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SUMMER INTERNSHIP TECHNICAL REPORT

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Tin Distribution and Fate in Tims Branch at the Savannah River Site

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ABSTRACT

Tims Branch is a small stream on the Department of Energy (DOE) Savannah River Site (SRS) in Aiken, South Carolina. Since 1985, Tims Branch has been receiving treated groundwater, which has been treated by air stripping to remove chlorinated solvents. In November 2007, an innovative treatment process to remove mercury was initiated – this process uses tin chloride addition prior to air stripping to convert the mercury to a strippable form for removal by the existing treatment equipment. The untreated groundwater has a mercury concentration of approximately 250 parts per trillion (ppt), and the treated groundwater entering Tims Branch at the A014 Outfall has a mercury concentration of approximately 10 ppt. As a result of the tin chloride addition procedure, the mercury concentration in the treated groundwater entering Tims Branch has significantly decreased, but the tin concentration in the treated groundwater entering Tims Branch has significantly increased. The objective of the present research is to determine the distribution and fate of tin in Tims Branch. Sediments, water, and biofilm samples were collected along Tims Branch. The data indicate that tin is accumulating primarily in the sediments of Tims Branch closest to the outfall. In particular, two ponded areas showed significant accumulation of tin. One of the sites has a weir that is placed to prevent further erosion along the outfall tributary into Tims Branch, and this site is located approximately 1,900 feet from the outfall. The other site that showed significant accumulation of tin in the sediments is a beaver pond, namely Beaver Pond 2, which is located approximately 6,700 feet from the A014 Outfall. These two sites are promising locations to focus future research on potential tin impacts in this small stream ecosystem. The weir site, though relatively small in surface area (approximately 200 square meters), contains approximately 2.9% of the total tin released in Tims Branch from November 2007 to March 2011. Analysis of several biofilm samples showed that biofilm appears to be able to accumulate significant concentrations of tin. The biofilm samples were collected from fibrous substrates so the results represent the content of the biological community as well as particulates and detritus that have been physically collected and trapped over an extended timeframe. The results presented in the research show how tin has distributed in a real ecosystem following three and a half years of operation of a tin chloride treatment system designed to reduce mercury concentration in the treated groundwater entering the ecosystem. In addition, the results of the present research will help to understand where tin may distribute in a real ecosystem and if tin chloride treatment, used for treating water that has been contaminated with mercury, can be applied to other ecosystems that have been contaminated with mercury, such as the East Fork Poplar Creek (EFPC) in Oak Ridge, Tennessee. The analytical results for other media in Tims Branch, water and fish, will be presented in separate research reports.

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1. INTRODUCTION

The Savannah River Site (SRS) is a United States government facility located on a 310 sq mile reservation in South Carolina. Operations at the site began in the 1950s and focused on production of nuclear materials and the associated support and waste management activities (SRS 2011). Over the years of operations at the site, contaminants have entered the environment, and work has been conducted within the site to remediate contaminated areas.

The Savannah River National Laboratory has initiated an applied research effort to study Tims Branch, a small stream ecosystem in the northern portion of SRS. Tims Branch originates on the SRS and flows into Upper Three Runs Creek, which eventually flows into the Savannah River. The overall research effort will assess the fate and potential impacts of inorganic tin released into this stream as well as the potential benefits of concomitant reduction in mercury discharge. These chemical changes resulted from the November 2007 start-up of an innovative system treating water discharged to Tims Branch – the treatment process removes mercury by chemical reduction and air stripping.

Since 1985, groundwater in the A/M Area of the SRS has been treated to reduce concentrations of chlorinated solvents (Looney et al. 2010). This treatment system consists of groundwater wells from which groundwater in the area is pumped to an air stripper, the M-1 air stripper, which removes chlorinated solvents. The treated groundwater is discharged to a tributary of Tims Branch (Looney et al. 2010). In November 2007, an additional operation was added to the treatment system to reduce mercury concentration in the groundwater (Looney et al. 2010). Just upstream of the air stripper, the pumped groundwater is amended with tin(II) chloride ($SnCl_2$ or stannous chloride), which reacts with mercury in the water to reduce it to elemental mercury. The groundwater enters the M-1 air stripper and the elemental mercury, which is more volatile than dissolved mercury, is stripped from the water along with the chlorinated solvents. The mercury concentration in the untreated groundwater is initially approximately 250 ng/L (parts per trillion) and the treatment system reduces the concentration of mercury in the treated groundwater to approximately 10 ng/L (Looney et al. 2010).

Thus, mercury concentration has significantly decreased in the treated groundwater entering Tims Branch after the initial startup of the tin chloride treatment process. The concentration of inorganic tin in the water, however, has increased. While tin is less toxic than mercury, it is important to understand tin behavior and the impacts of the treatment system (both negative and positive) in Tims Branch to help assess the process performance and potential viability for other sites.

Based on thermodynamics, tin from the treatment process is predicted to be predominantly inorganic tin in the +4 oxidation state, tin(IV), primarily as a solid tin(IV) oxide or hydroxide. Any residual inorganic tin(II) would be subject to oxidation and precipitation as the water flows downstream in Tims Branch. Tin(IV) oxides are relatively inert particles of low toxicity that would be expected to deposit in sediments and other niches where particles accumulate in the ecosystem. Thus, inorganic tin(IV) is the predominant chemical form for deposition and accumulation in sediments; once deposited in sediments, the literature suggests that a small fraction of the tin may be converted to organo-tin through methylation (Amouroux et al. 2000, and others). The potential significance of tin methylation will be evaluated in future studies.

The treated groundwater from the M-1 air stripper treatment system flows out of the A014 Outfall, which is the origin of a tributary of Tims Branch (the A014 tributary). At approximately 750 feet from the A014 outfall, a second tributary combines with the A014 tributary, and this second tributary originates from the A011 Outfall (the A011 tributary). Eventually, the A014 tributary combines with the main stream of Tims Branch at approximately 4500 feet from the A014 Outfall (Hayes 1984). At this point along the stream, Tims Branch is very braided and appears to be a marsh.

The following figure is a plot of elevation versus horizontal distance along Tims Branch in the Savannah River Site in Aiken, South Carolina. The figure is adapted from Hayes (1984) and has been edited to include additional features relevant to the present research. Along the A014 tributary and along the main stream of Tims Branch, there exist several areas of potential sediment accumulation. In the original figure that is found in Hayes (1984), the A014 Outfall was called the 300 Area Outfall. The figure has been edited to approximate the changes in elevation due to erosion resulting from the increased water flow rate into the A014 tributary starting in 1985 due to the M-1 air stripper water treatment system. The edited figure also includes additional sediment deposition sites, including an engineered erosion control pond (the "weir site") and several beaver ponds.

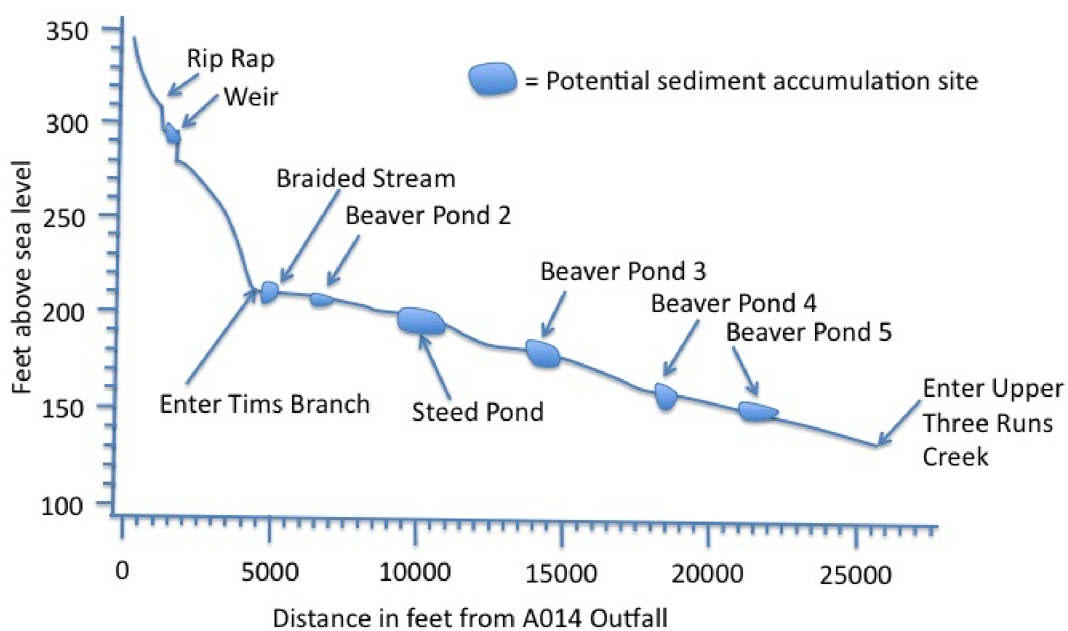

Figure 1. Elevation versus horizontal distance along the tributary originating from the A014 Outfall and along the main stream of Tims Branch, up to Upper Three Runs Creek, adapted and edited from Hayes (1984).

From the plot of elevation versus horizontal distance along the tributary of Tims Branch that originates at the A014 Outfall and along the main stream of Tims Branch, there are seven identified areas of potential sediment deposition and accumulation. In Figure 1, the rip rap is an area along the tributary that originates at the A014 Outfall that has a sudden drop in elevation, where sheet metal has been placed facing the flow of water in the tributary from one edge to the other in order to prevent further erosion from occurring. The rip rap site is visible but is difficult to access and is very rocky; it is uncertain if this site has any sediment deposition. The weir site is a location that has a large vertical pipe with a diameter of about three or four feet sticking up from the bottom of the tributary, allowing water to pass from a higher elevation to a lower elevation. The weir site has a sudden drop in elevation due to erosion. The vertical pipe has steel or iron bars on the top that prevent large debris from entering the pipe. The remaining sites for potential sediment accumulation are the braided stream, the beaver ponds, and Steed Pond. Steed Pond was not sampled because it is a radiological posted area.

The objective of the present research is to provide an initial survey of the distribution and fate of inorganic tin released to Tims Branch. To ascertain where tin is being deposited and accumulated along Tims Branch, samples of sediment, water, and biofilm along Tims Branch were collected and analyzed for tin. Samples were taken along the tributary of Tims Branch that originates at the A014 Outfall and also along the main stream of Tims Branch, excluding Steed Pond because of the radiological posting at this location [Steed Pond was the primary location where uranium accumulated during site operations in the M Area (Evans et al. 1992)], and up to a point just before the confluence of Tims Branch with Upper Three Runs Creek.

The importance of this research is to examine the risks and benefits of tin chloride treatment for reducing mercury inputs to ecosystems such as Tims Branch and the East Fork Poplar Creek (EFPC) in Oak Ridge, Tennessee. With a knowledge of where tin is accumulating in Tims Branch, further studies can investigate whether the concentrations of tin in sediments along Tims Branch at certain sites reach levels that may impact microorganisms and aquatic fauna and flora, and also whether or not the reduction of mercury concentration in the water in Tims Branch has beneficially decreased mercury concentration in Tims Branch fish.

2. EXECUTIVE SUMMARY

This research work has been supported by the DOE-FIU Science & Technology Workforce Initiative, an innovative program developed by the US Department of Energy's Environmental Management (DOE-EM) and Florida International University's Applied Research Center (FIU-ARC). During the summer of 2011, a DOE Fellow intern (Amaury Betancourt) spent 10 weeks doing a summer internship at Savannah River National Laboratory (SRNL) in the Savannah River Site (SRS) under the supervision and guidance of Dr. Brian B. Looney. The intern's project was initiated in June 6, 2011, and continued through August 12, 2011 with the objective of determining the fate and distribution of tin in the Tims Branch ecosystem in the SRS. Tin enters the ecosystem from an innovative mercury treatment system in which tin chloride reacts with mercury in contaminated groundwater to reduce mercury and allow mercury to be stripped from the groundwater by using an air stripper. The treated groundwater enters Tims Branch with a reduced mercury concentration but an increased tin concentration. Therefore, the distribution and fate of tin within Tims Branch are important in determining possible effects of tin on fauna and flora in this ecosystem.

The Savannah River Site (SRS) in Aiken, South Carolina, is a United States government facility. Historical operations at SRS include nuclear weapons production, nuclear power production, and, more recently, environmental cleanup operations, among other operations historically and currently. As a result of past research and operations at the site, contaminants have been released into the environment, and the SRS is currently involved in numerous projects for cleanup of the environments that have been affected by these contaminants.

At the A/M area in the SRS, groundwater has been contaminated with chlorinated solvents and mercury. In 1985, the M-1 Air Stripper Treatment System was installed to volatilize the chlorinated solvents from the groundwater by pumping the groundwater through the air stripper, then releasing the treated water to Tims Branch, and further treating the off gas from the air stripper for the volatilized chlorinated solvents. However, the treatment system originally was not designed to remove mercury from the groundwater, and in November 2007 a tin chloride treatment process was added just upstream of the M-1 air stripper. The tin chloride reacts with dissolved mercury in the groundwater to reduce dissolved mercury to elemental mercury, which is more volatile and can be removed from the groundwater by the air stripper. The inlet concentration of mercury to the treatment system is approximately 250 parts per trillion (ppt). After the groundwater is treated in the treatment system, the resulting concentration of mercury in the treated groundwater is 10 ppt. The concentrations of the chlorinated solvents in the untreated groundwater have decreased over the years to levels that are low enough that do not require further treatment of the off gas of the air stripper. In addition, the mercury concentration in the off gas is also low enough that further treatment of the off gas of the air stripper is not necessary. Thus, the off gas of the M-1 air stripper is not treated further.

Mercury concentration in the treated groundwater entering Tims Branch has significantly decreased since the startup of the tin chloride addition procedure to the M-1 Air Stripper in November 2007. However, the concentration of tin entering Tims Branch has significantly increased.

The objective of the present research is to determine the distribution and fate of tin in Tims Branch. To achieve this objective, different media along Tims Branch were sampled, specifically sediments, water, and biofilm. The focus of this report is on sediments and biofilm.

Sediment and biofilm samples were collected along the tributary of Tims Branch that originates at the A014 Outfall, then along the main stream of Tims Branch up to a point just before the confluence of Tims Branch with Upper Three Runs Creek, which eventually leads into the Savannah River. The sediment sampling sites along Tims Branch, including the A014 tributary, include various areas where sediments potentially accumulate: a weir site that was placed to prevent further erosion along Tims Branch, a braided stream area, and numerous beaver ponds. From the numerous sites sampled, two sites in particular showed relatively high tin concentrations. The first site where tin appeared to be accumulating was the site with a weir, which had been installed to prevent further erosion from occurring along Tims Branch. Samples were taken from a pond just upstream of the weir, and relatively high mercury concentrations were measured for sediment depths from 0 to 3 inches deep. The second site where tin appeared to be accumulating was a site named Beaver Pond 2, which is downstream of the confluence of the tributary that originates at the A014 Outfall and the main stream of Tims Branch.

The sediment sampling site that had the highest concentration of tin was a site just downstream of the A014 Outfall, but this site only had a high concentration in the sediment depth of 0 to 0.5 inches, just at the sediment surface, and the surface area of this site is relatively small. Therefore, tin did not appear to be accumulating in this location. Also, sites in between the A014 Outfall and the weir site also showed significant concentrations of tin in the sediments, although these sites also have small surface areas and do not appear to be sites of significant sediment accumulation. All the other sediment sampling sites downstream of Beaver Pond 2 did not show significant tin concentration in the sediments, except for the last sampling site before the confluence of Tims Branch with Upper Three Runs Creek. This last sampling site showed relatively high tin concentration in only the depth of sediment between 1.5 and 2.5 inches, and this site is relatively small in surface area, therefore tin accumulation does not appear to be significant at this site. Because tin was only detected in the sediment depths between 1.5 and 2.5 inches, it is possible that this tin may have come from historical releases into Tims Branch.

In addition, several biofilm samples were taken at various sites along the A014 tributary. The concentrations of tin in each of the biofilm samples were significantly higher than the concentrations of tin in the sediment samples for each respective site. However, these samples were not collected by conventional means for sampling biofilm so the results are only interpreted as a scoping study. Tin may be accumulating in biofilm because of the roots in the biofilm that may attach to suspended sediments in the water, which may include tin particles in the water. Further research on Biofilm in Tims Branch should be conducted.

The present research suggests that further research on the effects of tin chloride treatment in Tims Branch should focus on the two sediment accumulation areas where tin was detected in significant concentrations: the weir site, which is located approximately 1,900 feet downstream the A014 Outfall, and Beaver Pond 2, which is located approximately 6,700 feet downstream the A014 Outfall. The results of the present research are important to be able to predict tin distribution and fate in a real ecosystem, namely Tims Branch, and the results may be applied to potential use of tin chloride remediation in other ecosystems that are contaminated with mercury, such as the East Fork Poplar Creek (EFPC) in Oak Ridge, Tennessee. Further research is necessary to assess the effects of tin on fish and other wildlife in these ecosystems. The results of the water samples and fish samples will be presented in a separate report.

3. RESEARCH DESCRIPTIONS

Field Sampling

Four field sampling trips were conducted to select sampling sites and to collect sediment, water, and biofilm samples along Tims Branch. Samples were collected from 19 different sites along Tims Branch, with different types of samples collected at each site, and multiple samples collected at different locations at some of the sites.

Site Selection

Sites were selected at various locations all along Tims Branch, up to just before the confluence of Tims Branch with Upper Three Runs, which eventually flows into the Savannah River. Sites were selected along Tims Branch to obtain an adequate mapping of the distribution of tin. Some specific sites were selected because of either adequate deposition of sediments at the site, interesting biofilm at the site, or because of a particular formation at the site, such as a beaver pond, which could cause accumulation of sediments. In addition, control samples of sediment, water, and biofilm were collected at an unnamed tributary in Tims Branch, which originates from the new A011 Outfall, and which eventually flows into the tributary of Tims Branch that originates at the A014 Outfall (from where the treated groundwater enters).

Sample Collection

Almost all of the sediment samples were collected with sample core liners, which are made of plastic. Each sediment sample was collected by placing one end of the sample core liner on the surface of the sediments and then pressing down and twisting slightly until the core liner was submerged in the sediments as deep as possible. Then, the sediment around the sample core liner was dug and the bottom of the sample core liner was held by one hand as the sample core liner was lifted. Sometimes, while the sample core liner was still inside the sediments, the cap was placed on top of the sample core liner, which was then lifted slowly from the sediments, and the sample remained in the sample core liner because of vacuum conditions in the space where the sample core was collected. Following this, a cap was placed on the top of the sample core liner (if not already placed) and then a cap was placed on the bottom of the sample core liner or plastic was wrapped on the bottom of the sample core liner to hold the sample in place. Each core sample was between 1.5 to 6.5 inches deep., with an average sample depth of around 4.5 inches. A total of 34 sediment samples were collected using sample core liners, and 2 additional sediment samples were collected using a United States BMH-53 bed material sampler to evaluate the field performance of this sampler.

Water samples were collected with a cup-on-a-stick sampler. At each site where water samples were collected, two water samples were collected: one to be filtered and one to not be filtered. Filtering was done to be able to distinguish between dissolved tin, which was operationally defined as any tin that could pass through a 0.20 micrometer (μm) filter, and particulate tin, which was operationally defined as any tin that could not pass through the 0.20 μm filter.

At each location where a "biofilm" sample was taken, the sample was collected by removing a section of biofilm-coated substrate by hand and then placing the material in a plastic bag. Thus substrate for the biofilm was typically a mass of root fibers or similar fibrous material found in a stream "snag" area. Note that this was a screening study and samples collected in this manner contain significant quantities of detritus and particulate matter (relative to traditional biofilm samples that are collected on flat plates after a period of colonization/growth.

The following table shows the sample sites and types of samples collected at each site.

Table 1. Sampling Sites with Notes and Types of Samples Collected at each Site

Site[#]	Notes	Types of samples collected	Approximate Distance from the A014 Outfall (feet)
0	Outlet of M-1 Air Stripper System	Water	N/A
1	A014 Outfall	Water, Biofilm	5
2	Downstream about 20 feet from A014 Outfall	Sediment, Biofilm	20
3	Downstream of two culverts	Sediment,	400
5[*]	On stream originating from A014 Outfall, just before confluence with stream originating from the new A011 Outfall	Sediment, Biofilm, Water	750
6	Control stream, originating from the new A011 Outfall	Sediment, Biofilm, Water	N/A
7	Downstream about 25 feet from the confluence of the streams originating from the new A011 Outfall and the A014 Outfall	Water	800
8	Weir site	Sediment	1900
10	Upstream of Former A011 Outfall	Sediment	3600
9	Former A011 Outfall	Sediment, Biofilm, Water	3700
11	Beaver Pond 1, Control location, a former farm pond that is on the main northern tributary of Tims Branch that receives the discharge from the A-01 wetland treatment system	Sediment, Water	N/A
12	Braided stream, upstream of Beaver Pond 2 (Site 20), and downstream of Former A011 Outfall	Sediment	4700

Site#	Notes	Types of samples collected	Approximate Distance from the A014 Outfall (feet)
20	Beaver Pond 2, in between Former A011 Outfall and Steed Pond	Sediment	6700
13	Former United States Geological Survey (U.S.G.S.) sampling station, just downstream of Steed Pond	Sediment, Biofilm, Water	10500
15	Beaver Pond 3, downstream of the former U.S.G.S. sampling station	Sediment, Water	14000
16	Downstream of Beaver Pond 3, in a braided stream	Sediment, Water	15700
17	Beaver Pond 4, in between Beaver Ponds 3 and 5	Sediment, Water	18800
19	Beaver Pond 5, in pond	Sediment, Water	21000
18	Beaver Pond 5, channel downstream of beaver dam	Sediment, Water	21500
14	Tims Branch, just before confluence of Tims Branch with Upper Three Runs	Sediment, Water	25700
	#Sites are listed in order from upstream to downstream		
	*Site 4 was selected but was not sampled		

Processing Sediment Samples for Analysis

Most core samples were taken in Summer 2011, and the specific dates of sampling and field trips were July 15, July 22, July 29, and August 9, all in 2011. Once sediment core samples were collected and brought back to the laboratory, each sediment core sample was partitioned into segments to analyze the tin concentration in the sediment at different depths. For the first inch and a half (1.5 in.), each sediment core sample was divided into three equal slices, each with a thickness of 0.5 in. Therefore, the top three sediment portions were divided into depths of 0 to 0.5 in., 0.5 to 1 in., and 1 to 1.5 in. The following sections of the sediment core sample were each divided into segments of thicknesses each of 1 inch. Most of the sediment samples were about 4.5 inches long, and therefore the remaining depths of each sediment sample were 1.5 to 2.5 in., 2.5 to 3.5 in., and 3.5 to 4.5 in. Some sediment core samples were longer or shorter than 4.5 in., and these samples have either more segments or less segments.

An initial field sampling trip was carried out by Brian B. Looney and Dennis Jackson on March 16, 2011. Sediment samples were collected from a pond just upstream of a weir, which is along the tributary of Tims Branch that originates at the A014 Outfall. The weir allows water to flow from a part of Tims Branch with a higher elevation to a part of Tims

Branch with a lower elevation. This weir was placed to prevent further erosion from occurring, which is caused by the increase of volume flow rate of water that began in 1985 with the operation of the M-1 air stripper. In the present research, this site was later labeled Site 8 (Table 1).

The sediment samples from the initial field sampling trip were divided into equal sections of 1.5 inches each. Therefore, the sediment sample depths of these samples are 0 to 1.5 in., 1.5 to 3 in., and 3 to 4.5 in. Only a few of the samples from the initial field sampling trip had a depth of 4.5 in., but all samples from the initial field sampling trip were at least 3 in. deep.

Once the sediment samples from the Summer 2011 field sampling trip were divided into the appropriate segments, all the samples were dried in an oven at a fairly constant temperature around 60°C. Most samples were dried for about 24 hours. Some samples dried over one weekend and the temperature of drying for these samples began at around 60°C but dropped to about 39°C over the weekend. Nonetheless, these samples dried over the weekend.

The samples from the March 2011 field sampling trip had been dried earlier by simply air drying inside plastic bags left open in a laboratory. The drying process was approximately one week for these sediment samples. In addition, two samples from site 8, the weir site, which were collected on the July 15 field and sampling trip, were air dried for approximately two weeks because these samples were originally only to be used as test samples for the US-BMH Bed Material Sampler, but were eventually used for determining tin concentration at a part of this site.

Once samples were dried, each segment of dried sediment was disaggregated using a mortar and pestle, followed by passing the sample through a standard United States Sieve, Size 20, which has a pore size of 0.0331 inches (in.), or 850 micrometers (μm). During the shaking of each sample in the sieve, the remaining portion of sediment on top of the sieve was placed in the mortar and pestle again, disaggregated, and passed through the sieve again. Some sediment samples were disaggregated and passed through the sieve a third time. After this, the sediment sample was placed in a clean plastic bag, labeled, and the equipment was brushed with a clean paint brush to remove any debris. The process was repeated for all segments of sediments.

Each sediment sample was then placed in a X-ray fluorescence (XRF) spectrophotometer plastic sample cup. Each sample cup was covered with a Prolene film wrap that has a thickness of 4.0 μm, or 0.00016 in. To be analyzed using the XRF spectrophotometer, each sample cup was placed upside down inside the sample station, and the sediment sample rested on the Prolene film wrap in each sample cup.

The samples were analyzed using a Niton XL3t GOLDD+ analyzer in the Test All Geo mode. After evaluation of the XRF output for all of the samples and reference materials, the results for 31 elements were reported. The elements that were not reported were either below detection in all cases or were rejected due to poor performance on certified reference samples with similar matrices. The reported concentrations, except for tin, are based on the factory settings so they should be considered semi-quantitative. Because of its importance to this work, a site specific tin calibration standard was prepared by spiking inorganic tin into uncontaminated stream sediment collected from the Tims Branch control stream.

The relationship between the instrument response and the reference concentration in the standards was used to develop a calibration equation. All of the reported tin concentrations in this report were generated using the site-specific calibration. The relationship between the estimated and reference concentrations for the standards is depicted in Figure 3. Additional information on the instrument conditions, calibration, and relative standard deviation for each measured element are provided in Appendix A.

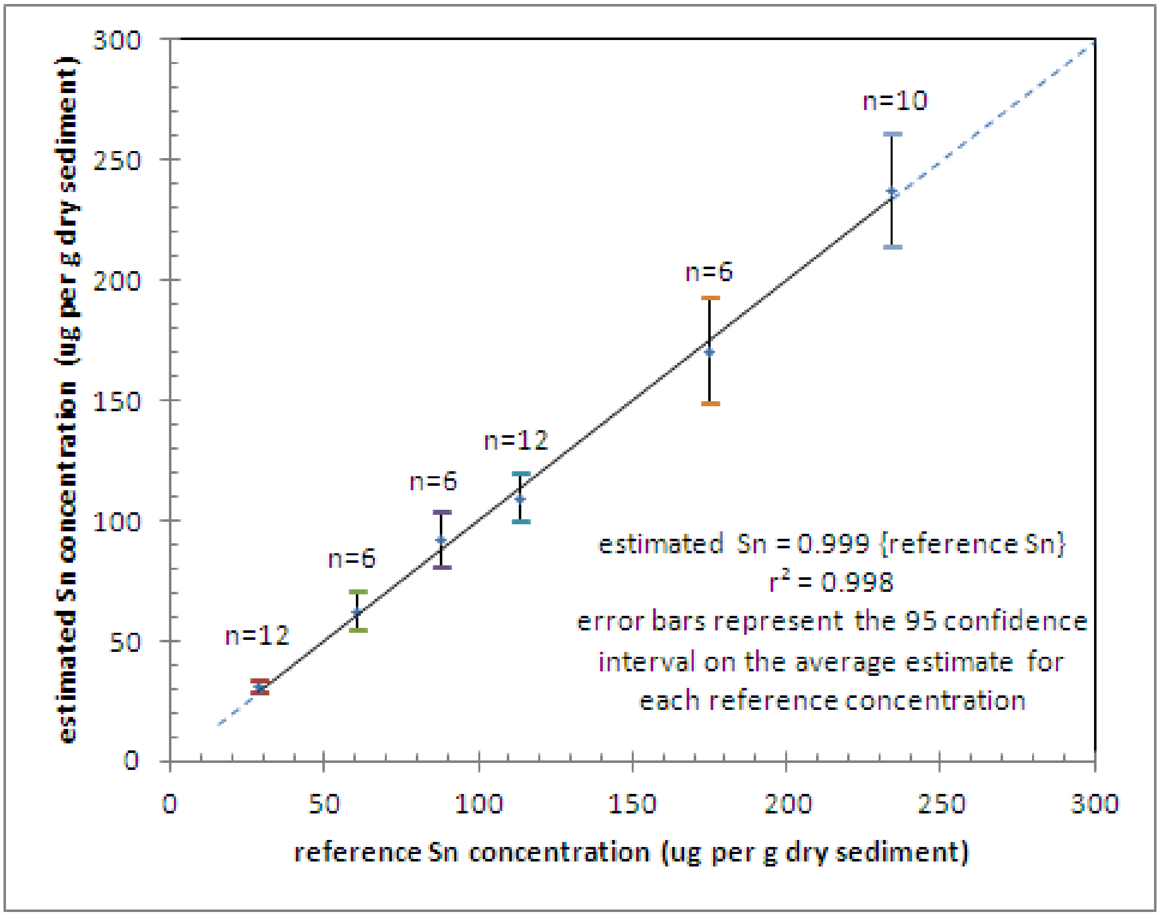

Figure 2. Documentation of the final calibration – estimated tin concentration versus the volumetrically prepared reference concentration of tin.

Sediment Sample Analysis

Each sediment sample was analyzed with a Thermo Scientific Niton XL3t GOLDD+ X-Ray Fluorescence (XRF) Spectrophotometer. To test each sample, the Test All Geo mode was used, which consists of four filters, each analyzing a different group of elements. The four filters are low, medium, high, and light. To analyze each sample, the XRF spectrophotometer was run for 60 seconds on each filter, for a total of 240 seconds (4 minutes), to analyze each sediment sample. Moreover, each sediment sample was analyzed twice and the results of each set of runs were averaged. Thus, a total of 8 minutes of analysis time was allotted for each sediment sample. In between the first and second sampling run for each sample, the sample was either shaken lightly or moved slightly in order for the XRF spectrophotometer to analyze a different section or different particles from the same sediment sample.

Biofilm Sample Preparation

Each biofilm sample was prepared and analyzed the same way as the sediment samples. Biofilm samples were more difficult to disaggregate because of the roots in the biofilm samples. Some biofilm samples that passed through the sieve had particles that were very small and which became airborne while samples were being poured from the sieve or while samples were being shaken. Most of the sample (including the fibrous substrate) for each biofilm sample remained in the sieve, however.

Water Sample Preparation

For each sampling site where a water sample was taken, a total of two water samples were actually collected. One of the water samples was filtered in order to remove suspended particles that were larger than 0.20 µm in diameter to analyze for the dissolved tin concentration (operationally defined as tin in the water that passes through a 0.20 µm filter), and the second water sample remained unfiltered to analyze for total tin in the water.

Water samples were analyzed using inductively-coupled plasma – mass spectrometry (ICP-MS). Water samples were sent to the Savannah River Ecology Laboratory (SREL) to be analyzed. The results of the water samples will be reported in a separate report.

Fish Samples

Fish samples were collected from Tims Branch in 2006, which is prior to the startup and operation of the tin chloride treatment process, and in 2010, which is more than two years after the startup and during the operation of the tin chloride treatment process. The fish samples collected in 2006 will provide valuable information on mercury and, potentially, tin concentrations in fish prior to the startup and operation of the tin chloride treatment process, while the fish samples collected in 2010 will provide valuable information on mercury and, potentially, tin concentrations in fish after more than two years of operation of the tin chloride treatment process.

4. RESULTS AND ANALYSIS

The objective of the present research is to determine the distribution and fate of tin along Tims Branch, following approximately three and a half years of continuous operation of a tin chloride treatment system in Tims Branch to reduce mercury concentrations in the branch. To accomplish this objective, sediments, water, and biofilm were sampled from Tims Branch.

Tin Concentration in Sediment Samples

The results of sediment samples are the focus of the present research, and the results of water samples will be discussed in a separate report. Biofilm samples were taken as a scoping study, and the results are presented here.

The following figure shows the concentration of tin at each of the sampled sites in Tims Branch, with each concentration corrected using the calibration curve for tin (Appendix A, Figure 10), for depths in the sediments from the surface to 2.5 inches deep.

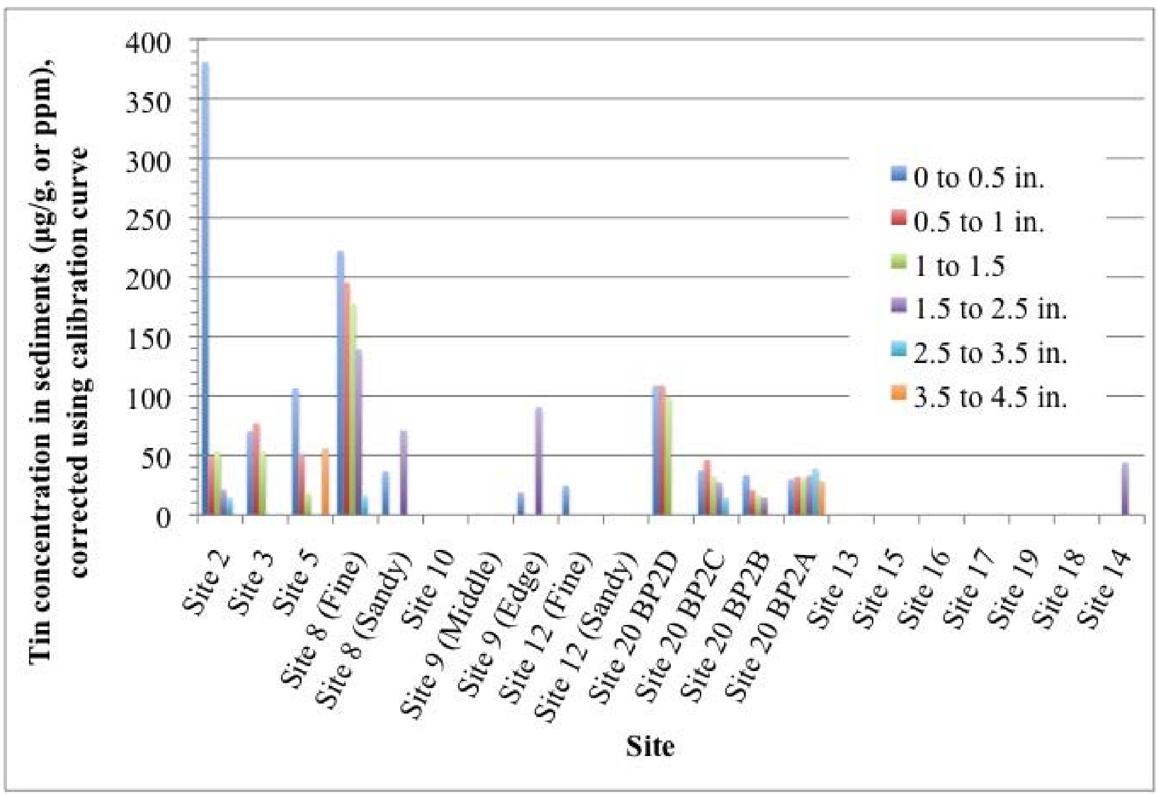

Figure 3. Tin concentration in sediments along Tims Branch at the different sites where sediments were sampled.

From the figure above, Figure 3, the two sites that seem to have the most significant tin accumulation in the sediments are site 8 and site 20. There are some interesting measurements of tin, such as from 1.5 to 2.5 inches deep at site 14. The tin present in the sediments from 1.5 to 2.5 inches deep at site 14 suggests that tin may have been in historical effluent to Tims Branch. Multiple samples were taken from sites 8, 9, 12, and 20. In sites 8, 9, and 12, a sandy and a fine sample were taken from each site. In addition, in site 8, multiple samples were collected on March 16, 2011, and these samples are discussed after the discussion after the results of the Summer 2011 sample results. In site 20, which is Beaver Pond 2, four different samples were taken at different locations in Beaver Pond 2, and the approximate locations of each of these samples are shown in the following figure.

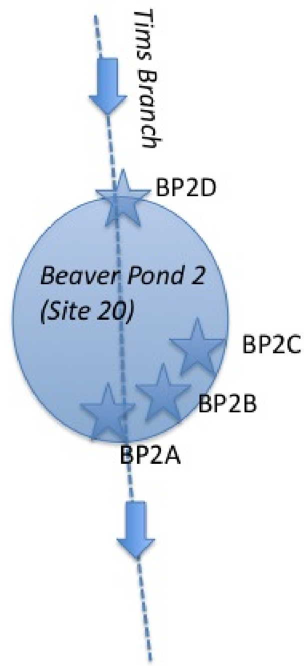

Figure 4. Beaver Pond 2 (site 20) with four sampling locations, approximately, where sediment samples were taken.

From Figure 3, tin concentrations in Beaver Pond 2 are highest at the inlet to Beaver Pond 2, which is sampling site 20 BP2D. Beaver Pond 2 is a site for sediment accumulation, as can be seen from Figure 3.

The following graph shows the same data as in Figure 3 for tin concentration in sediments along Tims Branch, but the tin concentration is plotted versus approximate distance from A014 Outfall, along Tims Branch. These distances were estimated using Google Maps (2011). Originally, a global positioning system (GPS) device was to be used, but the GPS satellite signals were mostly unavailable while out in the forest and in Tims Branch.

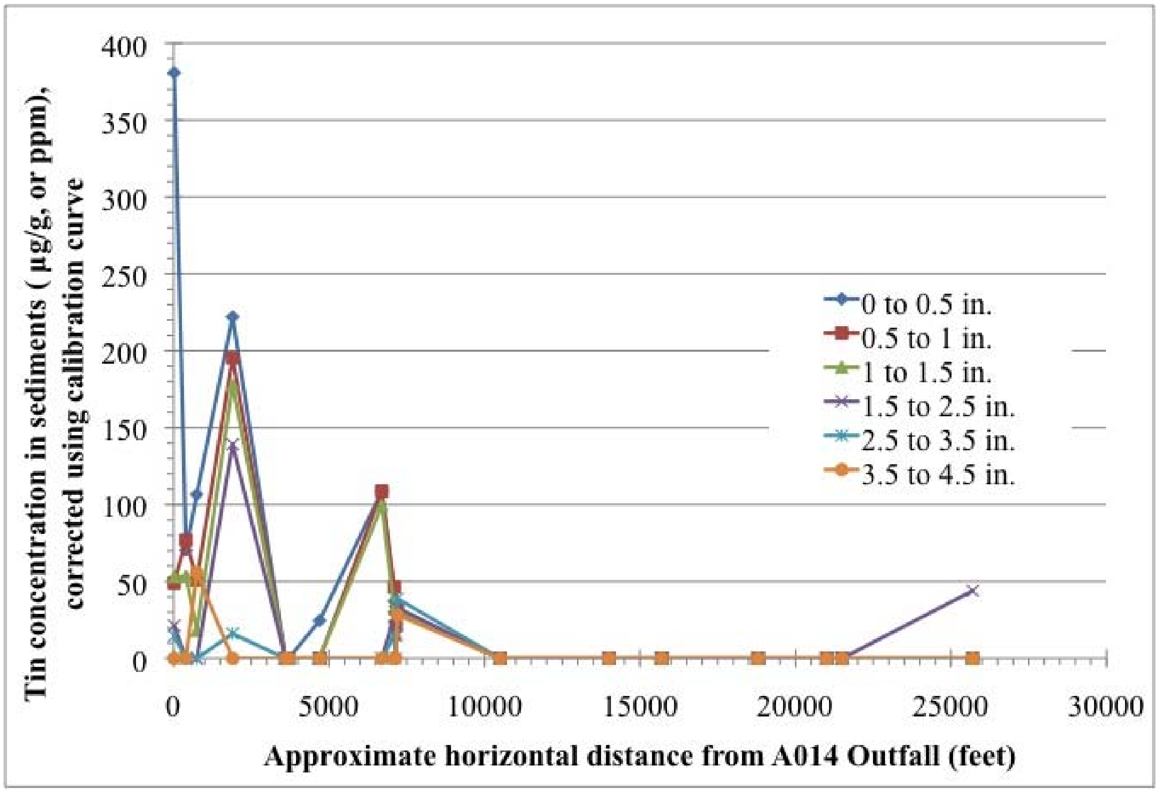

Figure 5. Tin concentration in sediments along Tims Branch versus distance from A014 Outfall.

From the data of tin concentration and distribution in sediments along Tims Branch, it appears that tin has a patchy distribution, with some sites having a relatively high concentration, then sites further downstream with little or no tin, and then a site with a relatively high tin concentration. It appears that from Figure 3, of the seven potential sites for sediment accumulation, which are shown in Figure 1, only two have significant concentrations of tin in the sediments, and these are the weir site (site 8) and Beaver Pond 2 (site 20). This patchy distribution was expected due to the uneven distribution of sediments along Tims Branch, especially along a significant portion of the tributary that originates at the A014 Outfall. This tributary appears to have been more affected by the increased flow rate of water due to the installation of the M-1 air stripper treatment system in 1985 than the main stream of Tims Branch. At a point just downstream of Steed Pond, Tims Branch changes from a losing stream, in which the elevation is above the level of the groundwater and thus water seeps from the stream to the groundwater, to a gaining stream, in which the elevation is below the level of the groundwater and thus groundwater enters Tims Branch. Because of this, the increased flow rate of water due to the M-1 air stripper treatment system may be more of an increase for the part of Tims Branch that is a losing stream than for the part of Tims Branch that is a gaining stream.

The first sediment accumulation area along the tributary of Tims Branch that originates at the A014 Outfall is the weir site. On March 16, 2011, Brian B. Looney and Dennis Jackson both collected field samples from the pond at the weir site. They collected a total of 13 samples from this site in order to obtain an estimate for a grid of tin distribution within the pond at the weir site. The following diagram shows the approximate locations where the samples were taken at the weir site on March 16, 2011.

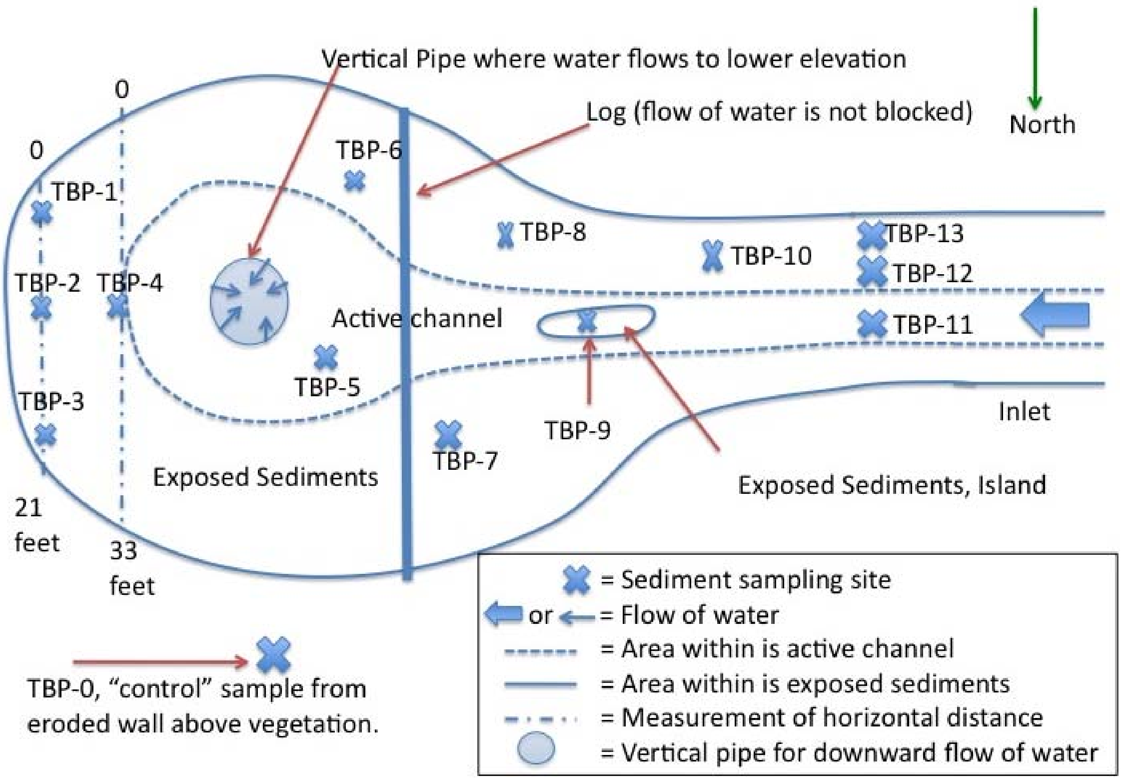

Figure 6. The pond at the weir site (site 8), with sediment sampling sites marked.

The M-1 Air Stripper was shut down on Monday, March 14, 2011, for annual maintenance. On Tuesday, March 15, 2011, much of the pond at the weir site was exposed (due to the significantly decreased flow rate of water along the A014 tributary). Sediments were sampled on Wednesday, March 16, 2011, and the sediment sampling sites are shown above in Figure 6. Originally, a full set of transects were planned to be sampled at the weir site. This was planned in order to obtain a grid to determine tin distribution within the pond in the weir site. However, the sediment was too wet and soft to do a full set of transects as planned. Sediments were collected using core liners driven into sediment at accessible locations. During sampling, there was no control for compression of samples (due to vacuum during collecting sediments in core liners at each location), so depths are only approximate and the top 1.5 inches may represent a thicker layer. Thus, this is only a scoping sampling. In each core, two or three intervals were collected: 0 to 1.5 inches, 1.5 to 3 inches, and sometimes 3 to 4.5 inches deep. A total of 31 samples were prepared to be analyzed.

The following graph shows the concentrations of tin in the sediments at different locations in the pond at the weir site (site 8), organized from upstream to downstream.

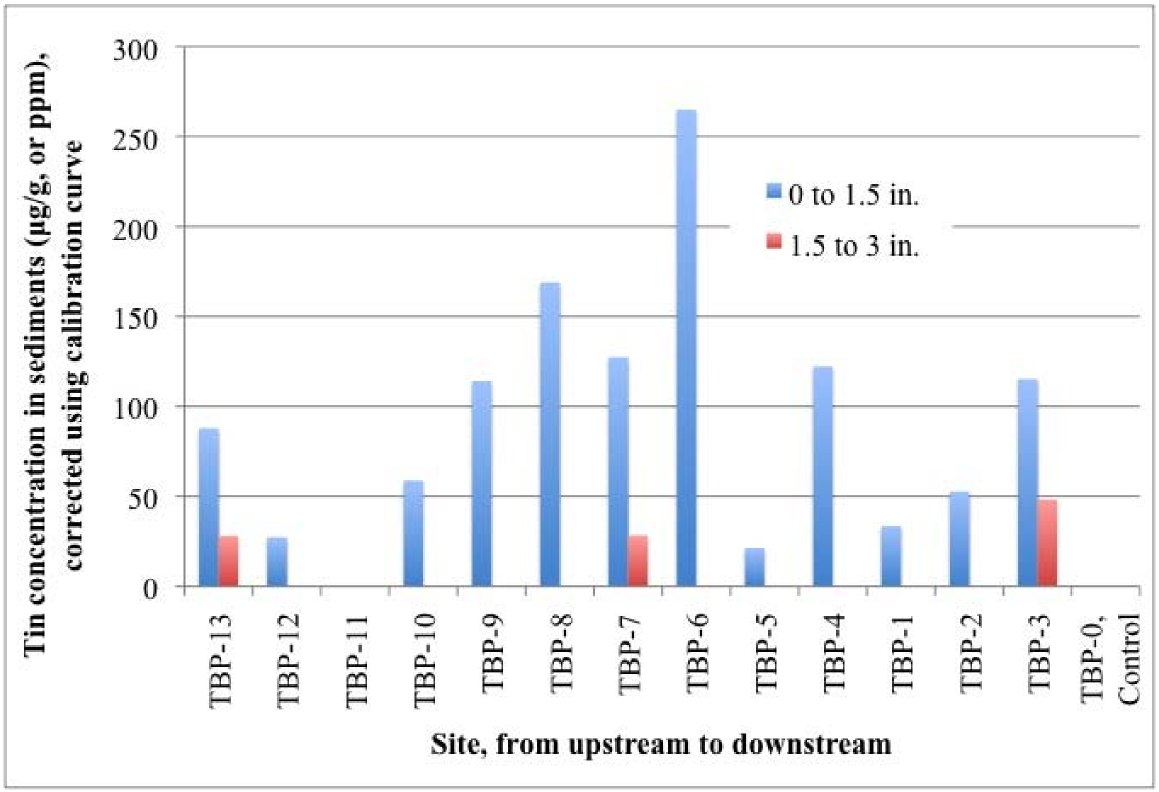

Figure 7. Concentrations of tin in the sediments at different locations within the pond at the weir site (site 8), organized from locations upstream to downstream within the weir site.

The concentration of tin in the sediments at the pond in the weir site appears to be highest at a location just south of the vertical pipe, in a section that had exposed sediments when sediment samples were taken on Wednesday, March 16, 2011. Comparing the concentrations of tin in the sediments in the pond at the weir site (Figure 7) to the concentrations of tin in the sediments at other sites (Figure 3), the weir site has significant tin accumulation in the sediments. Though the highest concentration of tin measured in the sediments along Tims Branch (including the tributary that originates at the A014 Outfall) is right by the A014 Outfall, there does not appear to be tin accumulation in the sediments at this site because this concentration is high only for the first 0.5 inches, and the tin concentration at this site drops significantly, by almost an order of magnitude, in the next 0.5 inches. In addition, the site right by the A014 Outfall has a small surface area, and thus is not a significant site for sediment accumulation. The two sites along Tims Branch (including the A014 tributary) with significant accumulation of tin in the sediments are the weir site (site 8) and Beaver Pond 2 (site 20).

Approximate Calculation of Mass Balance of Tin in Sediments

A rough approximation of the theoretical mass balance of tin in Tims Branch can be made through some simple calculations. A sample of the calculations for the mass balance are presented in Appendix D for one set of assumptions, including a length of Tims Branch of 26,000 feet, an average stream width of 6 feet, and a sediment depth with tin accumulation of 3.5 inches deep. The following steps outline the basic calculations performed to estimate the theoretical mass balance of tin in Tims Branch:

1. Calculate the total estimated amount of tin released in Tims Branch starting in November 2007 up to August 2011.
2. Calculate the average theoretical concentration of tin in the sediments in Tims Branch from the A014 Outfall downstream to the confluence of Tims Branch with Upper Three Runs Creek, based on the total estimated amount of tin released in Tims Branch from November 2007 to August 2011.

The estimated total tin released in Tims Branch from November 2007 to August 2011 is approximately 43 kg. This number is calculated based on the assumptions that the flow rate of groundwater into the system is constant at 450 gallons per minute during the time period, and that the tin concentration in the groundwater is 12.88 micrograms per liter (μg/L).

The average theoretical concentration of tin in the sediments in Tims Branch is calculated based on numerous assumptions, which are listed below:

1. The length of Tims Branch from the A014 Outfall to the confluence of Tims Branch with Upper Three Runs Creek is approximately 26,000 feet.
2. The average width of Tims Branch, from the A014 Outfall to the confluence of Tims Branch with Upper Three Runs Creek, is between 6 and 10 feet.
3. The depth of sediments in which tin has accumulated in significant amounts, due to the tin chloride treatment system, is between 1.5 and 3.5 inches.

A range of estimates for the average theoretical concentration of tin in the sediments in Tims Branch was calculated for the different estimated values of stream width and sediment depth in which tin accumulates in significant concentration. The table below shows the range of estimates of the average theoretical concentration of tin in the sediments in Tims Branch based on the assumptions listed above.

Table 2. Estimated Theoretical Average Concentration of Tin in Sediments in Tims Branch from November 2007 to August 2011 and from the A014 Outfall Downstream to the Confluence of Tims Branch to Upper Three Runs Creek

Estimate of sediment depth (interval, from sediment surface to depth, where tin is significantly present) (inches)	Estimate of average width of stream (from A014 Outfall downstream to confluence of Tims Branch with Upper Three Runs Creek) (feet)	Estimated average tin concentration (μg/g, or ppm)
1.5	6	46
2.5	6	28
3.5	6	20
1.5	7	40

Estimate of sediment depth (interval, from sediment surface to depth, where tin is significantly present) (inches)	Estimate of average width of stream (from A014 Outfall downstream to confluence of Tims Branch with Upper Three Runs Creek) (feet)	Estimated average tin concentration (µg/g, or ppm)
2.5	7	24
3.5	7	17
1.5	8	35
2.5	8	21
3.5	8	15
1.5	9	31
2.5	9	18
3.5	9	13
1.5	10	28
2.5	10	17
3.5	10	12

Although the width of the stream varies significantly from the A014 Outfall downstream to the confluence of Tims Branch with Upper Three Runs Creek, the best estimate of the average width of the stream, based on field observations, is approximately 6 feet. In addition, based on the results of the sediment samples (Figure 3 and Figure 7), tin is present in significant concentrations in the sediments from the sediment surface (0 inches) to approximately 2.5 inches deep. Therefore, based on field observations and results of the present study, the best estimate of the theoretical average tin concentration in the sediments in Tims Branch (from the A014 Outfall downstream to the confluence of Tims Branch with Upper Three Runs Creek) is approximately 28 µg/g.

From the experimental data in the present research, the estimated average tin concentration in the sediments in Tims Branch was calculated for the top 2.5 inches of sediment depth and from the A014 Outfall downstream to the confluence of Tims Branch with Upper Three Runs Creek. This average was calculated by using all of the measurements for all of the sites for the depth intervals of 0 to 0.5 inches, 0.5 to 1 inch, 1 to 1.5 inches, and 1.5 to 2.5 inches. This estimated average concentration is approximately 31 µg/g, which is relatively comparable to the theoretical approximation of the average tin concentration in the sediments, which is 28 µg/g.

In addition, because extra data was taken at the weir site, an average tin concentration in the sediments at the weir site was calculated. The percent of the total tin released in Tims Branch from the tin chloride treatment process, from November 2011 to March 2011, that has deposited at the weir site has been estimated. Based on the data on tin in the sediments in the pond at the weir site (Figure 7), the estimated average concentration of tin in the top 1.5 inches of sediments is approximately 85 µg/g. This calculation is based on the assumption that tin accumulates significantly in the top 1.5 inches of sediments in the pond at the weir site, and tin is not significantly present at a depth of 3 inches or lower. The following satellite image shows a close-up of the weir site, and a larger scale view of where the weir site is located along Tims Branch is in Appendix B (Figure 13).

<u>Mass balance calculation:</u>

(85 ug Sn / g dry sediment * (1.5*2.54) cm * (200*10000) sq cm * 1.7 g / cu cm) / 1000000000 ug / Kg = approx 1.1 Kg Sn
avg concentration * depth * surface area * density / convert to Kg = mass of tin in sediment

Total tin released between Nov 2007 and March 2011 = approx 38 Kg based on measured concentrations and reagent used.

Therefore, about 2.9% of the total tin released from the tin chloride treatment process into Tims Branch is deposited in the pond at the weir site.

Figure 8. Satellite image of weir site (site 8) with mass balance calculations for tin in the sediments in the pond at the weir site.

The mass balance calculation for the pond at the weir site estimates a total deposition of approximately 1 kg of tin at the pond, from November 2007 to March 2011. This accounts for approximately 2.9% of the total tin released into Tims Branch from the tin chloride treatment process from November 2007 to March 2011. This calculation is based on the estimate that the pond has a surface area of approximately 200 square meters (m^2). In addition, based on the results of the March 2011 samples of sediments from the weir site, most of the tin in the sediments at this site is estimated to be in the top 1.5 inches (in.). Furthermore, as with the mass balance of tin for the stretch of Tims Branch from the A014 Outfall to the confluence of Tims Branch with Upper Three Runs Creek, the density of the sediments are estimated to be approximately 1.7 grams per cubic centimeter (g/cm^3).

The weir site therefore appears to be a site of significant tin accumulation. Despite being a significant site for tin accumulation in the sediments, it seems that most of the tin in Tims Branch is past the weir site because only approximately 2.9% of the total tin released from the tin chloride treatment system from November 2007 to March 2011 is calculated to be at the weir site, and based on the sites sampled in the present research, it is not expected that any significant sediment accumulation sites exist upstream of the weir site. In addition, based on the estimated average tin concentration in the sediments along Tims Branch from the A014 Outfall to the confluence of Tims Branch with Upper Three Runs Creek, which is approximately 31 µg/g, Beaver Pond 2 has concentrations of tin in the upper layers of sediment (Figure 3) that are relatively higher than the estimated average tin concentration in the sediments along Tims Branch.

Relatively high concentrations of tin were detected in the upper 1.5 inches of sediments from site 3, which is approximately 400 feet downstream of the A014 Outfall, though the stream at this site is relatively narrow and does not appear to be a significant place for sediment or tin accumulation. The highest concentration of tin was observed in the upper 0.5 inches of sediments from site 2, and this site is by the A014 Outfall. However, this site does not appear to be a site for significant tin accumulation in the sediments because tin concentration was high only in the upper 0.5 inches of sediment and the surface area of this site is relatively small. The weir site and Beaver Pond 2 appear to be the significant sites of tin accumulation in the sediments in Tims Branch from the A014 Outfall downstream to the confluence of Tims Branch with Upper Three Runs Creek.

Tin Concentration in Biofilm Samples

In addition to analyzing the concentration of tin in sediments, biofilm samples were collected at some sites along the A014 tributary and one biofilm sample was collected from the main stream of Tims Branch. The following figure presents the data for biofilm from the sites where biofilm samples were collected.

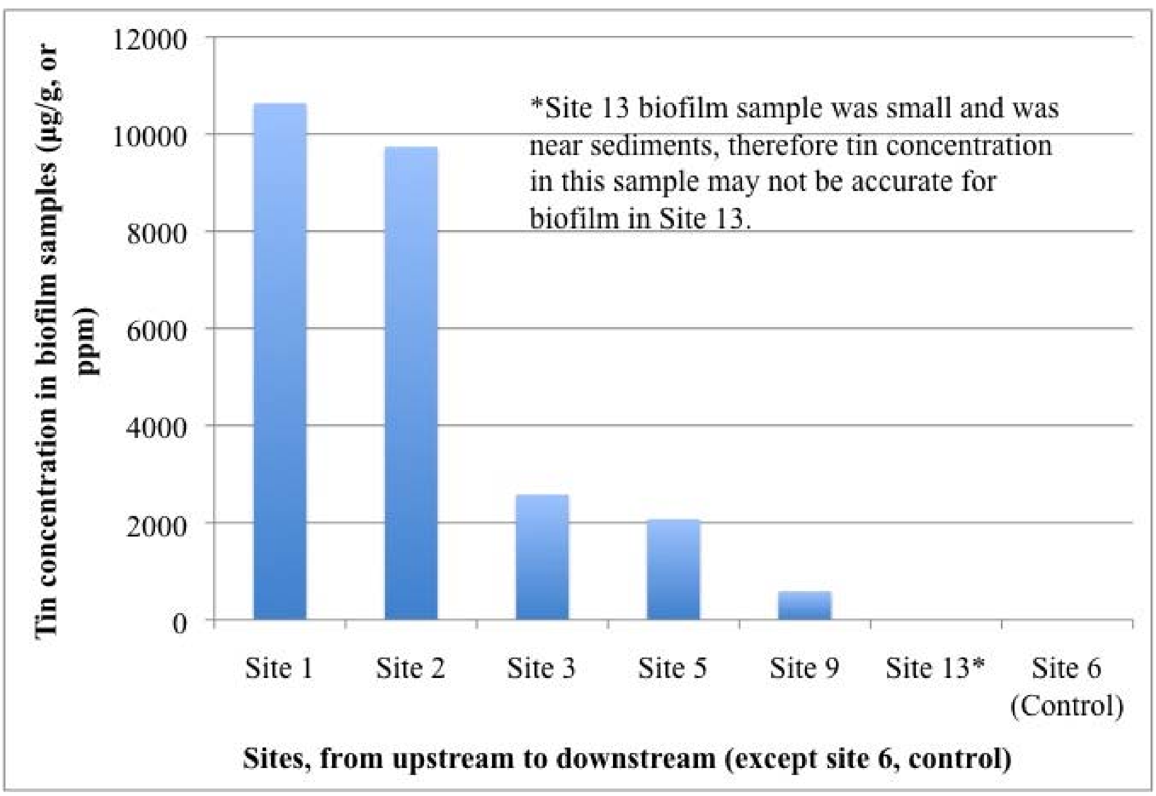

Figure 9. Tin concentration in biofilm along Tims Branch.

As can be seen from the biofilm data in Figure 9, it appears that tin concentration is significantly higher in biofilm samples (Figure 9) than in sediment samples (Figure 3) at each site. It is likely that biofilm grows better in locations along Tims Branch where the flow of water is slower, such as a pocket along the stream, or along the edge of the stream, or even in a section of the stream with debris. In these sections and locations along the stream, because of the decreased flow of water, tin may accumulate more in the sediments and in biofilm. At sites along the stream where plants and roots are present, biofilm can grow on or attach to the roots. In addition, suspended sediment particles, which may include tin particles, can attach to the roots and biofilm. Over time, these suspended sediments may accumulate in the biofilm and therefore have a relatively high concentration of tin. It is also possible that some of the microorganisms in the biofilm samples may be taking in tin from the water and/or sediments attached to the biofilm. The biofilm scoping experiment warrants further research to explain these high concentrations of tin in the biofilm samples collected in this study. As discussed above, the biofilm samples were not collected through traditional means, and the results of the biofilm tests are meant only to be interpreted as a scoping study that deserve further research.

5. CONCLUSION

Tin concentration in sediments along the tributary of Tims Branch that originates at the A014 Outfall is elevated at various sites along this tributary. In particular, tin appears to be accumulating at two sites, one of which is on the main stream of Tims Branch, downstream of the confluence between the A014 tributary and the main stream of Tims Branch. The first site where tin appears to be accumulating is at the weir site (site 8), which is along the A014 tributary. The weir site is located approximately 1900 feet downstream of the A014 Outfall. Downstream of the confluence of the A014 tributary with the main stream of Tims Branch, tin concentration was elevated as well in the sediments in Beaver Pond 2 (site 20), which is located approximately 6700 feet downstream of the A014 Outfall. In the sites sampled downstream of Beaver Pond 2, no tin was detected until the last sampled site, site 14, which is a point on Tims Branch just upstream of the confluence of Tims Branch with Upper Three Runs Creek. However, the tin detected at this site (site 14) was only detected at a sediment depth between 1.5 to 2.5 inches, which may indicate that the tin is from historical effluent released into Tims Branch and not from the tin chloride treatment process.

Therefore, further studies of the effects of the tin chloride treatment process on the flora and fauna in Tims Branch should focus on the weir site (site 8) and Beaver Pond 2 (site 20). These two sites appear to have the most tin accumulation from the sites sampled in the present research. The highest tin concentration in the sediments was located just near the A014 Outfall, at site 2, but this high concentration was only detected near the surface of the sediments, between 0 to 0.5 inches, and the tin concentration dropped significantly at a depth between 0.5 to 1 inch. In addition, the surface area of this site is small. Therefore, the sediments near the A014 Outfall do not appear to be significantly accumulating tin.

The results of the biofilm analysis showed significant accumulation of tin in biofilm along different sites in the tributary of Tims Branch that originates at the A014 Outfall. The measured tin concentrations in the biofilm samples for the various sites sampled were each more than an order of magnitude greater than the tin concentration in the sediments at each respective site. However, the biofilm study in the present research should only be interpreted as a scoping study because biofilm samples were not collected by conventional means. Further studies on biofilm in Tims Branch are necessary and will most likely provide interesting insight into distribution and fate of tin in Tims Branch.

The results of the present research may be useful for the potential future use of tin chloride treatment for other sites that are contaminated with mercury, such as the East Fork Poplar Creek (EFPC) in Oak Ridge, Tennessee. Further research on the distribution and fate of tin in Tims Branch and the effects of tin on the flora and fauna in Tims Branch will help to evaluate the success of the tin chloride treatment process. The results of water and fish samples from Tims Branch will be presented in a separate report.

6. REFERENCES

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APPENDIX A: Tin Calibration Curve

Preparation of Tin Standards and Tin Calibration Curve

Uncontaminated sediments from the control site, which is the tributary of Tims Branch that originates from the new A011 Outfall (Site 6), were collected and disaggregated to be used to prepare tin standards. A tin standard solution was prepared by mixing a measured mass of tin chloride dihydrate with water. The final tin concentration of this tin standard solution was 1.346 grams of tin per liter of solution (g/L, tin basis). To create a tin calibration curve for the X-ray fluorescence (XRF) spectrophotometer, individual samples of control site sediment were spiked with different volumes of the tin standard solution to create different sediment concentrations of tin. These different volumes are shown in the following table, with the resulting concentrations.

Table 3. Tin Concentrations in Reference Standard Sediment Samples

Soil concentration (added)	Units	Tin added	Units	Stock added	Units	Exact sediment mass	Units
--	**ug/g**	0	ug	0	mL	N/A	g
28.6	**ug/g**	336	ug	0.25	mL	11.77	g
60.5	**ug/g**	673	ug	0.50	mL	11.12	g
87.5	**ug/g**	1010	ug	0.75	mL	11.53	g
113	**ug/g**	1350	ug	1.00	mL	11.87	g
175	**ug/g**	2020	ug	1.50	mL	11.55	g
234	**ug/g**	2690	ug	2.00	mL	11.50	g

The tin standards were then analyzed using the X-ray fluorescence (XRF) spectrophotometer and the results are plotted in the following graph.

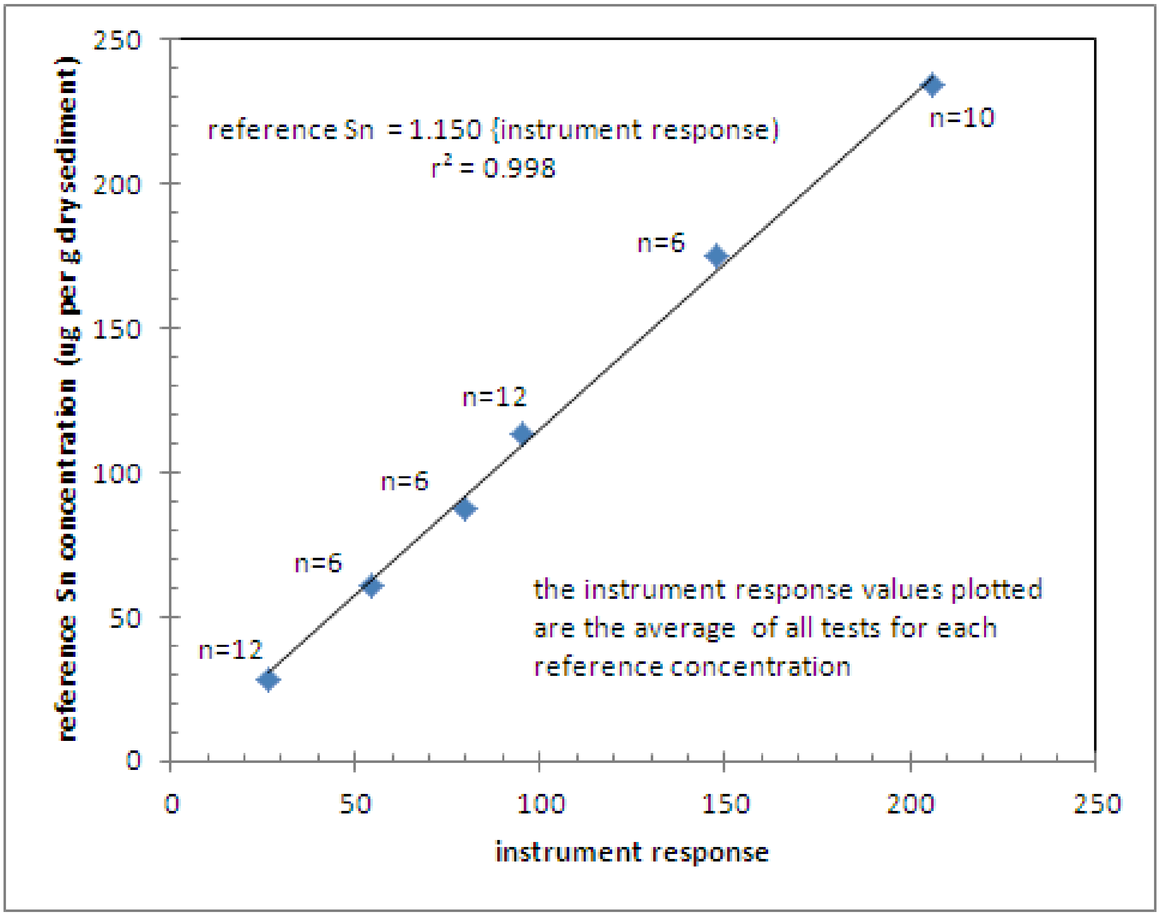

Figure 10. Calibration curve for tin analyzed with the Thermo Scientific Niton XL3t GOLDD+ X-Ray Fluorescence (XRF) Spectrophotometer. Each n value represents the number of runs that each reference sample was analyzed.

The calibration curve for tin is a plot of the concentration of tin measured volumetrically versus the concentration of tin measured using the X-ray fluorescence (XRF) spectrophotometer in each of the reference standard sediment samples for tin (Figure 10). The concentrations are measured in micrograms of tin per gram of sediment (µg of Sn/g of sediment, or simply µg/g), and these units are equivalent to parts per million (ppm). From the calibration curve for tin, it can be seen that the slope of the graph of tin concentration measured volumetrically versus tin concentration measured using the XRF spectrophotometer is approximately 1.150 and the y-intercept is close to zero. Therefore, as shown on the graph, the reference concentration of tin is approximated as the product of the correction factor, which is 1.150, and the concentration of tin measured using the XRF spectrophotometer.

Relative Standard Deviation (RSD) Discussion

The relative standard deviation (RSD) is a method of approximating the standard deviations of multiple samples over a range of concentrations. For this study, the RSD for tin was estimated in two ways: 1) based on multiple runs (n=6 to 12) of the reference standards, and 2) based on the differences observed in duplicate measurements for all of the Tims Branch samples and standards. The RSD for all other elements was estimated based on the differences observed in duplicate measurements for all of the Tims Branch samples (no standards were run for these elements and the concentrations reported are based on the factory calibration). The various estimates of RSD are summarized below.

The first method used to calculate the RSD for tin was by using the reference standards. Based on the standard curve (Figure 10), the instrument responses for all of the runs of the reference standards were each multiplied by 1.150 to generate a table of estimated concentrations. The standard deviation (sigma, or σ) was calculated and a bias correction was made for each concentration to achieve a more accurate estimate of population standard deviation at each concentration. The RSD is defined as the following linear equation: $\sigma_{concentration}$ = (RSD)(concentration). Therefore, the slope of the graph of concentration versus the standard deviation is the relative standard deviation (RSD). This analysis is shown in the following figure, which is a plot of the estimated tin concentration in each reference standard sediment sample versus standard deviation for each reference standard concentration. The relative standard deviation for tin in the following figure is based on the 26 sets of reference standard runs (52 total measurements, because each sample was run in duplicate).

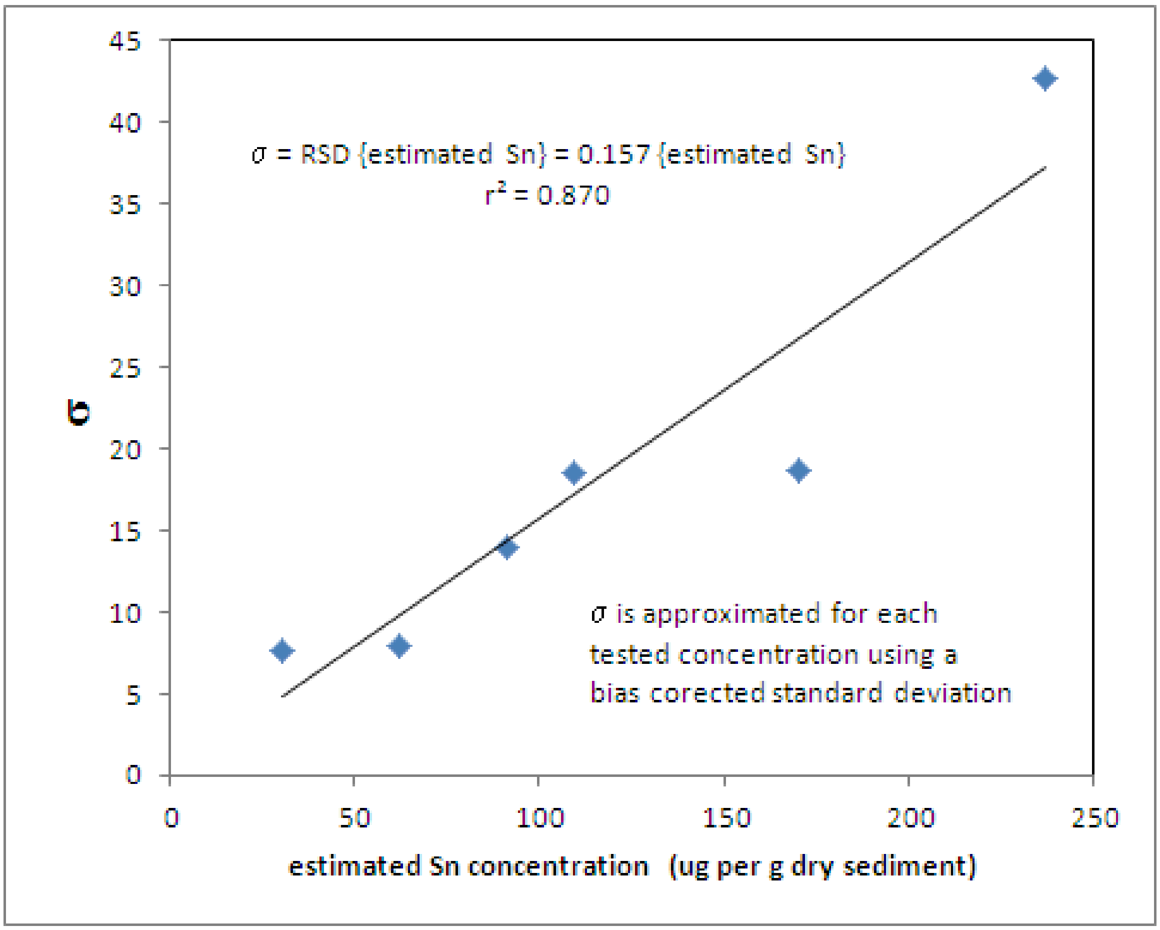

Figure 11. Plot of the estimated tin concentration versus the standard deviation for each reference standard sediment sample.

The plot of the estimated tin concentration versus the standard deviation for each reference standard sediment sample (Figure 11) shows that the relative standard deviation is approximately 0.16.

In addition, RSD values were calculated for the all 31 reported elements in Appendix C. These RSD values were calculated using the duplicate runs for each of the sediment samples analyzed using the XRF spectrophotometer, (see Thompson and Howarth 1973). A maximum of 221 samples (442 XRF analyses) were available to calculate RSD; the actual number of duplicates used for each element varied, however, and included only those duplicates in which both analyses were above the detection limit of the particular element. The resulting RSD values and the number of duplicates used to calculate the RSD are shown in the following table.

Table 4. Relative Standard Deviation (RSD) Values for the 31 Reported Elements and the Number of Duplicates used in Calculating the RSD

Element	RSD	n	Element	RSD	n
Sn	0.18	93	Mn	0.12	71
U	0.19	128	Ba	0.14	61
Ni	0.10	20	Cd	0.20	30
Mo	0.21	95	Pd	0.16	22
Zr	0.24	214	Nb	0.22	177
Sr	0.17	189	Bi	0.22	39
Rb	0.14	162	Cr	0.20	103
Th	0.22	177	V	0.18	197
Pb	0.14	62	Ti	0.17	214
As	0.20	68	Ca	0.22	101
Zn	0.14	151	K	0.16	212
W	0.13	3	Al	0.07	208
Cu	0.13	72	P	0.15	100
Co	0.06	4	Si	0.04	221
Fe	0.14	214	Cl	0.16	220
			S	0.22	89

The RSD values for all the elements range from about 4% to 24% (0.04 to 0.24) with most values between 10% and 20% (0.01 to 0.02). This is typical performance for a XRF Spectrophotometer.

As shown above, the RSD for tin was calculated two different ways: a) using only the reference standard sediment samples (26 sample sets, 52 measurements), and b) using all sample that had detectable tin in both duplicate runs (93 sample sets, 186 measurements). For tin, the universal duplicates included the prepared tin standards, standard reference materials from the United States National Institute of Standards and Technology (NIST), specifically NIST reference standard 2702 marine sediments, and many of the unknown sediment samples collected along Tims Branch. The RSD for tin based on the universal duplicates was 0.18, which is similar to the 0.16 estimated using the analyses of the reference standards.

APPENDIX B: Tims Branch Sites

The following satellite images, which were taken from Google Maps (2011), show the outline of Tims Branch and some tributaries. The following satellite image begins upstream of the Wetland Treatment System and up to a point downstream of Beaver Pond 1, which is a former farm pond. Sediment sampling sites are marked in all the satellite images.

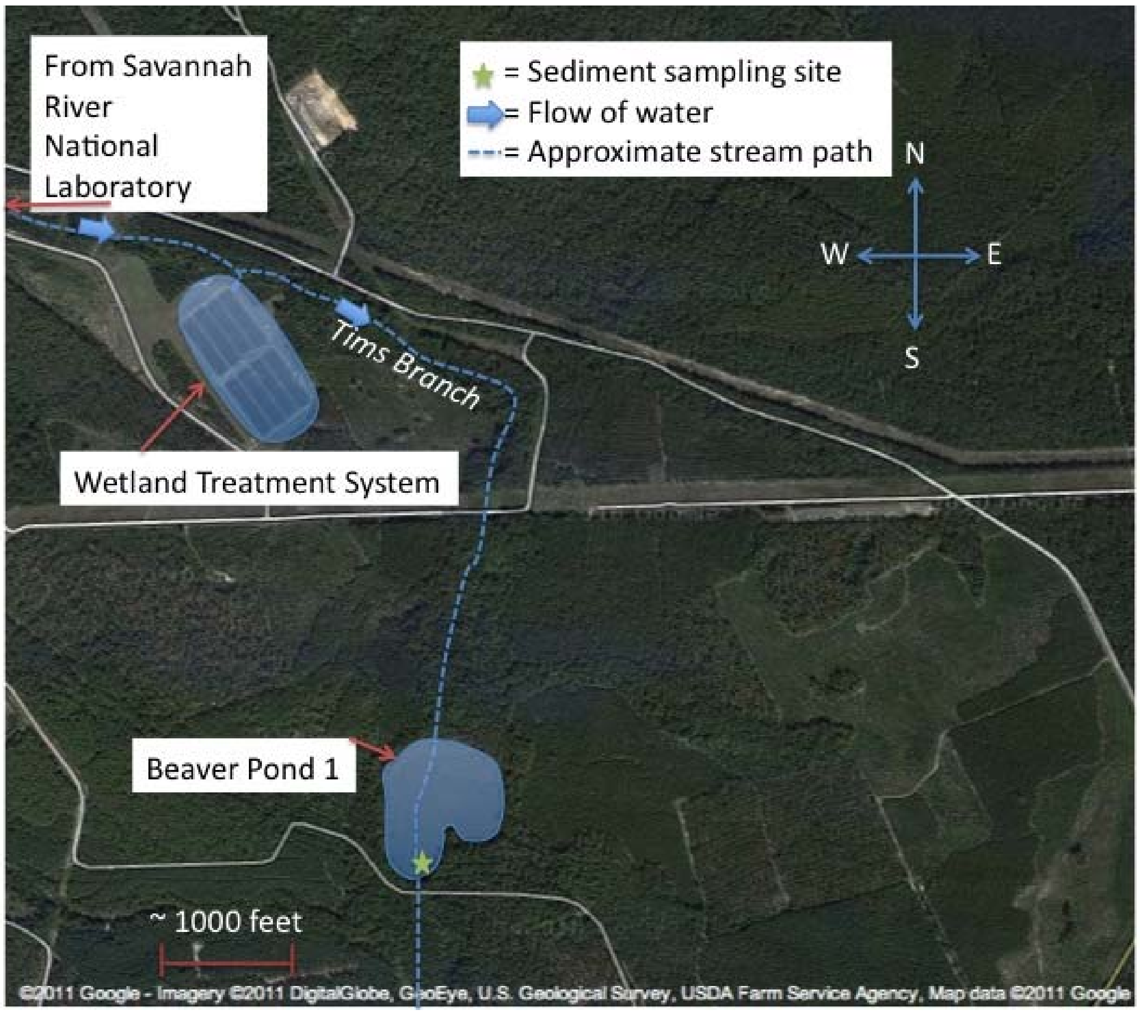

Figure 12. Tims Branch, from just upstream of the wetland treatment system to just downstream of Beaver Pond 1.

The following satellite image begins at the A014 Outfall, then to the confluence of the A014 tributary with the tributary that originates at the A011 Outfall, then continuing through to the confluence of the tributary that originates at the A014 Outfall and the main stream of Tims Branch, up to a Savannah River Ecology Laboratory (SREL) sampling station, which is just downstream of Steed Pond. No sediment samples were taken from Steed Pond because it is a radiological posted area.

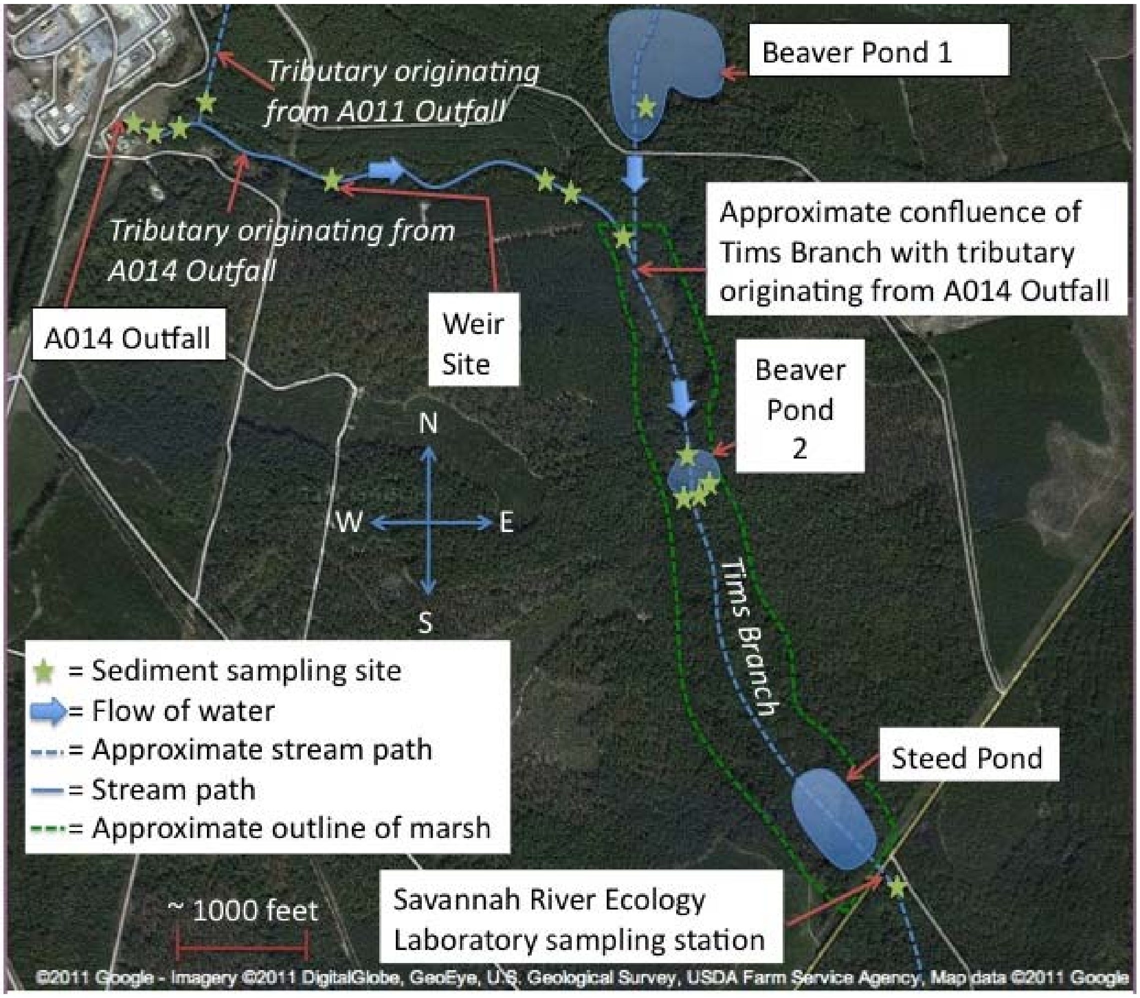

Figure 13. Tims Branch, from the tributary that originates from the A014 Outfall, then the confluence with the A011 tributary, then the confluence of the A014 tributary and the main stream of Tims Branch, downstream to a Savannah River Ecology Laboratory sampling station that is just downstream of Steed Pond.

The following satellite image shows Tims Branch from a Savannah River Ecology Laboratory (SREL) sampling station just downstream of Steed Pond, down through Beaver Pond 3 and Beaver Pond 4.

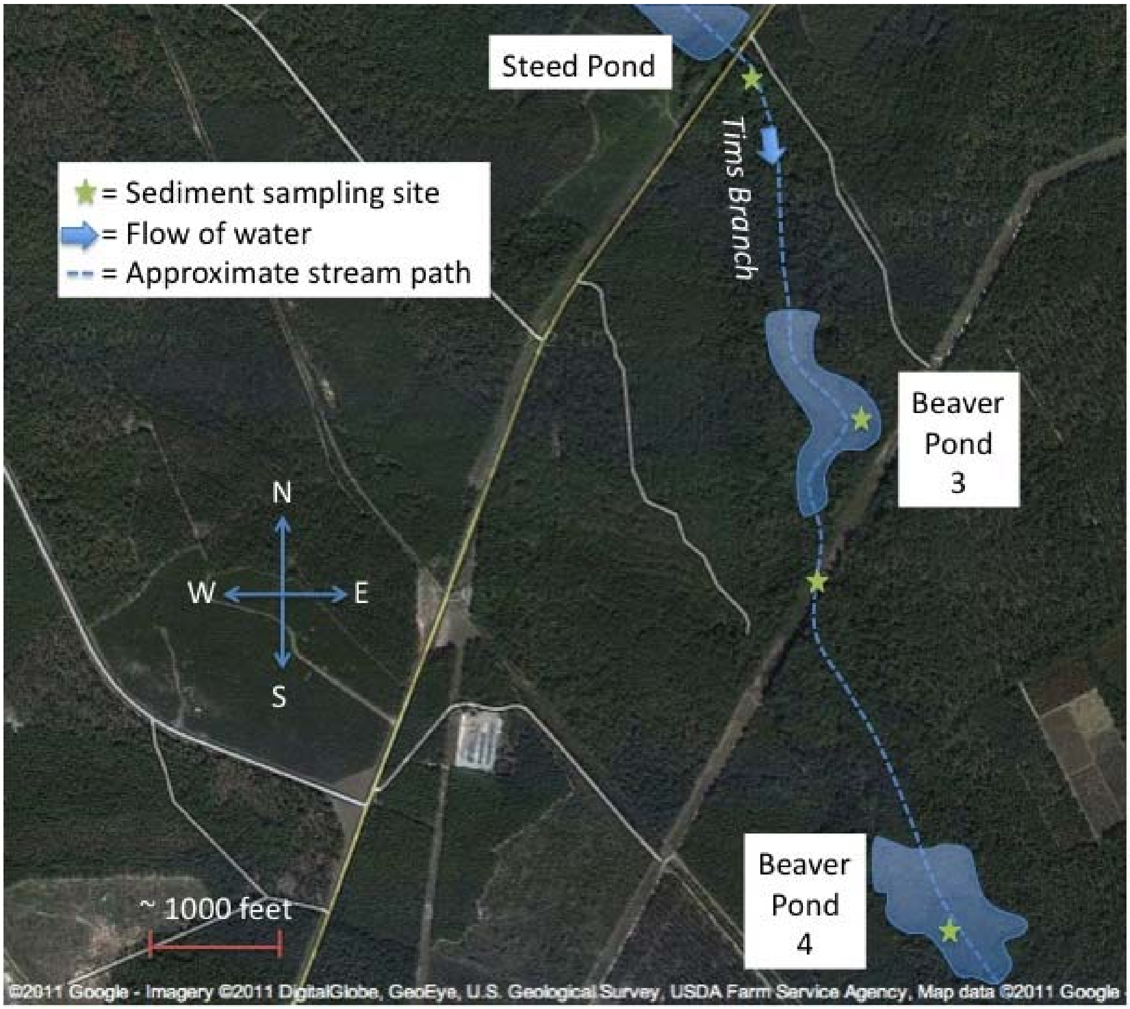

Figure 14. Tims Branch, from a Savannah River Ecology Laboratory (SREL) sampling station downstream of Steed Pond, down through Beaver Pond 3 and to Beaver Pond 4.

The following satellite image shows Tims Branch from just upstream of Beaver Pond 4 to the confluence of Tims Branch with Upper Three Runs Creek.

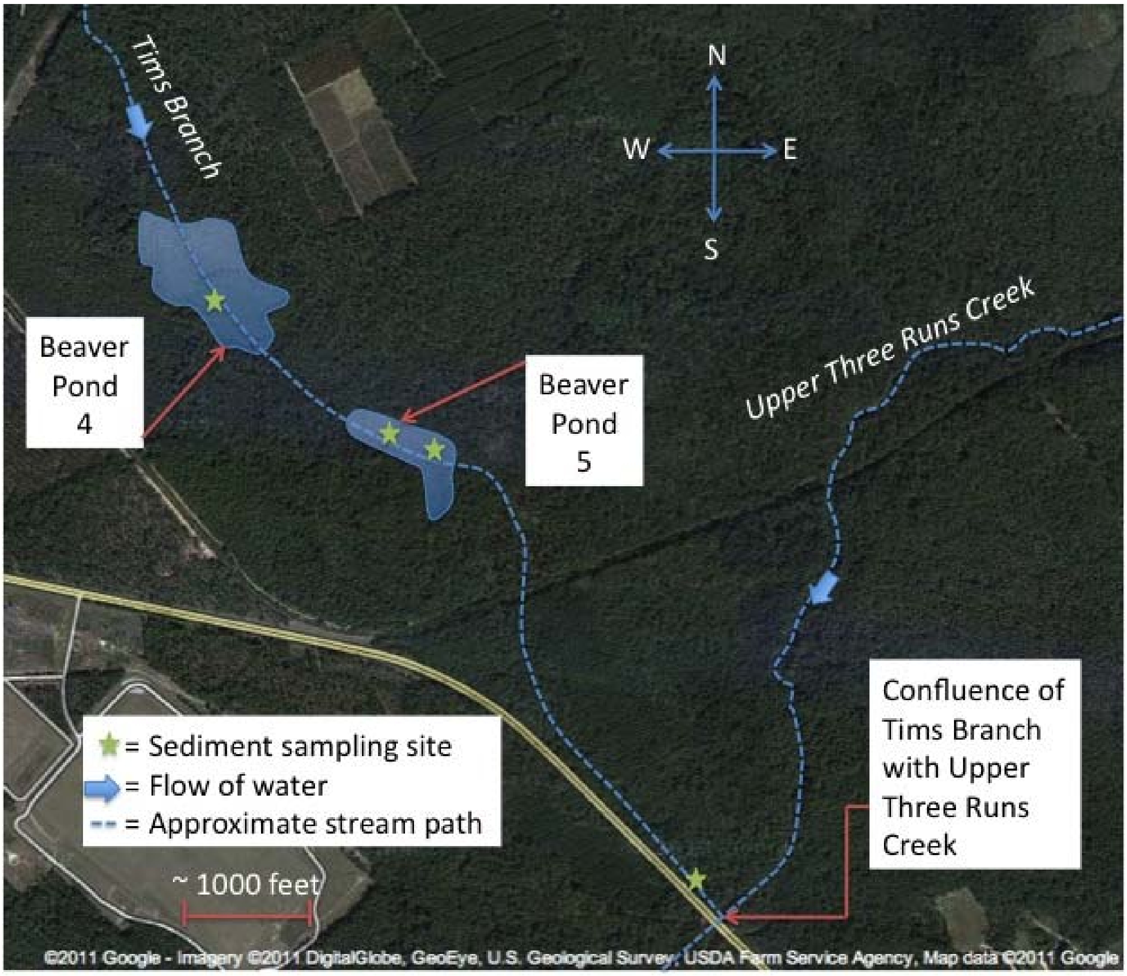

Figure 15. Tims Branch, from Beaver Pond 4 down to the confluence between Tims Branch and Upper Three Runs Creek.

In total, 19 sediment samples were taken along Tims Branch, starting at a point just downstream of the A014 Outfall, then along the tributary that originates at the A014 Outfall, then a control sample at the tributary that originates at the A011 Outfall, then another control sample at Beaver Pond 1, which is a former farm pond, that is on the main stream of Tims Branch and that is upstream of the confluence of the A014 tributary and the main stream of Tims Branch, then along Tims Branch up to a point just upstream of the confluence of the main stream of Tims Branch and Upper Three Runs Creek.

APPENDIX C: Concentrations of Elements in Standards, Sediments, and Biofilm, from X-Ray Fluorescence (XRF) Spectrophotometer Analysis

Std / Core / Sample ID	Avg Depth	Sn		U		Ni		Mo		Zr		Sr	
		µg/g	± SEM	µg/g	± SEM	µg/g	± SEM	µg/g	± SEM	µg/g	± SEM	µg/g	± SEM
Blank (SiO2)	n/a	< 12		< 3		< 25		< 2		< 25		< 3	
Blank (SiO2)	n/a	< 12		< 3		< 25		< 2		< 25		< 3	
Blank (SiO2)	n/a	< 12		< 3		< 25		< 2		< 25		< 3	
Blank (SiO2)	n/a	< 12		< 3		< 25		< 2		< 25		< 3	
Blank (SiO2)	n/a	< 12		< 3		< 25		< 2		< 25		< 3	
Blank (SiO2)	n/a	< 12		< 3		< 25		< 2		< 25		< 3	
Blank (SiO2)	n/a	< 12		< 3		< 25		< 2		< 25		< 3	
Blank (SiO2)	n/a	< 12		< 3		< 25		< 2		< 25		< 3	
NIST 2702 Standard	n/a	28	5	16	3	< 25		9	2	269	66	87	15
NIST 2702 Standard	n/a	31	6	13	2	< 25		9	2	290	71	93	16
NIST 2702 Standard	n/a	27	5	17	3	< 25		10	2	295	72	91	16
NIST 2702 Standard	n/a	30	6	13	2	< 25		9	2	296	72	90	16
NIST 2702 Standard	n/a	32	6	13	3	< 25		8	2	277	67	88	15
NIST 2702 Standard	n/a	40	7	13	2	< 25		10	2	299	73	90	16
NIST 2702 Standard	n/a	29	5	15	3	< 25		8	2	287	70	90	16
NIST 2709a STANDARD	n/a	< 12		6	1	< 25		2	0	130	32	183	32
NIST 2709a STANDARD	n/a	< 12		6	1	< 25		3	1	128	31	182	32
NIST 2709a STANDARD	n/a	< 12		6	1	< 25		< 2		128	31	181	32
NIST 2709a STANDARD	n/a	< 12		8	1	< 25		2	1	124	30	182	32
NIST 2709a STANDARD	n/a	< 12		< 3		< 25		3	1	120	29	183	32
NIST 2709a STANDARD	n/a	< 12		< 3		< 25		3	1	130	32	182	32
NIST 2709a STANDARD	n/a	< 12		8	1	< 25		2	1	110	27	182	32
Control Composite (no added tin)	n/a	< 12		< 3		< 25		< 2		61	15	9	2
Tin Std 28.587 ppm	n/a	31	6	< 3		< 25		< 2		84	20	10	2
Tin Std 28.587 ppm	n/a	31	6	< 3		< 25		< 2		71	17	8	1
Tin Std 28.587 ppm	n/a	31	6	< 3		< 25		< 2		94	23	7	1
Tin Std 28.587 ppm	n/a	33	6	< 3		< 25		< 2		95	23	9	2
Tin Std 28.587 ppm	n/a	22	4	< 3		< 25		< 2		68	17	9	2
Tin Std 28.587 ppm	n/a	35	6	< 3		< 25		< 2		127	31	6	1
Tin Std 60.517 ppm	n/a	68	12	< 3		< 25		< 2		80	19	4	1
Tin Std 60.517 ppm	n/a	63	12	< 3		< 25		< 2		77	19	6	1
Tin Std 60.517 ppm	n/a	120	22	< 3		< 25		< 2		238	58	9	2
Tin Std 60.517 ppm	n/a	84	16	< 3		< 25		< 2		93	23	7	1
Tin Std 60.517 ppm	n/a	56	10	< 3		< 25		< 2		65	16	8	1
Tin Std 87.548 ppm	n/a	96	18	< 3		< 25		< 2		181	44	9	2
Tin Std 87.548 ppm	n/a	96	18	< 3		< 25		< 2		76	19	5	1
Tin Std 87.548 ppm	n/a	83	15	< 3		< 25		< 2		63	15	9	2
Tin Std 113.387 ppm	n/a	108	20	< 3		< 25		< 2		66	16	8	1
Tin Std 113.387 ppm	n/a	106	20	< 3		< 25		< 2		77	19	7	1
Tin Std 113.387 ppm	n/a	109	20	< 3		< 25		< 2		82	20	9	2
Tin Std 113.387 ppm	n/a	96	18	< 3		< 25		< 2		103	25	7	1
Tin Std 113.387 ppm	n/a	99	18	< 3		< 25		< 2		55	13	5	1
Tin Std 113.387 ppm	n/a	137	25	< 3		< 25		< 2		239	58	7	1
Tin Std 174.792 ppm	n/a	180	33	< 3		< 25		< 2		75	18	8	1
Tin Std 174.792 ppm	n/a	161	30	< 3		< 25		< 2		76	19	14	2
Tin Std 174.792 ppm	n/a	145	27	< 3		< 25		< 2		76	19	7	1
Tin Std 174.792 ppm	n/a	169	31	< 3		< 25		< 2		168	41	11	2

Std / Core / Sample ID	Avg Depth	Sn		U		Ni		Mo		Zr		Sr	
		µg/g	± SEM	µg/g	± SEM	µg/g	± SEM	µg/g	± SEM	µg/g	± SEM	µg/g	± SEM
Tin Std 234.069 ppm	n/a	228	42	< 3		< 25		< 2		82	20	9	2
Tin Std 234.069 ppm	n/a	274	51	< 3		< 25		< 2		73	18	9	2
Tin Std 234.069 ppm	n/a	201	37	< 3		< 25		< 2		67	16	16	3
Tin Std 234.069 ppm	n/a	236	44	< 3		< 25		< 2		82	20	8	1
Tin Std 234.069 ppm	n/a	247	46	< 3		< 25		< 2		114	28	7	1
Control 0-0.5 in.	0.25	< 12		< 3		< 25		< 2		42	10	6	1
Control 0.5-1 in.	0.75	< 12		< 3		< 25		< 2		162	39	8	1
Control 1-1.5 in.	1.25	< 12		< 3		< 25		< 2		194	47	7	1
Control 1.5-2.5 in.	2.00	< 12		< 3		< 25		< 2		80	20	12	2
Control 2.5-3.5 in.	3.00	< 12		< 3		< 25		< 2		200	49	14	2
Site 2, 0-0.5 in.	0.25	381	70	< 3		< 25		< 2		92	22	7	1
Site 2, 0.5-1 in.	0.75	49	9	< 3		< 25		< 2		93	23	6	1
Site 2, 1-1.5 in.	1.25	53	10	< 3		< 25		< 2		269	66	5	1
Site 2, 1.5-2.5 in.	2.00	21	4	< 3		< 25		< 2		39	10	10	2
Site 2, 2.5-3.5 in.	3.00	15	3	< 3		< 25		< 2		42	10	9	2
Site 2, 3.5-4.5 in.	4.00	< 12		< 3		< 25		< 2		183	45	3	1
Site 3, 0-0.5 in.	0.25	70	13	5	1	< 25		< 2		59	14	3	1
Site 3, 0.5-1 in.	0.75	77	14	7	1	< 25		< 2		64	16	5	1
Site 3, 1-1.5 in.	1.25	54	10	5	1	< 25		2	0	119	29	5	1
Site 5, 0-0.5 in.	0.25	107	20	15	3	< 25		24	5	3838	936	5	1
Site 5, 0.5-1 in.	0.75	51	9	9	2	< 25		33	7	3166	772	5	1
Site 5, 1-1.5 in.	1.25	18	3	4	1	< 25		16	3	561	137	6	1
Site 5, 1.5-2.5 in.	2.00	< 12		< 3		< 25		4	1	216	53	4	1
Site 5, 2.5-3.5 in.	3.00	< 12		4	1	< 25		3	1	200	49	6	1
Site 5, 3.5-4.5 in.	4.00	56	10	10	2	< 25		17	4	873	213	9	2
TBP-0, Control	n/a	< 12		4	1	< 25		< 2		122	30	7	1
TBP-1, 0-1.5 in.	0.75	34	6	10	2	< 25		4	1	388	94	35	6
TBP-1, 1.5-3 in.	2.25	< 12		< 3		< 25		< 2		43	11	6	1
TBP-1, 3-4.5 in.	3.75	< 12		11	2	< 25		< 2		309	75	40	7
TBP-2, 0-1.5 in.	0.75	53	10	16	3	< 25		9	2	519	126	45	8
TBP-2, 1.5-3 in.	2.25	< 12		16	3	< 25		4	1	496	121	47	8
TBP-2, 3-4.5 in.	3.75	< 12		16	3	< 25		3	1	399	97	56	10
TBP-3, 0-1.5 in.	0.75	115	21	15	3	< 25		4	1	533	130	52	9
TBP-3, 1.5-3 in.	2.25	48	9	13	2	< 25		3	1	359	87	36	6
TBP-4, 0-1.5 in.	0.75	122	23	18	3	< 25		4	1	596	145	45	8
TBP-4, 1.5-3 in.	2.25	< 12		13	2	< 25		5	1	459	112	32	6
TBP-4, 3-4.5 in.	3.75	< 12		10	2	< 25		< 2		360	88	21	4
TBP-5, 0-1.5 in.	0.75	21	4	< 3		< 25		< 2		133	32	8	1
TBP-5, 1.5-3 in.	2.25	< 12		< 3		< 25		< 2		80	20	10	2
TBP-6, 0-1.5 in.	0.75	265	49	13	2	< 25		< 2		450	110	39	7
TBP-6, 1.5-3 in.	2.25	< 12		< 3		< 25		< 2		87	21	5	1
TBP-6, 3-4.5 in.	3.75	< 12		< 3		< 25		< 2		106	26	7	1
TBP-7, 0-1.5 in.	0.75	127	24	8	1	< 25		< 2		517	126	21	4
TBP-7, 1.5-3 in.	2.25	28	5	4	1	< 25		< 2		177	43	11	2
TBP-8, 0-1.5 in.	0.75	169	31	10	2	< 25		< 2		547	133	28	5
TBP-8, 1.5-3 in.	2.25	< 12		< 3		< 25		< 2		89	22	4	1
TBP-9, 0-1.5 in.	0.75	114	21	9	2	< 25		< 2		636	155	24	4

Std / Core / Sample ID	Avg Depth	Sn µg/g	Sn ± SEM	U µg/g	U ± SEM	Ni µg/g	Ni ± SEM	Mo µg/g	Mo ± SEM	Zr µg/g	Zr ± SEM	Sr µg/g	Sr ± SEM
TBP-9, 1.5-3 in.	2.25	< 12		4	1	< 25		4	1	459	112	5	1
TBP-10, 0-1.5 in.	0.75	59	11	7	1	< 25		< 2		329	80	14	2
TBP-10, 1.5-3 in.	2.25	< 12		< 3		< 25		< 2		71	17	5	1
TBP-11, 0-1.5 in.	0.75	< 12		< 3		< 25		< 2		41	10	3	1
TBP-11, 1.5-3 in.	2.25	15	3	< 3		< 25		3	1	283	69	3	0
TBP-12, 0-1.5 in.	0.75	27	5	4	1	< 25		< 2		212	52	9	2
TBP-12, 1.5-3 in.	2.25	< 12		6	1	< 25		3	1	856	209	7	1
TBP-12, 1.5-3 in.	3.75	16	3	8	1	< 25		< 2		1469	358	8	1
TBP-13, 0-1.5 in.	0.75	88	16	17	3	< 25		3	1	405	99	26	5
TBP-13, 1.5-3 in.	2.25	28	5	4	1	< 25		< 2		128	31	13	2
Site 8, fine, 0-0.5 in.	0.25	222	41	17	3	< 25		< 2		476	116	46	8
Site 8, fine, 0.5-1 in.	0.75	195	36	18	3	< 25		4	1	478	117	48	8
Site 8, fine, 1-1.5 in.	1.25	178	33	17	3	< 25		4	1	479	117	45	8
Site 8, fine, 1.5-2.5 in.	2.00	139	26	16	3	< 25		4	1	512	125	45	8
Site 8, fine, 2.5-3.5 in.	3.00	16	3	15	3	< 25		4	1	539	131	38	7
Site 8, fine, 3.5-4.5 in.	4.00	< 12		12	2	< 25		3	1	380	93	28	5
Site 8, sandy, 0-0.5 in.	0.25	36	7	4	1	< 25		< 2		91	22	8	1
Site 8, sandy, 0.5-1 in.	0.75	< 12		< 3		< 25		< 2		104	25	6	1
Site 8, sandy, 1-1.5 in.	1.25	< 12		< 3		< 25		< 2		39	9	5	1
Site 8, sandy, 1.5-2.5 in.	2.00	71	13	5	1	< 25		< 2		182	44	15	3
Site 8, sandy, 2.5-3.5 in.	3.00	< 12		< 3		< 25		< 2		256	62	11	2
Site 8, sandy, 3.5-4.5 in.	4.00	< 12		< 3		< 25		< 2		436	106	4	1
Site 10, 0-1.5 in.	0.75	< 12		< 3		< 25		< 2		31	8	< 3	
Site 10, 1.5-3 in.	2.25	< 12		< 3		< 25		< 2		38	9	8	1
Site 10, 3-4.5 in.	3.75	< 12		< 3		< 25		< 2		22	5	2	0
Site 9, mid, 0-0.5 in.	0.25	< 12		19	4	< 25		3	1	76	18	5	1
Site 9, mid, 0.5-1 in.	0.75	< 12		316	59	230	23	30	6	351	86	26	4
Site 9, mid, 1-1.5 in.	1.25	< 12		458	85	273	27	42	9	387	94	38	7
Site 9, mid, 1.5-2.5 in.	2.00	< 12		336	63	209	20	32	7	350	85	42	7
Site 9, mid, 2.5-3.5 in.	3.00	< 12		393	73	239	23	34	7	374	91	49	9
Site 9, mid, 3.5-4.5 in.	4.00	< 12		236	44	125	12	22	5	364	89	40	7
Site 9, mid, 4.5-5.5 in.	5.00	< 12		185	34	77	8	17	4	298	73	33	6
Site 9, edge, 0-0.5 in.	0.25	19	3	6	1	< 25		5	1	366	89	9	2
Site 9, edge, 0.5-1 in.	0.75	20	4	5	1	< 25		12	3	945	230	7	1
Site 9, edge, 1-1.5 in.	1.25	< 12		4	1	< 25		7	2	1186	289	4	1
Site 9, edge, 1.5-2.5 in.	2.00	91	17	17	3	< 25		5	1	2654	647	4	1
Site 11, 0-0.5 in.	0.25	< 12		< 3		< 25		< 2		243	59	9	2
Site 11, 0.5-1 in.	0.75	< 12		< 3		< 25		< 2		224	55	13	2
Site 11, 1-1.5 in.	1.25	< 12		< 3		< 25		< 2		174	42	6	1
Site 11, 1.5-2.5 in.	2.00	< 12		< 3		< 25		< 2		126	31	2	0
Site 11, 2.5-3 in.	2.75	< 12		< 3		< 25		< 2		41	10	4	1
Site 12, fine, 0-0.5 in.	0.25	25	5	48	9	< 25		5	1	141	34	12	2
Site 12, 0.5-1 in.	0.75	< 12		47	9	< 25		4	1	115	28	13	2
Site 12, 1-1.5 in.	1.25	< 12		104	19	< 25		8	2	185	45	15	3
Site 12, 1.5-2.5 in.	2.00	< 12		59	11	< 25		4	1	70	17	8	1
Site 12, 2.5-3.5 in.	3.00	< 12		83	15	< 25		7	2	78	19	9	2
Site 12, sandy, 0-0.5 in.	0.25	< 12		< 3		< 25		< 2		60	15	2	0

Std / Core / Sample ID	Avg Depth		Sn			U			Ni			Mo			Zr			Sr	
			µg/g	± SEM		µg/g	± SEM		µg/g	± SEM		µg/g	± SEM		µg/g	± SEM		µg/g	± SEM
Site 12, sandy, 0.5-1 in.	0.75	<	12			4	1	<	25		<	2			174	42		2	0
Site 12, sandy, 1-1.5 in.	1.25	<	12			3	1	<	25		<	2			76	19		2	0
Site 12, sandy, 1.5-2.5 in.	2.00	<	12			11	2	<	25		<	2			39	10		3	0
Site 12, sandy, 2.5-3.5 in.	3.00	<	12			59	11	<	25			6	1		183	45		10	2
Site 12, sandy, 3.5-4 in.	4.00	<	12			47	9	<	25			4	1		62	15		5	1
Site 20 BP2D 0-0.5 in.	0.25		109	20		408	76	<	25			37	8		385	94		67	12
Site 20 BP2D 0.5-1 in.	0.75		109	20		415	77	<	25			39	8		389	95		69	12
Site 20 BP2D 1-1.5 in.	1.25		99	18		343	64	<	25			32	7		358	87		62	11
Site 20 BP2D 1.5-2.5 in.	2.00	<	12			32	6	<	25		<	2			70	17		12	2
Site 20 BP2D 2.5-3.5 in.	3.00	<	12			6	1	<	25		<	2			30	7		9	2
Site 20 BP2D 3.5-4.5 in.	4.00	<	12			5	1	<	25		<	2			50	12		5	1
Site 20 BP2C 0-0.5 in.	0.25		37	7		284	53	<	25			27	6		223	54		70	12
Site 20 BP2C 0.5-1 in.	0.75		46	9		303	56	<	25			30	6		224	55		69	12
Site 20 BP2C 1-1.5 in.	1.25		32	6		246	46	<	25			24	5		184	45		55	10
Site 20 BP2C 1.5-2.5 in.	2.00		27	5		238	44	<	25			26	5		200	49		55	10
Site 20 BP2C 2.5-3.5 in.	3.00		15	3		245	46		59	6		23	5		184	45		53	9
Site 20 BP2B 0-0.5 in.	0.25		34	6		498	93		217	21		46	10		267	65		76	13
Site 20 BP2B 0.5-1 in.	0.75		21	4		413	77		172	17		38	8		226	55		59	10
Site 20 BP2B 1-1.5 in.	1.25		16	3		387	72		185	18		34	7		196	48		53	9
Site 20 BP2B 1.5-2.5 in.	2.00		15	3		260	48		138	14		24	5		146	36		37	6
Site 20 BP2B 2.5-3.5 in.	3.00	<	12			59	11	<	25			6	1		50	12		14	2
Site 20 BP2B 3.5-4.5 in.	4.00	<	12			20	4	<	25		<	2			29	7		9	2
Site 20 BP2B 4.5-5.25 in.	5.00	<	12			20	4	<	25		<	2			29	7		7	1
Site 20 BP2A 0-0.5 in.	0.25		30	5		520	97		170	17		48	10		259	63		66	11
Site 20 BP2A 0.5-1 in.	0.75		32	6		538	100		185	18		48	10		269	66		69	12
Site 20 BP2A 1-1.5 in.	1.25		31	6		501	93		184	18		44	9		244	59		61	11
Site 20 BP2A 1.5-2.5 in.	2.00		33	6		530	99		198	19		50	11		260	63		63	11
Site 20 BP2A 2.5-3.5 in.	3.00		39	7		576	107		212	21		53	11		268	65		68	12
Site 20 BP2A 3.5-4.5 in.	4.00		28	5		591	110		206	20		55	12		270	66		61	11
Site 20 BP2A 4.5-5.5 in.	5.00		24	4		475	89		204	20		44	9		196	48		47	8
Site 20 BP2A 5.5-6.5 in.	6.00		18	3		506	94		266	26		44	9		185	45		42	7
Site 13, 0-0.5 in.	0.25	<	12			7	1	<	25		<	2			32	8	<	3	
Site 13, 0.5-1 in.	0.75	<	12			21	4	<	25		<	2			35	8		2	0
Site 13, 1-1.5 in.	1.25		20	4		14	3	<	25		<	2			138	34	<	3	
Site 13, 1.5-2.5 in.	2.00	<	12			8	2	<	25		<	2			30	7		2	0
Site 13, 2.5-2.75 in.	2.63	<	12			13	2	<	25			3	1		253	62		2	0
Site 15 (BP3), 0-0.5 in.	0.25	<	12			36	7	<	25			4	1		505	123		13	2
Site 15 (BP3), 0.5-1 in.	0.75	<	12			11	2	<	25		<	2			474	115		10	2
Site 15 (BP3), 1-1.5 in.	1.25	<	12		<	3		<	25		<	2			579	141		7	1
Site 15 (BP3), 1.5-2.5 in.	2.00	<	12		<	3		<	25		<	2			228	56		9	2
Site 15 (BP3), 2.5-3.5 in.	3.00	<	12		<	3		<	25		<	2			379	92		8	1
Site 15 (BP3), 3.5-4.5 in.	4.00	<	12			3	1	<	25		<	2			282	69		6	1
Site 15 (BP3), 4.5-5.5 in.	5.00	<	12		<	3		<	25		<	2			120	29		4	1
Site 16 (BP3 channel), 0-0.5 in	0.25	<	12			34	6	<	25			5	1		190	46		5	1
Site 16 (BP3 channel), 0.5-1 in	0.75	<	12			5	1	<	25		<	2			82	20	<	3	
Site 16 (BP3 channel), 1-1.5 in	1.25	<	12			5	1	<	25		<	2			53	13	<	3	
Site 16 (BP3 channel) 1.5-2.5 i	2.00	<	12			8	1	<	25		<	2			60	15	<	3	

Std / Core / Sample ID	Avg Depth		Sn			U			Ni			Mo			Zr			Sr	
			µg/g	± SEM		µg/g	± SEM		µg/g	± SEM		µg/g	± SEM		µg/g	± SEM		µg/g	± SEM
Site 16 (BP3 channel) 2.5-3.5 i	3.00	<	12		<	3		<	25		<	2			22	5	<	3	
Site 17 (BP4) 0-0.5 in.	0.25	<	12			59	11	<	25			6	1		405	99		19	3
Site 17 (BP4) 0.5-1 in.	0.75	<	12			58	11	<	25			4	1		480	117		24	4
Site 17 (BP4) 1-1.5 in.	1.25	<	12			51	10	<	25			4	1		512	125		24	4
Site 17 (BP4) 1.5-2.5 in.	2.00	<	12			51	9	<	25			4	1		420	102		17	3
Site 17 (BP4) 2.5-3.5 in.	3.00	<	12			30	6	<	25			2	1		421	103		13	2
Site 17 (BP4) 3.5-4.5 in.	4.00	<	12			4	1	<	25		<	2			420	102		6	1
Site 17 (BP4) 4.5-5.5 in.	5.00	<	12			6	1	<	25		<	2			463	113		7	1
Site 19 (BP5 pond) 0-0.5 in.	0.25	<	12			62	12	<	25			7	1		328	80		6	1
Site 19 (BP5 pond) 0.5-1 in.	0.75	<	12			69	13	<	25			6	1		311	76		6	1
Site 19 (BP5 pond) 1-1.5 in.	1.25	<	12			44	8	<	25			4	1		201	49		5	1
Site 19 (BP5 pond) 1.5-2.5 in.	2.00	<	12			23	4	<	25			2	0		152	37		5	1
Site 19 (BP5 pond) 2.5-3.5 in.	3.00	<	12			24	5	<	25		<	2			348	85		3	1
Site 18 (BP5 channel) 0-0.5 in.	0.25	<	12			159	30	<	25			13	3		600	146		14	3
Site 18 (BP5 channel) 0.5-1 in.	0.75	<	12			142	26	<	25			14	3		544	133		16	3
Site 18 (BP5 channel) 1-1.5 in.	1.25	<	12			73	14	<	25			4	1		435	106		11	2
Site 18 (BP5 channel) 1.5-2.5 i	2.00	<	12			36	7	<	25			4	1		420	102		6	1
Site 18 (BP5 channel) 2.5-3.5 i	3.00	<	12			6	1	<	25		<	2			66	16	<	3	
Site 18 (BP5 channel) 3.5-4.5 i	4.00	<	12			4	1	<	25		<	2			45	11	<	3	
Site 18 (BP5 channel) 4.5-5.5 i	5.00	<	12			14	3	<	25		<	2			382	93		3	1
Site 18 (BP5 channel) 5.5-6 in.	6.00		20	4		9	2	<	25			11	2		872	213		2	0
Site 14, 0-0.5 in.	0.25	<	12		<	3		<	25			3	1		259	63	<	3	
Site 14, 0.5-1 in.	0.75		23	4		14	3	<	25			43	9		4357	1062		2	0
Site 14, 1-1.5 in.	1.25	<	12			4	1	<	25			14	3		1128	275		2	0
Site 14, 1.5-2.5 in.	2.00		44	8		49	9	<	25			72	15		11367	2771		4	1
Site 14, 2.5-3.5 in.	3.00		16	3	<	3		<	25			19	4		628	153	<	3	
Site 14, 3.5-3.75 in.	3.63	<	12			8	2	<	25			11	2		2474	603	<	3	
control biofilm	n/a	<	12			10	2	<	25		<	2			229	56		38	7
site 1 biofilm	n/a		10640	1966		31	6		249	24		3	1		237	58		24	4
Site 2 biofilm	n/a		9737	1799		37	7		266	26		5	1		167	41		30	5
Site 3 biofilm	n/a		2577	476		29	5	<	25			3	1		293	71		20	3
Site 5 biofilm	n/a		2071	383		24	4	<	25			4	1		345	84		19	3
Site 9 biofilm	n/a		585	108		37	7	<	25			11	2		1455	355		27	5
Site 13 biofilm	n/a	<	12			172	32		59	6		31	6		256	63		14	2

Std / Core / Sample ID	Avg Depth		Rb			Th			Pb			As			Zn			W	
			µg/g	± SEM		µg/g	± SEM		µg/g	± SEM		µg/g	± SEM		µg/g	± SEM		µg/g	± SEM
Blank (SiO2)	n/a	<	2		<	3		<	4		<	2.0		<	7		<	35	
Blank (SiO2)	n/a	<	2		<	3		<	4		<	2.0		<	7		<	35	
Blank (SiO2)	n/a	<	2		<	3		<	4		<	2.0		<	7		<	35	
Blank (SiO2)	n/a	<	2		<	3		<	4		<	2.0		<	7		<	35	
Blank (SiO2)	n/a	<	2		<	3		<	4		<	2.0		<	7		<	35	
Blank (SiO2)	n/a	<	2		<	3		<	4		<	2.0		<	7		<	35	
Blank (SiO2)	n/a	<	2		<	3		<	4		<	2.0		<	7		<	35	
Blank (SiO2)	n/a	<	2		<	3		<	4		<	2.0		<	7		<	35	
NIST 2702 Standard	n/a		67	9		25	6		117	17		34.9	6.9		480	69	<	35	
NIST 2702 Standard	n/a		71	10		27	6		123	18		36.6	7.2		493	71	<	35	
NIST 2702 Standard	n/a		70	10		27	6		113	16		40.2	8.0		501	72	<	35	
NIST 2702 Standard	n/a		69	9		30	7		119	17		35.5	7.0		481	69	<	35	
NIST 2702 Standard	n/a		68	9		27	6		115	16		36.7	7.3		475	69	<	35	
NIST 2702 Standard	n/a		69	10		27	6		120	17		38.1	7.5		497	72	<	35	
NIST 2702 Standard	n/a		70	10		28	6		120	17		38.5	7.6		487	70	<	35	
NIST 2709a STANDARD	n/a		51	7		14	3	<	4			7.3	1.4		98	14	<	35	
NIST 2709a STANDARD	n/a		51	7		12	3	<	4			7.8	1.5		92	13	<	35	
NIST 2709a STANDARD	n/a		50	7		14	3	<	4			8.3	1.6		92	13	<	35	
NIST 2709a STANDARD	n/a		50	7		14	3	<	4			7.0	1.4		93	13	<	35	
NIST 2709a STANDARD	n/a		50	7		13	3	<	4			7.3	1.4		92	13	<	35	
NIST 2709a STANDARD	n/a		50	7		14	3	<	4			7.1	1.4		93	13	<	35	
NIST 2709a STANDARD	n/a		50	7		13	3	<	4			7.2	1.4		98	14	<	35	
Control Composite (no added tin)	n/a		5	1		4	1	<	4		<	2.0			24	3	<	35	
Tin Std 28.587 ppm	n/a		5	1		5	1	<	4		<	2.0			28	4	<	35	
Tin Std 28.587 ppm	n/a		5	1		3	1	<	4		<	2.0			24	4	<	35	
Tin Std 28.587 ppm	n/a		4	1		3	1	<	4		<	2.0			21	3	<	35	
Tin Std 28.587 ppm	n/a		5	1		5	1	<	4		<	2.0			20	3	<	35	
Tin Std 28.587 ppm	n/a		6	1		4	1	<	4		<	2.0			23	3	<	35	
Tin Std 28.587 ppm	n/a		5	1		4	1	<	4		<	2.0			27	4	<	35	
Tin Std 60.517 ppm	n/a		3	0		4	1	<	4		<	2.0			16	2	<	35	
Tin Std 60.517 ppm	n/a		4	1		4	1	<	4		<	2.0			20	3	<	35	
Tin Std 60.517 ppm	n/a		4	1		8	2	<	4		<	2.0			29	4	<	35	
Tin Std 60.517 ppm	n/a		5	1		3	1	<	4			10.4	2.1		21	3	<	35	
Tin Std 60.517 ppm	n/a		5	1		3	1	<	4		<	2.0			19	3	<	35	
Tin Std 87.548 ppm	n/a		5	1		4	1	<	4		<	2.0			25	4	<	35	
Tin Std 87.548 ppm	n/a		4	1		4	1	<	4		<	2.0			22	3	<	35	
Tin Std 87.548 ppm	n/a		5	1		3	1	<	4		<	2.0			19	3	<	35	
Tin Std 113.387 ppm	n/a		4	0		4	1	<	4		<	2.0			25	4	<	35	
Tin Std 113.387 ppm	n/a		4	0		4	1	<	4		<	2.0			22	3	<	35	
Tin Std 113.387 ppm	n/a		5	1		3	1	<	4		<	2.0			17	3	<	35	
Tin Std 113.387 ppm	n/a		6	1		3	1	<	4		<	2.0			21	3	<	35	
Tin Std 113.387 ppm	n/a		3	0		3	1	<	4		<	2.0			19	3	<	35	
Tin Std 113.387 ppm	n/a		5	1		4	1	<	4		<	2.0			26	4	<	35	
Tin Std 174.792 ppm	n/a		4	1		3	1	<	4		<	2.0			28	4	<	35	
Tin Std 174.792 ppm	n/a		5	1		4	1	<	4		<	2.0			25	4	<	35	
Tin Std 174.792 ppm	n/a		4	1		4	1	<	4		<	2.0			28	4	<	35	
Tin Std 174.792 ppm	n/a		4	1		3	1	<	4		<	2.0			19	3	<	35	

Std / Core / Sample ID	Avg Depth	Rb		Th		Pb		As		Zn		W	
		µg/g	± SEM	µg/g	± SEM	µg/g	± SEM	µg/g	± SEM	µg/g	± SEM	µg/g	± SEM
Tin Std 234.069 ppm	n/a	6	1	3	1	< 4		< 2.0		29	4	< 35	
Tin Std 234.069 ppm	n/a	3	0	6	1	< 4		< 2.0		24	3	< 35	
Tin Std 234.069 ppm	n/a	5	1	3	1	< 4		< 2.0		25	4	< 35	
Tin Std 234.069 ppm	n/a	6	1	4	1	< 4		< 2.0		19	3	< 35	
Tin Std 234.069 ppm	n/a	5	1	4	1	< 4		< 2.0		24	4	< 35	
Control 0-0.5 in.	0.25	2	0	< 3		< 4		< 2.0		9	1	< 35	
Control 0.5-1 in.	0.75	5	1	5	1	< 4		< 2.0		27	4	< 35	
Control 1-1.5 in.	1.25	4	1	6	1	< 4		< 2.0		33	5	< 35	
Control 1.5-2.5 in.	2.00	6	1	3	1	< 4		< 2.0		78	11	< 35	
Control 2.5-3.5 in.	3.00	5	1	6	1	11	2	< 2.0		216	31	< 35	
Site 2, 0-0.5 in.	0.25	4	0	< 3		< 4		< 2.0		19	3	< 35	
Site 2, 0.5-1 in.	0.75	4	1	2	1	< 4		< 2.0		7	1	< 35	
Site 2, 1-1.5 in.	1.25	4	1	4	1	< 4		< 2.0		15	2	< 35	
Site 2, 1.5-2.5 in.	2.00	5	1	< 3		< 4		< 2.0		17	2	< 35	
Site 2, 2.5-3.5 in.	3.00	7	1	< 3		< 4		< 2.0		6	1	< 35	
Site 2, 3.5-4.5 in.	4.00	< 2		< 3		< 4		< 2.0		13	2	< 35	
Site 3, 0-0.5 in.	0.25	3	0	< 3		< 4		< 2.0		18	3	< 35	
Site 3, 0.5-1 in.	0.75	4	1	4	1	< 4		< 2.0		24	3	< 35	
Site 3, 1-1.5 in.	1.25	4	1	4	1	< 4		< 2.0		20	3	< 35	
Site 5, 0-0.5 in.	0.25	3	0	23	5	< 4		< 2.0		30	4	33	4
Site 5, 0.5-1 in.	0.75	2	0	25	6	< 4		< 2.0		13	2	< 35	
Site 5, 1-1.5 in.	1.25	4	1	7	2	< 4		< 2.0		< 7		< 35	
Site 5, 1.5-2.5 in.	2.00	4	1	3	1	< 4		< 2.0		< 7		< 35	
Site 5, 2.5-3.5 in.	3.00	5	1	13	3	< 4		< 2.0		11	2	< 35	
Site 5, 3.5-4.5 in.	4.00	6	1	13	3	< 4		< 2.0		33	5	< 35	
TBP-0, Control	n/a	5	1	6	1	< 4		< 2.0		< 7		< 35	
TBP-1, 0-1.5 in.	0.75	18	2	21	5	23	3	8.4	1.7	141	20	< 35	
TBP-1, 1.5-3 in.	2.25	2	0	3	1	< 4		< 2.0		< 7		< 35	
TBP-1, 3-4.5 in.	3.75	16	2	24	5	22	3	8.7	1.7	99	14	< 35	
TBP-2, 0-1.5 in.	0.75	23	3	30	7	35	5	11.5	2.3	210	30	< 35	
TBP-2, 1.5-3 in.	2.25	24	3	31	7	35	5	10.5	2.1	164	24	< 35	
TBP-2, 3-4.5 in.	3.75	22	3	36	8	35	5	12.2	2.4	128	18	< 35	
TBP-3, 0-1.5 in.	0.75	23	3	29	7	34	5	8.4	1.7	191	28	< 35	
TBP-3, 1.5-3 in.	2.25	16	2	20	4	22	3	6.7	1.3	152	22	< 35	
TBP-4, 0-1.5 in.	0.75	21	3	31	7	34	5	8.8	1.7	205	30	< 35	
TBP-4, 1.5-3 in.	2.25	15	2	22	5	23	3	5.7	1.1	139	20	< 35	
TBP-4, 3-4.5 in.	3.75	10	1	16	4	11	2	4.9	1.0	83	12	< 35	
TBP-5, 0-1.5 in.	0.75	4	1	5	1	< 4		< 2.0		14	2	< 35	
TBP-5, 1.5-3 in.	2.25	4	1	4	1	< 4		< 2.0		15	2	< 35	
TBP-6, 0-1.5 in.	0.75	16	2	27	6	25	4	8.3	1.6	130	19	< 35	
TBP-6, 1.5-3 in.	2.25	2	0	4	1	< 4		< 2.0		11	2	< 35	
TBP-6, 3-4.5 in.	3.75	4	1	4	1	< 4		< 2.0		12	2	< 35	
TBP-7, 0-1.5 in.	0.75	8	1	16	4	9	1	4.3	0.9	68	10	< 35	
TBP-7, 1.5-3 in.	2.25	4	0	9	2	< 4		< 2.0		30	4	< 35	
TBP-8, 0-1.5 in.	0.75	11	1	18	4	15	2	4.7	0.9	93	13	< 35	
TBP-8, 1.5-3 in.	2.25	< 2		4	1	< 4		< 2.0		< 7		< 35	
TBP-9, 0-1.5 in.	0.75	9	1	21	5	9	1	6.1	1.2	81	12	< 35	

Std / Core / Sample ID	Avg Depth	Rb		Th		Pb		As		Zn		W	
		µg/g	± SEM	µg/g	± SEM	µg/g	± SEM	µg/g	± SEM	µg/g	± SEM	µg/g	± SEM
TBP-9, 1.5-3 in.	2.25	3	0	4	1	< 4		< 2.0		23	3	< 35	
TBP-10, 0-1.5 in.	0.75	6	1	11	2	< 4		< 2.0		45	6	< 35	
TBP-10, 1.5-3 in.	2.25	< 2		3	1	< 4		< 2.0		< 7		< 35	
TBP-11, 0-1.5 in.	0.75	< 2		2	1	< 4		< 2.0		< 7		< 35	
TBP-11, 1.5-3 in.	2.25	< 2		4	1	< 4		< 2.0		< 7		< 35	
TBP-12, 0-1.5 in.	0.75	5	1	8	2	< 4		< 2.0		21	3	< 35	
TBP-12, 1.5-3 in.	2.25	3	0	23	5	< 4		< 2.0		19	3	< 35	
TBP-12, 1.5-3 in.	3.75	3	0	27	6	< 4		< 2.0		27	4	< 35	
TBP-13, 0-1.5 in.	0.75	10	1	17	4	13	2	4.4	0.9	88	13	< 35	
TBP-13, 1.5-3 in.	2.25	5	1	9	2	< 4		3.5	0.7	40	6	< 35	
Site 8, fine, 0-0.5 in.	0.25	23	3	30	7	38	5	9.2	1.8	223	32	< 35	
Site 8, fine, 0.5-1 in.	0.75	24	3	33	7	38	5	7.3	1.4	224	32	< 35	
Site 8, fine, 1-1.5 in.	1.25	24	3	31	7	39	6	7.1	1.4	222	32	< 35	
Site 8, fine, 1.5-2.5 in.	2.00	23	3	30	7	36	5	8.8	1.7	207	30	< 35	
Site 8, fine, 2.5-3.5 in.	3.00	21	3	30	7	32	5	6.8	1.3	229	33	< 35	
Site 8, fine, 3.5-4.5 in.	4.00	15	2	21	5	19	3	6.0	1.2	143	21	< 35	
Site 8, sandy, 0-0.5 in.	0.25	5	1	5	1	< 4		< 2.0		19	3	< 35	
Site 8, sandy, 0.5-1 in.	0.75	2	0	4	1	< 4		< 2.0		15	2	< 35	
Site 8, sandy, 1-1.5 in.	1.25	2	0	3	1	< 4		< 2.0		< 7		< 35	
Site 8, sandy, 1.5-2.5 in.	2.00	5	1	9	2	< 4		< 2.0		38	5	< 35	
Site 8, sandy, 2.5-3.5 in.	3.00	6	1	6	1	< 4		< 2.0		20	3	< 35	
Site 8, sandy, 3.5-4.5 in.	4.00	< 2		4	1	< 4		< 2.0		10	1	< 35	
Site 10, 0-1.5 in.	0.75	< 2		< 3		< 4		< 2.0		< 7		< 35	
Site 10, 1.5-3 in.	2.25	3	0	< 3		< 4		< 2.0		6	1	< 35	
Site 10, 3-4.5 in.	3.75	< 2		3	1	< 4		< 2.0		< 7		< 35	
Site 9, mid, 0-0.5 in.	0.25	2	0	2	1	< 4		< 2.0		< 7		< 35	
Site 9, mid, 0.5-1 in.	0.75	42	6	19	4	5	1	3.5	0.7	33	5	< 35	
Site 9, mid, 1-1.5 in.	1.25	62	8	16	4	11	2	4.7	0.9	41	6	< 35	
Site 9, mid, 1.5-2.5 in.	2.00	49	7	16	3	12	2	4.5	0.9	40	6	< 35	
Site 9, mid, 2.5-3.5 in.	3.00	57	8	19	4	15	2	6.4	1.3	47	7	< 35	
Site 9, mid, 3.5-4.5 in.	4.00	38	5	17	4	10	1	4.9	1.0	34	5	< 35	
Site 9, mid, 4.5-5.5 in.	5.00	31	4	13	3	7	1	3.7	0.7	31	5	< 35	
Site 9, edge, 0-0.5 in.	0.25	2	0	8	2	< 4		< 2.0		22	3	< 35	
Site 9, edge, 0.5-1 in.	0.75	< 2		18	4	< 4		< 2.0		12	2	< 35	
Site 9, edge, 1-1.5 in.	1.25	< 2		16	3	< 4		< 2.0		< 7		< 35	
Site 9, edge, 1.5-2.5 in.	2.00	2	0	38	8	< 4		< 2.0		9	1	< 35	
Site 11, 0-0.5 in.	0.25	5	1	6	1	< 4		< 2.0		14	2	< 35	
Site 11, 0.5-1 in.	0.75	6	1	9	2	< 4		< 2.0		22	3	< 35	
Site 11, 1-1.5 in.	1.25	6	1	5	1	< 4		< 2.0		< 7		< 35	
Site 11, 1.5-2.5 in.	2.00	< 2		2	1	< 4		< 2.0		< 7		< 35	
Site 11, 2.5-3 in.	2.75	3	0	3	1	< 4		< 2.0		< 7		< 35	
Site 12, fine, 0-0.5 in.	0.25	8	1	5	1	< 4		< 2.0		30	4	< 35	
Site 12, 0.5-1 in.	0.75	7	1	5	1	< 4		< 2.0		23	3	< 35	
Site 12, 1-1.5 in.	1.25	15	2	8	2	< 4		< 2.0		34	5	< 35	
Site 12, 1.5-2.5 in.	2.00	8	1	4	1	< 4		< 2.0		< 7		< 35	
Site 12, 2.5-3.5 in.	3.00	11	2	3	1	< 4		< 2.0		< 7		< 35	
Site 12, sandy, 0-0.5 in.	0.25	< 2		< 3		< 4		< 2.0		< 7		< 35	

Std / Core / Sample ID	Avg Depth		Rb			Th			Pb			As			Zn			W	
			µg/g	± SEM		µg/g	± SEM		µg/g	± SEM		µg/g	± SEM		µg/g	± SEM		µg/g	± SEM
Site 12, sandy, 0.5-1 in.	0.75	<	2			3	1	<	4		<	2.0		<	7		<	35	
Site 12, sandy, 1-1.5 in.	1.25	<	2			2	1	<	4		<	2.0		<	7		<	35	
Site 12, sandy, 1.5-2.5 in.	2.00	<	2		<	3		<	4		<	2.0		<	7		<	35	
Site 12, sandy, 2.5-3.5 in.	3.00		8	1		4	1	<	4		<	2.0			14	2	<	35	
Site 12, sandy, 3.5-4 in.	4.00		6	1	<	3		<	4		<	2.0		<	7		<	35	
Site 20 BP2D 0-0.5 in.	0.25		61	8		29	7		37	5		8.2	1.6		185	27	<	35	
Site 20 BP2D 0.5-1 in.	0.75		62	8		27	6		40	6		8.7	1.7		185	27	<	35	
Site 20 BP2D 1-1.5 in.	1.25		53	7		28	6		30	4		11.4	2.3		183	26	<	35	
Site 20 BP2D 1.5-2.5 in.	2.00		6	1		5	1	<	4		<	2.0			42	6	<	35	
Site 20 BP2D 2.5-3.5 in.	3.00		1	0	<	3		<	4		<	2.0			11	2	<	35	
Site 20 BP2D 3.5-4.5 in.	4.00		1	0		3	1	<	4		<	2.0			16	2	<	35	
Site 20 BP2C 0-0.5 in.	0.25		48	7		24	5		27	4		10.6	2.1		219	32	<	35	
Site 20 BP2C 0.5-1 in.	0.75		50	7		25	6		31	4		8.3	1.7		214	31	<	35	
Site 20 BP2C 1-1.5 in.	1.25		41	6		19	4		19	3		6.6	1.3		195	28	<	35	
Site 20 BP2C 1.5-2.5 in.	2.00		40	5		22	5		16	2		8.4	1.7		206	30	<	35	
Site 20 BP2C 2.5-3.5 in.	3.00		41	6		18	4		18	3		7.3	1.4		213	31	<	35	
Site 20 BP2B 0-0.5 in.	0.25		71	10		26	6		32	5		7.2	1.4		206	30	<	35	
Site 20 BP2B 0.5-1 in.	0.75		58	8		22	5		24	4		5.8	1.1		175	25	<	35	
Site 20 BP2B 1-1.5 in.	1.25		55	8		19	4		19	3		7.1	1.4		157	23	<	35	
Site 20 BP2B 1.5-2.5 in.	2.00		37	5		13	3		8	1		5.4	1.1		108	16	<	35	
Site 20 BP2B 2.5-3.5 in.	3.00		7	1		4	1	<	4		<	2.0			32	5	<	35	
Site 20 BP2B 3.5-4.5 in.	4.00	<	2		<	3		<	4		<	2.0			20	3	<	35	
Site 20 BP2B 4.5-5.25 in.	5.00	<	2		<	3		<	4		<	2.0		<	7		<	35	
Site 20 BP2A 0-0.5 in.	0.25		72	10		24	5		30	4		9.0	1.8		196	28	<	35	
Site 20 BP2A 0.5-1 in.	0.75		75	10		26	6		31	4		9.5	1.9		220	32	<	35	
Site 20 BP2A 1-1.5 in.	1.25		69	9		23	5		31	4		8.2	1.6		213	31	<	35	
Site 20 BP2A 1.5-2.5 in.	2.00		73	10		23	5		31	5		8.9	1.8		195	28	<	35	
Site 20 BP2A 2.5-3.5 in.	3.00		79	11		25	6		33	5		10.1	2.0		214	31	<	35	
Site 20 BP2A 3.5-4.5 in.	4.00		80	11		26	6		34	5		8.0	1.6		190	27	<	35	
Site 20 BP2A 4.5-5.5 in.	5.00		63	9		17	4		21	3		5.9	1.2		136	20	<	35	
Site 20 BP2A 5.5-6.5 in.	6.00		66	9		17	4		21	3		7.2	1.4		146	21	<	35	
Site 13, 0-0.5 in.	0.25	<	2		<	3		<	4			2.7	0.5	<	7		<	35	
Site 13, 0.5-1 in.	0.75	<	2		<	3		<	4			3.2	0.6	<	7		<	35	
Site 13, 1-1.5 in.	1.25	<	2		<	3		<	4			3.1	0.6	<	7		<	35	
Site 13, 1.5-2.5 in.	2.00	<	2		<	3		<	4			3.3	0.6	<	7		<	35	
Site 13, 2.5-2.75 in.	2.63	<	2			6	1	<	4			2.9	0.6	<	7		<	35	
Site 15 (BP3), 0-0.5 in.	0.25		8	1		12	3	<	4		<	2.0			19	3	<	35	
Site 15 (BP3), 0.5-1 in.	0.75		3	0		7	2	<	4		<	2.0		<	7		<	35	
Site 15 (BP3), 1-1.5 in.	1.25		2	0		11	2	<	4		<	2.0		<	7		<	35	
Site 15 (BP3), 1.5-2.5 in.	2.00		4	1		6	1	<	4		<	2.0		<	7		<	35	
Site 15 (BP3), 2.5-3.5 in.	3.00		3	0		7	2	<	4		<	2.0		<	7		<	35	
Site 15 (BP3), 3.5-4.5 in.	4.00		2	0		6	1	<	4		<	2.0		<	7		<	35	
Site 15 (BP3), 4.5-5.5 in.	5.00	<	2			5	1	<	4		<	2.0		<	7		<	35	
Site 16 (BP3 channel), 0-0.5 in	0.25		5	1		4	1	<	4			4.0	0.8	<	7		<	35	
Site 16 (BP3 channel), 0.5-1 in	0.75	<	2			3	1	<	4		<	2.0		<	7		<	35	
Site 16 (BP3 channel), 1-1.5 in	1.25	<	2			4	1	<	4		<	2.0		<	7		<	35	
Site 16 (BP3 channel) 1.5-2.5 i	2.00	<	2			3	1	<	4		<	2.0		<	7		<	35	

Std / Core / Sample ID	Avg Depth	Rb		Th		Pb		As		Zn		W	
		µg/g	± SEM	µg/g	± SEM	µg/g	± SEM	µg/g	± SEM	µg/g	± SEM	µg/g	± SEM
Site 16 (BP3 channel) 2.5-3.5 i	3.00	< 2		< 3		< 4		< 2.0		< 7		< 35	
Site 17 (BP4) 0-0.5 in.	0.25	19	3	13	3	< 4		10.7	2.1	40	6	< 35	
Site 17 (BP4) 0.5-1 in.	0.75	24	3	16	3	9	1	10.2	2.0	48	7	< 35	
Site 17 (BP4) 1-1.5 in.	1.25	22	3	18	4	10	1	11.0	2.2	45	7	< 35	
Site 17 (BP4) 1.5-2.5 in.	2.00	17	2	13	3	6	1	9.5	1.9	39	6	< 35	
Site 17 (BP4) 2.5-3.5 in.	3.00	11	1	14	3	< 4		9.5	1.9	24	3	< 35	
Site 17 (BP4) 3.5-4.5 in.	4.00	2	0	9	2	< 4		12.8	2.5	< 7		< 35	
Site 17 (BP4) 4.5-5.5 in.	5.00	2	0	10	2	< 4		12.1	2.4	< 7		< 35	
Site 19 (BP5 pond) 0-0.5 in.	0.25	9	1	7	2	< 4		< 2.0		16	2	< 35	
Site 19 (BP5 pond) 0.5-1 in.	0.75	9	1	6	1	< 4		< 2.0		14	2	< 35	
Site 19 (BP5 pond) 1-1.5 in.	1.25	6	1	3	1	< 4		< 2.0		< 7		< 35	
Site 19 (BP5 pond) 1.5-2.5 in.	2.00	< 2		2	1	< 4		< 2.0		< 7		< 35	
Site 19 (BP5 pond) 2.5-3.5 in.	3.00	3	0	8	2	< 4		< 2.0		< 7		< 35	
Site 18 (BP5 channel) 0-0.5 in.	0.25	23	3	19	4	< 4		4.0	0.8	29	4	< 35	
Site 18 (BP5 channel) 0.5-1 in.	0.75	22	3	13	3	5	1	< 2.0		29	4	< 35	
Site 18 (BP5 channel) 1-1.5 in.	1.25	11	2	10	2	< 4		< 2.0		14	2	< 35	
Site 18 (BP5 channel) 1.5-2.5 i	2.00	5	1	10	2	< 4		< 2.0		< 7		< 35	
Site 18 (BP5 channel) 2.5-3.5 i	3.00	< 2		< 3		< 4		< 2.0		< 7		< 35	
Site 18 (BP5 channel) 3.5-4.5 i	4.00	< 2		< 3		< 4		< 2.0		6	1	< 35	
Site 18 (BP5 channel) 4.5-5.5 i	5.00	< 2		10	2	< 4		< 2.0		< 7		< 35	
Site 18 (BP5 channel) 5.5-6 in.	6.00	< 2		25	6	< 4		< 2.0		< 7		< 35	
Site 14, 0-0.5 in.	0.25	< 2		3	1	< 4		< 2.0		< 7		< 35	
Site 14, 0.5-1 in.	0.75	< 2		47	11	< 4		< 2.0		< 7		< 35	
Site 14, 1-1.5 in.	1.25	< 2		9	2	< 4		< 2.0		< 7		< 35	
Site 14, 1.5-2.5 in.	2.00	< 2		240	54	< 4		< 2.0		< 7		< 35	
Site 14, 2.5-3.5 in.	3.00	< 2		7	2	< 4		< 2.0		< 7		< 35	
Site 14, 3.5-3.75 in.	3.63	< 2		48	11	< 4		< 2.0		< 7		< 35	
control biofilm	n/a	20	3	13	3	59	9	4.3	0.8	350	51	< 35	
site 1 biofilm	n/a	24	3	19	4	23	3	7.9	1.6	273	39	211	27
Site 2 biofilm	n/a	31	4	19	4	22	3	6.9	1.4	300	43	268	34
Site 3 biofilm	n/a	13	2	12	3	12	2	< 2.0		170	25	< 35	
Site 5 biofilm	n/a	16	2	13	3	12	2	< 2.0		308	44	< 35	
Site 9 biofilm	n/a	14	2	35	8	8	1	< 2.0		161	23	< 35	
Site 13 biofilm	n/a	24	3	10	2	< 4		55.7	11.0	36	5	< 35	

Std / Core / Sample ID	Avg Depth		Cu			Co			Fe			Mn			Ba			Cd	
			µg/g	± SEM		µg/g	± SEM		µg/g	± SEM		µg/g	± SEM		µg/g	± SEM		µg/g	± SEM
Blank (SiO2)	n/a	<	10		<	45		<	100		<	60		<	35		<	7.0	
Blank (SiO2)	n/a	<	10		<	45		<	100		<	60		<	35		<	7.0	
Blank (SiO2)	n/a	<	10		<	45		<	100		<	60		<	35		<	7.0	
Blank (SiO2)	n/a	<	10		<	45		<	100		<	60		<	35		<	7.0	
Blank (SiO2)	n/a	<	10		<	45		<	100		<	60		<	35		<	7.0	
Blank (SiO2)	n/a	<	10		<	45		<	100		<	60		<	35		<	7.0	
Blank (SiO2)	n/a	<	10		<	45		<	100		<	60		<	35		<	7.0	
Blank (SiO2)	n/a	<	10		<	45		<	100		<	60		<	35		<	7.0	
NIST 2702 Standard	n/a		118	16	<	45			86464	12084		2002	250		71	10		8.8	1.8
NIST 2702 Standard	n/a		123	17	<	45			90772	12687		2112	264	<	35			8.7	1.7
NIST 2702 Standard	n/a		121	16	<	45			91525	12792		2099	262		85	12		9.6	1.9
NIST 2702 Standard	n/a		116	16	<	45			88386	12353		2017	252		91	13		7.2	1.5
NIST 2702 Standard	n/a		125	17	<	45			86890	12144		2030	254		96	13		7.5	1.5
NIST 2702 Standard	n/a		128	17	<	45			89526	12512		2113	264		88	12		7.5	1.5
NIST 2702 Standard	n/a		116	16	<	45			90224	12610		2067	258		55	8		11.8	2.4
NIST 2709a STANDARD	n/a		31	4	<	45			30600	4277		442	55		325	45		10.9	2.2
NIST 2709a STANDARD	n/a		28	4	<	45			30561	4271		435	54		339	47		11.5	2.3
NIST 2709a STANDARD	n/a		30	4	<	45			30057	4201		441	55		344	48	<	7.0	
NIST 2709a STANDARD	n/a		28	4	<	45			29939	4184		432	54		358	49	<	7.0	
NIST 2709a STANDARD	n/a		35	5	<	45			30445	4255		452	56		348	48		7.5	1.5
NIST 2709a STANDARD	n/a		28	4	<	45			30241	4227		454	57		352	49		7.9	1.6
NIST 2709a STANDARD	n/a		29	4	<	45			30409	4250		457	57		325	45		9.2	1.8
Control Composite (no added tin)	n/a	<	10		<	45			10045	1404	<	60		<	35		<	7.0	
Tin Std 28.587 ppm	n/a	<	10		<	45			11913	1665	<	60		<	35		<	7.0	
Tin Std 28.587 ppm	n/a	<	10		<	45			9179	1283	<	60		<	35		<	7.0	
Tin Std 28.587 ppm	n/a	<	10		<	45			6758	944	<	60		<	35		<	7.0	
Tin Std 28.587 ppm	n/a	<	10		<	45			8345	1166	<	60		<	35		<	7.0	
Tin Std 28.587 ppm	n/a	<	10		<	45			8545	1194	<	60		<	35		<	7.0	
Tin Std 28.587 ppm	n/a	<	10		<	45			10122	1415	<	60		<	35		<	7.0	
Tin Std 60.517 ppm	n/a	<	10		<	45			6782	948	<	60		<	35		<	7.0	
Tin Std 60.517 ppm	n/a	<	10		<	45			7406	1035	<	60		<	35		<	7.0	
Tin Std 60.517 ppm	n/a	<	10		<	45			9612	1343	<	60		<	35		<	7.0	
Tin Std 60.517 ppm	n/a		21	3	<	45			10753	1503	<	60		<	35		<	7.0	
Tin Std 60.517 ppm	n/a	<	10		<	45			6856	958	<	60		<	35		<	7.0	
Tin Std 87.548 ppm	n/a	<	10		<	45			8225	1150	<	60		<	35		<	7.0	
Tin Std 87.548 ppm	n/a	<	10		<	45			7165	1001	<	60		<	35		<	7.0	
Tin Std 87.548 ppm	n/a	<	10		<	45			6524	912	<	60		<	35		<	7.0	
Tin Std 113.387 ppm	n/a	<	10		<	45			7488	1047	<	60		<	35		<	7.0	
Tin Std 113.387 ppm	n/a	<	10		<	45			6991	977	<	60		<	35		<	7.0	
Tin Std 113.387 ppm	n/a	<	10		<	45			7542	1054	<	60		<	35		<	7.0	
Tin Std 113.387 ppm	n/a	<	10		<	45			7468	1044	<	60		<	35		<	7.0	
Tin Std 113.387 ppm	n/a	<	10		<	45			6618	925	<	60		<	35		<	7.0	
Tin Std 113.387 ppm	n/a	<	10		<	45			10384	1451	<	60		<	35		<	7.0	
Tin Std 174.792 ppm	n/a	<	10		<	45			8507	1189	<	60		<	35		<	7.0	
Tin Std 174.792 ppm	n/a	<	10		<	45			8192	1145	<	60		<	35		<	7.0	
Tin Std 174.792 ppm	n/a	<	10		<	45			9343	1306	<	60		<	35		<	7.0	
Tin Std 174.792 ppm	n/a	<	10		<	45			8551	1195	<	60		<	35		<	7.0	

Std / Core / Sample ID	Avg Depth		Cu			Co			Fe			Mn			Ba			Cd	
			µg/g	± SEM		µg/g	± SEM		µg/g	± SEM		µg/g	± SEM		µg/g	± SEM		µg/g	± SEM
Tin Std 234.069 ppm	n/a	<	10		<	45			9036	1263	<	60		<	35		<	7.0	
Tin Std 234.069 ppm	n/a	<	10		<	45			7581	1060	<	60		<	35		<	7.0	
Tin Std 234.069 ppm	n/a	<	10		<	45			7701	1076	<	60		<	35		<	7.0	
Tin Std 234.069 ppm	n/a	<	10		<	45			6074	849	<	60		<	35		<	7.0	
Tin Std 234.069 ppm	n/a	<	10		<	45			8495	1187	<	60		<	35		<	7.0	
Control 0-0.5 in.	0.25	<	10		<	45			2905	406	<	60		<	35		<	7.0	
Control 0.5-1 in.	0.75	<	10		<	45			12734	1780	<	60		<	35		<	7.0	
Control 1-1.5 in.	1.25	<	10		<	45			12142	1697	<	60		<	35		<	7.0	
Control 1.5-2.5 in.	2.00		73	10	<	45			6248	873	<	60		<	35		<	7.0	
Control 2.5-3.5 in.	3.00		150	20	<	45			6944	971	<	60		<	35		<	7.0	
Site 2, 0-0.5 in.	0.25	<	10		<	45			1901	266	<	60		<	35		<	7.0	
Site 2, 0.5-1 in.	0.75	<	10		<	45			1997	279	<	60		<	35		<	7.0	
Site 2, 1-1.5 in.	1.25	<	10		<	45			2510	351	<	60			36	5	<	7.0	
Site 2, 1.5-2.5 in.	2.00	<	10		<	45			2235	312	<	60		<	35		<	7.0	
Site 2, 2.5-3.5 in.	3.00	<	10		<	45			4585	641	<	60		<	35		<	7.0	
Site 2, 3.5-4.5 in.	4.00	<	10		<	45			2852	399	<	60			42	6	<	7.0	
Site 3, 0-0.5 in.	0.25	<	10		<	45			2790	390	<	60		<	35		<	7.0	
Site 3, 0.5-1 in.	0.75	<	10		<	45			4531	633	<	60		<	35		<	7.0	
Site 3, 1-1.5 in.	1.25	<	10		<	45			5082	710		255	32	<	35		<	7.0	
Site 5, 0-0.5 in.	0.25		43	6	<	45			7932	1109		212	26		53	7	<	7.0	
Site 5, 0.5-1 in.	0.75	<	10		<	45			6910	966		113	14		39	5	<	7.0	
Site 5, 1-1.5 in.	1.25	<	10		<	45			9129	1276	<	60		<	35		<	7.0	
Site 5, 1.5-2.5 in.	2.00	<	10		<	45			3842	537	<	60			38	5	<	7.0	
Site 5, 2.5-3.5 in.	3.00	<	10		<	45			6121	856	<	60		<	35		<	7.0	
Site 5, 3.5-4.5 in.	4.00		30	4	<	45			13862	1937		298	37		64	9	<	7.0	
TBP-0, Control	n/a	<	10		<	45			8231	1150	<	60		<	35		<	7.0	
TBP-1, 0-1.5 in.	0.75		41	6	<	45			37186	5197		261	33		77	11	<	7.0	
TBP-1, 1.5-3 in.	2.25	<	10		<	45			4626	646	<	60		<	35		<	7.0	
TBP-1, 3-4.5 in.	3.75		43	6	<	45			40108	5606		107	13		123	17	<	7.0	
TBP-2, 0-1.5 in.	0.75		60	8	<	45			48537	6784		324	41		100	14		8.0	1.6
TBP-2, 1.5-3 in.	2.25		52	7	<	45			45663	6382		183	23		86	12	<	7.0	
TBP-2, 3-4.5 in.	3.75		47	6	<	45			52520	7340		99	12		115	16	<	7.0	
TBP-3, 0-1.5 in.	0.75		61	8	<	45			41566	5809		249	31		85	12		6.6	1.3
TBP-3, 1.5-3 in.	2.25		47	6	<	45			34508	4823		227	28		77	11	<	7.0	
TBP-4, 0-1.5 in.	0.75		59	8	<	45			42460	5934		293	37		93	13		7.3	1.5
TBP-4, 1.5-3 in.	2.25		34	5	<	45			29452	4116	<	60			58	8	<	7.0	
TBP-4, 3-4.5 in.	3.75		25	3	<	45			21118	2951	<	60			46	6	<	7.0	
TBP-5, 0-1.5 in.	0.75	<	10		<	45			6255	874	<	60		<	35		<	7.0	
TBP-5, 1.5-3 in.	2.25	<	10		<	45			7493	1047	<	60		<	35		<	7.0	
TBP-6, 0-1.5 in.	0.75		53	7	<	45			39502	5521		261	33		38	5		10.3	2.1
TBP-6, 1.5-3 in.	2.25	<	10		<	45			5224	730	<	60		<	35		<	7.0	
TBP-6, 3-4.5 in.	3.75	<	10		<	45			6159	861	<	60		<	35		<	7.0	
TBP-7, 0-1.5 in.	0.75		36	5	<	45			23521	3287		199	25		39	5	<	7.0	
TBP-7, 1.5-3 in.	2.25	<	10		<	45			12244	1711	<	60			33	5	<	7.0	
TBP-8, 0-1.5 in.	0.75		40	5	<	45			27132	3792		206	26	<	35		<	7.0	
TBP-8, 1.5-3 in.	2.25	<	10		<	45			3647	510	<	60		<	35		<	7.0	
TBP-9, 0-1.5 in.	0.75		36	5	<	45			25709	3593		107	13	<	35		<	7.0	

Std / Core / Sample ID	Avg Depth		Cu			Co			Fe			Mn			Ba			Cd	
			μg/g	± SEM		μg/g	± SEM		μg/g	± SEM		μg/g	± SEM		μg/g	± SEM		μg/g	± SEM
TBP-9, 1.5-3 in.	2.25	<	10		<	45			7218	1009	<	60		<	35		<	7.0	
TBP-10, 0-1.5 in.	0.75		12	2	<	45			16800	2348	<	60		<	35		<	7.0	
TBP-10, 1.5-3 in.	2.25	<	10		<	45			3783	529	<	60		<	35		<	7.0	
TBP-11, 0-1.5 in.	0.75	<	10		<	45			3450	482	<	60		<	35		<	7.0	
TBP-11, 1.5-3 in.	2.25	<	10		<	45			4463	624	<	60		<	35		<	7.0	
TBP-12, 0-1.5 in.	0.75	<	10		<	45			7480	1045	<	60		<	35		<	7.0	
TBP-12, 1.5-3 in.	2.25	<	10		<	45			12212	1707	<	60		<	35		<	7.0	
TBP-12, 1.5-3 in.	3.75		18	2	<	45			14709	2056	<	60			40	5	<	7.0	
TBP-13, 0-1.5 in.	0.75		42	6	<	45			23714	3314		241	30	<	35		<	7.0	
TBP-13, 1.5-3 in.	2.25		11	2	<	45			14884	2080	<	60			36	5	<	7.0	
Site 8, fine, 0-0.5 in.	0.25		67	9	<	45			44950	6282		232	29		71	10		9.7	1.9
Site 8, fine, 0.5-1 in.	0.75		65	9	<	45			43534	6084		228	28		68	9		8.4	1.7
Site 8, fine, 1-1.5 in.	1.25		64	9	<	45			42033	5875		208	26		71	10		9.4	1.9
Site 8, fine, 1.5-2.5 in.	2.00		57	8	<	45			41508	5801		185	23		81	11	<	7.0	
Site 8, fine, 2.5-3.5 in.	3.00		52	7	<	45			36607	5116		91	11		75	10	<	7.0	
Site 8, fine, 3.5-4.5 in.	4.00		34	5	<	45			28223	3945	<	60			54	7	<	7.0	
Site 8, sandy, 0-0.5 in.	0.25	<	10		<	45			7109	994	<	60		<	35		<	7.0	
Site 8, sandy, 0.5-1 in.	0.75	<	10		<	45			5855	818	<	60		<	35		<	7.0	
Site 8, sandy, 1-1.5 in.	1.25	<	10		<	45			4021	562	<	60			34	5	<	7.0	
Site 8, sandy, 1.5-2.5 in.	2.00		23	3	<	45			13954	1950	<	60		<	35		<	7.0	
Site 8, sandy, 2.5-3.5 in.	3.00	<	10		<	45			8154	1140	<	60		<	35		<	7.0	
Site 8, sandy, 3.5-4.5 in.	4.00	<	10		<	45			2207	309	<	60			44	6	<	7.0	
Site 10, 0-1.5 in.	0.75	<	10		<	45			1083	151	<	60			42	6	<	7.0	
Site 10, 1.5-3 in.	2.25	<	10		<	45			5909	826	<	60		<	35		<	7.0	
Site 10, 3-4.5 in.	3.75	<	10		<	45			1520	212	<	60		<	35		<	7.0	
Site 9, mid, 0-0.5 in.	0.25	<	10		<	45			8203	1147	<	60		<	35		<	7.0	
Site 9, mid, 0.5-1 in.	0.75		12	2	<	45			21888	3059		238	30		99	14	<	7.0	
Site 9, mid, 1-1.5 in.	1.25		23	3	<	45			25285	3534		307	38		153	21	<	7.0	
Site 9, mid, 1.5-2.5 in.	2.00		27	4	<	45			26539	3709		282	35		142	20	<	7.0	
Site 9, mid, 2.5-3.5 in.	3.00		30	4	<	45			33556	4690		333	42		163	22	<	7.0	
Site 9, mid, 3.5-4.5 in.	4.00		13	2	<	45			25185	3520		222	28		126	17	<	7.0	
Site 9, mid, 4.5-5.5 in.	5.00	<	10		<	45			21641	3025		232	29		103	14	<	7.0	
Site 9, edge, 0-0.5 in.	0.25	<	10		<	45			11654	1629	<	60		<	35		<	7.0	
Site 9, edge, 0.5-1 in.	0.75	<	10		<	45			5181	724	<	60		<	35		<	7.0	
Site 9, edge, 1-1.5 in.	1.25	<	10		<	45			8400	1174	<	60		<	35		<	7.0	
Site 9, edge, 1.5-2.5 in.	2.00		29	4	<	45			7883	1102	<	60		<	35		<	7.0	
Site 11, 0-0.5 in.	0.25	<	10		<	45			6010	840	<	60		<	35		<	7.0	
Site 11, 0.5-1 in.	0.75	<	10		<	45			9883	1381	<	60		<	35		<	7.0	
Site 11, 1-1.5 in.	1.25	<	10		<	45			5297	740	<	60		<	35		<	7.0	
Site 11, 1.5-2.5 in.	2.00	<	10		<	45			2317	324	<	60		<	35		<	7.0	
Site 11, 2.5-3 in.	2.75	<	10		<	45			4061	568	<	60		<	35		<	7.0	
Site 12, fine, 0-0.5 in.	0.25	<	10		<	45			10326	1443	<	60		<	35		<	7.0	
Site 12, 0.5-1 in.	0.75	<	10		<	45			9219	1289	<	60		<	35		<	7.0	
Site 12, 1-1.5 in.	1.25	<	10		<	45			14648	2047	<	60		<	35		<	7.0	
Site 12, 1.5-2.5 in.	2.00	<	10		<	45			6754	944	<	60		<	35		<	7.0	
Site 12, 2.5-3.5 in.	3.00	<	10		<	45			7180	1003	<	60		<	35		<	7.0	
Site 12, sandy, 0-0.5 in.	0.25	<	10		<	45			1649	231	<	60		<	35		<	7.0	

Std / Core / Sample ID	Avg Depth	Cu		Co		Fe		Mn		Ba		Cd	
		µg/g	± SEM	µg/g	± SEM	µg/g	± SEM	µg/g	± SEM	µg/g	± SEM	µg/g	± SEM
Site 12, sandy, 0.5-1 in.	0.75	< 10		< 45		2068	289	< 60		< 35		< 7.0	
Site 12, sandy, 1-1.5 in.	1.25	< 10		< 45		1980	277	< 60		< 35		< 7.0	
Site 12, sandy, 1.5-2.5 in.	2.00	< 10		< 45		3181	445	< 60		< 35		< 7.0	
Site 12, sandy, 2.5-3.5 in.	3.00	< 10		< 45		6084	850	< 60		< 35		< 7.0	
Site 12, sandy, 3.5-4 in.	4.00	< 10		< 45		4161	582	< 60		< 35		< 7.0	
Site 20 BP2D 0-0.5 in.	0.25	69	9	< 45		58599	8190	446	56	82	11	9.0	1.8
Site 20 BP2D 0.5-1 in.	0.75	71	10	< 45		59565	8325	410	51	104	14	6.9	1.4
Site 20 BP2D 1-1.5 in.	1.25	70	9	< 45		62387	8719	345	43	72	10	10.9	2.2
Site 20 BP2D 1.5-2.5 in.	2.00	< 10		< 45		12616	1763	< 60		< 35		< 7.0	
Site 20 BP2D 2.5-3.5 in.	3.00	< 10		< 45		4064	568	< 60		< 35		< 7.0	
Site 20 BP2D 3.5-4.5 in.	4.00	< 10		< 45		4168	583	< 60		< 35		< 7.0	
Site 20 BP2C 0-0.5 in.	0.25	52	7	< 45		83017	11603	447	56	< 35		14.6	2.9
Site 20 BP2C 0.5-1 in.	0.75	59	8	< 45		73753	10308	389	49	64	9	11.0	2.2
Site 20 BP2C 1-1.5 in.	1.25	47	6	< 45		54837	7664	247	31	71	10	7.9	1.6
Site 20 BP2C 1.5-2.5 in.	2.00	46	6	< 45		49984	6986	211	26	57	8	13.2	2.7
Site 20 BP2C 2.5-3.5 in.	3.00	46	6	< 45		43412	6067	207	26	49	7	5.7	1.2
Site 20 BP2B 0-0.5 in.	0.25	53	7	< 45		57233	7999	234	29	131	18	< 7.0	
Site 20 BP2B 0.5-1 in.	0.75	42	6	< 45		46840	6547	< 60		61	8	9.1	1.8
Site 20 BP2B 1-1.5 in.	1.25	40	5	< 45		42273	5908	193	24	76	10	< 7.0	
Site 20 BP2B 1.5-2.5 in.	2.00	29	4	< 45		29197	4081	< 60		53	7	< 7.0	
Site 20 BP2B 2.5-3.5 in.	3.00	< 10		< 45		10347	1446	< 60		< 35		< 7.0	
Site 20 BP2B 3.5-4.5 in.	4.00	< 10		< 45		4558	637	< 60		< 35		< 7.0	
Site 20 BP2B 4.5-5.25 in.	5.00	< 10		< 45		3153	441	< 60		< 35		< 7.0	
Site 20 BP2A 0-0.5 in.	0.25	58	8	< 45		59624	8333	219	27	71	10	9.5	1.9
Site 20 BP2A 0.5-1 in.	0.75	60	8	< 45		64241	8979	272	34	93	13	< 7.0	
Site 20 BP2A 1-1.5 in.	1.25	53	7	< 45		59691	8343	222	28	77	11	< 7.0	
Site 20 BP2A 1.5-2.5 in.	2.00	53	7	< 45		59243	8280	227	28	94	13	9.2	1.9
Site 20 BP2A 2.5-3.5 in.	3.00	60	8	< 45		60857	8506	243	30	126	17	< 7.0	
Site 20 BP2A 3.5-4.5 in.	4.00	53	7	< 45		54160	7570	251	31	120	17	< 7.0	
Site 20 BP2A 4.5-5.5 in.	5.00	39	5	< 45		41426	5790	226	28	82	11	< 7.0	
Site 20 BP2A 5.5-6.5 in.	6.00	46	6	< 45		42167	5893	268	34	71	10	< 7.0	
Site 13, 0-0.5 in.	0.25	< 10		< 45		7360	1029	< 60		< 35		< 7.0	
Site 13, 0.5-1 in.	0.75	< 10		< 45		12223	1708	< 60		< 35		< 7.0	
Site 13, 1-1.5 in.	1.25	< 10		< 45		8168	1142	< 60		< 35		< 7.0	
Site 13, 1.5-2.5 in.	2.00	< 10		< 45		8331	1164	< 60		< 35		< 7.0	
Site 13, 2.5-2.75 in.	2.63	< 10		< 45		6900	964	< 60		< 35		< 7.0	
Site 15 (BP3), 0-0.5 in.	0.25	< 10		< 45		6593	922	< 60		< 35		10.4	2.1
Site 15 (BP3), 0.5-1 in.	0.75	< 10		< 45		4919	688	< 60		< 35		< 7.0	
Site 15 (BP3), 1-1.5 in.	1.25	< 10		< 45		2839	397	< 60		< 35		< 7.0	
Site 15 (BP3), 1.5-2.5 in.	2.00	< 10		< 45		5148	719	< 60		< 35		< 7.0	
Site 15 (BP3), 2.5-3.5 in.	3.00	< 10		< 45		2910	407	< 60		< 35		< 7.0	
Site 15 (BP3), 3.5-4.5 in.	4.00	< 10		< 45		2153	301	< 60		< 35		< 7.0	
Site 15 (BP3), 4.5-5.5 in.	5.00	< 10		< 45		1820	254	< 60		< 35		< 7.0	
Site 16 (BP3 channel), 0-0.5 in	0.25	11	1	< 45		21473	3001	429	54	< 35		< 7.0	
Site 16 (BP3 channel), 0.5-1 in	0.75	< 10		< 45		1405	196	< 60		< 35		< 7.0	
Site 16 (BP3 channel), 1-1.5 in	1.25	< 10		< 45		1476	206	< 60		< 35		< 7.0	
Site 16 (BP3 channel) 1.5-2.5 i	2.00	< 10		< 45		1750	245	< 60		< 35		< 7.0	

Std / Core / Sample ID	Avg Depth	Cu		Co		Fe		Mn		Ba		Cd	
		µg/g	± SEM	µg/g	± SEM	µg/g	± SEM	µg/g	± SEM	µg/g	± SEM	µg/g	± SEM
Site 16 (BP3 channel) 2.5-3.5 i	3.00	< 10		< 45		722	101	< 60		< 35		< 7.0	
Site 17 (BP4) 0-0.5 in.	0.25	12	2	< 45		35737	4995	399	50	< 35		8.1	1.6
Site 17 (BP4) 0.5-1 in.	0.75	23	3	< 45		36874	5154	422	53	35	5	< 7.0	
Site 17 (BP4) 1-1.5 in.	1.25	< 10		< 45		32098	4486	300	37	45	6	< 7.0	
Site 17 (BP4) 1.5-2.5 in.	2.00	< 10		< 45		30608	4278	337	42	41	6	< 7.0	
Site 17 (BP4) 2.5-3.5 in.	3.00	< 10		< 45		25907	3621	205	26	< 35		< 7.0	
Site 17 (BP4) 3.5-4.5 in.	4.00	< 10		< 45		22775	3183	< 60		< 35		< 7.0	
Site 17 (BP4) 4.5-5.5 in.	5.00	< 10		< 45		20119	2812	< 60		< 35		< 7.0	
Site 19 (BP5 pond) 0-0.5 in.	0.25	< 10		< 45		4714	659	< 60		< 35		< 7.0	
Site 19 (BP5 pond) 0.5-1 in.	0.75	< 10		< 45		5686	795	194	24	< 35		< 7.0	
Site 19 (BP5 pond) 1-1.5 in.	1.25	< 10		< 45		1941	271	< 60		< 35		< 7.0	
Site 19 (BP5 pond) 1.5-2.5 in.	2.00	< 10		< 45		1250	175	< 60		< 35		< 7.0	
Site 19 (BP5 pond) 2.5-3.5 in.	3.00	< 10		< 45		1581	221	< 60		< 35		< 7.0	
Site 18 (BP5 channel) 0-0.5 in.	0.25	< 10		< 45		18970	2651	87	11	< 35		< 7.0	
Site 18 (BP5 channel) 0.5-1 in.	0.75	< 10		< 45		11982	1675	< 60		< 35		< 7.0	
Site 18 (BP5 channel) 1-1.5 in.	1.25	< 10		< 45		5855	818	< 60		< 35		< 7.0	
Site 18 (BP5 channel) 1.5-2.5 i	2.00	< 10		< 45		3424	479	< 60		< 35		< 7.0	
Site 18 (BP5 channel) 2.5-3.5 i	3.00	< 10		< 45		852	119	< 60		< 35		< 7.0	
Site 18 (BP5 channel) 3.5-4.5 i	4.00	< 10		< 45		1088	152	< 60		< 35		< 7.0	
Site 18 (BP5 channel) 4.5-5.5 i	5.00	< 10		< 45		1045	146	< 60		< 35		< 7.0	
Site 18 (BP5 channel) 5.5-6 in.	6.00	< 10		< 45		865	121	< 60		< 35		< 7.0	
Site 14, 0-0.5 in.	0.25	< 10		< 45		1089	152	101	13	< 35		< 7.0	
Site 14, 0.5-1 in.	0.75	< 10		< 45		1345	188	74	9	< 35		< 7.0	
Site 14, 1-1.5 in.	1.25	< 10		< 45		1513	211	68	8	< 35		< 7.0	
Site 14, 1.5-2.5 in.	2.00	< 10		< 45		1657	232	< 60		71	10	< 7.0	
Site 14, 2.5-3.5 in.	3.00	< 10		< 45		615	86	< 60		< 35		< 7.0	
Site 14, 3.5-3.75 in.	3.63	< 10		< 45		1594	223	< 60		< 35		< 7.0	
control biofilm	n/a	885	119	< 45		20705	2894	1262	158	< 35		12.7	2.6
site 1 biofilm	n/a	239	32	316	19	15255	2132	1153	144	< 35		93.7	18.8
Site 2 biofilm	n/a	311	42	363	22	15386	2150	1248	156	< 35		87.0	17.5
Site 3 biofilm	n/a	140	19	137	8	15726	2198	1102	138	< 35		30.5	6.1
Site 5 biofilm	n/a	163	22	217	13	14489	2025	1342	168	< 35		27.0	5.4
Site 9 biofilm	n/a	101	14	< 45		27485	3841	652	81	< 35		13.6	2.7
Site 13 biofilm	n/a	28	4	< 45		289151	40413	4103	513	< 35		14.5	2.9

Std / Core / Sample ID	Avg Depth		Pd			Nb			Bi			Cr			V			Ti	
			µg/g	± SEM		µg/g	± SEM		µg/g	± SEM		µg/g	± SEM		µg/g	± SEM		µg/g	± SEM
Blank (SiO2)	n/a	<	3		<	2		<	4		<	18		<	10		<	400	
Blank (SiO2)	n/a	<	3		<	2		<	4		<	18		<	10		<	400	
Blank (SiO2)	n/a	<	3		<	2		<	4		<	18			8	1	<	400	
Blank (SiO2)	n/a	<	3		<	2		<	4		<	18			13	2	<	400	
Blank (SiO2)	n/a	<	3		<	2		<	4		<	18		<	10		<	400	
Blank (SiO2)	n/a	<	3		<	2		<	4		<	18			7	1	<	400	
Blank (SiO2)	n/a	<	3		<	2		<	4		<	18			8	1	<	400	
Blank (SiO2)	n/a	<	3		<	2		<	4		<	18		<	10		<	400	
NIST 2702 Standard	n/a		4	1		61	13		13	3		489	97		645	117		7258	1211
NIST 2702 Standard	n/a		4	1		64	14		16	4		487	96		663	120		7498	1251
NIST 2702 Standard	n/a	<	3			63	14		16	4		511	101		683	123		7284	1215
NIST 2702 Standard	n/a	<	3			62	14		19	4		487	96		646	117		7311	1220
NIST 2702 Standard	n/a	<	3			60	13		16	4		478	95		612	110		7130	1189
NIST 2702 Standard	n/a	<	3			64	14		15	3		483	96		661	119		7329	1223
NIST 2702 Standard	n/a		4	1		63	14		16	4		477	94		661	119		7457	1244
NIST 2709a STANDARD	n/a		4	1		11	2	<	4			207	41		370	67		3003	501
NIST 2709a STANDARD	n/a	<	3			11	2	<	4			198	39		360	65		3003	501
NIST 2709a STANDARD	n/a	<	3			10	2	<	4			181	36		384	69		2831	472
NIST 2709a STANDARD	n/a	<	3			10	2	<	4			180	36		367	66		2929	489
NIST 2709a STANDARD	n/a	<	3			10	2	<	4			174	34		355	64		2903	484
NIST 2709a STANDARD	n/a		4	1		11	2	<	4			202	40		349	63		2923	488
NIST 2709a STANDARD	n/a	<	3			10	2	<	4			172	34		353	64		2964	494
Control Composite (no added tin)	n/a	<	3			2	0	<	4			33	7		72	13		2780	464
Tin Std 28.587 ppm	n/a	<	3			3	1	<	4			32	6		90	16		2180	364
Tin Std 28.587 ppm	n/a	<	3			2	0	<	4			34	7		79	14		1658	277
Tin Std 28.587 ppm	n/a	<	3			3	1	<	4			16	3		48	9		1292	215
Tin Std 28.587 ppm	n/a	<	3			2	0	<	4			18	4		43	8		1416	236
Tin Std 28.587 ppm	n/a	<	3			2	0	<	4			21	4		59	11		1485	248
Tin Std 28.587 ppm	n/a	<	3			3	1	<	4		<	18			69	13		1721	287
Tin Std 60.517 ppm	n/a	<	3			2	0	<	4		<	18			53	10		1295	216
Tin Std 60.517 ppm	n/a	<	3			2	0	<	4			32	6		73	13		1555	259
Tin Std 60.517 ppm	n/a	<	3			11	2	<	4			27	5		80	15		1785	298
Tin Std 60.517 ppm	n/a	<	3			3	1	<	4			26	5		60	11		1060	177
Tin Std 60.517 ppm	n/a	<	3			3	1	<	4			16	3		56	10		1353	226
Tin Std 87.548 ppm	n/a	<	3			4	1	<	4			52	10		80	14		1600	267
Tin Std 87.548 ppm	n/a	<	3			4	1	<	4		<	18			59	11		1361	227
Tin Std 87.548 ppm	n/a	<	3			2	0	<	4			20	4		57	10		1196	200
Tin Std 113.387 ppm	n/a	<	3			2	0	<	4		<	18			59	11		1447	241
Tin Std 113.387 ppm	n/a	<	3			2	0	<	4		<	18			52	9		1363	227
Tin Std 113.387 ppm	n/a	<	3			2	0	<	4			17	3		77	14		1383	231
Tin Std 113.387 ppm	n/a	<	3			2	0	<	4			23	5		68	12		1650	275
Tin Std 113.387 ppm	n/a	<	3		<	2		<	4			22	4		54	10		1074	179
Tin Std 113.387 ppm	n/a	<	3			5	1	<	4			42	8		83	15		1858	310
Tin Std 174.792 ppm	n/a	<	3			4	1	<	4		<	18			66	12		1747	291
Tin Std 174.792 ppm	n/a	<	3			3	1	<	4			20	4		69	12		1636	273
Tin Std 174.792 ppm	n/a	<	3			2	0	<	4			48	9		70	13		1707	285
Tin Std 174.792 ppm	n/a	<	3			3	1	<	4		<	18			54	10		1347	225

Std / Core / Sample ID	Avg Depth	Pd µg/g	Pd ± SEM	Nb µg/g	Nb ± SEM	Bi µg/g	Bi ± SEM	Cr µg/g	Cr ± SEM	V µg/g	V ± SEM	Ti µg/g	Ti ± SEM
Tin Std 234.069 ppm	n/a	< 3		3	1	< 4		21	4	63	11	1488	248
Tin Std 234.069 ppm	n/a	< 3		4	1	< 4		34	7	73	13	1265	211
Tin Std 234.069 ppm	n/a	< 3		2	0	< 4		< 18		61	11	1356	226
Tin Std 234.069 ppm	n/a	< 3		3	1	< 4		< 18		41	7	1053	176
Tin Std 234.069 ppm	n/a	< 3		4	1	< 4		< 18		51	9	1554	259
Control 0-0.5 in.	0.25	< 3		< 2		< 4		< 18		19	3	599	100
Control 0.5-1 in.	0.75	< 3		5	1	< 4		49	10	92	17	1719	287
Control 1-1.5 in.	1.25	< 3		8	2	< 4		44	9	108	19	2330	389
Control 1.5-2.5 in.	2.00	< 3		2	1	< 4		< 18		87	16	1564	261
Control 2.5-3.5 in.	3.00	< 3		12	3	< 4		32	6	125	23	2296	383
Site 2, 0-0.5 in.	0.25	< 3		2	1	< 4		34	7	30	5	433	72
Site 2, 0.5-1 in.	0.75	< 3		2	0	< 4		< 18		28	5	577	96
Site 2, 1-1.5 in.	1.25	< 3		7	1	< 4		< 18		21	4	882	147
Site 2, 1.5-2.5 in.	2.00	< 3		< 2		< 4		< 18		30	5	677	113
Site 2, 2.5-3.5 in.	3.00	< 3		< 2		< 4		< 18		11	2	425	71
Site 2, 3.5-4.5 in.	4.00	< 3		5	1	< 4		< 18		19	3	1490	248
Site 3, 0-0.5 in.	0.25	< 3		4	1	< 4		16	3	37	7	888	148
Site 3, 0.5-1 in.	0.75	< 3		5	1	< 4		< 18		49	9	1191	199
Site 3, 1-1.5 in.	1.25	< 3		4	1	< 4		< 18		70	13	1543	257
Site 5, 0-0.5 in.	0.25	< 3		100	22	9	2	< 18		100	18	9744	1625
Site 5, 0.5-1 in.	0.75	< 3		59	13	10	2	< 18		71	13	3529	589
Site 5, 1-1.5 in.	1.25	< 3		14	3	< 4		< 18		96	17	1714	286
Site 5, 1.5-2.5 in.	2.00	< 3		6	1	< 4		< 18		55	10	1589	265
Site 5, 2.5-3.5 in.	3.00	< 3		8	2	5	1	50	10	176	32	1909	318
Site 5, 3.5-4.5 in.	4.00	< 3		22	5	4	1	57	11	172	31	3069	512
TBP-0, Control	n/a	< 3		5	1	< 4		41	8	128	23	2616	436
TBP-1, 0-1.5 in.	0.75	< 3		22	5	10	2	147	29	337	61	5193	866
TBP-1, 1.5-3 in.	2.25	< 3		< 2		< 4		< 18		73	13	1440	240
TBP-1, 3-4.5 in.	3.75	< 3		19	4	14	3	158	31	363	66	5118	854
TBP-2, 0-1.5 in.	0.75	< 3		30	6	18	4	173	34	349	63	5854	977
TBP-2, 1.5-3 in.	2.25	< 3		30	6	19	4	181	36	372	67	5906	985
TBP-2, 3-4.5 in.	3.75	< 3		29	6	25	5	191	38	388	70	5909	986
TBP-3, 0-1.5 in.	0.75	< 3		30	6	17	4	162	32	356	64	5517	920
TBP-3, 1.5-3 in.	2.25	< 3		19	4	9	2	148	29	336	61	4964	828
TBP-4, 0-1.5 in.	0.75	< 3		31	7	20	4	158	31	339	61	5894	983
TBP-4, 1.5-3 in.	2.25	< 3		23	5	11	2	121	24	267	48	4792	799
TBP-4, 3-4.5 in.	3.75	< 3		16	4	5	1	96	19	212	38	4176	697
TBP-5, 0-1.5 in.	0.75	< 3		5	1	< 4		< 18		68	12	1536	256
TBP-5, 1.5-3 in.	2.25	< 3		2	1	< 4		25	5	66	12	1707	285
TBP-6, 0-1.5 in.	0.75	< 3		26	6	15	3	145	29	311	56	5104	851
TBP-6, 1.5-3 in.	2.25	< 3		3	1	< 4		< 18		63	11	1431	239
TBP-6, 3-4.5 in.	3.75	< 3		4	1	< 4		< 18		71	13	1367	228
TBP-7, 0-1.5 in.	0.75	< 3		17	4	4	1	100	20	228	41	3966	662
TBP-7, 1.5-3 in.	2.25	< 3		7	2	< 4		35	7	129	23	2439	407
TBP-8, 0-1.5 in.	0.75	< 3		21	4	6	1	103	20	239	43	4139	690
TBP-8, 1.5-3 in.	2.25	< 3		4	1	< 4		< 18		32	6	1252	209
TBP-9, 0-1.5 in.	0.75	< 3		21	5	9	2	106	21	237	43	4168	695

Std / Core / Sample ID	Avg Depth	Pd		Nb		Bi		Cr		V		Ti	
		µg/g	± SEM	µg/g	± SEM	µg/g	± SEM	µg/g	± SEM	µg/g	± SEM	µg/g	± SEM
TBP-9, 1.5-3 in.	2.25	< 3		9	2	< 4		< 18		100	18	1914	319
TBP-10, 0-1.5 in.	0.75	< 3		11	2	< 4		60	12	144	26	3016	503
TBP-10, 1.5-3 in.	2.25	< 3		< 2		< 4		< 18		33	6	1139	190
TBP-11, 0-1.5 in.	0.75	< 3		< 2		< 4		< 18		24	4	942	157
TBP-11, 1.5-3 in.	2.25	< 3		5	1	< 4		< 18		36	6	1038	173
TBP-12, 0-1.5 in.	0.75	< 3		9	2	< 4		< 18		84	15	1967	328
TBP-12, 1.5-3 in.	2.25	< 3		16	4	12	3	41	8	124	22	2595	433
TBP-12, 1.5-3 in.	3.75	< 3		21	5	14	3	46	9	129	23	3420	571
TBP-13, 0-1.5 in.	0.75	< 3		20	4	5	1	87	17	220	40	3986	665
TBP-13, 1.5-3 in.	2.25	< 3		6	1	< 4		63	12	134	24	2661	444
Site 8, fine, 0-0.5 in.	0.25	< 3		32	7	18	4	178	35	355	64	5948	992
Site 8, fine, 0.5-1 in.	0.75	< 3		33	7	22	5	174	34	363	66	5923	988
Site 8, fine, 1-1.5 in.	1.25	< 3		33	7	19	4	167	33	347	63	5882	981
Site 8, fine, 1.5-2.5 in.	2.00	< 3		33	7	20	4	172	34	360	65	5900	984
Site 8, fine, 2.5-3.5 in.	3.00	< 3		29	6	19	4	155	31	342	62	5672	946
Site 8, fine, 3.5-4.5 in.	4.00	< 3		19	4	10	2	125	25	261	47	4638	774
Site 8, sandy, 0-0.5 in.	0.25	< 3		4	1	< 4		< 18		75	13	1737	290
Site 8, sandy, 0.5-1 in.	0.75	< 3		4	1	< 4		< 18		71	13	2037	340
Site 8, sandy, 1-1.5 in.	1.25	< 3		< 2		< 4		< 18		35	6	867	145
Site 8, sandy, 1.5-2.5 in.	2.00	< 3		10	2	< 4		55	11	160	29	3309	552
Site 8, sandy, 2.5-3.5 in.	3.00	< 3		7	2	< 4		27	5	128	23	2340	390
Site 8, sandy, 3.5-4.5 in.	4.00	< 3		12	3	< 4		< 18		20	4	2009	335
Site 10, 0-1.5 in.	0.75	< 3		4	1	< 4		< 18		< 10		461	77
Site 10, 1.5-3 in.	2.25	< 3		< 2		< 4		< 18		92	17	923	154
Site 10, 3-4.5 in.	3.75	< 3		< 2		< 4		< 18		12	2	223	37
Site 9, mid, 0-0.5 in.	0.25	< 3		2	0	< 4		< 18		53	10	995	166
Site 9, mid, 0.5-1 in.	0.75	< 3		35	8	< 4		92	18	242	44	4635	773
Site 9, mid, 1-1.5 in.	1.25	4	1	47	10	< 4		117	23	290	52	5081	848
Site 9, mid, 1.5-2.5 in.	2.00	< 3		39	9	< 4		126	25	285	51	5168	862
Site 9, mid, 2.5-3.5 in.	3.00	< 3		43	9	< 4		146	29	353	64	5385	898
Site 9, mid, 3.5-4.5 in.	4.00	< 3		33	7	< 4		112	22	292	53	5464	912
Site 9, mid, 4.5-5.5 in.	5.00	< 3		26	6	< 4		98	19	262	47	5047	842
Site 9, edge, 0-0.5 in.	0.25	< 3		16	3	< 4		21	4	90	16	1828	305
Site 9, edge, 0.5-1 in.	0.75	< 3		17	4	6	1	< 18		60	11	1659	277
Site 9, edge, 1-1.5 in.	1.25	< 3		26	6	6	1	< 18		49	9	2052	342
Site 9, edge, 1.5-2.5 in.	2.00	< 3		60	13	23	5	< 18		85	15	3911	652
Site 11, 0-0.5 in.	0.25	< 3		8	2	< 4		18	4	89	16	2689	449
Site 11, 0.5-1 in.	0.75	< 3		7	2	< 4		51	10	132	24	3646	608
Site 11, 1-1.5 in.	1.25	< 3		5	1	< 4		< 18		69	12	2195	366
Site 11, 1.5-2.5 in.	2.00	< 3		2	0	< 4		< 18		24	4	1108	185
Site 11, 2.5-3 in.	2.75	< 3		< 2		< 4		< 18		57	10	1154	192
Site 12, fine, 0-0.5 in.	0.25	< 3		10	2	< 4		23	5	98	18	2299	384
Site 12, 0.5-1 in.	0.75	< 3		7	2	< 4		42	8	92	17	2166	361
Site 12, 1-1.5 in.	1.25	< 3		12	3	< 4		59	12	159	29	2752	459
Site 12, 1.5-2.5 in.	2.00	< 3		6	1	< 4		< 18		80	14	1686	281
Site 12, 2.5-3.5 in.	3.00	< 3		8	2	< 4		< 18		75	14	1846	308
Site 12, sandy, 0-0.5 in.	0.25	< 3		3	1	< 4		< 18		< 10		852	142

Std / Core / Sample ID	Avg Depth		Pd			Nb			Bi			Cr			V		Ti	
			µg/g	± SEM		µg/g	± SEM		µg/g	± SEM		µg/g	± SEM		µg/g	± SEM	µg/g	± SEM
Site 12, sandy, 0.5-1 in.	0.75	<	3			5	1	<	4		<	18			16	3	1757	293
Site 12, sandy, 1-1.5 in.	1.25	<	3			7	1	<	4		<	18			20	4	868	145
Site 12, sandy, 1.5-2.5 in.	2.00	<	3			2	0	<	4		<	18			14	3	697	116
Site 12, sandy, 2.5-3.5 in.	3.00	<	3			9	2	<	4		<	18			71	13	1447	241
Site 12, sandy, 3.5-4 in.	4.00	<	3			5	1	<	4		<	18			53	10	1265	211
Site 20 BP2D 0-0.5 in.	0.25		4	1		53	11		8	2		225	45		386	70	5646	942
Site 20 BP2D 0.5-1 in.	0.75		4	1		56	12		6	1		211	42		385	69	5703	951
Site 20 BP2D 1-1.5 in.	1.25		5	1		49	11		9	2		215	43		377	68	5632	940
Site 20 BP2D 1.5-2.5 in.	2.00	<	3			5	1	<	4			38	8		121	22	1954	326
Site 20 BP2D 2.5-3.5 in.	3.00	<	3		<	2		<	4		<	18			56	10	753	126
Site 20 BP2D 3.5-4.5 in.	4.00	<	3		<	2		<	4		<	18			31	6	891	149
Site 20 BP2C 0-0.5 in.	0.25		6	1		42	9		5	1		225	45		385	70	5289	882
Site 20 BP2C 0.5-1 in.	0.75	<	3			44	10		7	2		218	43		381	69	5323	888
Site 20 BP2C 1-1.5 in.	1.25		3	1		34	7	<	4			172	34		333	60	4680	781
Site 20 BP2C 1.5-2.5 in.	2.00		4	1		35	8		5	1		166	33		349	63	4863	811
Site 20 BP2C 2.5-3.5 in.	3.00	<	3			32	7	<	4			164	32		336	61	4721	788
Site 20 BP2B 0-0.5 in.	0.25		3	0		55	12	<	4			196	39		391	71	5594	933
Site 20 BP2B 0.5-1 in.	0.75		5	1		45	10	<	4			174	34		346	63	5042	841
Site 20 BP2B 1-1.5 in.	1.25		5	1		41	9	<	4			157	31		315	57	4876	813
Site 20 BP2B 1.5-2.5 in.	2.00	<	3			28	6	<	4			135	27		270	49	4039	674
Site 20 BP2B 2.5-3.5 in.	3.00	<	3			6	1	<	4			27	5		111	20	1575	263
Site 20 BP2B 3.5-4.5 in.	4.00	<	3		<	2		<	4		<	18			58	10	932	155
Site 20 BP2B 4.5-5.25 in.	5.00	<	3		<	2		<	4		<	18			37	7	635	106
Site 20 BP2A 0-0.5 in.	0.25		5	1		55	12	<	4			204	40		367	66	5230	873
Site 20 BP2A 0.5-1 in.	0.75		5	1		57	12	<	4			208	41		389	70	5440	907
Site 20 BP2A 1-1.5 in.	1.25		4	1		51	11	<	4			190	38		364	66	5245	875
Site 20 BP2A 1.5-2.5 in.	2.00		5	1		55	12	<	4			199	39		370	67	5426	905
Site 20 BP2A 2.5-3.5 in.	3.00		4	1		60	13	<	4			207	41		376	68	5505	918
Site 20 BP2A 3.5-4.5 in.	4.00		4	1		60	13	<	4			191	38		371	67	5447	909
Site 20 BP2A 4.5-5.5 in.	5.00		3	0		45	10	<	4			176	35		330	60	4877	814
Site 20 BP2A 5.5-6.5 in.	6.00	<	3			44	10	<	4			156	31		327	59	4554	760
Site 13, 0-0.5 in.	0.25	<	3		<	2		<	4		<	18			29	5	207	35
Site 13, 0.5-1 in.	0.75	<	3		<	2		<	4		<	18			53	10	692	115
Site 13, 1-1.5 in.	1.25	<	3			14	3	<	4		<	18			16	3	285	48
Site 13, 1.5-2.5 in.	2.00	<	3		<	2		<	4		<	18			21	4	351	59
Site 13, 2.5-2.75 in.	2.63	<	3			4	1	<	4		<	18			19	3	702	117
Site 15 (BP3), 0-0.5 in.	0.25		3	0		15	3	<	4		<	18			109	20	3540	591
Site 15 (BP3), 0.5-1 in.	0.75	<	3			12	3	<	4		<	18			96	17	3563	594
Site 15 (BP3), 1-1.5 in.	1.25	<	3			12	3	<	4		<	18			49	9	3484	581
Site 15 (BP3), 1.5-2.5 in.	2.00	<	3			7	1	<	4		<	18			92	17	3389	565
Site 15 (BP3), 2.5-3.5 in.	3.00	<	3			8	2	<	4		<	18			53	10	2860	477
Site 15 (BP3), 3.5-4.5 in.	4.00	<	3			6	1	<	4		<	18			39	7	2806	468
Site 15 (BP3), 4.5-5.5 in.	5.00	<	3			4	1	<	4		<	18			21	4	2051	342
Site 16 (BP3 channel), 0-0.5 in	0.25	<	3			6	1	<	4		<	18			58	11	1309	218
Site 16 (BP3 channel), 0.5-1 in	0.75	<	3		<	2		<	4		<	18		<	10		999	167
Site 16 (BP3 channel), 1-1.5 in	1.25	<	3			2	0	<	4		<	18			12	2	347	58
Site 16 (BP3 channel) 1.5-2.5 i	2.00	<	3		<	2		<	4		<	18			26	5	422	70

Std / Core / Sample ID	Avg Depth		Pd			Nb			Bi			Cr			V			Ti	
			µg/g	± SEM		µg/g	± SEM		µg/g	± SEM		µg/g	± SEM		µg/g	± SEM		µg/g	± SEM
Site 16 (BP3 channel) 2.5-3.5 i	3.00	<	3		<	2		<	4		<	18			22	4		181	30
Site 17 (BP4) 0-0.5 in.	0.25	<	3			22	5	<	4			81	16		203	37		4708	785
Site 17 (BP4) 0.5-1 in.	0.75	<	3			26	6	<	4			111	22		267	48		5774	963
Site 17 (BP4) 1-1.5 in.	1.25	<	3			26	6		5	1		93	18		258	47		5660	944
Site 17 (BP4) 1.5-2.5 in.	2.00	<	3			19	4	<	4			104	21		257	46		5261	878
Site 17 (BP4) 2.5-3.5 in.	3.00	<	3			19	4	<	4			76	15		207	37		4869	812
Site 17 (BP4) 3.5-4.5 in.	4.00	<	3			8	2	<	4			42	8		89	16		1815	303
Site 17 (BP4) 4.5-5.5 in.	5.00	<	3			9	2	<	4			24	5		80	15		2463	411
Site 19 (BP5 pond) 0-0.5 in.	0.25	<	3			11	2	<	4		<	18			86	15		2823	471
Site 19 (BP5 pond) 0.5-1 in.	0.75	<	3			10	2	<	4			31	6		106	19		2195	366
Site 19 (BP5 pond) 1-1.5 in.	1.25	<	3			6	1	<	4		<	18			20	4		1797	300
Site 19 (BP5 pond) 1.5-2.5 in.	2.00	<	3			4	1	<	4		<	18			17	3		957	160
Site 19 (BP5 pond) 2.5-3.5 in.	3.00	<	3			10	2	<	4		<	18			38	7		1289	215
Site 18 (BP5 channel) 0-0.5 in.	0.25	<	3			24	5		4	1		93	18		209	38		4228	705
Site 18 (BP5 channel) 0.5-1 in.	0.75	<	3			23	5	<	4			70	14		189	34		4032	673
Site 18 (BP5 channel) 1-1.5 in.	1.25	<	3			14	3	<	4			18	4		107	19		2975	496
Site 18 (BP5 channel) 1.5-2.5 i	2.00	<	3			10	2	<	4		<	18			79	14		2029	338
Site 18 (BP5 channel) 2.5-3.5 i	3.00	<	3		<	2		<	4		<	18		<	10			688	115
Site 18 (BP5 channel) 3.5-4.5 i	4.00	<	3		<	2		<	4		<	18			11	2		432	72
Site 18 (BP5 channel) 4.5-5.5 i	5.00	<	3			9	2	<	4		<	18			31	6		1524	254
Site 18 (BP5 channel) 5.5-6 in.	6.00	<	3			17	4		18	4	<	18			20	4		1352	226
Site 14, 0-0.5 in.	0.25	<	3			4	1	<	4		<	18		<	10			941	157
Site 14, 0.5-1 in.	0.75	<	3			54	12		27	6	<	18		<	10			1292	216
Site 14, 1-1.5 in.	1.25	<	3			33	7	<	4		<	18		<	10			2375	396
Site 14, 1.5-2.5 in.	2.00	<	3			106	23		130	28	<	18			78	14		2057	343
Site 14, 2.5-3.5 in.	3.00	<	3			16	4	<	4		<	18		<	10			1197	200
Site 14, 3.5-3.75 in.	3.63	<	3			34	7		35	8	<	18			22	4		3797	633
control biofilm	n/a		4	1		12	3	<	4			66	13		184	33		2557	427
site 1 biofilm	n/a		7	1		156	34		6	1		220	44		120	22		1404	234
Site 2 biofilm	n/a		8	1		173	38		7	2		230	46		130	23		1074	179
Site 3 biofilm	n/a		3	0		82	18	<	4			86	17		152	27		2340	390
Site 5 biofilm	n/a		3	0		99	21	<	4			86	17		167	30		2129	355
Site 9 biofilm	n/a	<	3			59	13		22	5		96	19		205	37		3685	615
Site 13 biofilm	n/a		6	1		110	24	<	4			172	34		164	30		1350	225

Std / Core / Sample ID	Avg Depth		Ca			K			Al			P			Si			Cl	
			µg/g	± SEM		µg/g	± SEM		µg/g	± SEM		µg/g	± SEM		µg/g	± SEM		µg/g	± SEM
Blank (SiO2)	n/a	<	65		<	300		<	1000		<	250.0			411888	15196		140	22
Blank (SiO2)	n/a	<	65		<	300		<	1000		<	250.0			410640	15150		160	25
Blank (SiO2)	n/a	<	65		<	300		<	1000		<	250.0			412237	15209		217	34
Blank (SiO2)	n/a	<	65		<	300		<	1000		<	250.0			412926	15235		163	26
Blank (SiO2)	n/a	<	65		<	300		<	1000		<	250.0			411687	15189		237	37
Blank (SiO2)	n/a	<	65		<	300		<	1000		<	250.0			407974	15052		207	33
Blank (SiO2)	n/a	<	65		<	300		<	1000		<	250.0			393328	14512		60	9
Blank (SiO2)	n/a	<	65		<	300		<	1000		<	250.0			402098	14835		107	17
NIST 2702 Standard	n/a		2949	657		18866	3039		64025	4380		1063.0	157.4		218702	8069		6518	1027
NIST 2702 Standard	n/a		3125	696		19323	3113		64035	4380		1128.9	167.1		217520	8025		6507	1025
NIST 2702 Standard	n/a		3081	686		18980	3057		62615	4283		1096.3	162.3		216385	7983		6518	1027
NIST 2702 Standard	n/a		3021	673		18702	3012		62258	4259		931.5	137.9		214475	7913		6446	1016
NIST 2702 Standard	n/a		2941	655		18476	2976		60649	4149		908.3	134.5		209834	7742		6271	988
NIST 2702 Standard	n/a		2990	666		19025	3064		63057	4314		1135.6	168.1		215534	7952		6524	1028
NIST 2702 Standard	n/a		2971	661		19357	3118		65126	4455		959.5	142.0		221960	8189		6636	1046
NIST 2709a STANDARD	n/a		19211	4278		16944	2729		52974	3624	<	250.0			259118	9560		543	86
NIST 2709a STANDARD	n/a		19318	4302		16972	2734		52267	3575	<	250.0			258565	9540		571	90
NIST 2709a STANDARD	n/a		18881	4204		16853	2715		51415	3517	<	250.0			257273	9492		624	98
NIST 2709a STANDARD	n/a		18921	4213		16478	2654		50052	3424	<	250.0			254045	9373		616	97
NIST 2709a STANDARD	n/a		19101	4253		17007	2739		52330	3580	<	250.0			258298	9530		660	104
NIST 2709a STANDARD	n/a		19218	4279		16652	2682		52663	3603	<	250.0			259953	9591		618	97
NIST 2709a STANDARD	n/a		19114	4256		16960	2732		51899	3550	<	250.0			256328	9457		514	81
Control Composite (no added tin)	n/a		139	31		994	160		43198	2955	<	250.0			233418	8612		354	56
Tin Std 28.587 ppm	n/a		302	67		1040	168		47259	3233	<	250.0			222906	8224		998	157
Tin Std 28.587 ppm	n/a		83	19		1049	169		43708	2990	<	250.0			248503	9168		1060	167
Tin Std 28.587 ppm	n/a	<	65			547	88		31823	2177	<	250.0			277381	10234		933	147
Tin Std 28.587 ppm	n/a		121	27		1249	201		37308	2552	<	250.0			279835	10324		1096	173
Tin Std 28.587 ppm	n/a		106	24		1554	250		35554	2432	<	250.0			256685	9470		1095	173
Tin Std 28.587 ppm	n/a	<	65			922	148		41588	2845	<	250.0			279404	10308		750	118
Tin Std 60.517 ppm	n/a	<	65			722	116		40581	2776	<	250.0			263611	9726		1448	228
Tin Std 60.517 ppm	n/a	<	65			714	115		43853	3000	<	250.0			268217	9896		1672	263
Tin Std 60.517 ppm	n/a	<	65			902	145		38809	2655	<	250.0			292100	10777		1436	226
Tin Std 60.517 ppm	n/a	<	65			1328	214		32012	2190	<	250.0			292642	10797		1491	235
Tin Std 60.517 ppm	n/a	<	65			851	137		30880	2112	<	250.0			278483	10274		1471	232
Tin Std 87.548 ppm	n/a		171	38		882	142		39140	2677	<	250.0			268791	9917		1937	305
Tin Std 87.548 ppm	n/a	<	65			629	101		36477	2495	<	250.0			281310	10379		1991	314
Tin Std 87.548 ppm	n/a		138	31		1492	240		35217	2409	<	250.0			283812	10471		1995	314
Tin Std 113.387 ppm	n/a		146	33		652	105		40368	2761	<	250.0			263292	9714		2636	415
Tin Std 113.387 ppm	n/a	<	65			652	105		38003	2600	<	250.0			267744	9878		2605	410
Tin Std 113.387 ppm	n/a		149	33		1061	171		34720	2375	<	250.0			267169	9857		2604	410
Tin Std 113.387 ppm	n/a	<	65			1232	198		39494	2702	<	250.0			268747	9915		2675	421
Tin Std 113.387 ppm	n/a	<	65			565	91		31637	2164	<	250.0			269230	9933		2197	346
Tin Std 113.387 ppm	n/a	<	65			728	117		35472	2426	<	250.0			261516	9648		2175	343
Tin Std 174.792 ppm	n/a	<	65			802	129		42837	2930	<	250.0			253435	9350		3896	614
Tin Std 174.792 ppm	n/a	<	65			1130	182		42448	2904	<	250.0			261820	9660		3572	563
Tin Std 174.792 ppm	n/a	<	65			729	117		41989	2872	<	250.0			260567	9613		3710	585
Tin Std 174.792 ppm	n/a	<	65			714	115		31764	2173	<	250.0			281347	10380		2917	460

Std / Core / Sample ID	Avg Depth	Ca		K		Al		P		Si		Cl	
		µg/g	± SEM	µg/g	± SEM	µg/g	± SEM	µg/g	± SEM	µg/g	± SEM	µg/g	± SEM
Tin Std 234.069 ppm	n/a	178	40	1204	194	38205	2613	< 250.0		263115	9707	4868	767
Tin Std 234.069 ppm	n/a	207	46	876	141	34126	2334	< 250.0		279564	10314	4412	695
Tin Std 234.069 ppm	n/a	141	31	635	102	29239	2000	< 250.0		273818	10102	4111	648
Tin Std 234.069 ppm	n/a	< 65		1016	164	27953	1912	< 250.0		294953	10882	3898	614
Tin Std 234.069 ppm	n/a	< 65		741	119	41181	2817	< 250.0		267851	9882	4836	762
Control 0-0.5 in.	0.25	156	35	623	100	16419	1123	< 250.0		338706	12496	241	38
Control 0.5-1 in.	0.75	81	18	1030	166	45274	3097	235.7	34.9	259277	9566	394	62
Control 1-1.5 in.	1.25	123	27	1122	181	53997	3694	< 250.0		243036	8967	364	57
Control 1.5-2.5 in.	2.00	1714	382	1579	254	37558	2569	< 250.0		254961	9407	455	72
Control 2.5-3.5 in.	3.00	2163	482	2731	440	46937	3211	269.8	39.9	236014	8708	431	68
Site 2, 0-0.5 in.	0.25	< 65		851	137	23517	1609	4445.5	658.1	327456	12081	231	36
Site 2, 0.5-1 in.	0.75	< 65		814	131	15339	1049	500.6	74.1	357103	13175	157	25
Site 2, 1-1.5 in.	1.25	< 65		945	152	16616	1137	< 250.0		343166	12661	129	20
Site 2, 1.5-2.5 in.	2.00	260	58	1521	245	15127	1035	< 250.0		343149	12660	227	36
Site 2, 2.5-3.5 in.	3.00	< 65		3005	484	13088	895	< 250.0		348491	12857	132	21
Site 2, 3.5-4.5 in.	4.00	< 65		509	82	15548	1064	< 250.0		349352	12889	258	41
Site 3, 0-0.5 in.	0.25	< 65		660	106	18323	1253	< 250.0		331420	12227	261	41
Site 3, 0.5-1 in.	0.75	133	30	801	129	21234	1453	< 250.0		326017	12028	164	26
Site 3, 1-1.5 in.	1.25	224	50	1035	167	38300	2620	237.7	35.2	275584	10167	410	65
Site 5, 0-0.5 in.	0.25	< 65		1081	174	37857	2590	1913.1	283.2	318817	11763	373	59
Site 5, 0.5-1 in.	0.75	< 65		821	132	30889	2113	< 250.0		340037	12545	242	38
Site 5, 1-1.5 in.	1.25	< 65		1245	200	37892	2592	< 250.0		277605	10242	392	62
Site 5, 1.5-2.5 in.	2.00	< 65		1022	165	33795	2312	< 250.0		303878	11211	259	41
Site 5, 2.5-3.5 in.	3.00	415	92	1089	175	37698	2579	< 250.0		281761	10395	313	49
Site 5, 3.5-4.5 in.	4.00	185	41	1601	258	57691	3946	< 250.0		221179	8160	498	79
TBP-0, Control	n/a	< 65		1760	283	52066	3562	432.9	64.1	251724	9287	447	70
TBP-1, 0-1.5 in.	0.75	1302	290	3006	484	84140	5756	663.5	98.2	181555	6698	572	90
TBP-1, 1.5-3 in.	2.25	< 65		985	159	43717	2990	< 250.0		277141	10225	420	66
TBP-1, 3-4.5 in.	3.75	567	126	3167	510	85701	5862	560.8	83.0	170968	6308	583	92
TBP-2, 0-1.5 in.	0.75	1421	316	3435	553	93364	6387	< 250.0		187744	6927	596	94
TBP-2, 1.5-3 in.	2.25	940	209	3329	536	97806	6691	< 250.0		178346	6580	598	94
TBP-2, 3-4.5 in.	3.75	767	171	3594	579	99346	6796	658.6	97.5	175178	6463	643	101
TBP-3, 0-1.5 in.	0.75	2403	535	3436	553	85937	5879	< 250.0		180419	6656	588	93
TBP-3, 1.5-3 in.	2.25	1797	400	3011	485	76765	5251	630.4	93.3	167323	6173	535	84
TBP-4, 0-1.5 in.	0.75	1402	312	3316	534	83864	5737	< 250.0		188647	6960	624	98
TBP-4, 1.5-3 in.	2.25	404	90	2782	448	84830	5803	492.5	72.9	200097	7382	536	85
TBP-4, 3-4.5 in.	3.75	< 65		2150	346	76773	5252	343.4	50.8	212246	7831	504	79
TBP-5, 0-1.5 in.	0.75	< 65		904	146	35977	2461	< 250.0		305945	11288	326	51
TBP-5, 1.5-3 in.	2.25	897	200	1299	209	39366	2693	< 250.0		256587	9467	472	74
TBP-6, 0-1.5 in.	0.75	1288	287	2774	447	84032	5748	607.5	89.9	176856	6525	591	93
TBP-6, 1.5-3 in.	2.25	< 65		864	139	41103	2812	< 250.0		288546	10646	316	50
TBP-6, 3-4.5 in.	3.75	< 65		971	156	38947	2664	< 250.0		279803	10323	307	48
TBP-7, 0-1.5 in.	0.75	979	218	2189	353	73191	5007	< 250.0		197333	7280	573	90
TBP-7, 1.5-3 in.	2.25	< 65		1350	217	57965	3965	240.3	35.6	239909	8851	426	67
TBP-8, 0-1.5 in.	0.75	1104	246	2246	362	80220	5488	< 250.0		198592	7327	568	90
TBP-8, 1.5-3 in.	2.25	< 65		736	119	33505	2292	< 250.0		302540	11162	386	61
TBP-9, 0-1.5 in.	0.75	1090	243	2071	334	75201	5144	< 250.0		200034	7380	526	83

Std / Core / Sample ID	Avg Depth	Ca		K		Al		P		Si		Cl	
		µg/g	± SEM	µg/g	± SEM	µg/g	± SEM	µg/g	± SEM	µg/g	± SEM	µg/g	± SEM
TBP-9, 1.5-3 in.	2.25	590	131	1295	209	44720	3059	< 250.0		245273	9049	384	61
TBP-10, 0-1.5 in.	0.75	417	93	1751	282	60740	4155	338.6	50.1	207377	7651	2366	373
TBP-10, 1.5-3 in.	2.25	< 65		929	150	32166	2200	< 250.0		309312	11412	1106	174
TBP-11, 0-1.5 in.	0.75	< 65		553	89	27809	1902	< 250.0		319707	11795	268	42
TBP-11, 1.5-3 in.	2.25	< 65		490	79	23705	1622	< 250.0		333323	12298	305	48
TBP-12, 0-1.5 in.	0.75	< 65		1117	180	47317	3237	241.1	35.7	287053	10591	389	61
TBP-12, 1.5-3 in.	2.25	148	33	1319	212	54101	3701	< 250.0		256059	9447	449	71
TBP-12, 1.5-3 in.	3.75	91	20	1438	232	59123	4044	< 250.0		250495	9242	460	72
TBP-13, 0-1.5 in.	0.75	2041	454	2074	334	73444	5024	545.6	80.8	202063	7455	541	85
TBP-13, 1.5-3 in.	2.25	429	96	1982	319	58493	4001	222.7	33.0	210291	7759	497	78
Site 8, fine, 0-0.5 in.	0.25	1443	321	3764	606	86931	5947	735.4	108.9	185422	6841	583	92
Site 8, fine, 0.5-1 in.	0.75	1147	255	3719	599	86839	5940	721.9	106.9	188289	6947	589	93
Site 8, fine, 1-1.5 in.	1.25	1059	236	3646	587	83901	5739	791.1	117.1	184796	6818	591	93
Site 8, fine, 1.5-2.5 in.	2.00	1018	227	3621	583	86586	5923	< 250.0		193792	7150	602	95
Site 8, fine, 2.5-3.5 in.	3.00	689	153	3275	528	88872	6079	< 250.0		193917	7154	598	94
Site 8, fine, 3.5-4.5 in.	4.00	415	92	2871	462	79761	5456	559.3	82.8	206368	7614	520	82
Site 8, sandy, 0-0.5 in.	0.25	< 65		1230	198	46343	3170	263.4	39.0	269026	9926	429	68
Site 8, sandy, 0.5-1 in.	0.75	< 65		1058	170	37959	2597	< 250.0		287530	10608	362	57
Site 8, sandy, 1-1.5 in.	1.25	< 65		504	81	26687	1826	< 250.0		322184	11887	255	40
Site 8, sandy, 1.5-2.5 in.	2.00	394	88	1864	300	61430	4202	326.8	48.4	231449	8539	505	80
Site 8, sandy, 2.5-3.5 in.	3.00	200	45	1610	259	47892	3276	< 250.0		270549	9982	373	59
Site 8, sandy, 3.5-4.5 in.	4.00	< 65		361	58	16965	1160	< 250.0		366778	13532	332	52
Site 10, 0-1.5 in.	0.75	< 65		147	24	3585	245	< 250.0		395319	14585	151	24
Site 10, 1.5-3 in.	2.25	120	27	1389	224	20340	1391	< 250.0		324972	11990	263	41
Site 10, 3-4.5 in.	3.75	< 65		299	48	5335	365	< 250.0		370979	13687	358	56
Site 9, mid, 0-0.5 in.	0.25	< 65		605	97	20925	1431	264.8	39.2	328944	12136	273	43
Site 9, mid, 0.5-1 in.	0.75	1066	237	2410	388	58968	4034	1757.3	260.1	230500	8504	476	75
Site 9, mid, 1-1.5 in.	1.25	1248	278	2616	421	63915	4372	2173.0	321.7	222513	8209	499	79
Site 9, mid, 1.5-2.5 in.	2.00	1429	318	2633	424	66971	4581	1890.2	279.8	219248	8089	513	81
Site 9, mid, 2.5-3.5 in.	3.00	2235	498	2710	437	65518	4482	1744.8	258.3	195723	7221	513	81
Site 9, mid, 3.5-4.5 in.	4.00	1527	340	2682	432	68615	4694	1945.3	288.0	225058	8303	482	76
Site 9, mid, 4.5-5.5 in.	5.00	1322	294	2492	401	61533	4209	1894.5	280.5	222617	8213	486	77
Site 9, edge, 0-0.5 in.	0.25	178	40	1184	191	35526	2430	350.5	51.9	288759	10654	400	63
Site 9, edge, 0.5-1 in.	0.75	< 65		683	110	24336	1665	< 250.0		347615	12825	250	39
Site 9, edge, 1-1.5 in.	1.25	< 65		1308	211	21748	1488	< 250.0		331481	12230	349	55
Site 9, edge, 1.5-2.5 in.	2.00	< 65		978	158	30663	2098	< 250.0		314089	11588	356	56
Site 11, 0-0.5 in.	0.25	216	48	1577	254	47301	3236	482.6	71.4	272318	10047	469	74
Site 11, 0.5-1 in.	0.75	348	78	2129	343	53586	3666	511.3	75.7	227749	8403	498	78
Site 11, 1-1.5 in.	1.25	< 65		1461	235	43058	2945	427.9	63.3	280370	10344	401	63
Site 11, 1.5-2.5 in.	2.00	< 65		735	118	27295	1867	< 250.0		324854	11985	288	45
Site 11, 2.5-3 in.	2.75	< 65		785	126	37346	2555	< 250.0		293250	10819	396	62
Site 12, fine, 0-0.5 in.	0.25	1252	279	1702	274	44266	3028	631.6	93.5	255789	9437	482	76
Site 12, 0.5-1 in.	0.75	1329	296	1634	263	39073	2673	443.6	65.7	247359	9126	462	73
Site 12, 1-1.5 in.	1.25	2514	560	1956	315	42869	2933	703.7	104.2	201551	7436	487	77
Site 12, 1.5-2.5 in.	2.00	808	180	1472	237	35794	2449	444.6	65.8	244122	9007	468	74
Site 12, 2.5-3.5 in.	3.00	251	56	1511	243	42007	2874	613.1	90.8	249235	9195	465	73
Site 12, sandy, 0-0.5 in.	0.25	< 65		133	21	4945	338	< 250.0		390806	14418	305	48

Std / Core / Sample ID	Avg Depth		Ca		K		Al			P		Si		Cl	
			µg/g	± SEM	µg/g	± SEM	µg/g	± SEM		µg/g	± SEM	µg/g	± SEM	µg/g	± SEM
Site 12, sandy, 0.5-1 in.	0.75	<	65		321	52	9524	652	<	250.0		378591	13968	230	36
Site 12, sandy, 1-1.5 in.	1.25	<	65		386	62	11186	765	<	250.0		370422	13666	253	40
Site 12, sandy, 1.5-2.5 in.	2.00		87	19	311	50	10596	725	<	250.0		348234	12848	363	57
Site 12, sandy, 2.5-3.5 in.	3.00		1018	227	1125	181	34937	2390		459.2	68.0	273559	10093	435	69
Site 12, sandy, 3.5-4 in.	4.00	<	65		971	156	36164	2474		341.7	50.6	280888	10363	456	72
Site 20 BP2D 0-0.5 in.	0.25		2472	551	3484	561	87650	5996		1526.9	226.0	168037	6200	636	100
Site 20 BP2D 0.5-1 in.	0.75		2113	471	3612	582	89996	6156		1426.2	211.1	165878	6120	592	93
Site 20 BP2D 1-1.5 in.	1.25		1697	378	3520	567	86422	5912		1524.1	225.6	165887	6120	578	91
Site 20 BP2D 1.5-2.5 in.	2.00		358	80	1443	232	39484	2701		678.8	100.5	253332	9346	397	63
Site 20 BP2D 2.5-3.5 in.	3.00	<	65		750	121	22797	1559		274.2	40.6	342228	12626	155	24
Site 20 BP2D 3.5-4.5 in.	4.00	<	65		735	118	26086	1784		466.9	69.1	341118	12585	216	34
Site 20 BP2C 0-0.5 in.	0.25		2586	576	3416	550	80787	5526		2059.7	304.9	163947	6049	601	95
Site 20 BP2C 0.5-1 in.	0.75		2062	459	3404	548	81959	5606		2090.0	309.4	167643	6185	578	91
Site 20 BP2C 1-1.5 in.	1.25		1571	350	3161	509	73034	4996		1766.5	261.5	169988	6272	519	82
Site 20 BP2C 1.5-2.5 in.	2.00		1622	361	3251	524	74592	5103		1739.8	257.6	175294	6467	523	82
Site 20 BP2C 2.5-3.5 in.	3.00		1175	262	3144	506	71064	4861		1762.3	260.9	173559	6403	493	78
Site 20 BP2B 0-0.5 in.	0.25		1500	334	3644	587	82062	5614		1787.3	264.6	172273	6356	579	91
Site 20 BP2B 0.5-1 in.	0.75		1199	267	3398	547	78300	5356		1788.9	264.8	186468	6880	540	85
Site 20 BP2B 1-1.5 in.	1.25		1153	257	3255	524	74266	5080		1679.8	248.7	185191	6832	493	78
Site 20 BP2B 1.5-2.5 in.	2.00		940	209	2855	460	67843	4641		1543.5	228.5	197424	7284	455	72
Site 20 BP2B 2.5-3.5 in.	3.00		125	28	1364	220	44602	3051		1073.1	158.9	252777	9326	510	80
Site 20 BP2B 3.5-4.5 in.	4.00	<	65		930	150	29022	1985		678.3	100.4	310168	11443	206	32
Site 20 BP2B 4.5-5.25 in.	5.00	<	65		690	111	22132	1514		603.7	89.4	341504	12600	233	37
Site 20 BP2A 0-0.5 in.	0.25		1839	410	3394	547	74928	5126		2067.1	306.0	171757	6337	516	81
Site 20 BP2A 0.5-1 in.	0.75		1797	400	3499	564	77796	5322		2003.9	296.7	164641	6074	529	83
Site 20 BP2A 1-1.5 in.	1.25		1666	371	3356	541	72443	4956		2098.1	310.6	159950	5901	505	80
Site 20 BP2A 1.5-2.5 in.	2.00		1497	333	3443	555	78201	5349		2137.2	316.4	169042	6237	530	84
Site 20 BP2A 2.5-3.5 in.	3.00		1482	330	3527	568	79638	5448		2268.4	335.8	167119	6166	534	84
Site 20 BP2A 3.5-4.5 in.	4.00		1382	308	3442	554	78662	5381		2578.6	381.7	173771	6411	493	78
Site 20 BP2A 4.5-5.5 in.	5.00		1317	293	3353	540	73927	5057		2601.8	385.2	174365	6433	511	81
Site 20 BP2A 5.5-6.5 in.	6.00		1575	351	3151	508	67195	4597		2398.2	355.0	165950	6123	465	73
Site 13, 0-0.5 in.	0.25	<	65		87	14	1760	120		1286.3	190.4	333132	12291	283	45
Site 13, 0.5-1 in.	0.75	<	65		341	55	5627	385		1562.0	231.2	295150	10889	369	58
Site 13, 1-1.5 in.	1.25	<	65		186	30	3592	246		1356.7	200.8	335173	12366	335	53
Site 13, 1.5-2.5 in.	2.00	<	65		135	22	4188	286		1386.8	205.3	318613	11755	351	55
Site 13, 2.5-2.75 in.	2.63	<	65		281	45	7178	491		1956.6	289.7	327955	12100	365	57
Site 15 (BP3), 0-0.5 in.	0.25		896	200	1301	210	19600	1341	<	250.0		268762	9916	615	97
Site 15 (BP3), 0.5-1 in.	0.75		588	131	1295	209	23137	1583		1076.7	159.4	296083	10924	483	76
Site 15 (BP3), 1-1.5 in.	1.25	<	65		830	134	20905	1430	<	250.0		344066	12694	378	60
Site 15 (BP3), 1.5-2.5 in.	2.00		705	157	1240	200	26203	1792		644.2	95.4	305484	11271	481	76
Site 15 (BP3), 2.5-3.5 in.	3.00	<	65		1083	174	25758	1762		542.5	80.3	327043	12066	446	70
Site 15 (BP3), 3.5-4.5 in.	4.00	<	65		1023	165	22993	1573		446.1	66.0	318167	11739	430	68
Site 15 (BP3), 4.5-5.5 in.	5.00	<	65		862	139	18157	1242	<	250.0		326335	12040	380	60
Site 16 (BP3 channel), 0-0.5 in	0.25		138	31	855	138	11525	788		830.2	122.9	239908	8851	610	96
Site 16 (BP3 channel), 0.5-1 in	0.75	<	65		185	30	2503	171	<	250.0		368213	13585	286	45
Site 16 (BP3 channel), 1-1.5 in	1.25	<	65		213	34	3425	234	<	250.0		367225	13548	201	32
Site 16 (BP3 channel) 1.5-2.5 i	2.00	<	65		287	46	4840	331		357.1	52.9	362205	13363	316	50

Std / Core / Sample ID	Avg Depth	Ca		K		Al		P		Si		Cl	
		µg/g	± SEM	µg/g	± SEM	µg/g	± SEM	µg/g	± SEM	µg/g	± SEM	µg/g	± SEM
Site 16 (BP3 channel) 2.5-3.5 i	3.00	< 65		77	12	855	59	< 250.0		387857	14310	239	38
Site 17 (BP4) 0-0.5 in.	0.25	347	77	2634	424	37184	2544	1324.6	196.1	244971	9038	481	76
Site 17 (BP4) 0.5-1 in.	0.75	384	86	3273	527	46808	3202	1216.2	180.1	232633	8583	503	79
Site 17 (BP4) 1-1.5 in.	1.25	173	38	3036	489	48107	3291	< 250.0		255440	9424	516	81
Site 17 (BP4) 1.5-2.5 in.	2.00	295	66	3032	488	42903	2935	1069.1	158.3	229865	8481	486	77
Site 17 (BP4) 2.5-3.5 in.	3.00	< 65		2633	424	41809	2860	797.4	118.0	242116	8933	516	81
Site 17 (BP4) 3.5-4.5 in.	4.00	< 65		707	114	22118	1513	< 250.0		282626	10427	447	70
Site 17 (BP4) 4.5-5.5 in.	5.00	< 65		1028	166	25414	1738	< 250.0		280480	10348	473	75
Site 19 (BP5 pond) 0-0.5 in.	0.25	127	28	1270	205	21282	1456	782.7	115.9	292385	10787	446	70
Site 19 (BP5 pond) 0.5-1 in.	0.75	237	53	1233	199	23213	1588	872.5	129.2	269631	9948	480	76
Site 19 (BP5 pond) 1-1.5 in.	1.25	< 65		669	108	15999	1094	497.4	73.6	359459	13262	289	46
Site 19 (BP5 pond) 1.5-2.5 in.	2.00	< 65		452	73	10627	727	292.8	43.3	359988	13281	172	27
Site 19 (BP5 pond) 2.5-3.5 in.	3.00	< 65		683	110	14878	1018	507.0	75.0	340797	12573	264	42
Site 18 (BP5 channel) 0-0.5 in.	0.25	< 65		2378	383	50838	3478	2477.5	366.8	235006	8670	500	79
Site 18 (BP5 channel) 0.5-1 in.	0.75	< 65		2217	357	48421	3312	1698.7	251.5	248842	9181	464	73
Site 18 (BP5 channel) 1-1.5 in.	1.25	< 65		1447	233	33067	2262	1395.8	206.6	290341	10712	437	69
Site 18 (BP5 channel) 1.5-2.5 i	2.00	< 65		1133	182	28191	1928	627.2	92.9	314212	11593	310	49
Site 18 (BP5 channel) 2.5-3.5 i	3.00	< 65		289	47	7829	536	< 250.0		375488	13853	168	26
Site 18 (BP5 channel) 3.5-4.5 i	4.00	< 65		259	42	6684	457	< 250.0		374617	13821	280	44
Site 18 (BP5 channel) 4.5-5.5 i	5.00	< 65		157	25	4411	302	365.2	54.1	389796	14381	281	44
Site 18 (BP5 channel) 5.5-6 in.	6.00	< 65		253	41	7293	499	< 250.0		391692	14451	249	39
Site 14, 0-0.5 in.	0.25	< 65		91	15	883	60	< 250.0		383271	14140	239	38
Site 14, 0.5-1 in.	0.75	< 65		45	7	1088	74	< 250.0		400373	14771	168	27
Site 14, 1-1.5 in.	1.25	< 65		51	8	< 1000		< 250.0		398447	14700	196	31
Site 14, 1.5-2.5 in.	2.00	< 65		160	26	1789	122	< 250.0		426016	15718	287	45
Site 14, 2.5-3.5 in.	3.00	< 65		32	5	< 1000		< 250.0		398089	14687	222	35
Site 14, 3.5-3.75 in.	3.63	< 65		49	8	1207	83	< 250.0		400967	14793	249	39
control biofilm	n/a	11572	2577	4717	760	25286	1730	1142.8	169.2	153141	5650	1012	159
site 1 biofilm	n/a	1654	368	5524	890	68069	4656	23571.5	3489.6	75323	2779	2581	407
Site 2 biofilm	n/a	2204	491	10498	1691	50512	3455	20485.9	3032.8	50614	1867	4676	737
Site 3 biofilm	n/a	3001	668	3862	622	45600	3119	7723.7	1143.4	150456	5551	1336	211
Site 5 biofilm	n/a	2868	639	7294	1175	33688	2304	5848.2	865.8	93483	3449	3505	552
Site 9 biofilm	n/a	3216	716	4180	673	47194	3228	2243.0	332.1	164072	6053	1083	171
Site 13 biofilm	n/a	4475	996	1663	268	4706	322	2511.4	371.8	94007	3468	1068	168

Std / Core / Sample ID	Avg Depth		S	
			µg/g	± SEM
Blank (SiO2)	n/a	<	100	
Blank (SiO2)	n/a	<	100	
Blank (SiO2)	n/a	<	100	
Blank (SiO2)	n/a	<	100	
Blank (SiO2)	n/a	<	100	
Blank (SiO2)	n/a	<	100	
Blank (SiO2)	n/a	<	100	
Blank (SiO2)	n/a	<	100	
NIST 2702 Standard	n/a		18170	3928
NIST 2702 Standard	n/a		18342	3966
NIST 2702 Standard	n/a		17920	3874
NIST 2702 Standard	n/a		17954	3882
NIST 2702 Standard	n/a		17267	3733
NIST 2702 Standard	n/a		18009	3894
NIST 2702 Standard	n/a		18629	4028
NIST 2709a STANDARD	n/a		635	137
NIST 2709a STANDARD	n/a		619	134
NIST 2709a STANDARD	n/a		625	135
NIST 2709a STANDARD	n/a		618	134
NIST 2709a STANDARD	n/a		628	136
NIST 2709a STANDARD	n/a		726	157
NIST 2709a STANDARD	n/a		622	134
Control Composite (no added tin)	n/a	<	100	
Tin Std 28.587 ppm	n/a	<	100	
Tin Std 28.587 ppm	n/a	<	100	
Tin Std 28.587 ppm	n/a	<	100	
Tin Std 28.587 ppm	n/a	<	100	
Tin Std 28.587 ppm	n/a	<	100	
Tin Std 28.587 ppm	n/a		199	43
Tin Std 60.517 ppm	n/a	<	100	
Tin Std 60.517 ppm	n/a	<	100	
Tin Std 60.517 ppm	n/a	<	100	
Tin Std 60.517 ppm	n/a		622	135
Tin Std 60.517 ppm	n/a	<	100	
Tin Std 87.548 ppm	n/a	<	100	
Tin Std 87.548 ppm	n/a	<	100	
Tin Std 87.548 ppm	n/a	<	100	
Tin Std 113.387 ppm	n/a	<	100	
Tin Std 113.387 ppm	n/a	<	100	
Tin Std 113.387 ppm	n/a	<	100	
Tin Std 113.387 ppm	n/a		288	62
Tin Std 113.387 ppm	n/a	<	100	
Tin Std 113.387 ppm	n/a	<	100	
Tin Std 174.792 ppm	n/a	<	100	
Tin Std 174.792 ppm	n/a	<	100	
Tin Std 174.792 ppm	n/a	<	100	
Tin Std 174.792 ppm	n/a	<	100	

Std / Core / Sample ID	Avg Depth		S	
			µg/g	± SEM
Tin Std 234.069 ppm	n/a	<	100	
Tin Std 234.069 ppm	n/a		395	85
Tin Std 234.069 ppm	n/a	<	100	
Tin Std 234.069 ppm	n/a	<	100	
Tin Std 234.069 ppm	n/a	<	100	
Control 0-0.5 in.	0.25		98	21
Control 0.5-1 in.	0.75	<	100	
Control 1-1.5 in.	1.25	<	100	
Control 1.5-2.5 in.	2.00		2797	605
Control 2.5-3.5 in.	3.00		3822	826
Site 2, 0-0.5 in.	0.25	<	100	
Site 2, 0.5-1 in.	0.75	<	100	
Site 2, 1-1.5 in.	1.25	<	100	
Site 2, 1.5-2.5 in.	2.00	<	100	
Site 2, 2.5-3.5 in.	3.00	<	100	
Site 2, 3.5-4.5 in.	4.00	<	100	
Site 3, 0-0.5 in.	0.25	<	100	
Site 3, 0.5-1 in.	0.75	<	100	
Site 3, 1-1.5 in.	1.25	<	100	
Site 5, 0-0.5 in.	0.25	<	100	
Site 5, 0.5-1 in.	0.75	<	100	
Site 5, 1-1.5 in.	1.25	<	100	
Site 5, 1.5-2.5 in.	2.00	<	100	
Site 5, 2.5-3.5 in.	3.00		538	116
Site 5, 3.5-4.5 in.	4.00	<	100	
TBP-0, Control	n/a	<	100	
TBP-1, 0-1.5 in.	0.75	<	100	
TBP-1, 1.5-3 in.	2.25	<	100	
TBP-1, 3-4.5 in.	3.75		113	25
TBP-2, 0-1.5 in.	0.75		194	42
TBP-2, 1.5-3 in.	2.25	<	100	
TBP-2, 3-4.5 in.	3.75		186	40
TBP-3, 0-1.5 in.	0.75		451	97
TBP-3, 1.5-3 in.	2.25		478	103
TBP-4, 0-1.5 in.	0.75		214	46
TBP-4, 1.5-3 in.	2.25	<	100	
TBP-4, 3-4.5 in.	3.75	<	100	
TBP-5, 0-1.5 in.	0.75	<	100	
TBP-5, 1.5-3 in.	2.25	<	100	
TBP-6, 0-1.5 in.	0.75		212	46
TBP-6, 1.5-3 in.	2.25	<	100	
TBP-6, 3-4.5 in.	3.75	<	100	
TBP-7, 0-1.5 in.	0.75		125	27
TBP-7, 1.5-3 in.	2.25	<	100	
TBP-8, 0-1.5 in.	0.75		200	43
TBP-8, 1.5-3 in.	2.25	<	100	
TBP-9, 0-1.5 in.	0.75		201	43

Std / Core / Sample ID	Avg Depth		S	
			µg/g	± SEM
TBP-9, 1.5-3 in.	2.25	<	100	
TBP-10, 0-1.5 in.	0.75	<	100	
TBP-10, 1.5-3 in.	2.25	<	100	
TBP-11, 0-1.5 in.	0.75	<	100	
TBP-11, 1.5-3 in.	2.25	<	100	
TBP-12, 0-1.5 in.	0.75	<	100	
TBP-12, 1.5-3 in.	2.25	<	100	
TBP-12, 1.5-3 in.	3.75	<	100	
TBP-13, 0-1.5 in.	0.75		319	69
TBP-13, 1.5-3 in.	2.25		141	30
Site 8, fine, 0-0.5 in.	0.25		644	139
Site 8, fine, 0.5-1 in.	0.75		453	98
Site 8, fine, 1-1.5 in.	1.25		460	99
Site 8, fine, 1.5-2.5 in.	2.00		542	117
Site 8, fine, 2.5-3.5 in.	3.00		395	86
Site 8, fine, 3.5-4.5 in.	4.00		257	56
Site 8, sandy, 0-0.5 in.	0.25	<	100	
Site 8, sandy, 0.5-1 in.	0.75	<	100	
Site 8, sandy, 1-1.5 in.	1.25	<	100	
Site 8, sandy, 1.5-2.5 in.	2.00	<	100	
Site 8, sandy, 2.5-3.5 in.	3.00		268	58
Site 8, sandy, 3.5-4.5 in.	4.00	<	100	
Site 10, 0-1.5 in.	0.75	<	100	
Site 10, 1.5-3 in.	2.25	<	100	
Site 10, 3-4.5 in.	3.75	<	100	
Site 9, mid, 0-0.5 in.	0.25	<	100	
Site 9, mid, 0.5-1 in.	0.75	<	100	
Site 9, mid, 1-1.5 in.	1.25	<	100	
Site 9, mid, 1.5-2.5 in.	2.00	<	100	
Site 9, mid, 2.5-3.5 in.	3.00	<	100	
Site 9, mid, 3.5-4.5 in.	4.00	<	100	
Site 9, mid, 4.5-5.5 in.	5.00	<	100	
Site 9, edge, 0-0.5 in.	0.25	<	100	
Site 9, edge, 0.5-1 in.	0.75	<	100	
Site 9, edge, 1-1.5 in.	1.25	<	100	
Site 9, edge, 1.5-2.5 in.	2.00	<	100	
Site 11, 0-0.5 in.	0.25		1269	274
Site 11, 0.5-1 in.	0.75		1389	300
Site 11, 1-1.5 in.	1.25		673	146
Site 11, 1.5-2.5 in.	2.00		177	38
Site 11, 2.5-3 in.	2.75	<	100	
Site 12, fine, 0-0.5 in.	0.25		146	31
Site 12, 0.5-1 in.	0.75		142	31
Site 12, 1-1.5 in.	1.25		418	90
Site 12, 1.5-2.5 in.	2.00		95	20
Site 12, 2.5-3.5 in.	3.00	<	100	
Site 12, sandy, 0-0.5 in.	0.25	<	100	

Std / Core / Sample ID	Avg Depth		S	
			μg/g	± SEM
Site 12, sandy, 0.5-1 in.	0.75	<	100	
Site 12, sandy, 1-1.5 in.	1.25	<	100	
Site 12, sandy, 1.5-2.5 in.	2.00		434	94
Site 12, sandy, 2.5-3.5 in.	3.00		107	23
Site 12, sandy, 3.5-4 in.	4.00	<	100	
Site 20 BP2D 0-0.5 in.	0.25		985	213
Site 20 BP2D 0.5-1 in.	0.75		932	202
Site 20 BP2D 1-1.5 in.	1.25		980	212
Site 20 BP2D 1.5-2.5 in.	2.00		530	115
Site 20 BP2D 2.5-3.5 in.	3.00	<	100	
Site 20 BP2D 3.5-4.5 in.	4.00	<	100	
Site 20 BP2C 0-0.5 in.	0.25		1810	391
Site 20 BP2C 0.5-1 in.	0.75		1815	392
Site 20 BP2C 1-1.5 in.	1.25		1681	363
Site 20 BP2C 1.5-2.5 in.	2.00		1999	432
Site 20 BP2C 2.5-3.5 in.	3.00		1947	421
Site 20 BP2B 0-0.5 in.	0.25		1691	366
Site 20 BP2B 0.5-1 in.	0.75		1593	344
Site 20 BP2B 1-1.5 in.	1.25		1479	320
Site 20 BP2B 1.5-2.5 in.	2.00		1545	334
Site 20 BP2B 2.5-3.5 in.	3.00		1513	327
Site 20 BP2B 3.5-4.5 in.	4.00		989	214
Site 20 BP2B 4.5-5.25 in.	5.00		956	207
Site 20 BP2A 0-0.5 in.	0.25		1636	354
Site 20 BP2A 0.5-1 in.	0.75		1703	368
Site 20 BP2A 1-1.5 in.	1.25		1801	389
Site 20 BP2A 1.5-2.5 in.	2.00		1805	390
Site 20 BP2A 2.5-3.5 in.	3.00		1770	383
Site 20 BP2A 3.5-4.5 in.	4.00		1773	383
Site 20 BP2A 4.5-5.5 in.	5.00		1816	393
Site 20 BP2A 5.5-6.5 in.	6.00		2214	479
Site 13, 0-0.5 in.	0.25	<	100	
Site 13, 0.5-1 in.	0.75	<	100	
Site 13, 1-1.5 in.	1.25	<	100	
Site 13, 1.5-2.5 in.	2.00	<	100	
Site 13, 2.5-2.75 in.	2.63	<	100	
Site 15 (BP3), 0-0.5 in.	0.25		3917	847
Site 15 (BP3), 0.5-1 in.	0.75		1296	280
Site 15 (BP3), 1-1.5 in.	1.25	<	100	
Site 15 (BP3), 1.5-2.5 in.	2.00		344	74
Site 15 (BP3), 2.5-3.5 in.	3.00		142	31
Site 15 (BP3), 3.5-4.5 in.	4.00		300	65
Site 15 (BP3), 4.5-5.5 in.	5.00	<	100	
Site 16 (BP3 channel), 0-0.5 in	0.25		1672	361
Site 16 (BP3 channel), 0.5-1 in	0.75	<	100	
Site 16 (BP3 channel), 1-1.5 in	1.25	<	100	
Site 16 (BP3 channel) 1.5-2.5 i	2.00	<	100	

Std / Core / Sample ID	Avg Depth		S	
			µg/g	± SEM
Site 16 (BP3 channel) 2.5-3.5 i	3.00	<	100	
Site 17 (BP4) 0-0.5 in.	0.25		1531	331
Site 17 (BP4) 0.5-1 in.	0.75		1167	252
Site 17 (BP4) 1-1.5 in.	1.25		1036	224
Site 17 (BP4) 1.5-2.5 in.	2.00		1355	293
Site 17 (BP4) 2.5-3.5 in.	3.00		1014	219
Site 17 (BP4) 3.5-4.5 in.	4.00	<	100	
Site 17 (BP4) 4.5-5.5 in.	5.00	<	100	
Site 19 (BP5 pond) 0-0.5 in.	0.25		1161	251
Site 19 (BP5 pond) 0.5-1 in.	0.75		1511	327
Site 19 (BP5 pond) 1-1.5 in.	1.25		142	31
Site 19 (BP5 pond) 1.5-2.5 in.	2.00	<	100	
Site 19 (BP5 pond) 2.5-3.5 in.	3.00		797	172
Site 18 (BP5 channel) 0-0.5 in.	0.25		1099	238
Site 18 (BP5 channel) 0.5-1 in.	0.75		648	140
Site 18 (BP5 channel) 1-1.5 in.	1.25		648	140
Site 18 (BP5 channel) 1.5-2.5 i	2.00		181	39
Site 18 (BP5 channel) 2.5-3.5 i	3.00	<	100	
Site 18 (BP5 channel) 3.5-4.5 i	4.00	<	100	
Site 18 (BP5 channel) 4.5-5.5 i	5.00	<	100	
Site 18 (BP5 channel) 5.5-6 in.	6.00	<	100	
Site 14, 0-0.5 in.	0.25	<	100	
Site 14, 0.5-1 in.	0.75	<	100	
Site 14, 1-1.5 in.	1.25	<	100	
Site 14, 1.5-2.5 in.	2.00	<	100	
Site 14, 2.5-3.5 in.	3.00	<	100	
Site 14, 3.5-3.75 in.	3.63	<	100	
control biofilm	n/a		4445	961
site 1 biofilm	n/a		3428	741
Site 2 biofilm	n/a		3952	854
Site 3 biofilm	n/a		2870	621
Site 5 biofilm	n/a		3483	753
Site 9 biofilm	n/a		942	204
Site 13 biofilm	n/a		2513	543

APPENDIX D: Example Mass Balance Calculations

Amaury Betancourt 09/02/2011

Mass Balance calculations for tin in Tims Branch, comparing theoretical mass balance to experimentally measured and estimated mass balance.

(1.) Calculation of approximate total mass of tin that has entered Tims Branch from the M-1 Air Stripper Treatment System from November 2007 to August 2011.

Assumptions:

Q = flow rate of treated groundwater entering Tims Branch from the M-1 Air Stripper Treatment System through the AØ14 Outfall $= \frac{450 \text{ gallons}}{\text{minute}}$

Source: Looney et al., 2010

[Sn] = Theoretical tin concentration in treated groundwater from the M-1 Air Stripper Treatment System $= \frac{12.88 \ \mu g \text{ Sn}}{L \text{ water}}$

Source: Looney et al., 2010

Equations:

After unit conversions,

Q * [Sn] * total time = total mass of tin that has entered Tims Branch from M-1 Air Stripper Treatment System

↳ continued

Unit Convessions:

$$Q = \frac{450 \text{ gallons}}{\text{minute}} * \frac{1000 \text{ Liters}}{264 \text{ gallons}} * \frac{60 \text{ minutes}}{\text{hour}}$$

$$* \frac{24 \text{ hours}}{\text{day}} = \frac{2{,}454{,}545 \text{ Liters}}{\text{day}}$$

$$[Sn] = \frac{12.88 \mu g \text{ Sn}}{L \text{ water}} * \frac{1 \text{ kg}}{10^9 \mu g} = \frac{12.88 * 10^{-9} \text{ kg Sn}}{\text{Liters water}}$$

$$\text{Total time} = 3 \text{ years}, 9 \text{ months} = \left[\left(\frac{365.25 \text{ days}}{\text{year}} * 3 \text{ years}\right) + \left(\frac{\sim 273 \text{ days}}{9 \text{ months}} * 9 \text{ months}\right)\right]$$

$$\approx 1369 \text{ days}$$

Calculations:

$$Q * [Sn] * \text{total time} = \frac{2{,}454{,}545 \text{ Liters}}{\text{day}} * \frac{12.88 * 10^{-9} \text{ kg Sn}}{\text{Liters of water}} * 1{,}369 \text{ days}$$

↳ continued

$$Q * [Sn] * \text{total time} =$$

$$\frac{2{,}454{,}545 \text{ Liters}}{\text{day}} * \frac{12.88 * 10^{-9} \text{ kg Sn}}{\text{Liters}} * 1{,}369 \text{ days} = \underline{\underline{43.28 \text{ kg Sn}}}$$

② Estimation of theoretical average approximate concentration of tin in sediments along Tims Branch, from AØ14 Outfall to confluence of Tims Branch with Upper Three Runs Creek.

Assumptions:

ⓐ Assume tin is present in significant concentrations only in upper 3.5 inches of sediments along Tims Branch. This assumption is made from experimental data from the present research.

ⓑ Average is calculated by assuming that sediments are evenly distributed along Tims Branch, which they are not. This assumption is necessary to calculate a theoretical average, since sediments along Tims Branch have a patchy distribution.

4 continued

$\mathcal{L}$ = estimate of length of Tims Branch from AØ14 Outfall downstream to confluence of Tims Branch with Upper Three Runs Creek

= 26,000 feet

Estimated using satellite images of Tims Branch from Google Maps, 2011.

w = estimate of the average width of Tims Branch from AØ14 Outfall downstream to confluence of Tims Branch with Upper Three Runs Creek

= 6 feet

Estimated from field observations

d = estimate of sediment depth where significant concentrations of tin are detected, from the surface of the sediment ~~de~~ bed to this depth

= 3.5 inches

Estimated from experimental data from the present research

↳ continued

ρ = estimate of density of sediments

$= \frac{1.7 \text{ g}}{\text{cm}^3}$

Estimated from research experience

Equations:

After unit conversions,

$$\left[\frac{(\text{Total tin that has entered Tims Branch from Nov. 2007 to Aug. 2011})}{\mathcal{L} * w * d * \rho}\right]$$

= Average tin concentration along Tims Branch, from AØ14 Outfall to confluence of Tims Branch with Upper Three Runs Creek

Unit Conversions:

$d = 3.5 \text{ inches} * \frac{1 \text{ foot}}{12 \text{ inches}} = \left(\frac{3.5}{12}\right) \text{ feet}$

↳ continued

$$\rho = \frac{1.7\ g}{cm^3} * \frac{10^6\ cm^3}{1\ m^3} * \frac{1\ m^3}{1000\ L} * \frac{1000\ L}{35.3\ ft^3} = \frac{48159\ g}{ft^3}$$

Calculations:

$$\left[\frac{\text{(total tin that has entered Tims Branch from Nov. 2007 to Aug. 2011)}}{\mathcal{L} * w * d * \rho}\right]$$

$$= \left[\frac{43.28\ kg * \frac{10^9\ \mu g}{kg}}{26{,}000\ ft * 6\ ft * \frac{3.5}{12}\ ft * \frac{48159\ g}{ft^3}}\right]$$

$$= \frac{19.75\ \mu g\ Sn}{g\ \text{sediment}} \approx \frac{20\ \mu g\ Sn}{g\ \text{sediment}}$$

↳ continued

(3.) Comparison of the theoretical approximation of average tin concentration to the estimated average tin concentration from measurements in the present research, for sediments along Tims Branch from the AØ14 Outfall downstream to the confluence of Tims Branch with Upper Three Runs Creek.

Theoretical average tin concentration in sediments $\approx 20 \frac{\mu g}{g}$

Estimated average tin concentration in sediments, from measurements in the present research $\approx 26 \frac{\mu g}{g}$

(see discussion in Results and Analysis section of report)

The theoretical and estimated (from measurements) average tin concentrations in sediments along Tims Branch, from the AØ14 Outfall to the confluence of Tims Branch with Upper Three Runs Creek, are relatively close. It appears that the mass balance ~~ag~~ calculated from the theory agrees fairly with the mass balance estimated from measurements in the present research.