The magnetic susceptibility method is an undistruptive technique and did not alter sediment material or composition of the core half MP-02-19.

2.3 Inductively Coupled Plasma - Optical Emission Spectrometer (ICP-OES) Sediment Sample Preparation

The samples from MP-02-19A were freeze dried to remove all water. The samples were then were microwave digested using the EPA method 3051A. Approximately 0.5 gram of sediments were put into a fluorocarbon polymer vessel with 10 ml of concentrated trace metal grade nitric acid. Each sediment sample was placed into induvial pressure cylinders and heated to 175°F for 5.5 minutes. Once the cylinder reached the temperature of 175°F they were kept there for 4.5 minutes. The samples were then cooled for 24 hours to ensure safe handling of the pressurized nitric acid. After cooling the samples were transferred and diluted into 50ml volumetric flasks with E-pure. 10 ml of the diluted solution was transferred into 15 ml plastic test tubes for analysis using an inductively coupled plasma - optical emission spectrometer.

2.4 Inductively Coupled Plasma - Optical Emission Spectrometer (ICP-OES)

The instrument used for ICP-OES analysis was an iCAP6300 spectrometer. The method used consisted of seven standards. A calibration curve was made for each the seven standards and run prior to every analysis to ensure accuracy. Refer to table 2.3 for specific standards used. The ICP-OES recorded the element concentration (ppm) from 26 different elements with 36 total wavelengths. A calculation was made for metal content taking into account the known concentration of 50 ml used. For this study nine elements were analyzed. The following includes all nine elements and corresponding wavelength displayed in nanometers: As189.0, Cd226.5, Cu324.7, Cr283.5 Fe259.9, Mg279.5, Ni221.6 Pb220.3 and Zn213.8. The metal concentrations were also converted to mg metals/kg sediment. Bellow displays the mathematical calculations used for converting the concentrations to mg/kg, taking into account the known 50ml volume.

$$\left(\frac{\text{Element concentration (mg/L)} * 0.05 \text{ (L)}}{\text{(mass of sediment (g))} * (kg) = 1000 \text{ (g)}} \right) = \text{Element concentration (mg/kg)}$$

Standards:	Blank (2%HNO ₃)	ICS2 0.01 ppm	ICS2 0.1 ppm	ICS2 1.0 ppm	ICS2 10.0 ppm	0.1 Sc std	1.0 Sc std
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Table 2.3: Calibration standards used for ICP-OES for duration of project including all runs. These calibration standards were used for both sediment samples and water samples.

2.5 Water Samples

Six water samples MPWS-01-19 - MPWS-06-19 were taken for this study. Prior to ICP-OES analysis all water sampled had nitric acid added to them ultimately lowering the initial pH to two. This was done to ensure all metals are fully dissolved before analysis using ICP-OES analysis in all six water samples. The water samples were then processed with the ICP-OES and converted to mg metals/kg sediment following the same calculation above.

Results

3.1 Core Description

The stratigraphy of MP-02-19 was relatively homogeneous (fig 3.1). The entirety of the core was rich in organic matter and only showed few changes in color throughout. The first unit was a loosely packed, rich brown color classified as 10 yr 2/2, that extended from 0-37.1cm (boundary A, fig 3.1). Between 37.1 cm and 38.5 cm thin grey bands with a color classification of GLE yr 1-5, N were present within the same material for the previous section (boundary B, fig 3.1). Sediments between 37.1 cm and 38.5 were packed slightly more densely. From 38.5 cm to 39 cm there was a distinct continuous grey layer with the color classification of GLE yr 1-5, N (boundary C, fig 3.1). This material in this five millimeter band was the densest material seen in core MP-02-19. From 39 cm to 47 cm a deep red layer was present classified as 10 yr-2.5/1. The layer from 39 cm to 47 cm was rich in color and had a distinct change from previous layers in color. The material has a slim discontinuous layer that was orange classified as 10 yr 5/6. This material was very loose and did not hold its shape well. See figure X for images of the core and figure X for an interpretative diagram.

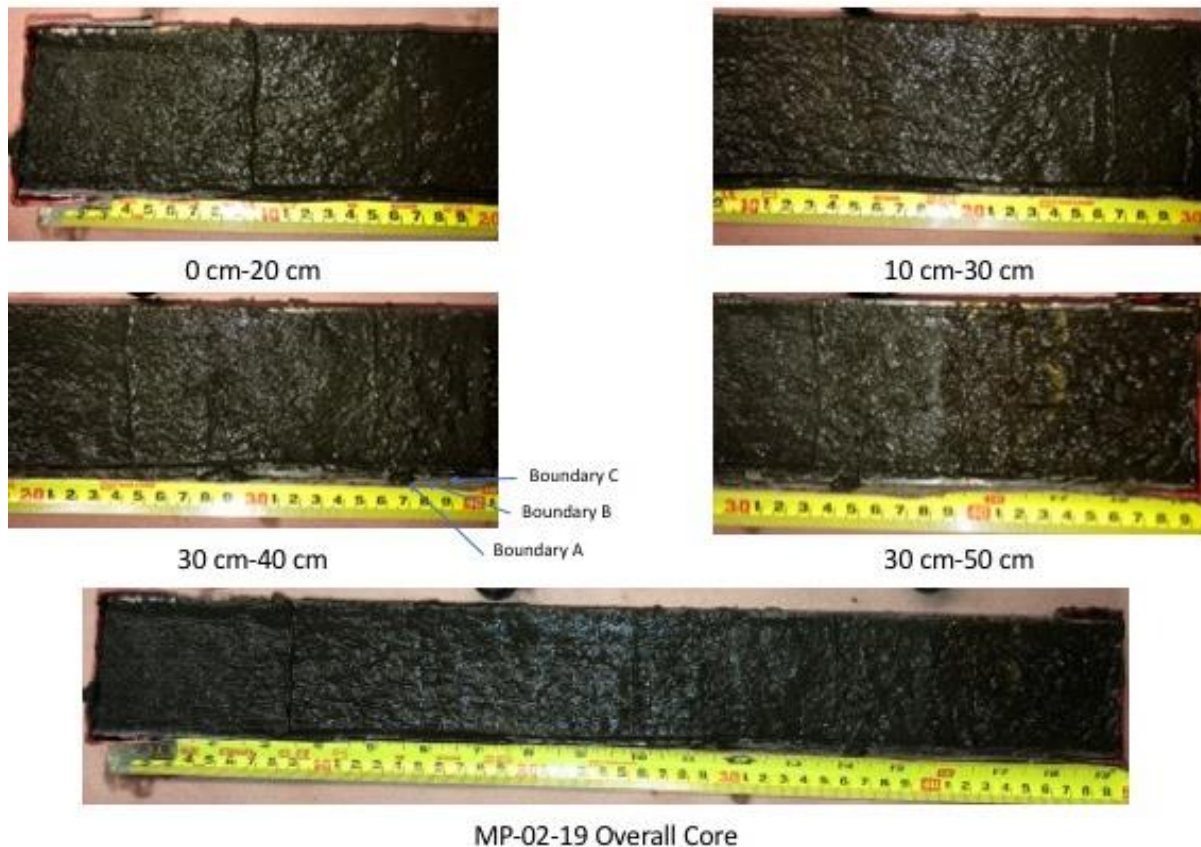


Figure 3.1: Photos of core MP-02-19. Four photos are present left to right of the core in 20 cm increments. The overall core can be seen in the bottom image.

3.2 Loss on Ignition (LOI) (fig 3.2)

The highest LOI values were between 42 cm and 46 cm with values of 61, 59 and 62 respectively. The lowest value was at 38 cm with an LOI of 32%. Worthy of note is LOI values change along the lines of material changes previously described. GLE yr 1-5,N gray layer was located from 38.5 cm to 39 cm. This layer was the densest material noted in the core and where significant decrease occurred in LOI. The overall trend of the LOI data revealed relatively consistent values between 0 and 38 cm.

3.3 Water Content (fig 3.2)

The percent water for MP-02-19 had consistently high values throughout the core. The maximum water content in the core was 94 percent, at centimeter 44 in the core. It is worth noting that the orange 10 yr-5/6 discontinuous layer seen in the core was within close proximity to the maximum water content. The orange material was the previously noted as the least dense material in the core.

The minimum water content value was at the 38 cm with a percent water value of 89 percent. It is worth noting that the GLE yr 1/5, gray layer was located from 38.5 cm to 39 cm. This layer was the densest material noted in the core.

3.4 Magnetic Susceptibility (fig 3.2)

The maximum value seen for magnetic susceptibility was located at 30 cm and had a value of -0.3 SU. The lowest values seen throughout the core had a value of -2.6 SU, seen at 4 cm and 5cm. Values were within similar ranges from 47 cm to 36 cm. A substantial spike occurred from 36 cm to 37 cm with values of -1.3 SU and -0.7 SU respectively. Values remained high until 31 cm where a decreasing trend occurred to the lowest values located near the top 10 cm of the core.

3.5 Bulk Density (fig 3.2)

The maximum bulk density values seen were at 39 and 28cm with a value of 0.0973 g/cm³ of 0.0965 g/cm³ respectively. The minimum value seen for the core was located at sample 46 cm with a value of 0.0496 g/cm³. The bulk density displayed wavering trends for the bottom half of core (26 cm to 47cm). The upper half of core (0 cm to 26 cm) had values with a smaller overall range.

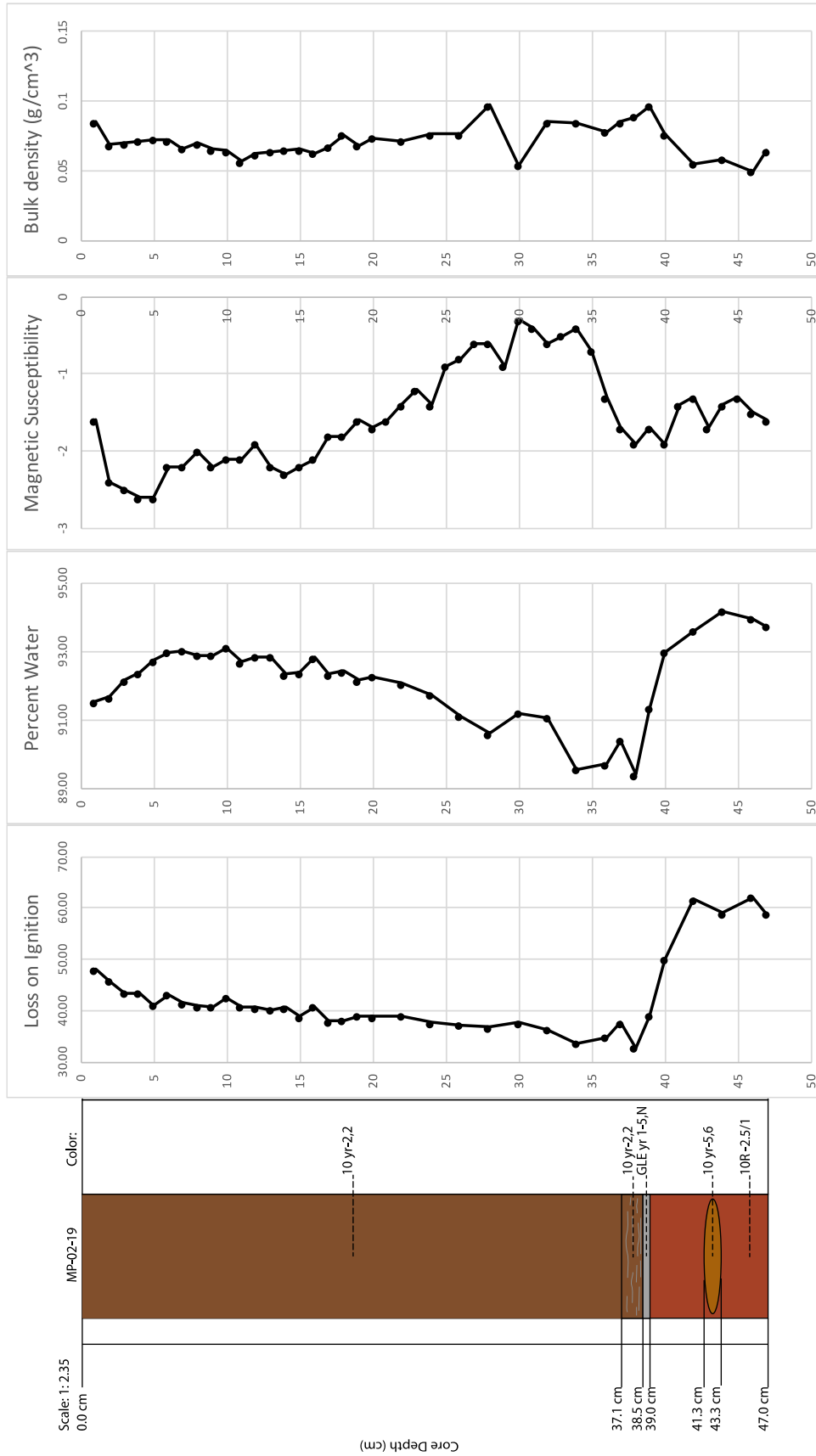


Figure 3.2: Results from MP-02-19. Refer to sections (3.1)-(3.5).

3.6 Lead Analysis

The maximum value seen for lead concentration in the sediment core was 3918 mg/kg at the 34 cm. There were two other peaks close to the maximum with values of 3793 mg/kg and 3755mg/kg at the 35 cm and 37 cm respectively. The minimum value seen was 8 mg/kg at the 46th centimeter. From 41 cm to 47 cm the values did not increase above 62 mg/kg.

At the top of the sediment core, the lead concentration were around 2000 mg/kg increasing down towards the lower 30 cm section of the core where the peak values were seen. There was a rapid decrease starting at the 37 cm. The values decreased from 3755 mg/kg, 1076 mg/kg 274 mg/kg 274mg/kg and 20 mg/kg from the 37th centimeter to 41st centimeter respectively. After the drastic decrease the values remained low for the remainder of the core.

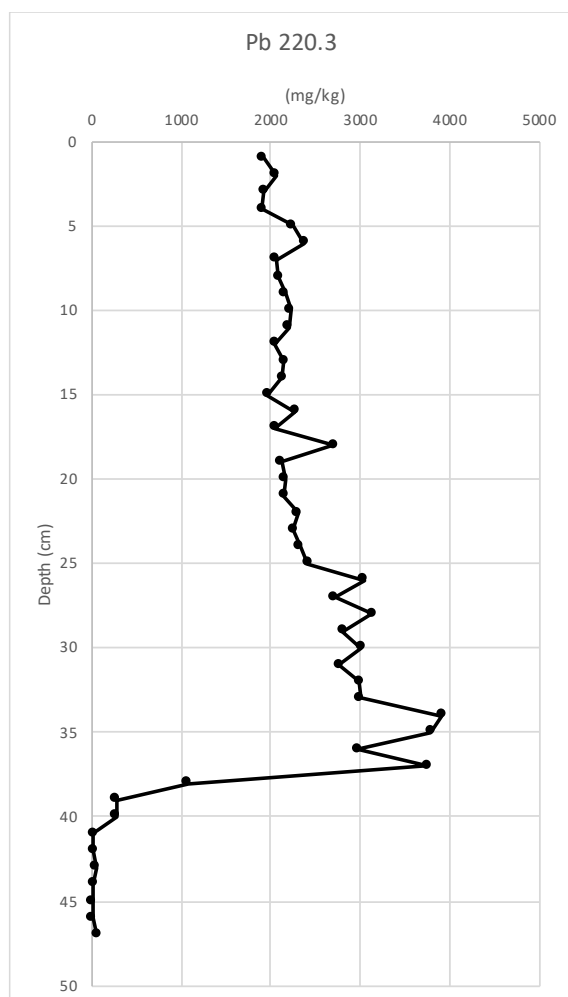


Figure 3.3: Plot of lead concentration. The Y-axis is core depth in centimeters. The X-axis represents lead 220 concentration in core MP-02-19.

3.7 Nine Potential Toxic Elements

Given the goal of analyzing the environmental impact that the Mascot Mine had on Mascot Pond and its surrounding environment, eight other metal concentrations are reported. The total of nine metals reported on are all potential toxic elements depending on concentration and element itself. Below is the concentration graphs for As, Cd, Cr, Cu, Fe, Mg, Ni, Pb and Zn (fig 3.4). Looking at all metals there are peaks in concentrations at 35 ± 2 cm. All metals show consistently low concentrations from 47cm to 40cm. Above 33 cm concentrations remain higher then seen from 47cm to 40cm, however are lower than peak concentrations. The values from 35 ± 2 cm to 0 cm follow a slight decreasing trend. Refer to appendix A for specific concentrations values. These metals are elements that make up the major minerals seen at Mascot Mine and were targeted for extraction. When looking at the scale (fig 3.4) these metals increasing from values two orders of magnitude smaller than they were at their peak. The influence of mining practice must examined.

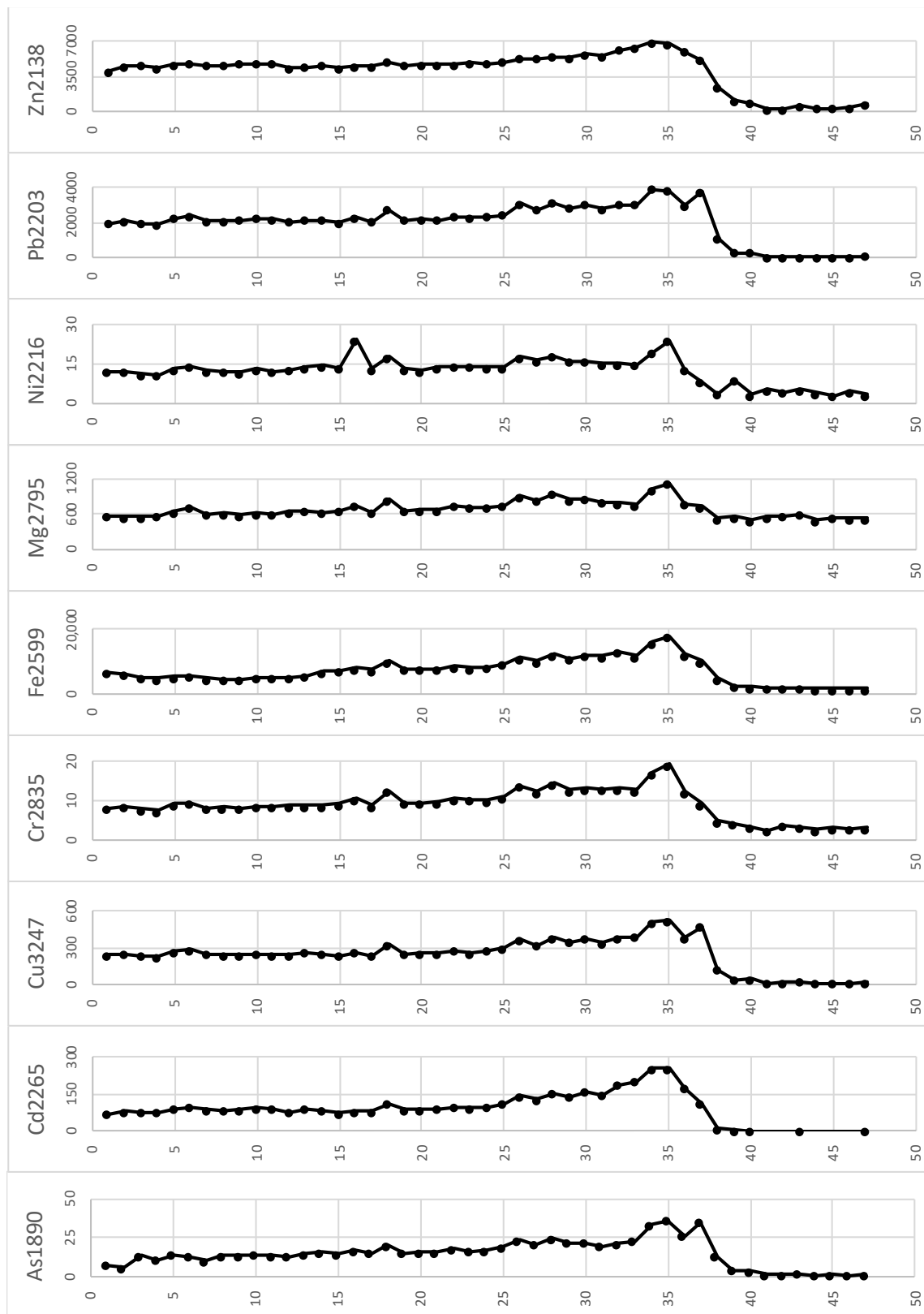


Figure 3.4

Figure 4.5: Nine potentially toxic elements reported on. Refer to section (3.7).

3.8 Water Sample Field Results

Water samples MPWS-03-19, MPWS-04-19 and MPWS-05-19 all were taken from the waters of Mascot Pond and display similar results with regards to temperature and specific conductivity (table 3.1). The highest temperature was MPWS-03-19 with 1.61 degrees Celsius. The lowest was .82 degrees Celsius taken at the far end of the pond (MPWS-04-19).

The maximum specific conductivity value was .036 $\mu\text{S/m}$ and the minimum was .024 $\mu\text{S/m}$. The specific conductivity values (SpC) were low and had similar values. The range of the data was .012 $\mu\text{S/m}$. MPWS-06-19 taken from the nearby stream had a specific conductivity value of .028 $\mu\text{S/m}$, in between the maximum and minimum of Mascot Pond.

The maximum dissolved oxygen value was 25.92 mg/L taken at MPWS-03-19, near the beach of the pond. The minimum value was seen at the entrance end of the pond with a value of 17.01mg/L. MPWS-06-19 had a value in between the maximum and minimum for Mascot Pond's values. The results for dissolved oxygen may be flawed as they are higher than anticipated. Potentially the calibration was improperly done for the dissolved oxygen component of the hydrolab.

The pH measurements were relatively similar. The highest value seen was at the nearby stream with a pH of 6.70. The pH values of the three samples from Mascot pond were lower with a maximum of 5.39. The minimum pH value was 4.70. The range among values for Mascot pond was 0.69.

Sample:	Water Depth:	Temp (°C):	SpC ($\mu\text{S/m}$):	DO (mg/L):	pH
MPWS-03-19	40cm	1.61	.027	25.92	5.00
MPWS-04-19	20cm	.82	.036	19.56	4.70
MPWS-05-19	60cm	.89	.024	17.01	5.39
MPWS-06-19	10cm	-.15	.028	18.42	6.70

Table 3.1 Hydrolab data from Mascot Pond. Temperature, specific conductivity, dissolved oxygen and pH are displayed with sample they were taken from. The water depth at the sample location is also displayed.

3.9 Water Sample Laboratory Results

Nine Elements are reported for the respective concretion seen within all six water samples. Arsenic, Cadmium, Chromium, Copper, Iron, Magnesium Nickel and Lead all had non detectable (N-D) concentrations for all six water samples. The only element with detectable

amounts was Zinc. Zinc concentration were only seen within the five water samples from Mascot Pond. There was no amount detected for MPWS-06-19 taken at the nearby stream. The maximum value (0.463 ppm) was seen at MPWS-03-19 at the tailing beach and the minimum value (0.173 ppm) was seen at MPWS-01-19

PTE	As	Cd	Cr	Cu	Fe	Mg	Ni	Pb	Zn
MPWS-01-19	(N-D)	(N-D)	(N-D)	(N-D)	(N-D)	(N-D)	(N-D)	(N-D)	0.173
MPWS-02-19	(N-D)	(N-D)	(N-D)	(N-D)	(N-D)	(N-D)	(N-D)	(N-D)	0.325
MPWS-03-19	(N-D)	(N-D)	(N-D)	(N-D)	(N-D)	(N-D)	(N-D)	(N-D)	0.463
MPWS-04-19	(N-D)	(N-D)	(N-D)	(N-D)	(N-D)	(N-D)	(N-D)	(N-D)	0.358
MPWS-05-19	(N-D)	(N-D)	(N-D)	(N-D)	(N-D)	(N-D)	(N-D)	(N-D)	0.425
MPWS-06-19	(N-D)	(N-D)	(N-D)	(N-D)	(N-D)	(N-D)	(N-D)	(N-D)	(N-D)

Table 3.2: Results from ICP-OES metal concentration analysis for all six water samples. Note “N-D” represents non detectable values.

Discussion

4.1 Baseline Lead Deposition From the Watershed

The bottom section of the sediment core MP-02-19 contains lead concentrations that represent natural occurring levels within the geologic region. Based on 11,316 soil samples, pre-industrial soils in the Appalachian geological region have an average lead concentration value of 15.3 ± 17.5 mg/kg (Saint-Laurent et al, 2010). Mascot Pond resides within the Appalachian region in which 15.3 ± 17.5 mg/kg is the natural lead level. Sections 40-47 cm in core MP-02-19 have an average lead concentration value of 26.3 ± 20.05 mg/kg.

The last sample section of the core at 47 centimeters has a lead concentration value of 62.7 mg/kg which is significantly higher than any of the previous concentrations in the six centimeters above. The mean value of samples from 41-46 cm is 20.3 mg/kg, whereas including the 47 cm sample the average value is 26.3 mg/kg. The high value at 47 cm may be a result of a natural unloading process into the watershed. For an example it is possible that more lead was mobilized from a forest fire event.

It is important to recognize that the pre-industrial average lead value for the Appalachian region (15.3 ± 17.5 mg/kg) and average lead concentration for the bottom seven centimeters of the core at Mascot Pond (26.3 ± 20.05 mg/kg) are within one standard deviation of each other. This suggests there is statistically no difference between the lead concentration at the bottom of the core for Mascot Pond and the established baseline lead concentration for the region. A conclusion can be made that the bottom seven centimeters of the core represent natural lead concentrations.

A marked increase in lead concentrations begins at 40cm. The first non-baseline lead concentration is 274.6 mg/kg for both 40cm and 39cm. The 38 cm section has a lead concentration of 1076.5 mg/kg. The peak lead concentration is 3918.91 mg/kg at the 35 cm. These abrupt changes in lead concentrations in a relatively short distance are not natural occurring lead concentrations for this region. This data suggests that there was some sort of anthropogenic influence on the area because they cannot be classified as natural. The start of mining is attributed to this significant increase.

4.2 Age Model

The lead levels seen from 47cm to 40 cm are classified as natural levels. Due to the rapid increase in lead concentrations after 40cm, samples above correspond to a time period after the opening of the lead mine in 1881. The top of the sediment core (0 cm) is assigned to year 2019 when the core was sampled. From the interpreted change in natural lead concentration and the known opening of the mine a calculated sedimentation rate can be determined. Assuming 40 cm represents the beginning of mining at Mascot Mine (1881), the calculated sedimentation rate for Mascot Pond is 40cm/138 years or 0.30 cm/yr.

A nearby pond is recorded to have a similar sedimentation rate as the one calculated for Mascot Pond. Sessions Pond is located in Drummer, New Hampshire approximately 30 miles north of Mascot Pond (fig 4.1). Sessions Pond is located slightly west of the Androscoggin river. Through lead 210 activity in the soil, the constant rate of supply model was utilized and a sedimentation rate was determined for Sessions pond. In 1998 the established Sessions Pond's sedimentation rate was 0.35 cm/yr (Kamman et. al, 2002). Sessions Pond displays relatively similar bathymetrical make up to Mascot Pond (fig 4.2, fig 1.1). Sessions Pond has a watershed area of 378 ac and surface area of 43 ac. The resulting watershed to surface area ratio is 1-8.79 ac. Mascot Pond has a watershed area of 92 ac and a surface area of 12 ac. Mascot Pond's resulting

watershed to surface area ratio is 1-7.67 ac. Though Sessions Pond is larger than Mascot Pond, both display similar watershed to surface area ratios. Given the similarity in sedimentation rate and relatively close proximity to Mascot Pond the established sedimentation rates at Sessions Pond supports the findings for the sedimentation rate at Mascot Pond.

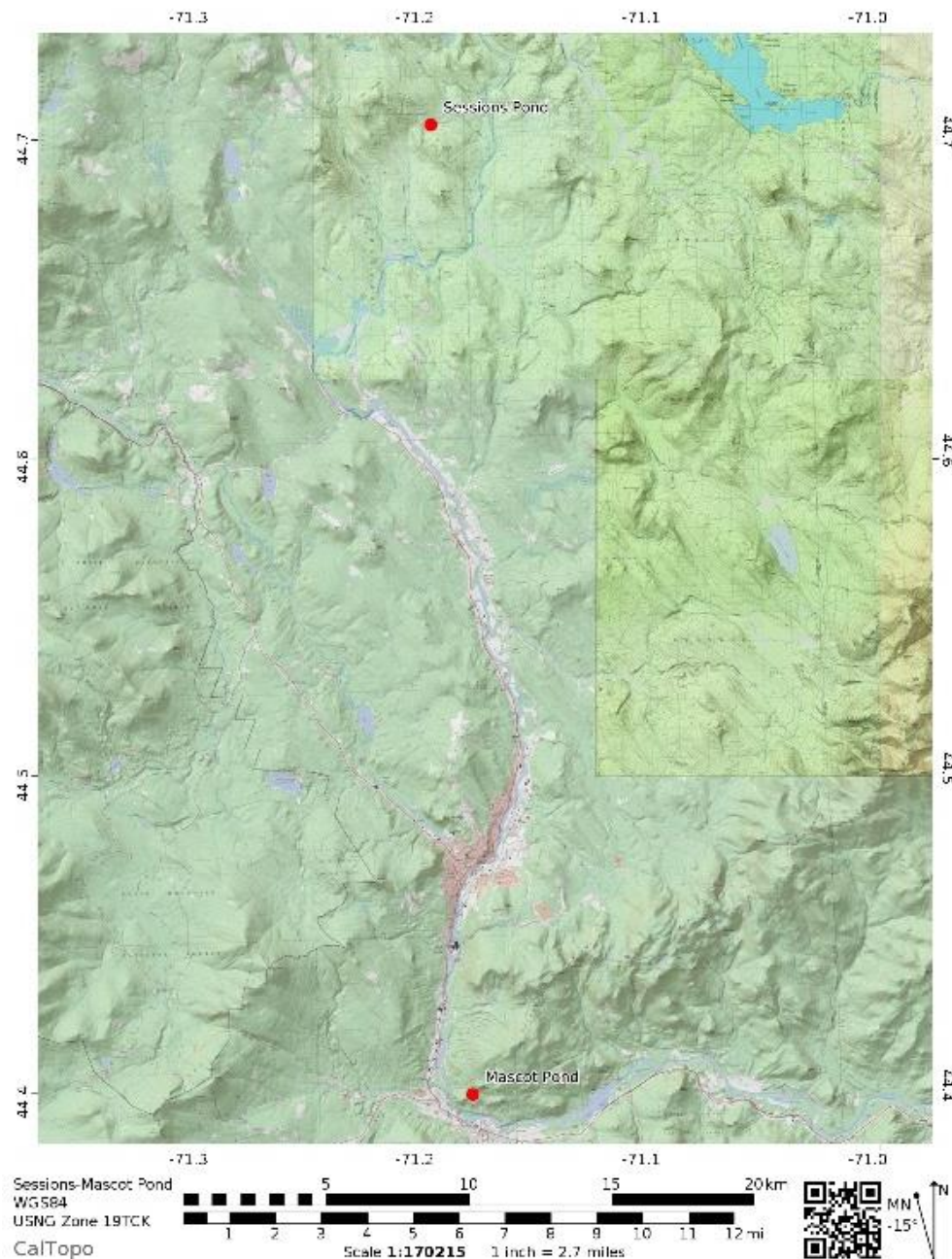


Figure 4.1: Map displaying relationship of Sessions Pond to Mascot Pond. Map was generated using "CalTopo".

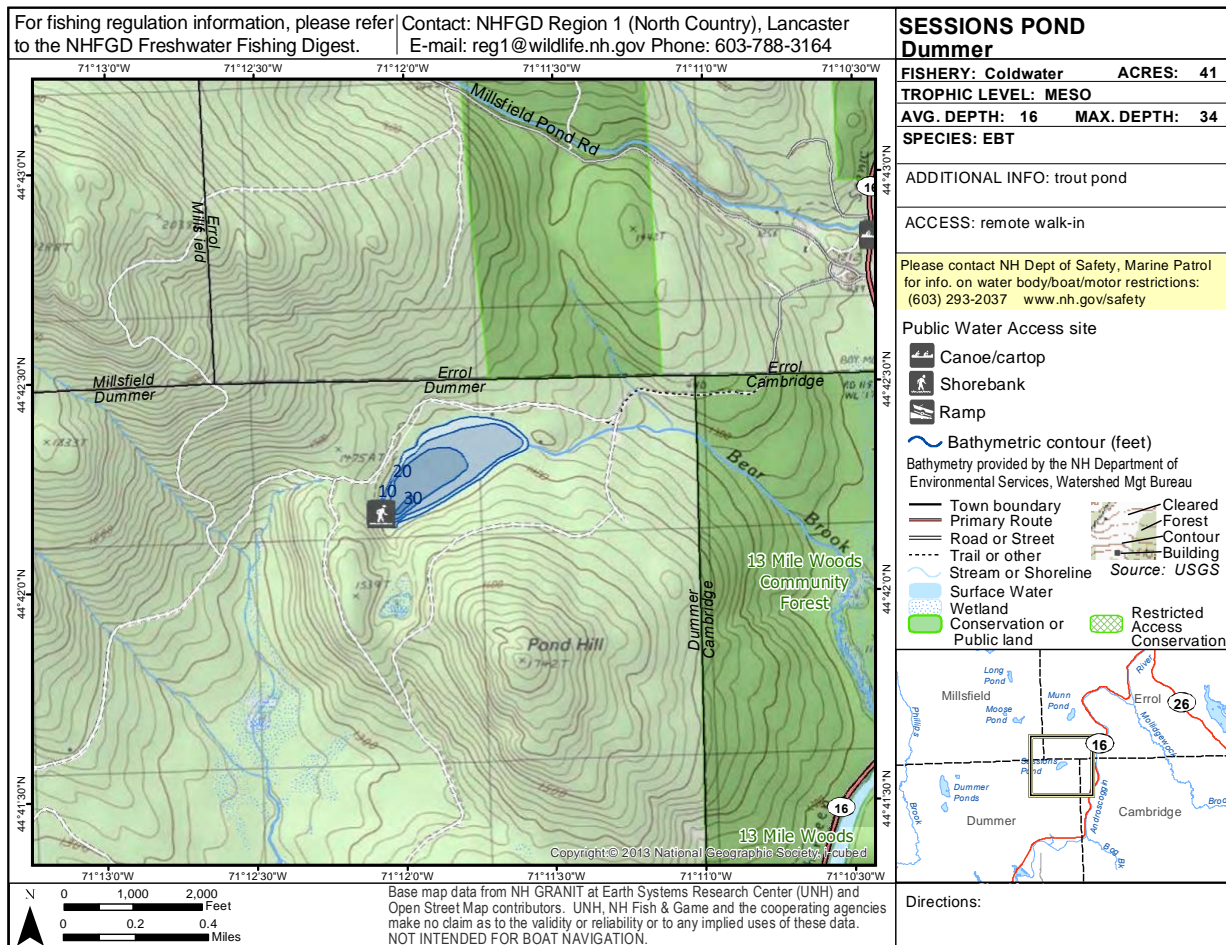


Figure 4.2: Map of Sessions Pond in Drummer New Hampshire displaying topographical make up. Map from New Hampshire Fish and Game depth maps of selected NH lakes and ponds database.

4.3 Mascot Pond was Likely Dammed and is Spring Fed

Mascot Pond was likely dammed. This conclusion can be attributed to the visible feature in the lidar data, displayed in a hill shade map of Mascot Pond and surrounding area (fig 4.3). A dam was also found during field collection days in fall 2019 (fig 4.3). Mascot Pond is also likely spring fed. This conclusion can be made from not being able to see any surface inputs when analyzing the hill shade imagery. Also while exploring Mascot Pond in the fall of 2019 there was no visible tributary sources found. Worthy of note, the hill shade imagery revealed an alluvial fan (fig 3.3). However after field analysis, it is clear that the alluvial fan ends in a wetland that is situated in a topographical low not associated with Mascot Pond and ultimately drains to a nearby stream. The water sources from the alluvial fan are not inputs to Mascot Pond. Therefore Mascot Pond is spring fed.



Figure 4.3 Image showing hill shade imagery and dam found on field collection days. Note the red circle is the dam on hill shade imagery. Pictures of dam at the outflow of Mascot Pond are on right. Pictures were taken on November 13th 2019 the second day of field work. Left image shows dam feature from shore of pond. Right image was taken on dam feature showing width. The bottom of the alluvial fan can be seen directly above sample MPWS-05-19.

4.4 Chemical Weathering of Minerals at Mascot Mine

From the mining process that started in 1881 (Reuben, 2012) a large amount of bedrock material was pulverized and stored in tailings piles. Pulverizing the bedrock increases the surface area of the previous unaltered bedrock as well as exposes material to the atmosphere and precipitation. As water comes into contact with the tailings pile at Mascot Mine, dissociation occurs. Given the large quantities of sulfide rock containing minerals such as galena (PbS), sphalerite ($(\text{Zn,Fe})_2\text{S}$), chalcopyrite (CuFeS_2) and pyrite (FeS_2) (Cox, 1970) oxidation of sulfides gives rise to the mobilization and migration of trace metals from the mining waste into the environment (Candeias et. al 2015) (fig 4.4). As the dissociation process occurs heavy metals are released as well as acidic byproducts (fig 4.4).

The result from when dissociation occurs is acidic waters rich in metals. This is evident at Mascot Pond. There are two supporting trends within the data collected for dissociation occurring at Mascot Pond. The first, a significant increase can be seen in all nine metals (fig 3.4) when the mining period started (40cm). Secondly, Mascot Pond has a relative acidic pH compared to nearby water sources (table 3.1).

Significance of pH at Mascot Pond

Scavenging of metals such as the nine reported on are pH dependent. Specifically heavy metals are pH dependent like zinc, lead and cadmium (Stumm et. al, 1996). The measured pH at Mascot Pond can reflect the dissociation process occurring. As water comes into contact with sulfur bearing minerals a chemical reaction occurs (example fig 4.4). The results of this chemical

reaction includes metal ions as well as hydrogen atoms. Hydrogen atoms are mixed with the water of Mascot Pond, resulting in an increase in acidity. The pH at Mascot Pond has an average pH value of 5.03. The values can be classified as relative acidic for the nature of the pond. When looking at the neighboring stream's pH (sample MPWS-06-19) of 6.70 the, low pH of Mascot Pond must be attributed to dissociation processes. In contaminated waters such as Mascot Pond, containing highly dissolved sulfate from sulfide bearing rocks, such as those associated with acid mine drainage, free Pb^{2+} is the dominant species seen where the body of water is below a pH of about seven ("National", 2017). So ultimately the lowered pH at Mascot Pond supports the high concentrations of metals seen in the sediment. There is an overall relationship that can be seen between the pulverized sulfide bearing rocks, local precipitation, the water's pH levels at Mascot Pond and the metals seen in the sediment (fig 4.4).

4.5 Uptake of Metals by Particulate Matter

When metals are introduced to a natural body of water they interact with solutes as well as inorganic and organic (phytoplankton) particles (Stumm and Morgan, 1996). The way in which the particles settle within the water is from the affinity of the reactive metals and the qualities of the water body. This may determine the relative residence time of the elements in the water (Stumm and Morgan, 1996). As the heavy metals such as Pb^{2+} are transported to the water they bond with particulate matter because the particulates are negatively charged and the metals are positively charged (fig 4.4). Both organic particles (algae) and inorganic particles have a role in binding, assimilation and transport of reactive elements (Stumm et. al, 1996). The overwhelming influence of metals from the source (tailings piles) results in a large uptake of the metals by particulates like organic material. The process is clearly evident at Mascot Pond (fig 4.4).

Lower concentrations of metals and smaller flux rates will display a relative small impact on the water column and sediment. This is due to the efficiency of settling, absorbing, scavenging and assimilating particles (Stumm and Morgan, 1996). Larger amounts of metals inputs will change the water column and concentration within the sediment because there is an overload on the system. At Mascot Pond there is an overwhelming spike in metal concentrations in the sediments differing from baseline natural concentrations for the area. This is because the mine caused an overload. Based off of the composition of the bedrock material there was the

opportunity for the dissociation process to occur and products then bond with particulates in Mascot Pond (fig 4.4).

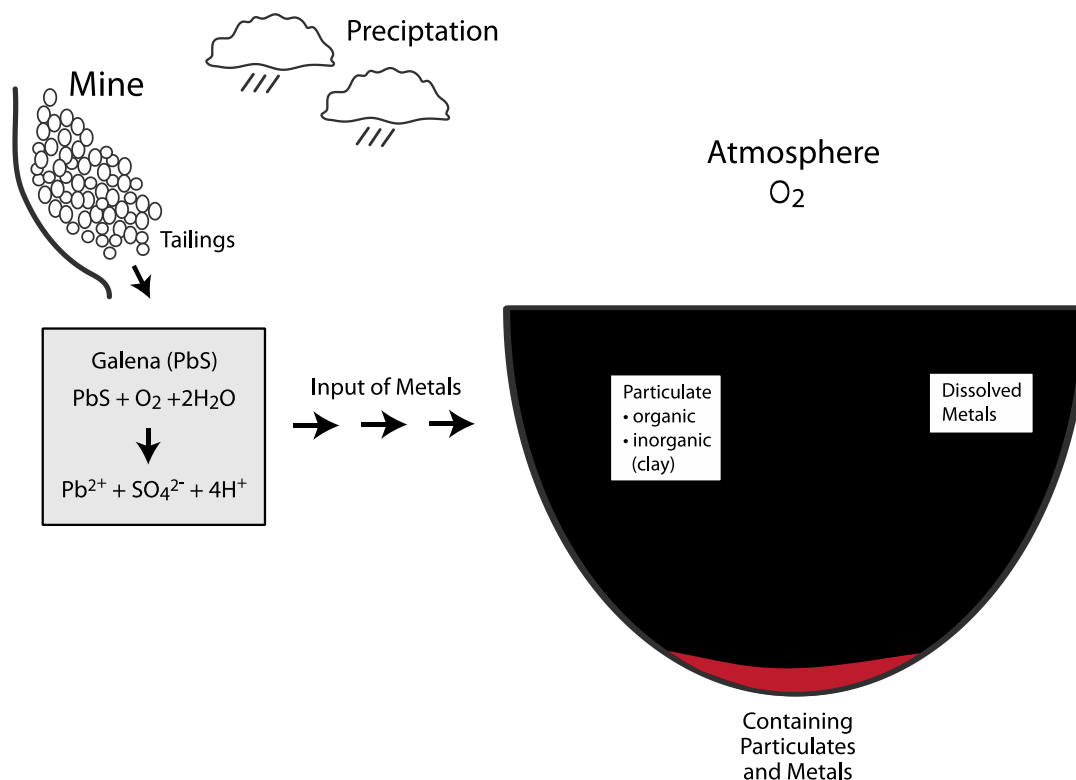


Figure 4.4: Dissociation and bonding process for metals in Mascot Pond. Left to right. Bedrock is exposed through mining. Precipitation and exposed minerals create opportunity for dissociation. Resulting particles are transported through ground water sources. Heavy positively charged metals bond with negatively charged particulates. Particulates bonded with metals fall and form sediment record.

4.6 Periodic Timeline of Mascot Pond

Figure 4.6 displays an interpretive timeline of Mascot Pond. Section A illustrates what pre-human impact on Mascot Pond and Mount Hayes would look like (pre 1881). Note the water level is lower than post-human impact (sections B, C, D) and no mining on Mount Hayes is visible. Section B represents the post 1881 era when the mining had started at Mascot Mine. Note that audit mining occurring exposing inner bedrock to air and precipitation. Also note the water depth increases due to the damming of the outflow of the pond. Section B also displays the inflow of water into the pond with lower acidity and heavy metal transport. Tailings are also

visible. Section C represents the time period after the mines closing to present day. Note the minerals continue to dissociate and allow for metals to enter Mascot Pond. The water remains acidic. Note metal accumulation is occurring in the sediment at the bottom of the pond. Sulfide rich minerals are known for creating acid mine waste for years after mines have closed (Candeias et. al, 2015). The environmental impact from this process can be damaging as well prevalent for decades after mine operations end. With exposed tailings piles the opportunity for this process is still present. Section D represents present day where the highest amount of accumulation of heavy metals would have occurred. Even though mining ended 138 years ago the residual minerals are still exposed continuing the chemical weathering process.

4.7 Relative Severity of Metal Concentrations Seen at Mascot Pond

Metals such as copper, chromium, iron, magnesium, nickel, and zinc are essential nutrients for human biological function (Tchounwou et. al 2012). Inadequate supply of these metals can cause deficiencies and health effects. Overdose of these metals can also cause health problems. Other metals tested for in this study such as arsenic, cadmium and lead are not needed for biological processes and are toxic. In biological systems metals in high concentrations or toxic metals can affect and alter cell membrane, mitochondrial, lysosome, endoplasmic reticulum, nuclei, and some enzymes involved in metabolism, detoxification and damage repair processes (Tchounwou et. al 2012).

It is important to recognize the full extent that the Mascot Mine had on the area. The following is a table showing nine metals displaying the maximum concentration, minimum concentration and current (surface) concentration. The EPA public health goal for water contamination is also included as well as the EPA regional screening level for superfund sites in residential soils.

Though there was significant impact and change from the natural environment from Mascot Mine, most metal concentration values are not worry for concern. For all five water samples taken from Mascot Pond, the only detectable metal was zinc. The mean value of all five zinc samples was .3488 mg/kg (ppm). This value is lower than the EPA public health goal water quality standards for zinc at 5.0 ppm. Therefore the actual water of Mascot Pond does not contain any of the nine potentially toxic elements at dangerous concentrations.

The sediment of Mascot Pond has high metal concentrations that are a result of Mascot Mine. This may be cause for concern. Once metals from mines are dispersed within the local environment toxic effects are often observed (Candeias et. al, 2015). The metals that exceed recommended levels are arsenic, cadmium and lead. This is based off of the surface values for these metals being higher than the recommended EPA regional screening level for superfund sites in residential soils. It is important to recognize that that no humans inhabit the area and the sediments are contained at the bottom of the pond.

	As	Cd	Cu	Cr	Fe	Mg	Ni	Pb	Zn
EPA Public health goal water quality standards (mg/l) (ppm)	0	.005	1.3	0.1	0.3	0.05	0.1	0	5.0
EPA regional Screening level for superfund Sites, Residential Soil (ppm)	0.07	1.7	3,100	120,000			1500	80	23,000
Minimum Value Seen (mg/kg) (ppm)	1.22 (47cm)	0 (41,42,44-46cm)	16.53 (46cm)	2.51 (41cm)	501.38 (44cm)	490.72 (40cm)	2.71 (45cm)	8.10 (46cm)	196.12 (41cm)
Maximum Value Seen (mg/kg) (ppm)	36.06 (35cm)	254.72 (34cm)	520.46 (35cm)	19.46 (35cm)	18,034.53 (35cm)	1120.83 (35)	23.96 (35)	3918.91 (34cm)	6880.71 (34cm)
Surface Value 2019 (mg/kg) (ppm)	7.78	70.59	245.12	8.21	6784.78	571.27	12.25	1914.64	4021.54

Table 4.1 EPA Public health goal water quality standards (mg/l) (ppm), EPA regional Screening level for superfund Sites, Residential Soil (ppm), Minimum Value Seen (mg/kg) (ppm), Maximum Value Seen (mg/kg) (ppm) and Surface Value 2019 (mg/kg) (ppm) for all nine potential toxic elements reported on.

4.8 Conclusion and Future Work

The goal of this study was to examine the impact that Mascot Mine had on Mascot Pond. In concluding with this project it is evident that Mascot Mine undoubtedly changed Mascot Pond and its surrounding environment. Mascot Pond has not gone back to its relative natural state and may never return. Mascot Pond is altered by having high metals concentrations and relatively acidic waters. Mascot Mine can be used as a small scale model of how larger mines impact their environment. Future work may include analysis of the two other sediment cores taken at Mascot Pond. Future work may also entail analysis of ground water. Lastly future work could entail performing detailed isotope reconstruction on the sediments from Mascot Pond.

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Appendix A: Average Concentration Values for Nine Reported Metals:

Appendix A is a complete table of the average metal concentration analysis for the nine reported metals in this report with respect to core depth.

Core Depth	As1890	Cd2265	Cu3247	Cr2835	Fe2599	Mg2795	Ni2216	Pb2203	Zn2138
1	7.78	70.59	245.12	8.21	6784.78	571.27	12.25	1914.64	4021.54
2	5.92	81.63	250.15	8.53	6149.59	559.59	12.20	2064.63	4542.98
3	13.57	76.08	234.45	8.05	5144.96	554.16	11.06	1923.70	4577.21
4	11.15	75.39	232.13	7.63	4866.12	563.02	10.87	1904.57	4368.83
5	14.09	91.30	268.47	9.21	5391.58	648.28	13.03	2248.84	4712.10
6	12.93	96.67	284.68	9.56	5608.01	709.68	14.20	2377.69	4716.13
7	10.39	86.29	251.26	8.19	4854.04	599.36	12.34	2061.61	4599.36
8	13.78	84.45	246.83	8.32	4644.65	618.99	12.19	2085.77	4624.52
9	13.62	89.05	246.12	8.14	4658.75	578.62	11.71	2158.24	4733.24
10	14.32	94.06	249.25	8.61	5151.00	616.87	13.06	2222.67	4780.55
11	13.56	90.89	243.00	8.72	5155.02	593.92	11.98	2203.54	4754.38
12	13.16	77.97	243.55	8.77	5123.96	647.63	12.81	2046.33	4298.92
13	15.01	90.26	262.45	8.86	5693.96	654.24	13.84	2148.95	4392.40
14	15.98	85.30	250.66	8.80	7109.33	625.48	14.47	2132.70	4625.08
15	14.65	75.02	239.59	9.22	7150.99	649.56	13.29	1969.11	4331.44
16	17.04	81.62	265.90	10.62	8144.69	751.37	24.30	2279.01	4469.62
17	15.14	80.16	238.67	8.86	7459.87	629.95	13.03	2052.43	4466.57
18	20.54	112.48	325.75	12.53	10312.94	851.55	17.74	2708.80	4904.49
19	15.63	86.93	249.75	9.47	7929.28	658.00	12.95	2121.52	4585.45
20	16.04	86.89	255.64	9.44	7728.10	678.11	12.59	2166.23	4631.17
21	15.94	89.67	256.25	9.72	7712.86	668.66	13.68	2155.05	4652.51
22	18.14	98.33	279.21	10.54	8557.20	745.07	14.04	2309.49	4692.14
23	16.57	93.68	258.38	10.35	8010.57	718.96	14.10	2257.67	4816.09
24	16.85	98.35	275.45	10.17	8263.56	715.10	13.65	2327.78	4727.70
25	19.26	113.19	296.79	11.12	9361.92	736.94	13.86	2423.29	4924.81
26	23.89	143.47	370.76	13.84	11400.12	900.22	17.59	3045.11	5270.27
27	20.99	129.45	319.45	12.33	10312.94	828.79	16.46	2717.94	5240.80
28	24.54	153.93	380.92	14.49	12233.29	949.10	18.00	3135.54	5483.64
29	21.72	140.72	344.75	12.88	11125.79	844.14	16.11	2811.42	5329.20
30	21.78	159.42	375.43	13.30	12050.40	855.01	16.12	3014.63	5658.40
31	20.04	145.70	340.68	13.05	11857.35	801.26	14.94	2764.68	5490.75
32	21.22	188.58	380.11	13.29	13127.41	792.62	15.10	2995.33	6091.24
33	22.90	202.80	386.81	12.71	11796.38	764.07	14.62	3001.42	6364.56
34	33.41	254.72	507.93	17.29	16195.90	1017.07	19.27	3918.92	6880.72
35	36.06	252.93	520.46	19.46	18034.53	1129.82	23.96	3793.43	6709.66
36	26.23	174.16	379.13	12.33	12257.51	773.50	12.94	2970.58	5969.94
37	34.97	110.21	470.26	9.35	10298.44	736.09	8.25	3755.06	5082.07
38	13.23	12.63	128.22	4.85	4788.96	525.69	3.45	1076.53	2359.84
39	4.60	3.70	45.65	4.26	2505.86	551.27	8.72	274.67	1106.37
40	3.94	2.31	47.45	3.27	2118.95	490.73	3.28	274.57	850.14
41	1.75	-0.87	17.69	2.52	1885.53	547.32	5.34	20.05	196.12
42	1.74	-0.54	21.39	3.70	1926.03	572.27	4.23	16.94	250.48
43	2.08	1.07	27.42	3.42	1921.77	595.18	5.15	44.82	603.18
44	1.34	-0.45	17.70	2.71	1548.71	501.39	3.95	21.64	318.27
45	1.73	-1.01	17.64	3.13	1759.75	544.23	2.72	10.03	303.99
46	1.23	-1.31	16.53	2.80	1612.66	526.33	4.46	8.10	398.10
47	1.84	0.18	23.82	3.04	1774.67	521.53	3.24	62.72	724.05

Appendix B: Values for Core MP-02-19: Loss on Ignition, Percent water, Bulk Density and Magnetic Susceptibility

Appendix B is a complete table of the values for Loss on Ignition, Percent water, Bulk Density and Magnetic Susceptibility with respect to core depth.

Core Depth	Loss on Ignition	Percent Water	Bulk density (g/cm ³)	Magnetic Susceptibility
1	48.01	91.52	0.0854	-1.6
2	45.86	91.66	0.0689	-2.4
3	43.43	92.14	0.07	-2.5
4	43.48	92.37	0.0713	-2.6
5	41.10	92.73	0.0725	-2.6
6	43.18	92.97	0.0718	-2.2
7	41.58	93.03	0.0659	-2.2
8	40.92	92.89	0.0699	-2
9	40.79	92.88	0.0657	-2.2
10	42.61	93.12	0.0643	-2.1
11	40.81	92.69	0.0566	-2.1
12	40.61	92.84	0.0623	-1.9
13	40.16	92.84	0.064	-2.2
14	40.59	92.33	0.0648	-2.3
15	38.84	92.37	0.0654	-2.2
16	40.73	92.82	0.0626	-2.1
17	37.97	92.33	0.0669	-1.8
18	38.04	92.41	0.0757	-1.8
19	39.06	92.15	0.0681	-1.6
20	38.89	92.26	0.0738	-1.7
21				-1.6
22	38.97	92.05	0.0716	-1.4
23				-1.2
24	37.61	91.73	0.0763	-1.4
25				-0.9
26	37.19	91.10	0.0761	-0.8
27				-0.6
28	36.79	90.59	0.0973	-0.6
29				-0.9
30	37.66	91.20	0.0539	-0.3
31				-0.4
32	36.31	91.07	0.0851	-0.6
33				-0.5
34	33.69	89.55	0.0846	-0.4
35				-0.7
36	34.79	89.71	0.0779	-1.3
37	37.72	90.39	0.0851	-1.7
38	32.81	89.39	0.089	-1.9
39	38.96	91.33	0.0965	-1.7
40	49.93	92.98	0.0761	-1.9
41				-1.4
42	61.66	93.59	0.0553	-1.3
43				-1.7
44	59.01	94.19	0.0583	-1.4
45				-1.3
46	62.10	93.96	0.0496	-1.5
47	58.91	93.73	0.0645	-1.6