ONONDAGA LAKE

MICROBEAD MARKER 2008 PRE-MOBILIZATION FIELD TEST DATA SUMMARY REPORT
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LIST OF ACRONYMS

cm	centimeter
ETS	Environmental Tracing Systems, Ltd. (Helensburgh, Scotland, UK)
GPS	Global Positioning System
mg/Kg	milligrams per kilogram
MNR	Monitored Natural Recovery
MSDS	Material Safety Data Sheet
NYSDEC	New York State Department of Environmental Conservation
PDI	Pre-Design Investigation
ppm	parts per million (1 ppm is the same as 1 mg/Kg)
QA/QC	Quality Assurance / Quality Control
ROD	Record of Decision
RTK	real time kinematic (a type of GPS unit capable of better accuracy than non-RTK units)
SMU	Sediment Management Unit
SOP	Standard Operating Procedure
USEPA	United States Environmental Protection Agency

Note**:** One centimeter is approximately equivalent to 0.4 inch, and one inch is approximately equivalent to 2.5 centimeters.

MICROBEAD MARKER PRE-MOBILIZATION FIELD TEST DATA SUMMARY REPORT

EXECUTIVE SUMMARY

A microbead marker is a tool that can be used to document monitored natural recovery in the form of sedimentation rates and/or sediment mixing depths for many years following marker placement. During October-November 2008, four types of field tests were conducted to determine if microbead markers could serve as an effective tool in the deep water portion of Onondaga Lake. The conclusion from the work reported herein is that application of one or more microbead markers can effectively address monitoring objectives in the deep water portion of Onondaga Lake. Settling tests showed various microbead markers can position themselves effectively on top of SMU 8 sediment. Background fluorescence measurements showed no significant effect from local sediment characteristics that would hamper the ability to analyze for marker presence. A marker placement trial showed markers could be placed within SMU 8 with some modifications to the equipment used during the placement trial. Finally, sediment sampling and sediment processing procedures were used that provided representative surface sediment samples needed to document sedimentation rates over the marker and/or surface sediment mixing depth. As a result of this work, placement of two different microbead markers is being planned for 2009. Additional sediment sampling enhancements will be evaluated as well.

1.0 INTRODUCTION

This data summary report describes procedures and results from microbead marker field tests conducted during late 2008 within Onondaga Lake Sediment Management Unit (SMU) 8. SMU 8 is the deeper water portion of Onondaga Lake where water depths exceed 9 meters (30 ft) where waters become vertically stratified each year from late spring until fall. All of the work described herein was conducted in accordance with an approved work plan (Parsons, 2008b) and consistent with the monitoring and contingency approach approved by the State of New York Department of Environmental Conservation (NYSDEC) for monitoring natural recovery in SMU 8 (Parsons, 2008a). Pre-mobilization field work was conducted at Onondaga Lake during the weeks of October 27 and November 2, 2008.

The purpose of placing and monitoring a microbead marker is to measure ongoing sedimentation rate and/or surface sediment mixing depth as part of the evaluation of monitored natural recovery (MNR) in SMU 8. MNR is one of the elements of the remedy for Onondaga Lake specified in the Record of Decision for the Onondaga Lake Bottom Subsite (NYSDEC and USEPA, 2005). A microbead marker can document MNR progress during the design and construction phases of the Onondaga lake remedy and also following remedy construction.

Quantifying recent sedimentation rates and/or mixed layer depths will provide basis for refining the MNR assessment and predictions described in the Feasibility Study Report for

Onondaga Lake (Parsons, 2004). It has been hypothesized that surface sediment can mix vertically due to lake water circulation, bioturbation, and/or ebullition, although little evidence of substantial mixing of surface sediment has been observed during past core observations. However, future lake conditions could change some of these parameters and increase surface sediment mixing. Significant sediment mixing could limit the ability to quantify sedimentation rates over time if the marker were to gradually mix vertically within the sediment. Deploying one or more microbead markers at specific locations throughout SMU 8 could help establish a new basis to assess surface sediment changes over the next 15 to 20 years. The average sediment settling rate in SMU 8 since 1986 is approximately 0.3 to 0.6 centimeter per year at the South Deep station based on available data summarized in the Feasibility Study Report (Parsons, 2004, Appendix N). Given this average annual sedimentation rate generally observed in SMU 8 and available sampling resolution of one to two centimeters, it will likely take at least two years to quantify a preliminary sedimentation rate based on sampling of microbead markers.

Four types of pre-mobilization field tests were conducted. Settling tests were conducted to further assess how microbead markers would position themselves on top of SMU 8 sediment. Background fluorescence was measured to determine if local sediment characteristics would adversely affect the ability to measure marker fluorescence. A marker placement trial was conducted to determine how effectively markers could be placed within SMU 8. The fourth type of test was to assess sediment sampling and sediment processing options for providing representative surface sediment samples given the silt-clay, low percent solids nature of SMU 8 surface sediment.

Section 2 of this report describes the pre-mobilization field test procedures. Section 3 describes the pre-mobilization field test results. Section 4 summarizes sample and data management procedures. Section 5 outlines future considerations for applying microbead one or more microbead markers in SMU 8. Section 6 is a list of references. Appendix A provides a photo log of field test efforts. Appendix B presents the procedures used by the ETS laboratory in Scotland to measure background fluorescence. Appendix C is the bottom water velocity and corresponding wind data collected as the microbead marker placement trial was being conducted.

2.0 MICROBEAD MARKER PRE-MOBILIZATION FIELD TEST SAMPLING AND ANALYSIS

Parsons and subcontracted firms (Environmental Tracing Systems - ETS - from Helensburgh, Scotland and Quantitative Environmental Analysis - QEA - from Liverpool, NY) performed the pre-mobilization field tests to determine whether available microbead markers could serve as suitable markers of sedimentation and vertical sediment mixing for approximately 20 years following marker placement. The four completed pre-mobilization field test tasks as described in the approved work plan (Parsons, 2008c) were as follows:

a. Settling Tests – Ten sediment cores were collected in clear, 3.5-inch diameter core tubes including one from the vicinity of each of the SMU 8 microbead marker locations and two other locations. Each of the sample locations was within a few hundred feet of the locations selected for future marker placement as shown on Figure 1 in the approved microbead marker work plan. Core tubes with a 3.5-inch diameter were used instead of 4 to 6-inch diameter core tubes as indicated in the work plan, because less sample volume was needed by the laboratories than originally planned. The collected cores were kept in a vertical position and as undisturbed as reasonably possible while transporting and staging the sediment cores from the boat to a work area onshore. These core samples were handled carefully by maintaining the sampling tubes in a vertical position until the samples were segmented into sections and minimizing movement of the sampling tubes on the boat and at the shoreline where the samples were processed. Once the core tubes were onshore, microbead marker material available from past ETS projects was applied within the core tubes to simulate placing a layer of microbeads on top of SMU 8 sediment. Microbeads added to the core tubes were observed for approximately 24 hours to assess how the microbeads interact with SMU 8 surface sediment. ETS applied different types of microbeads encompassing a range of densities and sizes. Of particular interest was how the microbeads positioned themselves with the top of the sediment.

b. <u>Background Fluorescence</u> - Core samples were collected from lake sediment and from representative lake tributary sediment within Ninemile Creek and Harbor Brook (see Figure 1 for sample locations). Background fluorescence was measured by ETS in their Scotland laboratory for each of these sediment cores to ensure the fluorescent spectra of the microbead markers are measurable without significant interferences from background sediment.

c. <u>Marker Placement Trial</u> – Two different mimic marker materials were placed in a one to two millimeter thick layer on top of sediment at one representative SMU 8 location. The two mimic markers were an inert white natural sand and a fine-grained microbead marker. These two mimic markers were mixed with SMU 8 sediment and placed as a thin layer at a test area within the eastern half of the North Basin of SMU 8 (see Figure 1) in relatively shallow portion of SMU 8 where water velocities were expected to be higher than in the deepest portions of the lake. A sufficient quantity of the mimic sand marker was placed to allow visual assessment without the marker being masked by the sediment. Following placement, the marked sediment was core sampled to assess the homogeneity of marker placement across the test bed.

Near-bottom water velocities were measured during two days of the microbead marker field tests similar to the fall 2007 water velocity measurements collected near South Deep as part of the sediment incubation work effort (Parsons, 2007b). The objective of the 2007 water velocity measurements was to provide a basis for representing within laboratory sediment incubation tests the bottom turbulence at South Deep within the South Corner portion of SMU 8. The objective of the 2008 water velocity measurements was to determine if bottom water velocities at the time of the marker placement trial in the North Basin could affect marker placement. Near bottom water velocities were measured on October 31 and November 1, 2008 in the North Basin adjacent to the microbead placement trial location (shown on Figure 1) where the lake water depth is approximately 12 meters (40 ft).

d. Sediment Sampling and Processing Tests – Various sediment sampling and processing procedures and equipment were used to evaluate their utility for SMU 8 surface sediment. These core samples were handled carefully by slowly siphoning off most but not all of the overlying water, maintaining the sampling tubes in a vertical position until the samples were segmented into sections, and minimizing movement of the sampling tubes on the boat and at the shoreline where the samples were processed.

2.1 Settling Tests

Parsons and ETS collected sediment core samples from eight microbead marker placement locations throughout SMU 8 consistent with the approved work plan (Parsons, 2008c). Actual core locations are presented on Figure 1. One additional core was collected at two of the eight marker placement locations (at OL-MB-80093 and OL-MB-80100) for testing and comparison. A sufficiently long core tube was used to ensure that each sediment sample had a minimum of six to eight feet of water overlying the cored sediment.

Each core was collected carefully by: (a) lowering the push core sampler to the bed very slowly in order to minimize any disturbance of the water-sediment interface; (b) maintaining the cores vertically on the vessel after collection; (c) transporting the cores individually; and (d) storing the cores vertically within the Parsons field laboratory compound until required for testing. Visual observations of the core samples immediately after collection confirmed that a relatively undisturbed sample had been collected in each case, with very soft highly unconsolidated sediment present at the sediment water interface and very clear (i.e. low suspended solids) overlying water.

Prior to conducting the settling tests, the core samples were allowed to sit for one to two days. Prior to commencing the tests, Parsons/ETS observed that no significant change had occurred in the overall sediment layers/stratigraphy in the core sample. At the same time, Parsons/ETS did observe gas escaping occasionally from the underlying sediment over time most likely to be due to the change in pressure resulting from sample collection. The occasional escape of gas was infrequent and observed only when a core tube was tapped or as the marker material settled onto the sediment surface. Escaping gas did not alter the overall stratigraphy of the sediment core; however, it did affect the sediment within the localized area along the route the gas escaped, with limited migration vertically of sediment.

Once the cores had been allowed to stabilize, Parsons/ETS commenced the settling tests. Table 1 summarizes the different materials used to mimic a silt-clay and a sand microbead marker. In order to compare the effect of particle density, ETS released different test markers with the same particles size but different densities in addition to one that included a broader range of clay, silt and very fine sand from one to 90 microns with a different grain density.

Prior to release in the settling tubes, ETS measured eight grams of each test microbead marker. Eight grams represented the approximate quantity intended to be placed as part of the microbead marker placement trial based on the given sediment surface area for the core tube. Each test marker was wetted prior to release, to ensure all the microbeads settled out. Each release took place at the top of a designated core tube with the appropriate microbead marker and noted for a given tube. The surrogate microbeads were poured into each core tube at the top of the water column over a time period of approximately one minute.

TABLE 1
MICROBEAD MARKERS EVALUATED DURING 2008 SETTLING TESTS

Marker Code	Marker Color	Size Range (microns)	Peak size (microns)	Density (grams per cm^3)
Microbead markers similar to SMU 8 surface sediment (silt-clay)				
80094	Magenta	1 to 40	15	2.65
80098	Yellow	1 to 40	15	1.40
80096	Pink	1 to 90	30	2.40
Microbeads as a visible (sand) marker				
80097	Yellow	1 to 160	125	1.40
80095	UV Blue	1 to 160	125	2.65
80093A	UV Blue	300 to 500	375	2.65
80099B	Natural sand	125 to 500	NA	2.65

NA – not available

2.2 Background Fluorescence

Parsons/ETS collected sediment core samples for background fluorescence analysis from a total of 50 locations representing the extent of Onondaga Lake sediment including SMU 8 and the littoral zone (see Figure 1). In addition, two sediment samples were collected for background fluorescence analysis from Ninemile Creek and one sediment sample was collected from Harbor Brook as being representative of watershed tributary inputs. A push core was used to collect these samples.

Once collected, each core sample was described and photographed. Then the top four centimeters (approximately 1.5 inches) of the sediment core was removed and placed into a labeled bag and shipped to ETS in Scotland for analysis of background fluorescence as described in Appendix B. A fluorescence microscope was used to assess whether any fluorescent particles or species within those sediments would interfere with the measurement and/or detection limits of the fluorescent microbead markers.

2.3 Marker Placement Trial

The placement trial consisted of placing two markers in approximately 40 feet of water at a SMU 8 location on the northeastern side of the North Basin (see Figure 1). The two markers used during the placement trial were Test Code 80094 (a silt-clay marker with a magenta color) and a uniform white sand marker material purchased from a local retail distributor.

SMU 8 sediment was collected prior to marker placement and mixed with the sediment markers at a ratio of approximately one sediment particle to every two microbead particles. SMU 8 sediment and the markers needed to be mixed prior to placement in order to ensure the microbeads adsorb any available organic charge in a well mixed manner. Once wetted and mixed, the marked sediment was stored temporarily in sealable buckets or drums, washed down, and then loaded onto the boat to be used for marker placement.

Placement trial dosing equipment consisted of a bar with multiple discharge hoses spaced at approximately one per foot along the length of the bar to provide an even spread of microbeads (see page 2 in Appendix A). The hose had multiple discharge ports along the length of the bar to promote spreading of the microbeads over the bar width in a uniform manner. The hoses were connected to a regulating pump with dose material (test microbeads) fed from a reservoir. Two different sets of dosing equipment were needed. The release velocity needed to maintain the marker in suspension and flowing without blocking the dose hoses was much higher for the sand marker than for the silt-clay marker. A slower release velocity was needed for the silt marker to ensure the release would avoid jetting of the fine fraction into the water column. Therefore two different pumps were used, one with a large bore tubing and high velocity for the sand marker and a smaller bore tubing with a lower velocity pump for the silt-clay marker. For both releases, the length of dose hose was adjusted to ensure the flux rate of material from each discharge was the same, whether at the center of the bar or at the extremities of the bar.

For both releases, the marker was pumped down a feed hose to the bar where the microbeads were distributed evenly along the length of the bar and discharged as uniformly as possible. A circulation pump was used to keep everything in suspension and well mixed in the barrel prior to release. Lake water mixed with the marker was pumped from the deeper waters within the lake in order to match the temperature of the water into which the markers was discharged.

The marker placement trial took place on October 31, 2008 during a period of westerly wind. The two markers employed during the placement trial were placed on SMU 8 sediment in a controlled manner and distributed uniformly at approximately 5 to 6 feet above the sediment surface over a pre-determined bottom area at each location. To achieve effective, uniform distribution, a sand surrogate marker and silt-clay microbeads were pumped down a hose to the horizontal bar and towed approximately five to six feet above the mudline. The sand marker was placed in three batches over the two trial placement areas with the lake sediment surface area for each batch being 10 meters by three meters in size, making a total of six releases for the two areas. In each batch, a total of two 25 kilogram (50 pound) bags of sand were added pre-mixed with one-third of a tote of natural sediment collected from the lake bed. The sand marker was placed first to avoid disturbance of the silt-clay marker. The silt-clay marker was placed as a single layer over the placed sand.

One day following trial placements of both markers, push core samples comprising four sets of samples orientated perpendicular to the line of placement were collected from each trial placement area. For each set of four samples, the samples designated as A and D were outside of the placement area and samples B and C were within the placement area. A total of 16 cores were collected (see the inset on Figure 1). In order to determine the distribution of the silt-clay marker, which was not visible, sediment samples were collected, segmented vertically, and shipped to the ETS laboratory in Scotland for analysis. Each vertical push core was sub-sampled into slices to four centimeters below the sediment surface. The presence of the sand marker was assessed visually.

To assess the presence and velocity of lake bottom water movement during the microbead marker placement trial, Parsons/ETS deployed two Sontek Vector current meters close to the trial placement location. The current meters were deployed on a mooring frame with the lowest Vector located 49.5 centimeters (19 inches) above the base of the frame. The highest Vector was located 73.7 centimeters (29 inches) above the base of the frame. The base of the frame may have somewhat sunk into the lake sediment, although the frame had a large surface area to limit this. Bottom water movement data were logged from approximately 12:00 hours Eastern Daylight Time (EDT) on October 31, 2008 to 14:30 hours EDT on the November 1, 2008. The data are plotted in Appendix C separately for the lower meter and the upper meter showing a range of logged measurements including water velocity, water level, pitch – heading, and local wind data provided from the Honeywell lakeshore meteorological station.

2.4 Sediment Sampling and Processing

Sediment samples were collected at each sample location with the objective of providing intact cores that included the top centimeter of surface sediment intact. Three different types of sediment sampling equipment were employed during the microbead marker pre-mobilization field tests: a Vibracore™, a box core, and a push core without a catcher. The push core was selected as a suitable device for obtaining representative samples of SMU 8 surface sediment. A push core was used to collect each of the types of sediment cores described in this report.

One 3.5-inch diameter core tube was collected from each test location. Sampling tubes were capped on both ends and stored vertically on the boat and on ice prior to processing onshore and then shipment of processed samples to the laboratory in Scotland. Sediment compaction due to sampling was quantified by measuring the penetration depth on the outside of the sampling device and comparing penetration depth of the sampler with the depth of sediment recovered inside the push core (see Table 2). Sample processing onshore consisted of segmenting each core into vertical intervals using the sample processing SOP from the 2007 MNR sampling effort (Parsons, 2008a). Sample management, equipment decontamination, and other field procedures not specified herein followed procedures provided in the Onondaga Lake PDI Standard Operating Procedures (Parsons, 2005b).

Segmenting of sediment samples into vertical intervals was conducted using an extrusion device as described on page A-1 in the Phase IV PDI Addendum 8 work plan for SMU 8 high-resolution cores (Parsons, 2008d). Split core tubes were also evaluated. The field crew attempted to process SMU 8 sediment at one centimeter vertical intervals and found that the material did not have a high enough solids content to sample at a one centimeter sample resolution. As samples with a one centimeter thickness were extruded, the sediment ran out of the sides of the sample extrusion equipment.

3.0 PRE-MOBILIZATION FIELD TEST RESULTS

3.1 Settling Test Results

Both the sand and silt-clay markers settled on the surface of the sediment core in a layer one to two millimeters thick. In the case of core samples with an uneven sediment surface, the microbeads still deposited relatively evenly over the surface. Each of the sand markers settled at approximately the same speed reaching terminal velocity within a few seconds and continuing to settle at approximately the same rate as a free-falling particle. This was the case irrespective of the density and size of the particles. The finer-grained silt-clay markers tended to flocculate and settle more in line with fine suspended sediment.

Parsons/ETS observed each of the test microbead markers over two to three days following placement of the markers within the core tubes. Over that time, virtually no change in the microbead-sediment horizon was observed. The only exception was if gas bubbles had escaped from the underlying sediment causing the sediment and microbeads to mix slightly.

Based on visual observations during the settling tests, the addition of different sized microbead particles made no discernible difference to the layer that settled on the sediment surface or the thickness of the microbead marker deposited. This was also the case for the higher and lower density particles. Even the larger sand-sized particles did not sink through the silt-clay surface sediment due most likely to the low weight and pressure of the sand marker and/or the density or other characteristic of the sand marker material relative to the underlying SMU 8 sediment.

All four of the sand microbead markers were quite visible in the relatively dark brown or black sediment and hence would be a suitable visual aid for observing actual sedimentation rates. As long as sufficient quantity of microbead marker material is placed, the sand microbead marker should remain clearly visible over the long term. The layer of silt-clay microbead marker was also visible during the settling tests. However, if vertical mixing does occur even over a few millimeters, given that the individual grains are not visible by the naked eye, it will become harder to determine the position and spread of the silt-clay microbead marker without resorting to sub-sampling of the sediment core and laboratory analysis which is a reasonable potential contingency.

Based on gas escaping occasionally during the settling tests, there appeared to be less disruption to the layers of coarser sand microbead marker compared with the finer-grained silt-clay microbead marker. Given the larger size and heavier density this makes sense. ETS believe that the addition of a sand microbead marker would therefore lead to less disturbance of the microbead layer and better and more accurate determination of sedimentation rates over subsequent years following marker placement without relying on laboratory analysis.

Following the settling tests, Parsons/ETS conducted a supplemental test with one of the remaining core tubes. A total of 100 grams (0.2 pound) of natural sand used in the microbead placement trial was released at one time at the top of the tube. The intention was to simulate a much larger plug of material and investigate whether a large plug of sand dosed during placement could disrupt the sediment bed. The net effect and deposition on the sediment core was the same as for smaller releases conducted during the settling tests with the sand grains from the post-settling test release reaching terminal velocity and settling gradually onto the sediment surface.

3.2 Background Fluorescence Results

Analysis of the samples for background fluorescence indicated presence of particulates in the high ultraviolet and throughout the visible spectrum consistent with sediment affected by watershed development (see Figure 2). Background fluorescence levels are similar throughout Onondaga Lake and very low relative to fluorescence levels associated with microbeads. Each of the 53 background samples were analysed for naturally-occurring fluorescent particles in four parts of the visible spectrum visualized with different excitation/emission filter sets, corresponding to red, orange, yellow, blue and violet. The number of fluorescent particles within each color band was determined for each sample. The bar charts included in Figure 2 show particles measured for each of the four of the color bands, with the highest count (at Bloody Brook) being 14 particles for Orange. All other bars shown on Figure 2 are to scale. The size of the orange bar in the legend would represent a count of approximately 16.6.

Despite background fluorescence being present across the range of visible spectrum, lake and tributary sediment particles have patchy fluorescence and are much weaker in intensity compared to the microbead markers evaluated during these field tests which are very intense and bright and have uniform fluorescence. Therefore, any background fluorescence that does exist should not impede the measurement of microbead fluorescence in Onondaga Lake.

3.3 Marker Placement Trial Results and Path Forward for Future Marker Placement

The marker placement trial was successfully completed for both the sand surrogate and the silt-clay microbead marker. Near-bottom water velocities of a few centimeters per second as measured during the marker placement trial could lead to dispersion of the silt-clay marker outside a future marker placement area at the time the marker is being placed. For this reason, use of suitable marker application equipment and limiting the extent that the marker settles through the water column are important considerations for future silt-clay marker placement.

Marker application equipment used during the placement trial worked relatively well despite difficulties with boat positioning and sediment sampling. During the marker placement trial, the QEA boat did not stay within the designated area despite keeping the anchor lines taut at all times. Parsons/ETS found that the anchors were not holding and so drift occurred over time as the sand and silt-clay microbead markers were spread. Lateral movement varied dependent on the distance on the boat from the bow or stern anchors. Rather than relying on the anchors to hold and maintain position, Parsons operated a RTK satellite positioning system to try to orientate the dose vessel on station and accurately each time a new position was required.

A westerly wind during the marker placement trial appeared to promote bottom water currents in the lake at the placement trial location of up to five centimeters per second in the horizontal dimensions. Once the wind speed dropped around the time of darkness on October 31, the measurements of water velocities decreased suggesting a reasonable link between wind and near-bed currents. It is important to note that the water velocity remained up to five centimeters per second for several hours and therefore was not an episodic event as observed in deeper waters at South Deep during fall 2007 current velocity data collection by Cornell University.

Based on a theoretical settling velocity of 0.17 millimeters per second for discrete (non-cohesive) silt-clay particles (each particle being 16 to 31 microns in diameter), neglecting flocculation, and based on a water temperature of 10 degrees Celsius, the silt-clay microbead marker could, without careful placement control, travel many meters laterally in the water column before settling.

Recommendations developed based on the marker placement trial for future application of microbead markers in Onondaga Lake are as follows:

a) The dosing equipment needs some refinement in order to achieve a more controlled dosing for both microbeads but perhaps particularly for the silt-clay microbead marker.
b) The dose vessel must be larger than the QEA boat providing more deck space and being able to hold position and move in a controlled way irrespective of low to moderate wind speeds and currents.
c) Prepare to add microbeads within the water column at a water depth closer to the mudline than was attempted during the placement trial. To do this, more accurate sensing of the true position of the bar relative to the bed will be needed. This may require detailed

bathymetric data for each dose location, a sensor on the dose bar detecting the distance from the bed, a depth sensor on the dose bar, and a spatial map of the dose area in order to plan and position accurately.

d) Undertake a repeat trial placement with a larger boat and optimized sampling equipment and procedure to ensure that placement and sample collection can be successfully carried out with minimal or no disturbance.
e) Deploy the microbeads (particularly any silt-clay microbeads) during low or zero wind conditions, if reasonably possible. The direction and wind speed from previous days will also be a factor.

3.4 Sediment Sampling and Processing Results

Although shallow sediments in SMU 8 are generally very soft and fluffy, sample recovery using a push core was at least 80 to 90 percent sample recovery in a relatively undisturbed condition. Some of the samples showed an angled sediment surface within the core tube which could have been caused by the boat not being stationary or the push core not penetrating vertically into the sediment. Other sampling devices, such as gravity corers, are being considered for possible future application in SMU 8.

Sample segmenting was successfully conducted to vertical intervals as small as two centimeters using an extrusion device. Split core tubes were also tested, but the low solids content of the surface sediment led to this device not being effective.

4.0 MICROBEAD MARKER SAMPLE AND DATA MANAGEMENT

Sample names, QA/QC procedures, sample collection, and data entry for this portion of the work were conducted in accordance with the Phase I PDI Work Plan (Parsons, 2005a, Appendix A and Appendix B).

ETS conduct the fluorescence analyses in its Scotland laboratory. The silt-clay marker used during the marker placement trial and SMU 8 sediment samples collected for background fluorescence analysis were analyzed by ETS in Scotland using fluorescence microscopy to count the number of fluorescent silt-clay microbeads (see Appendix B). The non-fluorescent sand marker used during the marker placement trial was observed visually. Following shipment of the samples to the ETS lab in Scotland, each sub-sample of sediment was weighed, labeled, and dried to a constant weight noting weight loss due to drying. Counts are expressed as numbers of marker particles per dry gram.

Analytical data generated during this investigation was reviewed for usability. Following laboratory analyses, the data were assessed to determine whether the extent of microbead markers in each of the marker locations is relatively uniform.

5.0 MICROBEAD MARKER CONSIDERATIONS FOR FUTURE APPLICATIONS

Three important items are discussed in this section: (1) whether to place one or two microbead markers in SMU 8; (2) more specific marker characteristics; and (3) marker quantity and placement method. Table 3 summarizes other marker placement considerations.

Based on project objectives and results from the pre-mobilization field tests, placement at eight locations of two different fluorescent microbead markers onto the surface of SMU 8 sediment is being planned for 2009. One of the microbead markers (hereafter called Marker A) will mimic SMU 8 surface sediment by being a fine (silt-clay) microbead. The more Marker A becomes mixed within the surface sediment, the more difficult it would be to quantify sedimentation rate based on Marker A. In addition, being silt-clay in size, Marker A particles will not be visible, so Marker A will need to be detected by analysis of a sediment sample at the ETS laboratory in Scotland. The second microbead marker (hereafter called Marker B) will have a larger (sand) grain size having a higher erosion shear stress and, therefore, would be less prone to vertical mixing than Marker A. Marker B will be placed in order to quantify future rates of sedimentation on top of the marker (i.e., the mudline or top of sediment at the time the marker is placed). Marker B will be able to be detected visibly at the project site by collecting a sediment sample for visual observation.

The characteristics of these two microbead markers to be placed in Onondaga Lake are as follows.

- Marker A consisting of microbeads each with a particle diameter distributed relatively evenly between 2 to 60 microns (silt-clay) and a dry density of 2.6 grams per cubic centimeter (i.e., 160 pounds per cubic foot) based on the results from particle size and specific gravity analyses completed on 11 surface sediment samples collected throughout SMU 8 during November 2007 (Parsons, 2008c). The purpose of this marker is to mimic vertical mixing of SMU 8 sediment, if any; and
- Marker B consisting of microbeads with a particle diameter of 100 to 300 microns (or 0.2 to 0.3 millimeters) and marker particle shape similar to Marker A.

To quantify mixed layer depth, Marker A must be able to mix vertically at the same rate as SMU 8 surface sediment. Due to the small size of the SMU 8 sediment particles (silt and clay), Marker A will not be visible. Marker B, on the other hand, will be much less likely to be affected by any natural vertical mixing due to its larger particle size. Marker B will also be visible and, therefore, observable from collecting and examining sediment samples without conducting laboratory analyses of the marker following placement. Thus, the primary purpose of Marker A will be to quantify any vertical mixing, and the primary purpose of Marker B will be to quantify future sedimentation by acting as relatively stable vertical marker that is less prone to vertical mixing over time.

The target marker placement thickness for both markers will be one to two millimeters. The basis for assigning a placement thickness for the marker with a sand consistency is to confirm with visible observations location of the sedimentation line (i.e., the marker elevation). A placement of this marker that is too thin would be difficult to see visually with the black SMU 8 sediment. As ETS demonstrated during a job for the US Army Corps of Engineers (New Orleans District) on the Mississippi River, the fluorescent microbead marker with a sand consistency is quite visible. A thickness of one to two millimeters is a thickness that should be seen clearly by the field team so as to provide confidence that the microbead layer has been effectively placed while in the future being able to sample above or below the microbead layer with confidence and also observe sediment in the core referenced to the visible marker layer. The microbead marker with a silt-clay consistency will not be visible since the marker grains will be too small. This marker needs to be measureable in the ETS laboratory even if the marker becomes mixed vertically with SMU 8 sediment through bioturbation or resuspension. A one to two millimeter placement thickness for this marker will be detectable in the ETS Laboratory even if this marker does mix with SMU 8 sediment to a depth of a few centimeters.

The microbead markers will be manufactured in Scotland by Environmental Tracing Systems, Ltd, using non-toxic polyester-based polymers that are known to be highly resistant to photodegradation and biochemical breakdown even when exposed to the natural elements. Both markers will include a naturally-occurring mineral such as barium sulfate to adjust physical properties of the marker (such as dry density) as needed to meet project objectives. The two markers will be manufactured with the same fluorescent pigment label. The fluorescent pigment will comprise approximately three percent by weight of the final microbead marker composition. The fluorescent chemical signature will be thermoset into the pigment polymer and will represent less than five percent by weight of the overall pigment. With this design, if the microbead does break down gradually over time, the pigment will still retain its fluorescent property.

Additional sediment characterization tests may be conducted prior to marker placement. These tests may include analysis for particle size and specific gravity.

Both markers will be placed based on a target marker thickness of one to two millimeters using placement equipment similar to what was used during the marker placement trial.

Sediment sampling to confirm marker placement will be conducted using a push core, gravity core, piston core, or a multiple core based on tests with SMU 8 sediment to be conducted in 2009 prior to placing either marker. Surface sediment samples to be collected to quantify marker depth need to be as undisturbed as reasonably possible. Sample processing will be conducted as conducted during the pre-mobilization field tests.

Post-placement marker sampling and analysis and post-placement control checks will be conducted as described in the microbead marker work plan (Parsons, 2008c).

6.0 REFERENCES

Honeywell, Parsons, and O'Brien & Gere, 2007. Honeywell Syracuse Portfolio Health and Safety Program. June 15, 2007.

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Parsons, 2004. Feasibility Study Report for Onondaga Lake. Prepared for Honeywell. November 2004. (MNR is described in detail in Appendix N.)

Parsons. 2005a. Onondaga Lake Pre-Design Investigation: Phase I Work Plan. Prepared for Honeywell. September 2005.

Appendix A Phase I Sampling And Analysis Plan

Appendix B Quality Assurance Project Plan

Appendix C Project Safety Plan Updated March 2007.

Parsons. 2005b. Onondaga Lake Pre-Design Investigation: Standard Operating Procedures. Prepared for Honeywell. November 2005.

Parsons. 2006. Onondaga Lake Pre-Design Investigation: Phase II Work Plan. Prepared for Honeywell. September 2006.

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Parsons, 2008a. Onondaga Lake Pre-Design Investigation: Phase III Work Plan – Addendum 6. SMU 8 Sampling to Monitor Natural Recovery. Prepared for Honeywell. Prepared in association with Exponent and Anchor Environmental. Revised January 2008.

Parsons, 2008b. Onondaga Lake Pre-Design Investigation: Phase III Addendum 6 Data Summary Report. Prepared for Honeywell. Prepared in association with Exponent and Anchor Environmental. June 2008.

Parsons, 2008c. Microbead Marker Work Plan for Monitoring Natural Recovery in SMU 8. Prepared for Honeywell. Prepared in association with Anchor Environmental and Environmental Tracing Systems. September 2008.

Parsons, 2008d. Onondaga Lake Pre-Design Investigation: Phase IV Work Plan – Addendum 8. SMU 8 High Resolution Cores. Prepared for Honeywell. Prepared in association with Anchor Environmental and Exponent. November 2008.

TAMS Consultants and YEC, Inc., 2002. Onondaga Lake Remedial Investigation Report. Prepared for the State of New York Department of Environmental Conservation. Based on an original document prepared by Exponent for Honeywell. December 2002.

Upstate Freshwater Institute and Syracuse University, 2008. Onondaga Lake Baseline Monitoring Book 1. Deep Basin Water and Zooplankton Monitoring Work Plan for 2008. Prepared for Honeywell. Prepared by Steven Effler and C. Driscoll. May 2008

TABLE 2

SEDIMENT RECOVERY FROM LATE 2008 SETTLING TEST CORES

Location ID	Push Core Penetration Depth (inches)	Sediment Recovery depth (inches)	Percent Sample Recovery(1)
OL-MB-80093 A/B	72/72	16.5/11.3	23 / 16
OL-MB-80094	72/72	23.5	33
OL-MB-80095	72/72	22.5	31
OL-MB-80096	72/72	10	14
OL-MB-80097	72/72	28	39
OL-MB-80098	72/72	24.5	34
OL-MB-80099 A/B	72/72	35.5/28	49 / 39
OL-MB-80100 A/B	72/72	31/30	43 / 42

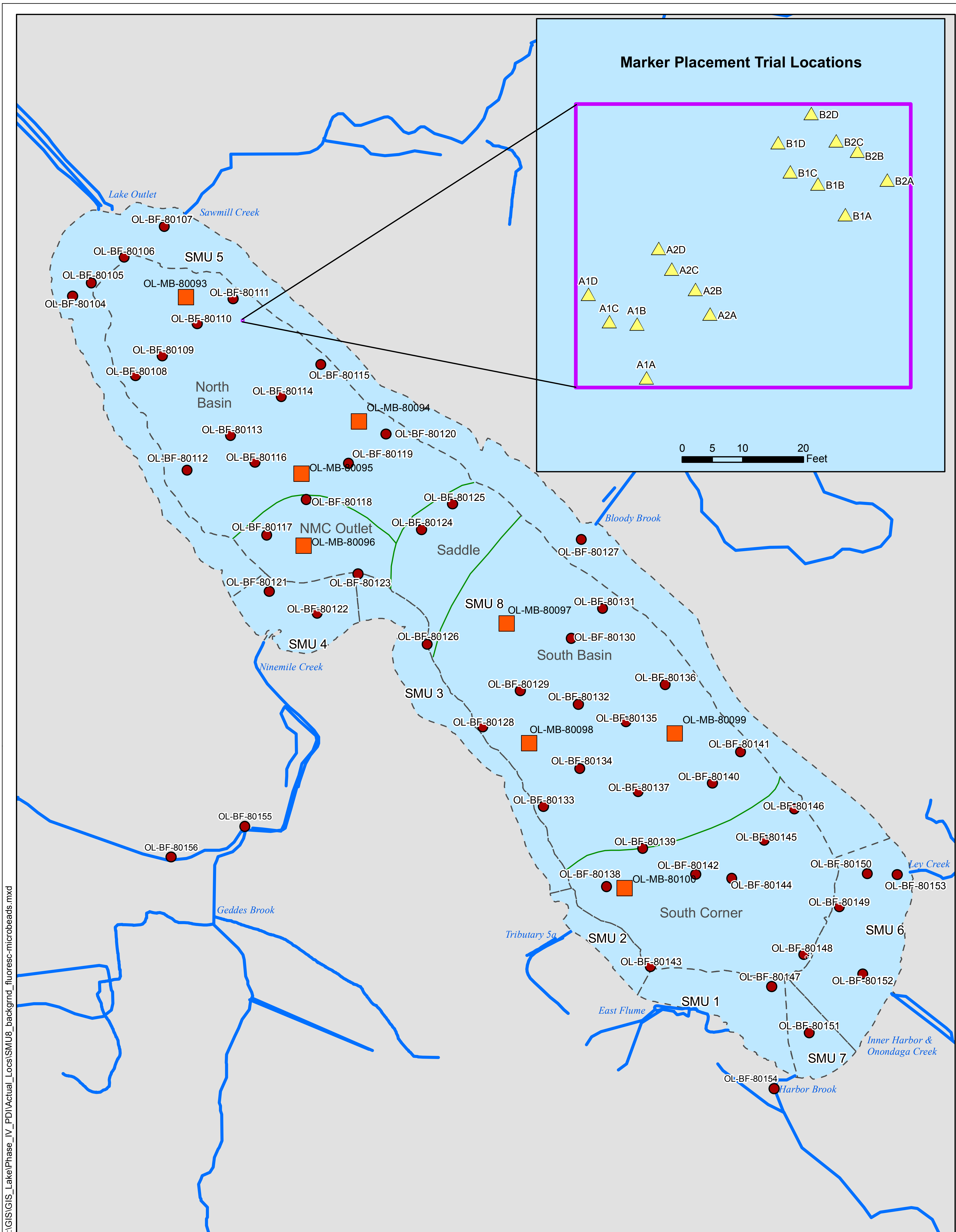
1 inch = 2.54 centimeters (cm).

(1) Percent sample recovery is equal to sediment recovery depth divided by push core penetration depth over the entire 72-inch penetration depth. Note that the top 6 to 12 inches of sediment are what was needed to conduct settling test work with test microbeads. Sample recovery for the top 6 to 12 inches has consistently exceeded 90 percent for SMU 8 sediment with the sampling technique employed as part of this work effort.

TABLE 3

CONSIDERATIONS FOR FUTURE SMU 8 MICROBEAD MARKER PLACEMENT

Marker types	Two markers could be placed: (Marker A) silt particle size and resembling SMU 8 sediment characteristics; and (Marker B) sand particle size but also resembling settling characteristics of SMU 8 sediment without possible vertical mixing due to water movement, bioturbation, and/or gas ebullition.
Marker objectives	Marker A will assess combined effects of vertical mixing and sedimentation Marker B will assess sedimentation without vertical mixing
Marker placement locations and size	Eight each approximately 100 square meters in area (see Figure 1 in Parsons, 2008c).
Sample collection method	Push core, gravity core, piston core, or multiple core sampler depending on results from tests with SMU 8 sediment to be conducted prior to marker placement.
Laboratory analyses	For Marker A: fluorescence microscopy and/or analytical flow cytometry. Image analysis can also be used to provide a count and microbead particle distribution if required. For Marker B: fluorescent magnification and microscopy
Quality assurance	Post marker placement control check (see Section 4.5 in Parsons, 2008c) Field duplicates as appropriate



ACTUAL LOCATIONS

- Settling Test Sample
- Background Fluorescence for Microbeads
- Marker Placement Trial Sample
- Marker Placement Trial Area

NYSDEC Demarcation for SMU 8

NOTES

1. Bathymetry contour interval = 10 feet.
2. Water depth based on average lake elevation of 362.82 feet.

0 750 1,500 3,000 4,500 6,000

Feet

FIGURE 1

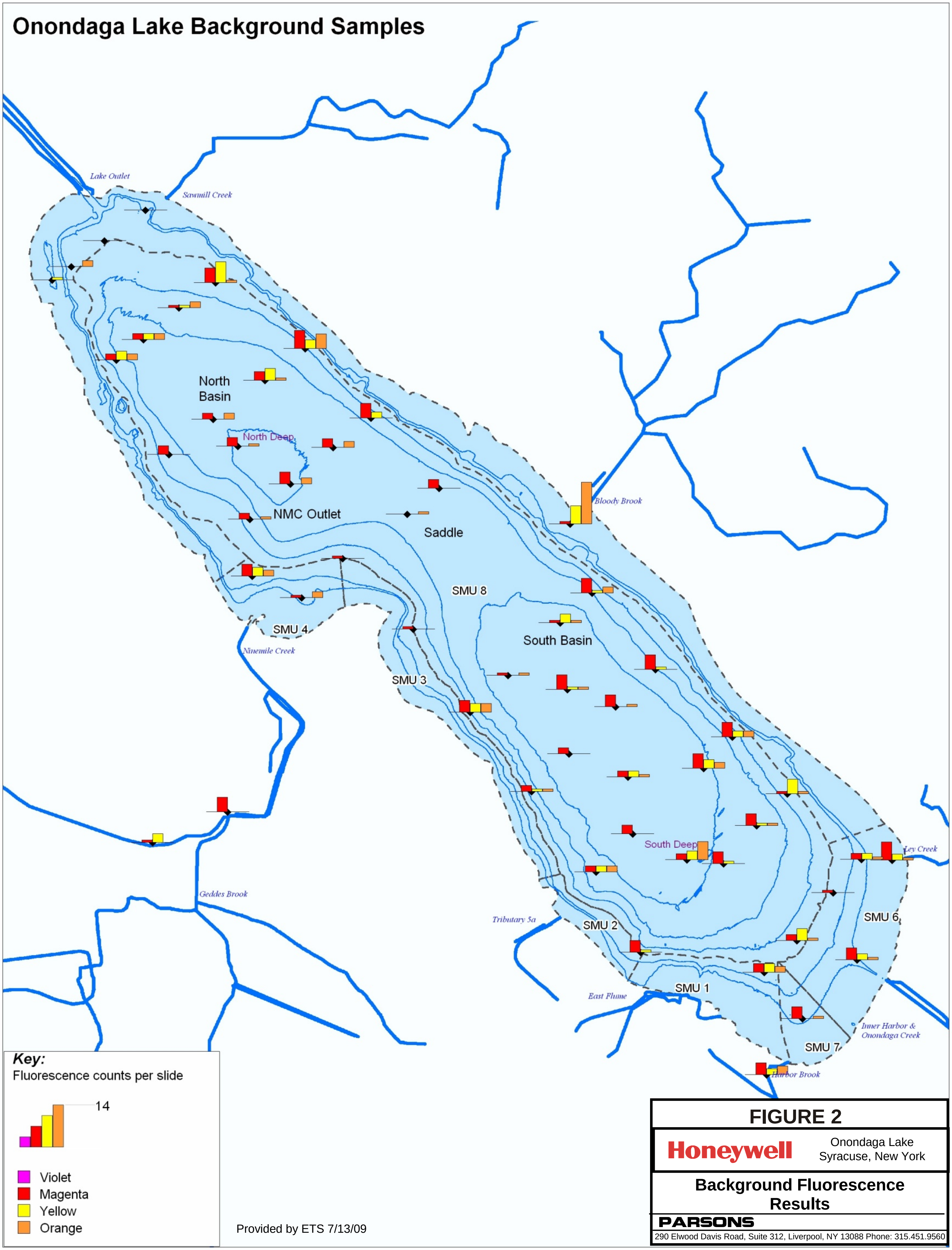
Honeywell

Onondaga Lake
Syracuse, New York

SMU 8
2008 Settling Test, Background Fluorescence and Marker Placement Trial Sample Locations

PARSONS

290 ELWOOD DAVIS RD, SUITE 312, LIVERPOOL, NY 13088 Phone:(315)451-9560



P:\h-well-syr-445103\9.0\Microbead Report\Figure 2.ppt

APPENDIX A

PHOTO LOGS

PHOTOGRAPHIC LOG

PARSONS

PROJECT: Phase IV Pre-Design Investigation
PROJECT #: 444540
TASK: Microbead Tracer
CLIENT: Honeywell

Gravity Corer

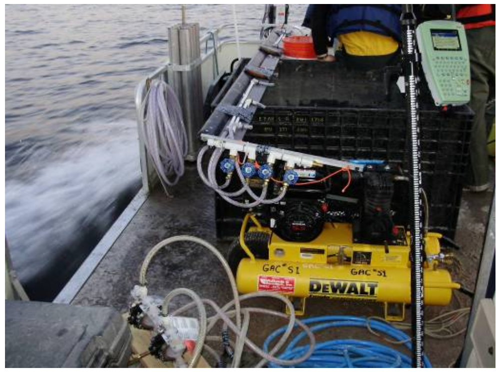
Push Corer

Two collection methods used to determine the most effective way of collecting an undisturbed core. The push corer proved most successful and was used to collect initial cores along with the background cores.

Deploying Velocity Meter: Velocity Meter was placed "downstream" of the test area to take continuous readings of lake bottom velocity.

Microbead Marker dose equipment: The discharge bar for the fine fraction (Marker A) is on the ground with small bore hose and the discharge bar for coarse fraction (Marker B) is off the ground with the larger bore hose.

Hose/Drill combination used to mix Markers A & B before pumping



Pumping Markers

The fine fraction dose bar, valves and hose resting on the black tote, with the pumps in the foreground and (yellow) compressor in the middle of the photo. Parsons RTK system is shown on the top right corner. For each dose system, the equipment comprised a bar that was lowered to approximately 5 to 6 feet above the sediment surface, with multiple (8 of; approximately 1 per foot) discharge hoses along the length of the bar to provide an even spread of microbeads. The hoses were connected to a regulating pump with dose material (surrogate microbeads) fed from a reservoir .

Mixing flocculent and tracer which was then spread on top of Markers A & B

PHOTOGRAPHIC LOG

PARSONS

PROJECT: Phase IV Pre-Design Investigation TASK: Settling Test Day 2 Following Application
PROJECT #: 444540 CLIENT: Honeywell

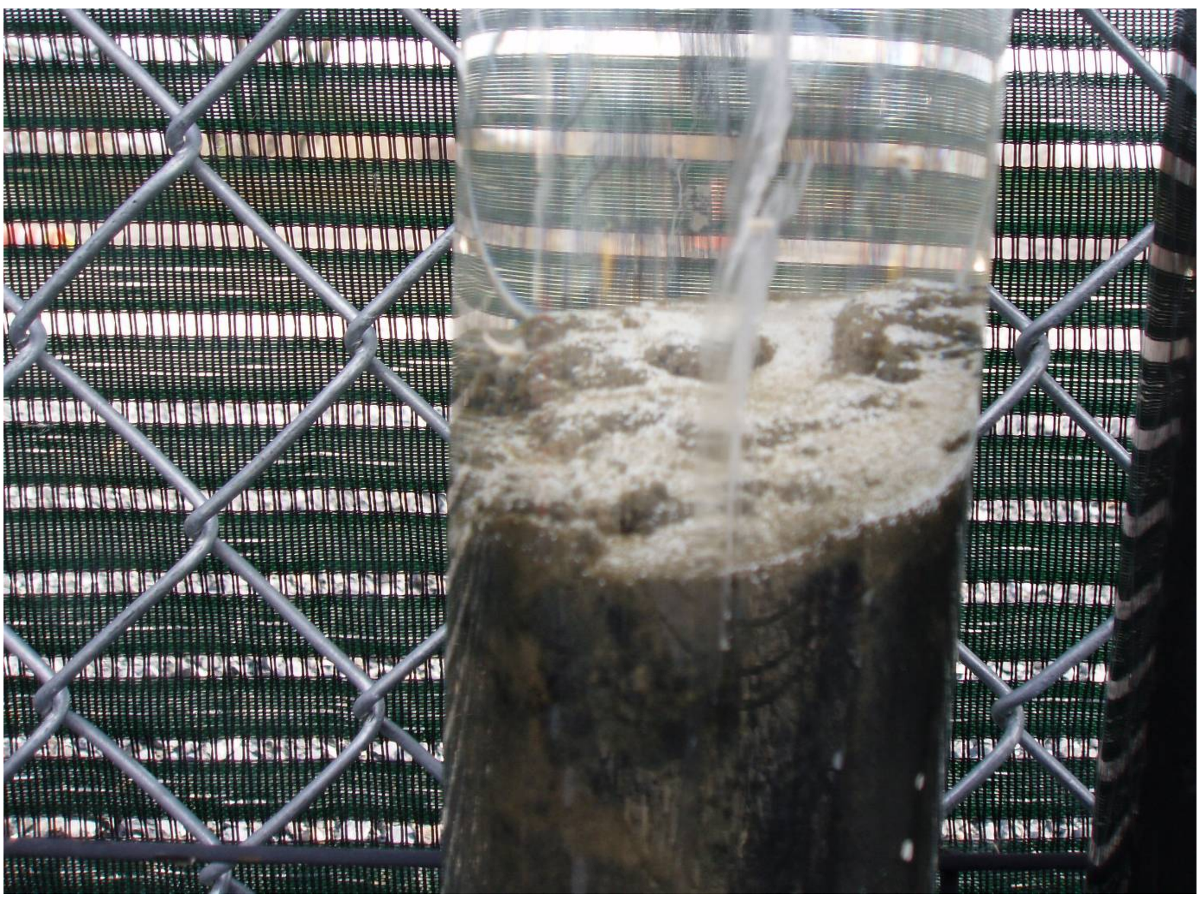
OL-MB-80093 A

Date/Time of Application: 11/06/08 @ 1323

Tracer Type: Moszum, > 300mm

Color: UV Blue

Comments: tracer is white (as noted on 11/05/08), tracer expanded into sediment up to 0.25" at the deepest.



PHOTOGRAPHIC LOG

PARSONS

PROJECT: Phase IV Pre-Design Investigation
PROJECT #: 444540

TASK: Settling Test Day 2 Following Application
CLIENT: Honeywell

OL-MB-80093 B

Date/Time of Application: 11/06/08 @ 1323

Tracer Type: 8 grams of play sand

Color: none

Comments: No noticeable changes.

PHOTOGRAPHIC LOG

PARSONS

PROJECT: Phase IV Pre-Design Investigation TASK: Settling Test Day 2 Following Application
PROJECT #: 444540 CLIENT: Honeywell

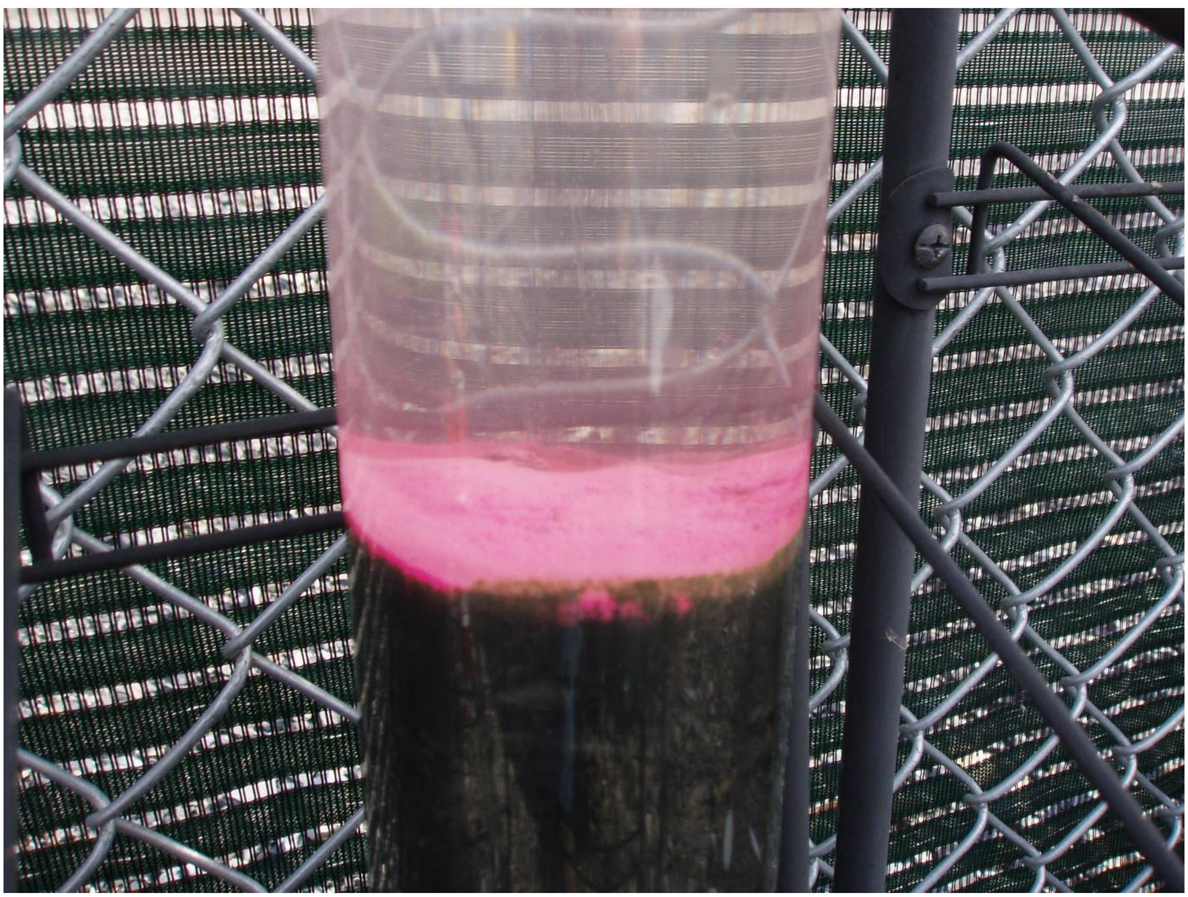
OL-MB-80094

Date/Time of Application: 11/06/08 @ 1330

Tracer Type: Thermop 2-7, 20-40 mm

Color: Magenta

Comments: core settled approximately 0.25" compared to 11/05/08. No other noticeable changes.



PHOTOGRAPHIC LOG

PARSONS

PROJECT: Phase IV Pre-Design Investigation TASK: Settling Test Day 2 Following Application
PROJECT #: 444540 CLIENT: Honeywell

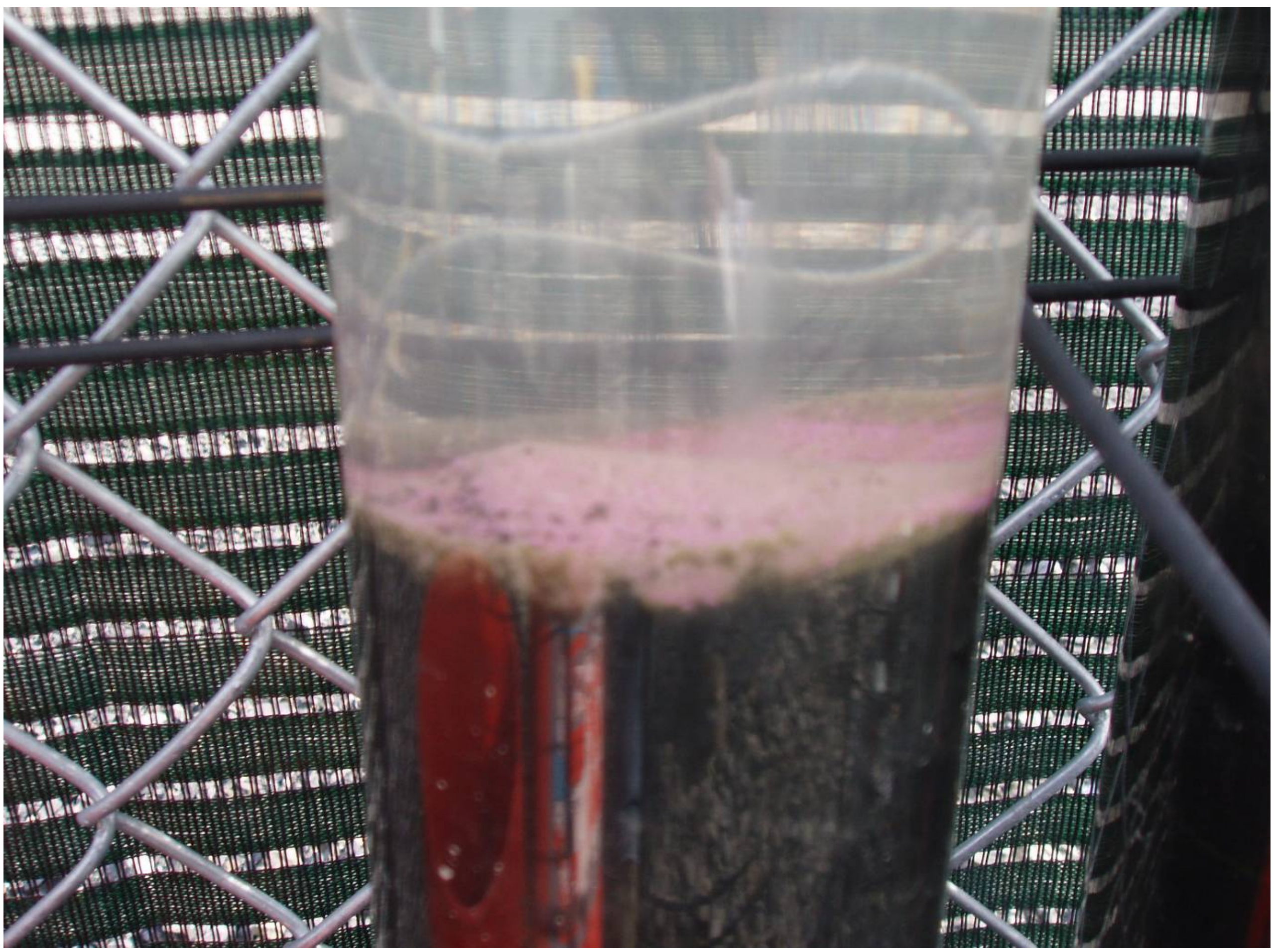
OL-MB-80095

Date/Time of Application: 11/06/08 @ 1330

Tracer Type: Ex-brons

Color: Violet

Comments: 1 mm thick nephloid layer on top of the tracer, no other noticeable changes.



PHOTOGRAPHIC LOG

PARSONS

PROJECT: Phase IV Pre-Design Investigation TASK: Settling Test Day 2 Following Application
PROJECT #: 444540 CLIENT: Honeywell

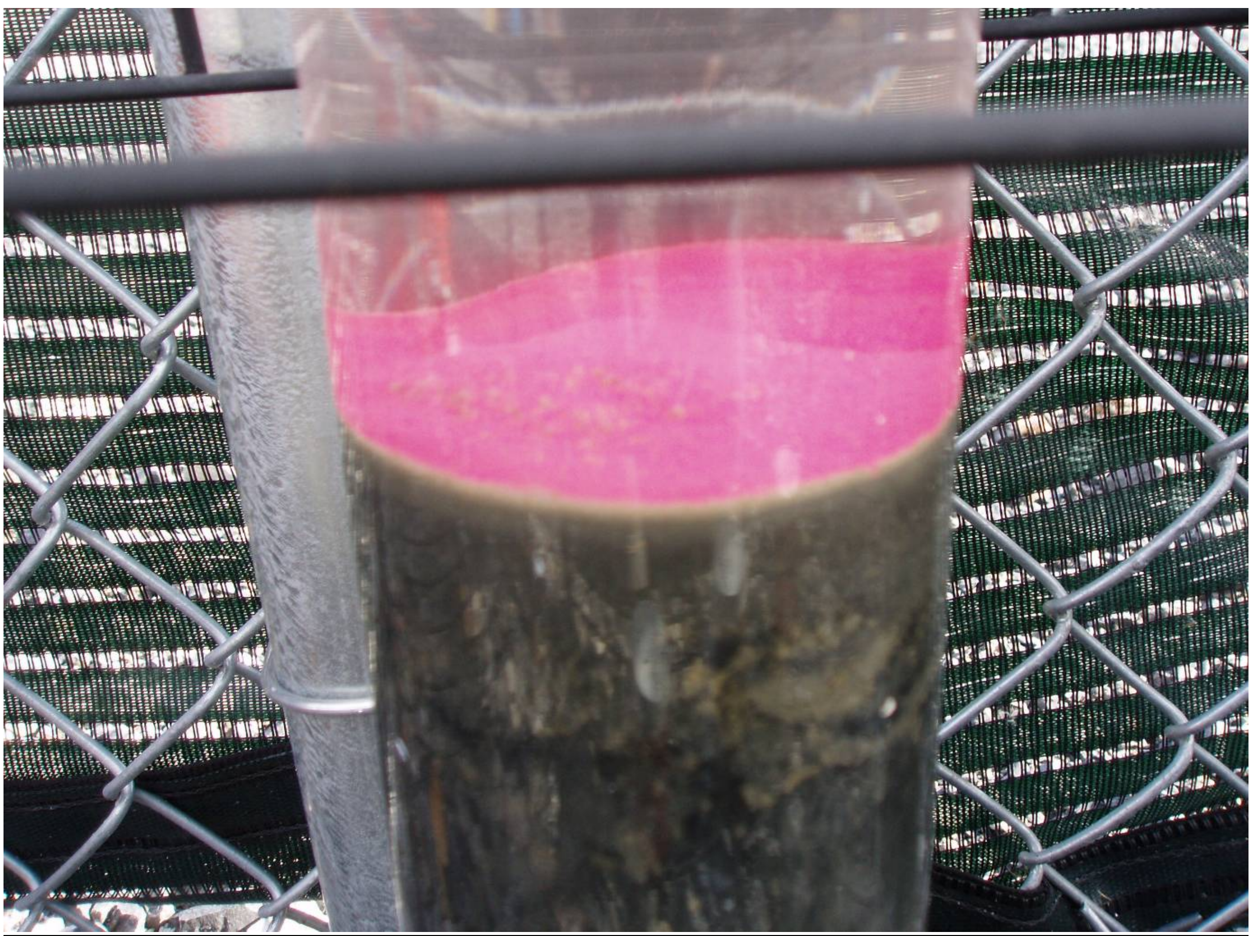
OL-MB-80096

Date/Time of Application: 11/06/08 @ 1330

Tracer Type: Helwick, < 90 mm

Color: Pink

Comments: No noticeable changes.



PHOTOGRAPHIC LOG
PARSONS

PROJECT: Phase IV Pre-Design Investigation TASK: Settling Test Day 2 Following Application
PROJECT #: 444540 CLIENT: Honeywell

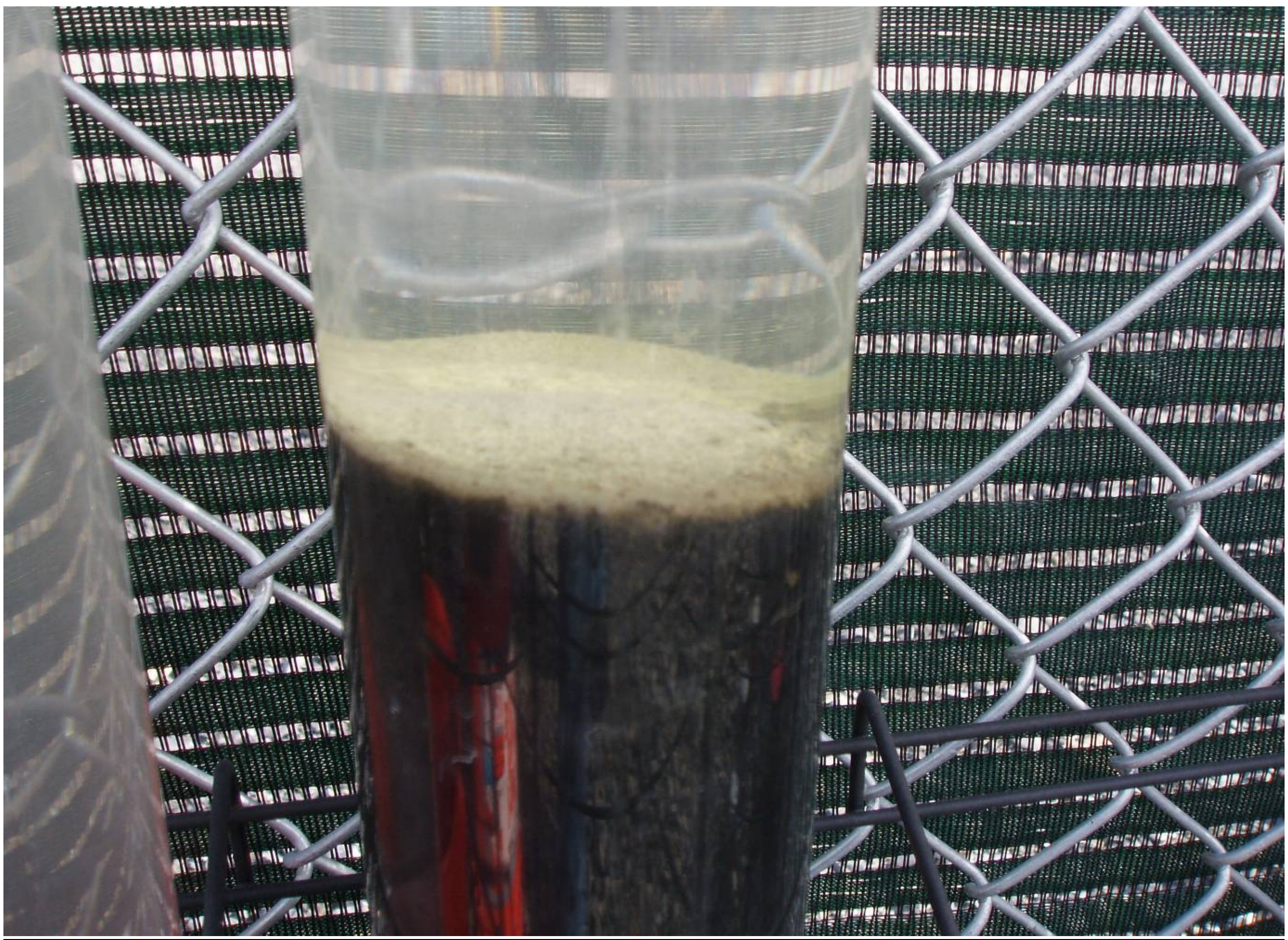
OL-MB-80097

Date/Time of Application: 11/06/08 @ 1330

Tracer Type: Hosokawa 1-4, 0-180 mm

Color: Yellow

Comments: 1 mm thick nephloid layer on top of tracer. No other noticeable changes.



PHOTOGRAPHIC LOG

PARSONS

PROJECT: Phase IV Pre-Design Investigation TASK: Settling Test Day 2 Following Application

PROJECT #: 444540 CLIENT: Honeywell

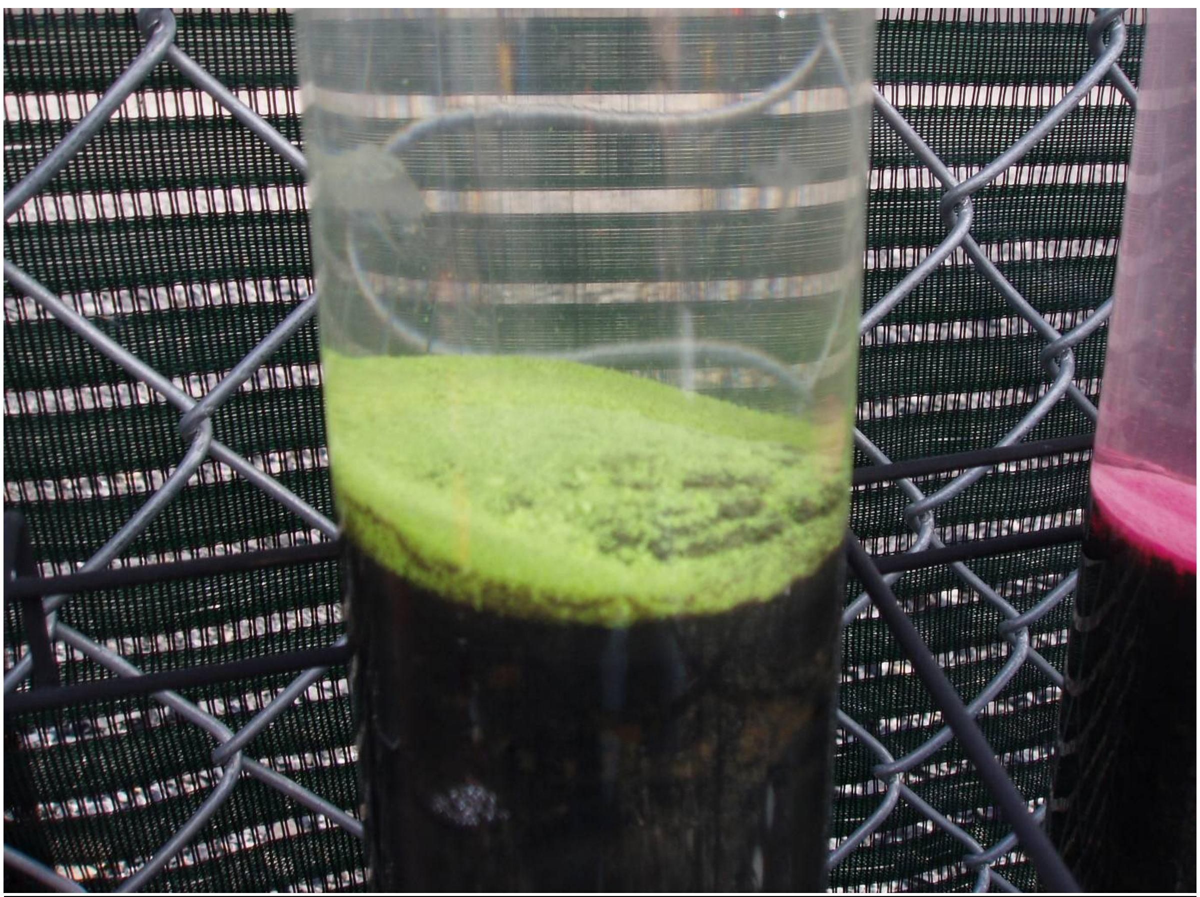
OL-MB-80098

Date/Time of Application: 11/06/08 @ 1330

Tracer Type: Kirkcaldy 1-4, various size

Color: Yellow

Comments: core settled approximately 0.25" compared to 11/05/08. Some white nephloid material on top of tracer. No other noticeable changes.



PHOTOGRAPHIC LOG
PARSONS

PROJECT: Phase IV Pre-Design Investigation TASK: Settling Test Day 2 Following Application

PROJECT #: 444540 CLIENT: Honeywell

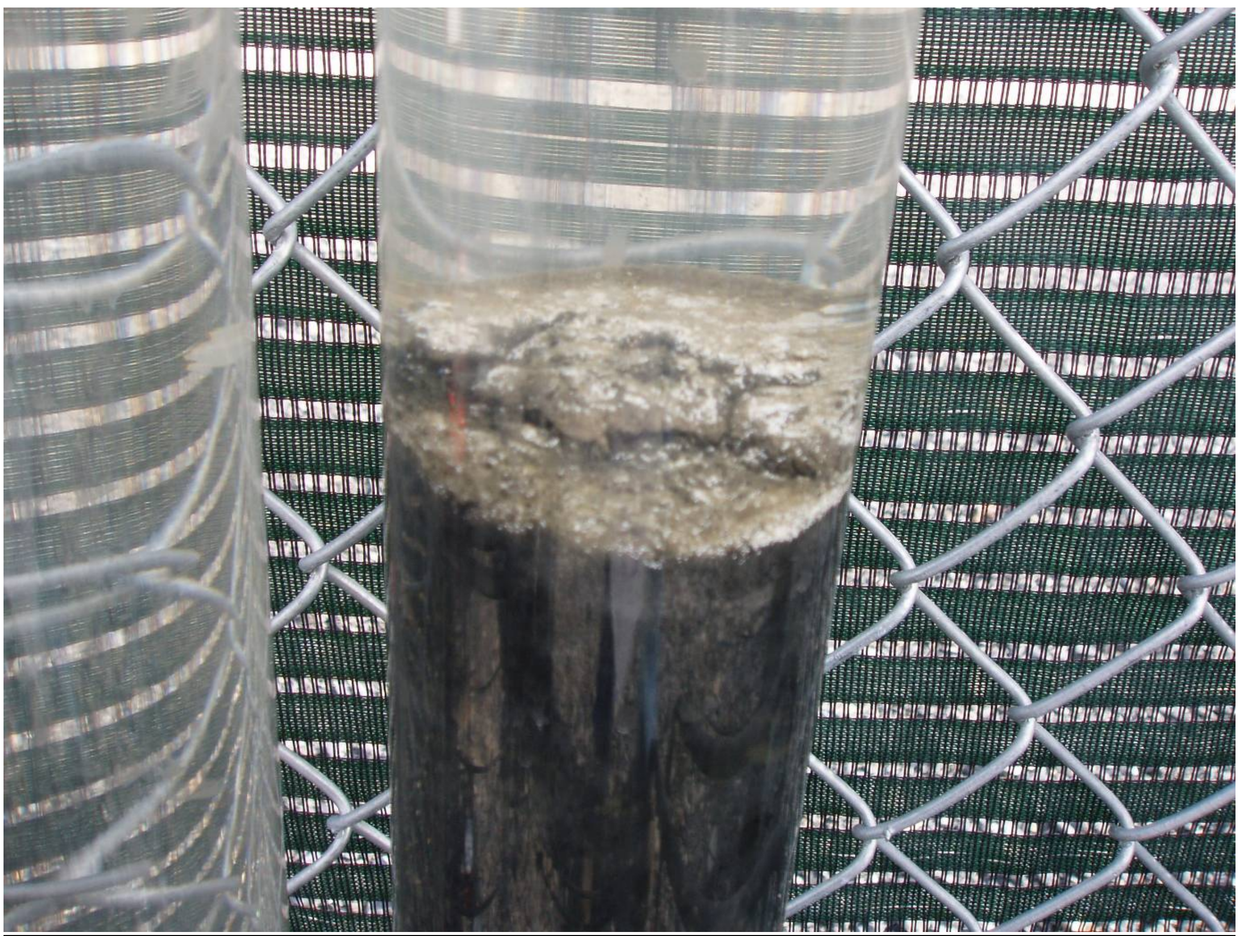
OL-MB-80099 A

Date/Time of Application: 11/06/08 @ 1323

Tracer Type: Moszun, > 300 mm-

Color: UV Blue

Comments: Many white fine grained material on surface of tracer – possibly material that was still suspended in the water column that took a longer period of time to settle?. No other noticeable changes.



PHOTOGRAPHIC LOG

PARSONS

PROJECT: Phase IV Pre-Design Investigation TASK: Settling Test Day 2 Following Application

PROJECT #: 444540 CLIENT: Honeywell

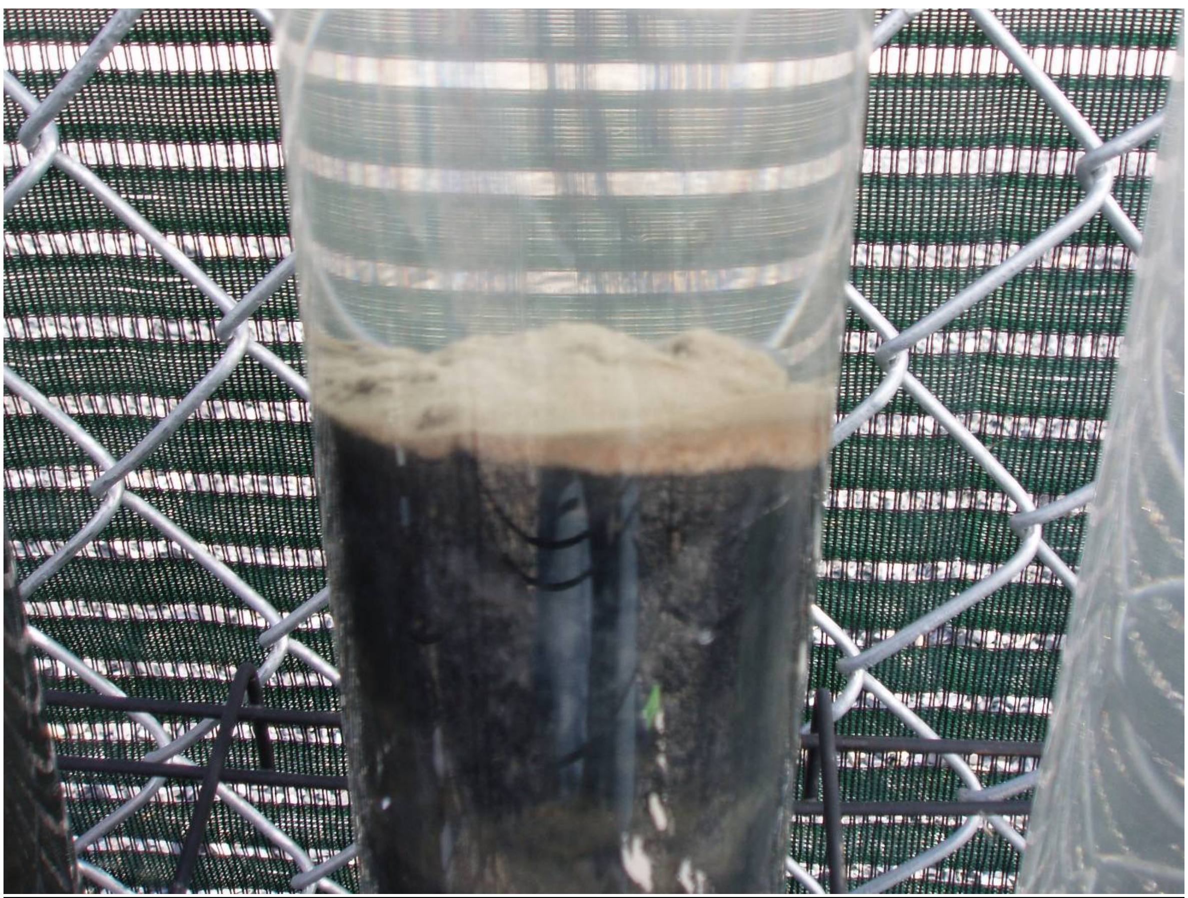
OL-MB-80099 B

Date/Time of Application: 11/06/08 @ 1323

Tracer Type: 8 grams of play sand with water

Color: None

Comments: Many white fine grained material on surface of sand – possibly material that was still suspended in the water column that took a longer period of time to settle?. No other noticeable changes.



PHOTOGRAPHIC LOG

PARSONS

PROJECT: Phase IV Pre-Design Investigation TASK: Settling Test Day 2 Following Application

PROJECT #: 444540 CLIENT: Honeywell

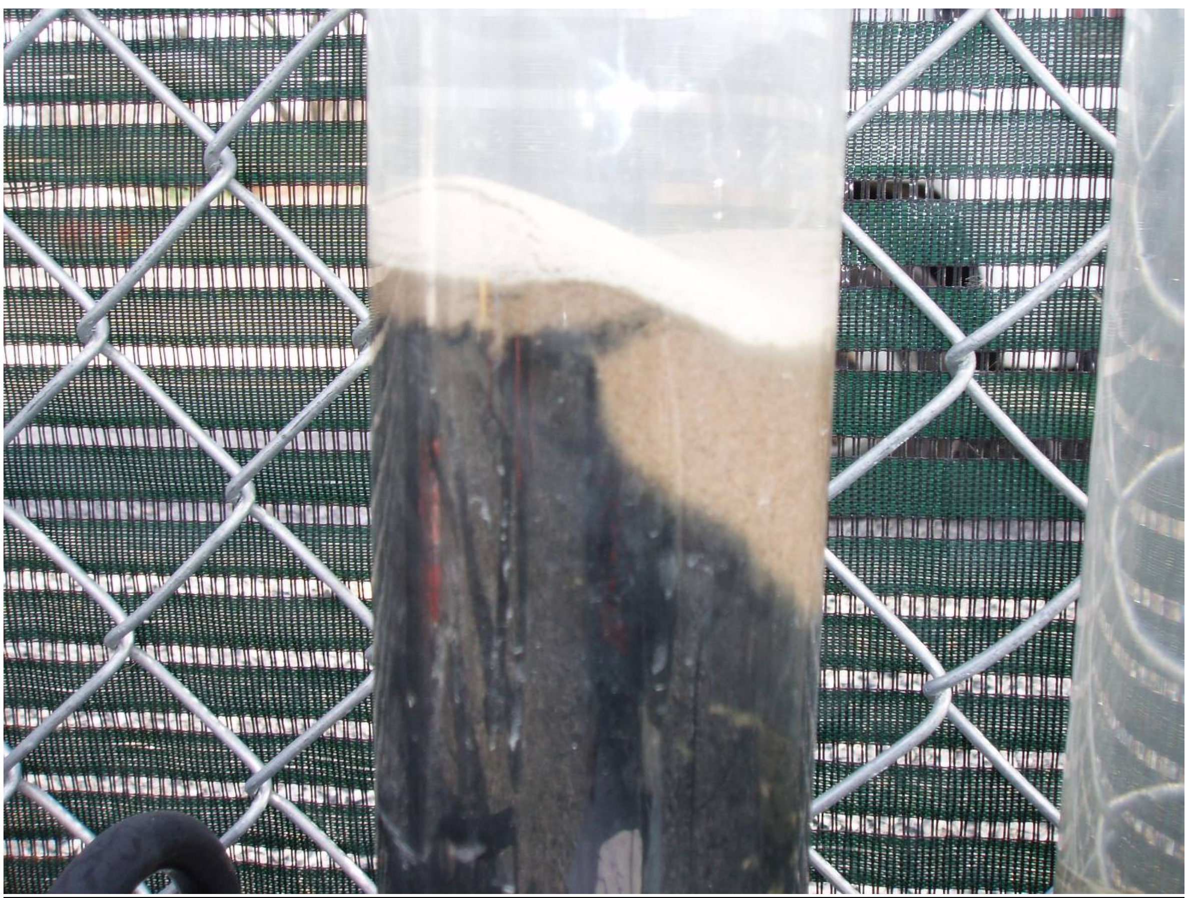
OL-MB-80100 A

Date/Time of Application: 11/06/08 @ 1323

Tracer Type: 100 grams of play sand

Color: None

Comments: Many white fine grained material on surface of sand – possibly material that was still suspended in the water column that took a longer period of time to settle?. No other noticeable changes.



PHOTOGRAPHIC LOG
PARSONS

PROJECT: Phase IV Pre-Design Investigation TASK: Settling Test Day 2 Following Application

PROJECT #: 444540 CLIENT: Honeywell

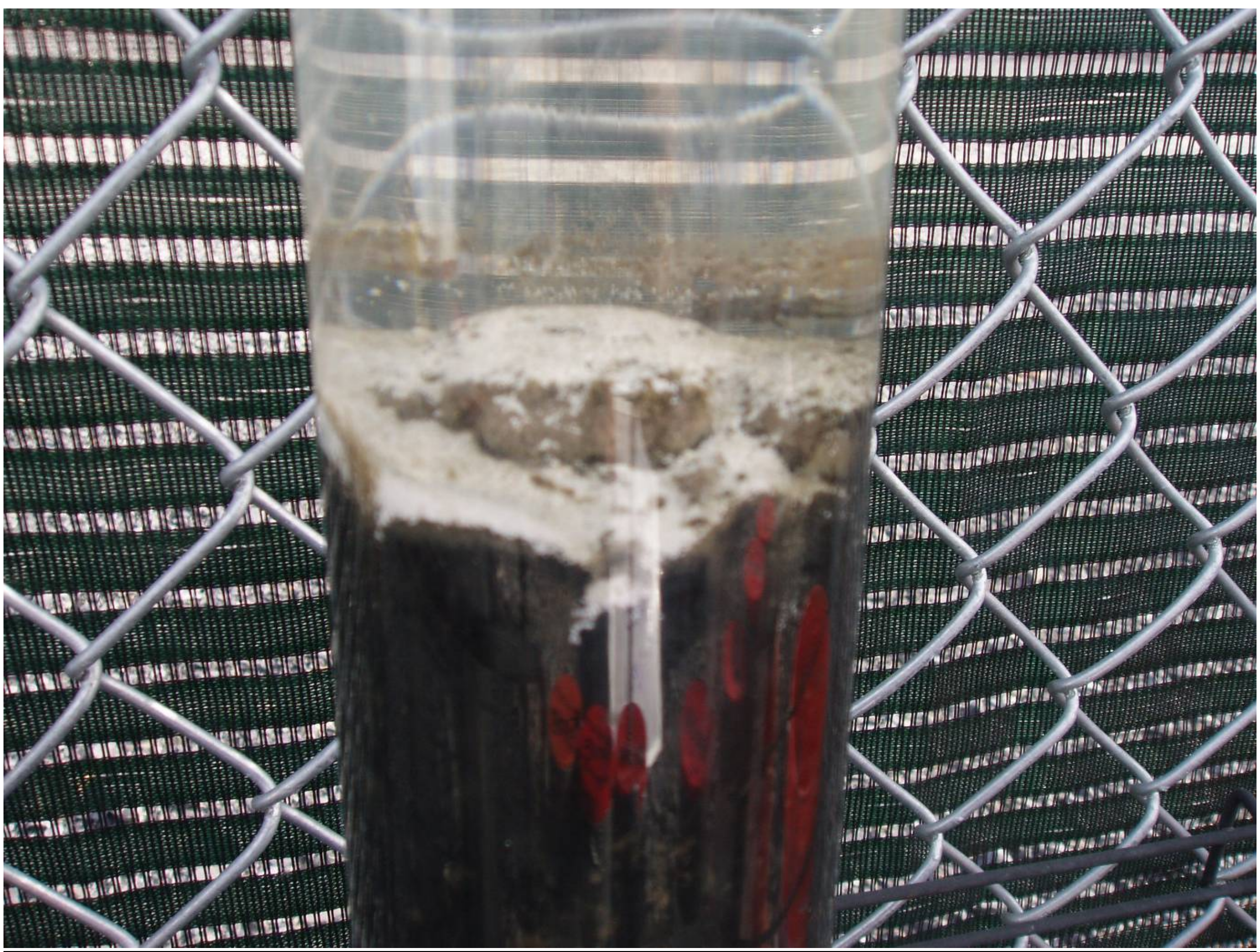
OL-MB-80100 B

Date/Time of Application: 11/06/08 @ 1330

Tracer Type: Moszun, > 300 mm

Color: UV Blue

Comments: Tracer expanded into sediment approximately 1" at points. Tracer is white (was UV Blue) No other noticeable changes.



APPENDIX B

PROCEDURE FOR FLUORESCENCE ANALYSES PERFORMED AT ETS LABORATORY

APPENDIX B

PROCEDURE FOR FLUORESCENCE ANALYSES

SAMPLE ARRIVAL

On arrival all samples were inspected and compared with any information provided.

SAMPLE LOGIN

Each sample was allocated a unique identification number, linked to any information provided by the client. Within the login sheet, notes were made concerning the samples. All samples were kept in a cool, dark storage room while awaiting preparation and analysis.

SAMPLE PREPARATION

Each sample was checked for integrity and wiped down to reduce the possibility of contamination of the sample contents. They were then cross-checked with the login sheet and each sample was labeled with ETS' unique identification number.

DRY WEIGHT DETERMINATION OF SEDIMENT SAMPLES

Each original sample was mixed until homogeneous and then a 5 gram sample was removed. This sub-sample was weighed then dried, to a constant weight. The ratio obtained was used to convert the 'number of microbead particles per wet weight' to 'number of microbead particles per dry weight' once analysis was completed. 1 gram sub-samples of the dried samples were then taken and suspended in 49 g deionized water.

CORE SAMPLE PREPARATION

Each sample was then mixed until homogeneous including placement in an ultrasonic bath for 10 minutes. From this suspension, a 0.5 milliliter was passed through a prepared filtration unit comprised of a 0.45 micron pore size membrane filter held within polypropylene filter housing. This filtration leaves all particulate material on the surface of the filter paper. The membrane was carefully removed from the filter housing and transferred using tweezers to a labeled microscope slide. A cover slip (larger than the filter paper) was gently placed on the slide, and secured in place with superglue.

MICROSCOPE SLIDE ANALYSIS

The prepared slides were then transferred to the microscope analysis area. Prior to the commencement of counting, the slides were cross-checked to confirm correct labeling and documentation. The slide integrity was also checked. The correct filter set for the Magenta microbead was placed in the relevant position (e.g. the "Leica Filter Block I3" was used for determining Magenta microbead marker).

The entire surface of the filter paper was examined under a fluorescent microscope with specially selected light source and filter cubes to best view the Magenta microbead marker used.

A preliminary assessment of all prepared slides was conducted and slides classified into four groups. These were:

Slides that appear:

- zero
- low in microbead counts (less than 50)
- medium in microbead counts (~ 50 to 100)
- high in microbead counts (more than 100)

Precise counts for the zero, low and medium groups were determined. The whole of the filter paper surface is assessed for the presence of the microbead particles.

The microbead particle counts are reported as 'number of microbead particle counts per gram dry weight for mud samples (taking into account any dilution factors).

CONTROLS AND REPLICATE ANALYSIS

As a quality control measure 10 percent of the samples were randomly selected for replicate analysis covering, where possible, the range of results – zero, low, medium and high counts. New slides were prepared for each sample and analyzed as detailed above. This ensures consistency between microscope operatives and repeatability of methodology.

Throughout the analysis procedure, control samples were prepared to ensure that any equipment or laboratory working area or space remained clean and uncontaminated. Due to the enforcement of the ETS

Standard Laboratory Procedures (outlined above), no contamination was found and all control/blank samples gave zero counts.

PREPARATION AND ANALYSIS OF ONONDAGA LAKE BACKGROUND CORE SAMPLES

In the preparation and analysis of the 50 background samples, ETS used exactly the same procedure as per the Live Samples described above. The analysis of background samples varied only in that ETS analyzed the samples not only for Magenta microbead color but also for other particles with visible and high ultraviolet spectral emission that may interfere with the detection of ETS microbead markers.

APPENDIX C

WATER VELOCITY AND WIND DATA FOR THE OCTOBER 31 - NOVEMBER 1, 2008 MICROBEAD MARKER PLACEMENT TRIAL

APPENDIX C

WATER VELOCITY AND WIND DATA FOR THE OCTOBER 31 - NOVEMBER 1, 2008 ONONDAGA LAKE MICROBEAD MARKER PLACEMENT TRIAL

Various parameters are shown in the plots of the vector data. A brief description of each plot is provided below:

Current magnitude and direction – The horizontal magnitude of the current in centimeters per second (cm/s) is shown as the line plot and the direction is indicated by the blue vectors. The vectors point in the direction the current is going and the length is proportional to the velocity. The vertical component of water velocity is also available from these measurements.

Pitch and roll – The pitch and roll of the sensors measured by the internal pitch and roll sensors located in the electronics package for the meters. The electronics package is separate from the wand on which the current sensor is mounted. The electronics package was attached to the side of the frame. The wand is connected to the electronics package via a cable.

Temperature – The water temperature at the sensor depth in degrees Celsius. The lower vector did not appear to be reporting temperature accurately.

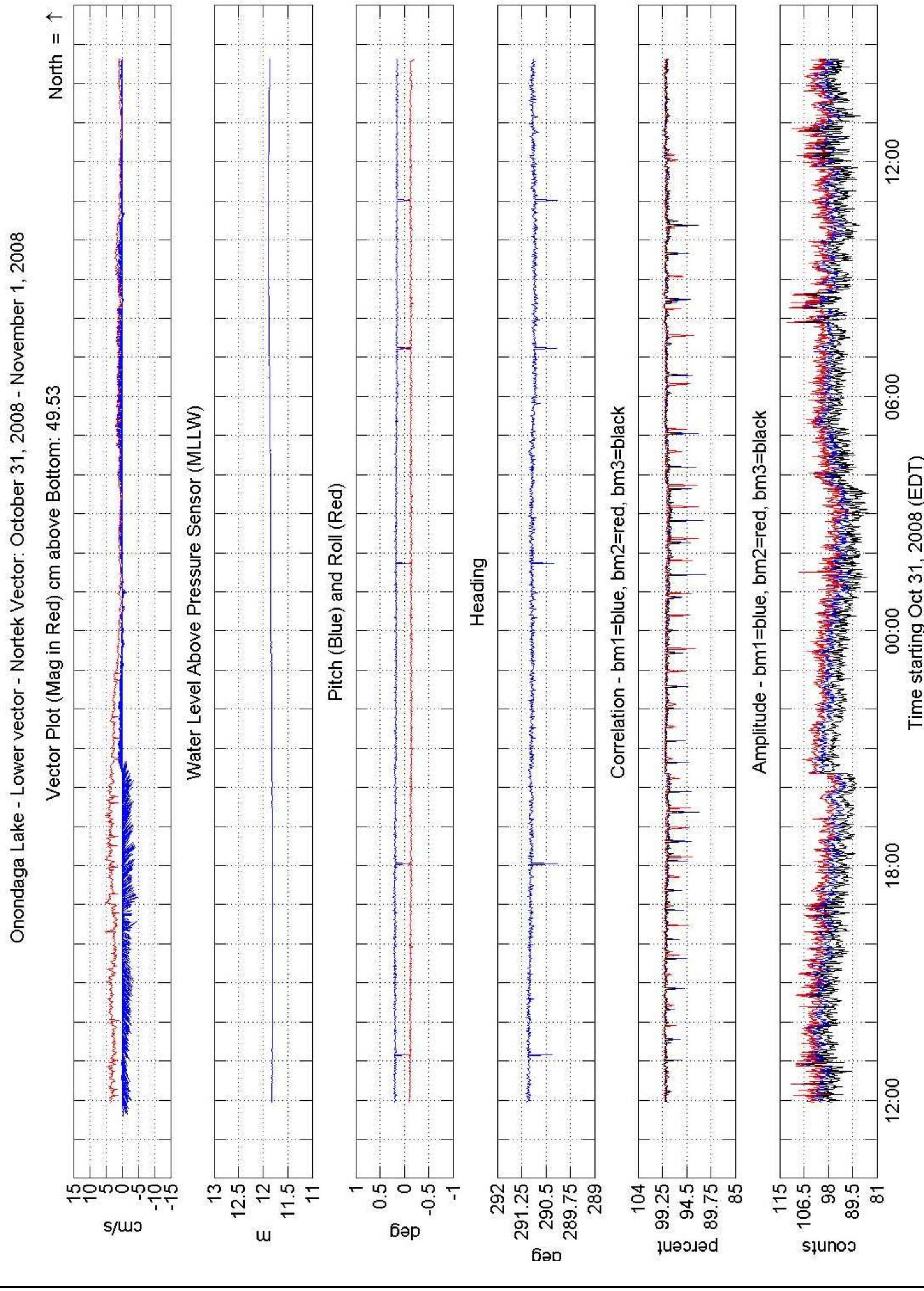
Water depth above the sensor – the depth of the water (in meters) over the pressure sensor mounted on the electronics package housing. The electronics packages for the current meters were mounted on the side of the frame at approximately the same height above the bottom.

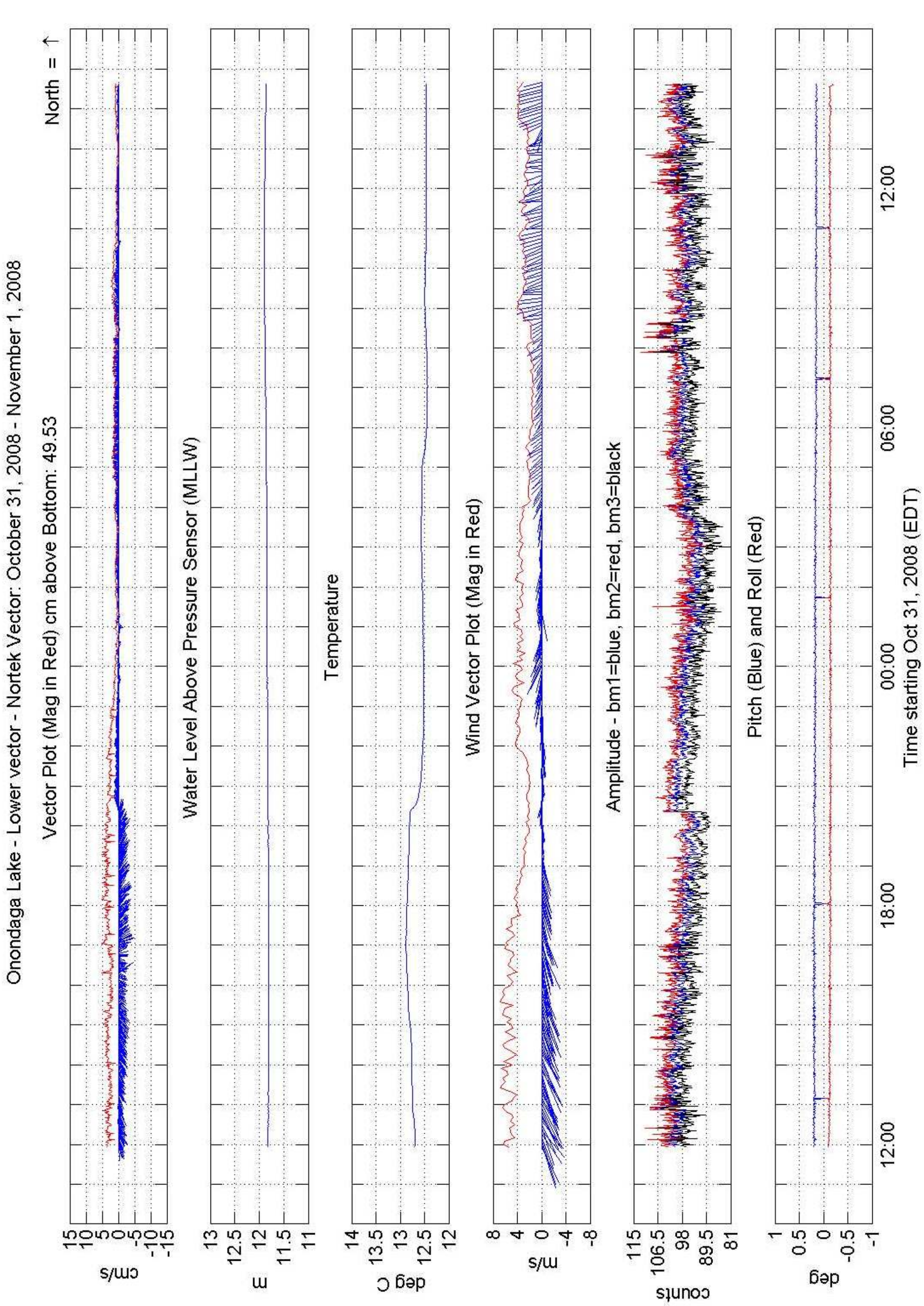
Heading – The heading of the sensors measured using the compass mounted inside the electronics package. The heading is reported in degrees relative to true north.

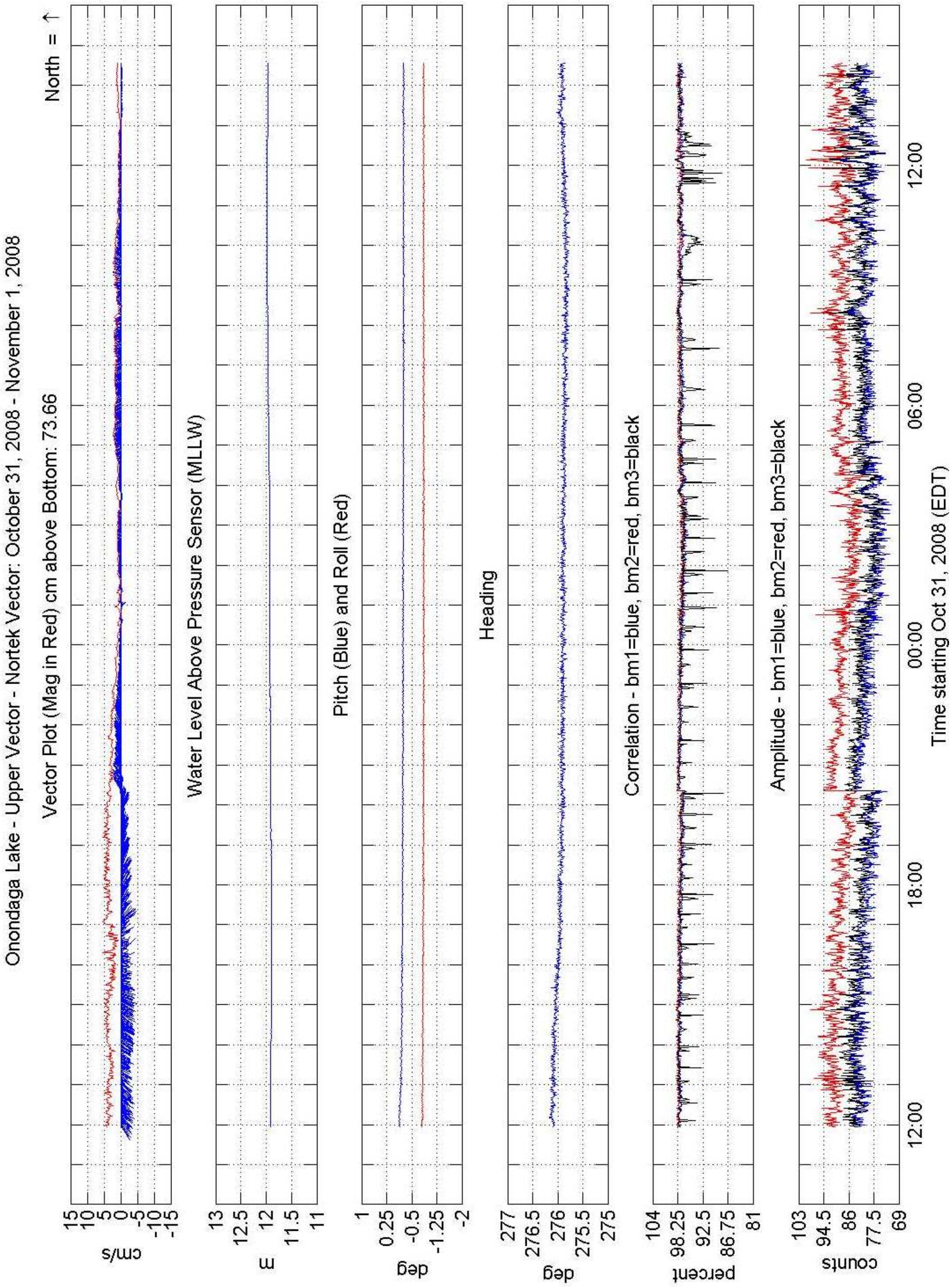
Correlation – The correlation of the acoustic signal used to measure the water velocity. A high correlation (above 85) is required for good velocity measurements.

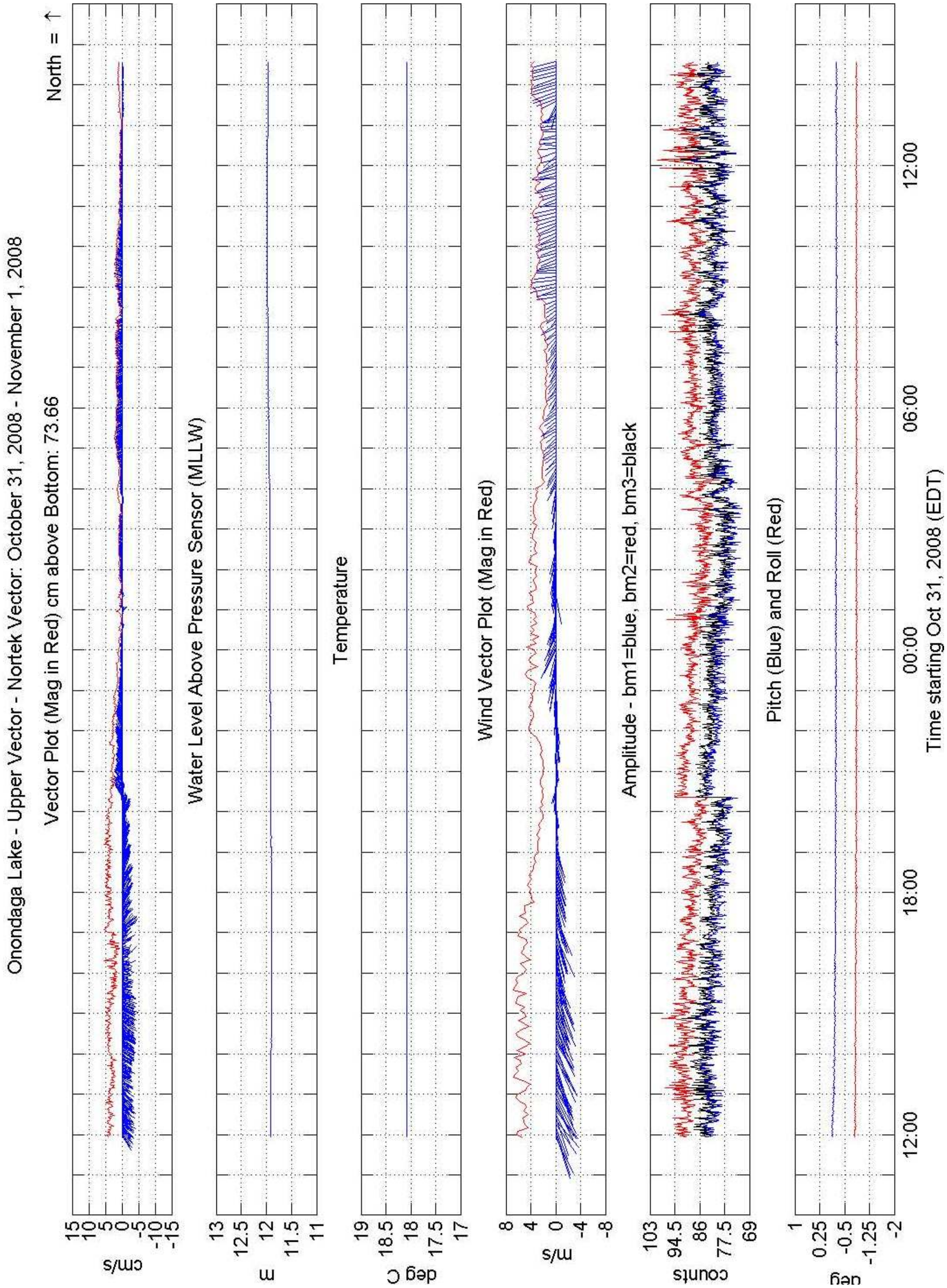
Amplitude – The amplitude of the received signal used to measure the water velocity. Low amplitude indicates a low number of scatters in the water column whereas high amplitude indicates a high number of scatters.

Wind speed and direction - The wind speed is shown in meters per second as the reddish-colored line plot and the direction is indicated by the blue vectors. The vectors point in the direction the current is coming from and the length is proportional to the velocity. Wind data was based on data from a nearby Honeywell meteorological station.


Onondaga Lake - Lower vector - Nortek Vector: October 31, 2008 - November 1, 2008
Vector Plot (Mag in Red) cm above Bottom: 49.53
North = ↑
Water Level Above Pressure Sensor (MLLW)
Pitch (Blue) and Roll (Red)
Heading
Correlation - bm1=blue, bm2=red, bm3=black
Amplitude - bm1=blue, bm2=red, bm3=black
Time starting Oct 31, 2008 (EDT)
cm/s
m
deg
deg
percent
counts


Onondaga Lake - Lower vector - Nortek Vector: October 31, 2008 - November 1, 2008
Vector Plot (Mag in Red) cm above Bottom: 49.53
North = ↑
cm/s
Water Level Above Pressure Sensor (MLLW)
m
Temperature
deg C
Wind Vector Plot (Mag in Red)
m/s
Amplitude - bm1=blue, bm2=red, bm3=black
counts
Pitch (Blue) and Roll (Red)
deg
12:00
18:00
00:00
06:00
12:00
Time starting Oct 31, 2008 (EDT)


Onondaga Lake - Upper Vector - Nortek Vector: October 31, 2008 - November 1, 2008
Vector Plot (Mag in Red) cm above Bottom: 73.66
North = ↑
cm/s
Water Level Above Pressure Sensor (MLLW)
m
Pitch (Blue) and Roll (Red)
deg
Heading
deg
Correlation - bm1=blue, bm2=red, bm3=black
percent
Amplitude - bm1=blue, bm2=red, bm3=black
counts
12:00
18:00
00:00
06:00
12:00
Time starting Oct 31, 2008 (EDT)


Onondaga Lake - Upper Vector - Nortek Vector: October 31, 2008 - November 1, 2008
Vector Plot (Mag in Red) cm above Bottom: 73.66
North = ↑
cm/s
Water Level Above Pressure Sensor (MLLW)
m
Temperature
deg C
Wind Vector Plot (Mag in Red)
m/s
Amplitude - bm1=blue, bm2=red, bm3=black
counts
Pitch (Blue) and Roll (Red)
deg
12:00
18:00
00:00
06:00
12:00
Time starting Oct 31, 2008 (EDT)