Water Quality Evaluation of Asylum Lake and Little Asylum Lake With Management Recommendations

Prepared for:
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CHAPTER 1.0

INTRODUCTION

Western Michigan University (WMU), on behalf of the Asylum Lake Policy and Management Council, authorized Kieser & Associates, LLC (K&A) to initiate a study of Asylum Lake and Little Asylum Lake beginning in July 2006. The purpose of this effort was to develop a robust understanding of current lake conditions, identify factors influencing water quality and recommend strategies for long-term management and improvements. A range of efforts was conducted by K&A that included:

- Watershed delineation and assessment of runoff contributions
- Identification of stormwater pollutant sources and loading estimates
- Water quality monitoring (seasonal and wet weather)
- Stormwater inlet and lake outlet sampling
- Sediment sampling
- Aquatic plant surveying
- Development of a hydraulic mass balance
- Development of a phosphorus mass balance, and
- BMP recommendations and preliminary stormwater treatment concepts

The results of these efforts are presented in the following chapters of this report. Results are presented in tables interspersed with each chapter, figures presented in order following the reference section at the end of this report, and appendices.

1.1 Watershed Delineation

Asylum Lake and Little Asylum Lake are located in Kalamazoo County, Michigan in Section 30 in the City of Kalamazoo (Figure 1). These two lakes represent the headwaters of the west fork of Portage Creek that eventually connect to Portage Creek, which in turn drains to the Kalamazoo River. These are glacial kettle lakes formed during the last ice age. Asylum Lake has a surface area of approximately 46.5 acres; Little Asylum Lake is 9 acres. The land uses surrounding the lakes are comprised of commercial, residential, forests, farmland, and open areas. Beyond the immediate vicinity of the lake, land use includes mainly urban areas.

The contributing watershed of Asylum Lake and Little Asylum Lake was determined using a combination of topographic maps, satellite imagery, geographic information systems (GIS) software, and field reconnaissance surveys. A watershed is defined as the land area that contributes runoff to a water body during storm events and is determined by topographic (land elevation) boundaries and storm sewer connections. A reconnaissance survey of watershed areas adjacent to Asylum Lake was conducted in July 2006 to confirm land cover data for the project area generated from 2000 Landsat 5 Thematic Mapper satellite imagery and physical watershed boundaries. Satellite data were further refined based on field observations and knowledge of the watershed.

The topographically mapped Asylum Lake/Little Asylum Lake watershed was calculated to be 1,644 acres. This K&A delineation generally matches the Michigan Department of Natural Resources delineation for the Kalamazoo River Watershed, however includes more land than the state's delineation.

For the purposes of this study, the watershed for both lakes was divided into seventeen subwatersheds as shown in Figure 2. The land cover and total area for each of these subwatersheds is shown in Table 1. Subwatersheds 1-8 drain directly to the lake by overland runoff (i.e., subwatersheds 1 and 2), by surface water channels (subwatersheds 3 and 4), or via storm sewers (subwatersheds 5-8). Subwatersheds 9-11 are drained by storm sewers but they discharge into wetlands to the east of the lake. Thus, contributions from these latter storm sewered areas do not appear to actually reach the lake. Subwatersheds 12-17 topographically appear to be in the upper Asylum Lake drainage, however, these are hydraulically separated from the rest of the watershed by the presence of US-131. There are no indications of any physical (i.e., surface water) connections from the western to the eastern sides of the highway. Therefore, these watersheds were excluded from calculations of runoff contributions to Asylum Lake.

The surface area of Asylum Lake was confirmed to be 46.5 acres based on K&A generated computer-aided design (CAD) mapping of bathymetry compiled by Sauck et al. (1991). The surface area for Little Asylum Lake was 8.9 acres based on a bathymetric map provided by WMU (see Section 2.15 for a discussion of additional bathymetric resources).

Table 1. Asylum Lake and Little Asylum Lake Subwatershed Land Cover and Acreages.

	Subwatersheds																
Land Cover (acres)	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**
Low density urban	36	6	1	1	14	1	3	1	2	1	9	32	40	13	15	8	0
High density urban	32	0	0	0	22	0	0	0	0	2	2	15	22	5	12	10	0
Road/parking lot	29	2	3	5	16	3	1	0	0	1	3	41	16	10	22	11	2
Farmland/orchards	101	2	10	0	0	11	0	0	0	0	0	0	0	52	306	2	0
Herbaceous open land	30	5	4	1	5	6	0	0	0	0	2	10	15	19	28	4	0
Forest	139	27	7	3	12	14	1	4	9	12	22	20	48	56	37	11	0
Water	40	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wetlands	38	15	0	1	0	0	0	0	0	9	0	0	0	5	3	0	0
Sand/bare soil	2	0	0	0	1	0	0	0	0	0	0	1	1	0	2	1	0
Total Acreage	**446**	**63**	**26**	**11**	**69**	**36**	**5**	**5**	**11**	**25**	**39**	**118**	**144**	**161**	**425**	**47**	**2**

1.2 Surface and Stormwater Runoff Contributions

Stormwater runoff and overland flow drain to Asylum and Little Asylum Lakes through roadway ditches, culverts, stormwater inlets, and direct discharge. There is one outflow from Asylum Lake in its southeastern portion that drains to Little Asylum Lake. Likewise, there is one outflow from Little Asylum Lake in its southern sections under Parkview Avenue and into Cherry Creek/Willow Lake. These features dictate important hydraulic and water quality characteristics of these lakes.

There are two inlet pipes to Asylum Lake, designated as stormwater inlet #1 and stormwater inlet #2 for the purposes of this study. Both inlets are located in the northwestern portion of the lake. One additional stormwater inlet is located on the eastern edge of Asylum Lake, but there is no indication that flows from this storm sewer actually reach the lake at this location. Little Asylum Lake has two stormwater inlets, designated as stormwater inlet #3 and inlet #4. Stormwater inlet #3 is located on the northeastern edge of Little Asylum Lake and stormwater inlet #4 is located on the southeastern edge.

CHAPTER 2.0

MONITORING METHODS AND ANALYSIS

Methods for water quality monitoring and information regarding various analyses performed for this study are described in this chapter. Included are explanations as to the purpose and benefits of these analyses.

2.1 In-lake Water Quality Monitoring

Water quality monitoring provides information on the condition of a water body in relation to water quality standards or other generally recognized metrics used to gage the health of the system. Strategic sampling of water quality flowing into a lake can also be used to identify areas that may be the source of existing water quality problems. As such, K&A collected a variety of water quality samples for Asylum and Little Asylum Lakes over the period of August 2006-April 2007. These seasonal in-lake monitoring events were strategically conducted to assess conditions during summer stratification, fall turnover, winter ice cover and spring turnover. Additionally, samples were collected during two wet weather events from various stormwater inlets to these lakes when flow was observed. Various methods used for water quality sampling are described as appropriate in the remainder of this chapter.

In-lake sampling stations were established at three locations on Asylum Lake (AS-1, AS-2 and AS- 3) and one on Little Asylum (LA-1) (refer to Figure 3). These were considered representative locations in each lake with regards to flow entering Asylum Lake in its northwest reaches and discharging at its southeastern end into Little Asylum Lake. Depths for stations in Asylum Lake included: AS-1 at 39 feet; AS-2 at 51 feet and AS-3 at 36 feet. Station LA-1 was 10 feet deep and situated at the deepest point observed in Little Asylum Lake. Station AS-4 represented the location of the Asylum Lake outlet that discharges to Little Asylum Lake. (This station was sampled during seasonal in-lake monitoring events.) LA-2 was a location near the outflow channel from Little Asylum Lake connecting to Cherry Creek south of Parkview Avenue. (LA-2 is referred to herein as the Little Asylum Lake outlet.) This was sampled only when outflow was observed.

A hand-held global positioning system (GPS) unit was used to locate each of the in-lake water quality (and sediment sampling) locations during each field visit. GPS coordinates of each sampling station are provided in Appendix A. Using these designated GPS coordinates, K&A field staff were able to return to the same locations in the lake with an approximate 30-foot accuracy during subsequent sampling events.

At all in-lake water sampling locations, field measurements of temperature and dissolved oxygen were collected at one-foot intervals using a YSI-57 Dissolved Oxygen meter. At other select depths, field measurements of conductivity, pH and turbidity were made using Oakton ECTestr, Oakton pHTestr 3, and Global Water WQ770 Turbidimeter hand-held models, respectively. Secchi depth measurements were also collected at each open lake station. Where multiple samples were obtained for various water quality parameters, sampling proceeded from the surface and downward. In addition, all water quality samples were collected prior to collecting sediment samples (if both were obtained from the same location). K&A sampling staff donned disposable nitrile gloves during collection and handling of all water and sediment samples.

All lake surface grab samples were collected from within the upper 12-inches of the water column, near the bow of the boat, away and upwind from the gasoline outboard engine. Surface samples were collected by placing the mouth of the sample bottle just below the water surface and allowing the bottle to slowly fill. Care was taken to avoid any skimming of the water surface or loss of laboratory preservatives within bottles during surface sample collection activities.

Lake bottom and mid-column water quality grab samples were collected at depth using a Wildco Van Dorn water quality sampler. These subsurface samples were collected at stations AS-2 and LA-1. This sampler utilizes a weighted messenger release mechanism to properly seal the sampling chamber when the sampler reaches the desired depth. Once each subsurface grab sample was obtained (approximate volume of two gallons), the sampler was raised to the lake surface. Lake water was then discharged from the sampler (via a slow release port) into pre-prepared sample containers provided by the analytical laboratory. The Van Dorn sampler was properly washed with Liquinox detergent and rinsed with deionized water between uses at each sampling location.

All samples were temporarily placed in a cooler with ice for submittal to the lab following field collection. A chain-of-custody record was completed and utilized to accompany all samples to their shipping and delivery destination.

Water samples were analyzed by Upstate Freshwater Institute (UFI), in Syracuse, New York for total phosphorus (TP), soluble reactive phosphorus (SRP), total nitrogen (TN), and chlorophyll *a*. Kar Laboratories, Inc. (Kar), in Kalamazoo, Michigan analyzed water samples for calcium, iron, magnesium, mercury, potassium, sodium, alkalinity, chloride, ammonia, nitrate, sulfate, total suspended solids (TSS), and atrazine. Mercury analyses were conducted by A&L Great Lakes Laboratories, Inc. (A&L) in Fort Wayne, Indiana. With the exception of TSS, these analyses conducted by Kar and A&L were at the request of Asylum Lake Policy and Management Council members.

During the course of this study, K&A also collected numerous lake water quality and sediment samples on behalf of WMU for analyses performed by Dr. Carla Koretsky and Melanie Haveman in the Geosciences Department and Environmental Studies Program. Samples obtained for WMU water quality and sediment analyses were handled in the same manner as K&A samples. The only difference with collection methods for WMU samples was field-filtering a 50 mL plastic container for metals analyses. Each WMU metals sample was syringe-filtered through a 0.2mm nylon filter into a sterile plastic vial. All WMU samples were returned with a chain-of-custody record to the Geosciences Department to Dr. Koretsky's attention for subsequent analysis of desired compounds.

2.2 Sediment Sampling

Lake bottom sediment samples were collected from the deepest locations in Asylum Lake and Little Asylum Lake. In addition, sediment samples were also collected from each of the water quality sampling locations (Figure 3) during a second sampling event. Lake bottom sediment samples were obtained (at depth) using a Wildco stainless steel, self-tripping, Petite Ponar grab sampler. A single grab sample, filling the ponar dredge sample bucket (approximate volume of 0.3 cubic feet), was obtained from each bottom sampling location and raised to the lake surface. Each grab was emptied into a 2.5-gallon stainless steel mixing bowl, mixed thoroughly, and placed into a sterile 4 oz glass sample container using a disposable sterile tongue depressor at each sample station. The ponar dredge sampler and stainless steel mixing bowl were each properly washed with a phosphate-free detergent (i.e., Liquinox™) and rinsed with deionized water following each use at each sampling location.

Sediment nutrient samples were submitted to Upstate Freshwater Institute (UFI) in Syracuse, New York for analysis of total nitrogen and total phosphorus. Mercury samples were submitted to A&L Great Lakes Laboratories, Inc. (A&L) in Fort Wayne, Indiana.

2.3 Wet Weather Sampling

Stormwater inlets to Asylum Lake (SW-1, SW-2) and Little Asylum Lake (SW-4) were sampled during two separate wet weather events (September 22, 2006 and July 17, 2007). (The SW-3 stormwater inlet to Little Asylum Lake was not noted to be flowing during either event.) Only during the July 2007 event was outflow noted from Little Asylum Lake whereby water quality samples could be collected. (The Asylum Lake outflow—AS-4, was sampled during seasonal lake monitoring events but not during wet weather as this would have had limited value due the distance from stormwater inlets.)

Water quality samples for the full suite of analyses were collected for the September 2006 wet weather event. For July 2007, only samples for TP, SRP, TN, TSS and *E. coli* were collected. Where possible, flow through storm sewer pipes or channels was measured using a Marsh-McBirney® Flowmate 2000 velocity meter. With cross-sectional measurements and water depths, velocity measurements were converted to flows. Using TP water quality sampling results, instantaneous phosphorus loads were calculated for these locations. Stormwater inlet loads can be used to identify significant sources relative to other inflows. Measured lake outlet hydraulic and phosphorus loads are coarsely extrapolated in this report to estimate annual discharges from each lake for mass balance calculations.

2.4 Modeling Watershed Pollutant Loads

Using the identified land cover types and areas from Table 1, a common modeling technique for watershed runoff estimation was applied to contributing subwatersheds to estimate annual runoff volumes to Asylum and Little Asylum Lakes. Such modeling estimates are valuable where it is prohibitively expensive to alternatively collect continuous field measurements (as was the case for this project). This loading estimation technique is based on the State of Michigan Part 30-Water Quality Trading Rules (MDEQ, 2002). The benefit of employing this approach is that it allows for identification of pollutant source areas that are suspect or problematic. In turn, management strategies can be developed that target the areas of greatest need/concern.

In this particular application, the model is used to estimate runoff volume and various pollutant loads from subwatersheds 1-8; i.e., those areas that drain to the lake via overland flow or via channels or storm sewers. It uses the same calculation for generating runoff and pollutant loads from a variety of land covers despite whether these are directly connected to the lake via storm sewers or whether the runoff reaches the lake via overland flow.

Pollutant loads for TP, TN and TSS from watershed runoff were estimated by coupling the model estimated runoff volumes with Event Mean Concentrations (EMCs). EMCs are estimated concentrations of nonpoint source pollution determined by the U.S. Environmental Protection Agency (USEPA) Nationwide Urban Runoff Program (NURP). While EMC values do not correspond to water quality criteria, they do represent average pollutant concentrations observed in areas of similar land cover during wet weather events. EMCs used for the Asylum Lake study are displayed in Table 2. With this method, stormwater pollutant loads are also based on pollutant loading factors that vary by land use type and percent imperviousness (MDEQ, 2002). Loads are then computed using Equations 1 and 2 as follows.

$$M_L = EMC_L \times R_L \times K \qquad \text{Eq. 1}$$

Where:

M_L	= Loading factor from land use L (pounds/acre/year)
EMC_L	= Event mean concentration of runoff from land use L (mg/L)
R_L	= Total average surface runoff from land use L computed from Eq. 2
K	= Unit conversion factor of 0.2266

Runoff Equation:

$$R_L = [C_P + (C_I - C_P) \times DCIA_f \times IMP_L] \times AL \times I \qquad \text{Eq. 2}$$

Where:

R_L	= Total average annual surface runoff from land use L (acre-inches/year)
C_P	= Pervious area runoff coefficient (0.20)
C_I	= Impervious area runoff coefficient (0.95)
$DCIA_f$	= Fraction of impervious area that is directly contributing (0.50)
IMP_L	= Fractional imperviousness of land use L
I	= Long term average annual precipitation (inches/year)

Equation 1 shows that the loading factor (M_L) for land use L is the product of the EMC for land use L, the annual runoff for land use L, and a unit conversion factor. The runoff calculation in Equation 2 provides the R_L value used in Equation 1 through the product of the annual rainfall depth from the local airport, and the percent imperviousness of land use L, with the tuning coefficients C_P and C_I. The loading factor, M_L, is multiplied by the area of land use L to obtain a total annual loading for that land use. Loads for each land use were then totaled.

Table 2. Asylum Lake and Little Asylum Lake runoff and Event Mean Concentration (EMC) values.

		Pollutant EMC (mg/L)		
Land Cover	RL Value	Total Phosphorus	Total Nitrogen	Total Suspended Solids
Low density urban	11.27	0.52	1.83	70
High density urban	28.18	0.24	2.12	97
Road/parking lot	28.18	0.43	0.83	141
Farmland/orchards	6.44	0.11	0.8	51
Herbaceous open land	6.44	0.37	4.06	51
Forest	6.44	0.11	0.8	51
Water	30.59	0.08	0.59	6
Wetlands	30.59	0.08	0.59	6
Sand/bare soil	18.52	0.08	0.8	51

2.5 Hydraulic Mass Balance

A hydraulic mass balance for a lake system considers all inflows and outflows of water. In combination with information on the volume of the lake, the hydraulic retention time (HRT) can be computed. The HRT is an estimate of the average time it takes to completely renew a lake's water volume. It provides insight into how long contaminants loaded to the lake will remain in the system. For these lakes, sources and losses of water to and from the lakes considered in this mass balance include: stormwater runoff from storm sewered areas (e.g., subwatersheds 5-8); overland flow (not delivered via storm sewers; e.g., subwatersheds 1-4); direct rainfall onto the lakes' surface; groundwater; evaporation/evapotranspiration; and, lake outflow.

To estimate flow leaving these lakes, K&A field personnel collected flow measurements from lake outlets on select site visits. These measurements were coarsely extrapolated to annual discharges. Though stormwater inlet flows were measured during wet weather events, these were not used for the hydraulic mass balance. Measured stormwater inflows rather were used for assessing the magnitude of stormwater inputs and cursory pollutant loads as a check on empirical modeling.

Estimated annual runoff volumes used in the final mass balance from all subwatersheds (including those with direct stormwater inlets to the lake) were derived from the empirical loading model discussed above. These latter estimates were used given the very limited amount of field data collected during wet weather conditions.

Rainfall data for this study were obtained from the Kalamazoo/Battle Creek International Airport for the project study period from July 2006 to July 2007. Rates for evaporation from the lakes' surface, and evapotranspiration (from wetlands) were derived from state of Michigan recommendations for calculating water budgets (MDEQ, 2006). For this hydraulic mass balance, these two losses were combined for simplification of the annual water budget.

K&A used a bathymetric map from Sauck et al. (1991) for calculating Asylum Lake volume. Bathymetry was digitized using computer aided design (CAD) software to calculate lake volume and area. A 2006 bathymetric map of Asylum Lake was provided by WMU late in the project as a second source for calculating this information used to determine lake area and volume. A similar and recent bathymetric map showing the depth and bottom contours of Little Asylum Lake provided by WMU was used to determine volume and surface area for Little Asylum Lake. (Appendix B contains bathymetric maps referenced here). Hydraulic residence times for Asylum Lake and Little Asylum Lake were calculated using estimated annual hydraulic inputs from the empirical model and estimated lake volumes from bathymetric data.

2.6 Phosphorus Mass Balance

A pollutant mass balance provides valuable information for targeting the most significant sources of watershed loading to the lake that are manageable. For the Asylum and Little Asylum Lake applications, a mass balance for phosphorus was constructed in a manner similar to the hydraulic mass balance. Annual loading estimates from empirical modeling were used here to estimate loads from the various sources of phosphorus to these lakes associated with watershed runoff. Atmospheric deposition estimates were obtained from Reckhow et al. (1980). In this mass balance, phosphorus losses are attributable to lake outflows and in-lake settling. Losses and gains of phosphorus associated with groundwater are considered negligible for this application.

2.7 Aquatic Plant Survey

The aquatic plant survey design used in this study was based on the Michigan Department of Environmental Quality publication, "*Procedures for Aquatic Plant Surveys*" (MDEQ, 2003). Using this method, K&A sampled 27 sites around Asylum Lake and 15 sites around Little Asylum Lake. The mapped location of each site is illustrated in Figure 4. Aquatic plant samples were collected from the littoral (nearshore) zone around each lake.

At each site, a weighted plant-sampling rake was thrown into the lake from an anchored boat. Aquatic plants attached to the sampling device were removed after each toss and collected in a sampling pan for identification and a relative density rating of present (a), sparse (b), common (c), or dense (d). Visual observations of submergent, floating and emergent plant species were recorded at each site.

CHAPTER 3.0

RESULTS

Results for water quality monitoring and related analyses performed by K&A are reported in this chapter. Select information is discussed here and presented in tables and figures. The compendium of K&A water quality data is found in Appendix C. Seasonal water quality sampling results are compiled in this appendix as: Table C-1 for August 9, 2006; Table C-2 for November 20, 2006; Table C-3 from February 22, 2007; and Table C-4 for April 19, 2007. Field recorded data are included in Tables C-5 to C-8. Sampling results from the September 2006 and July 2007 wet weather events for stormwater inlets and Little Asylum Lake outlet are presented in Table C-9 and C-10 (water quality monitoring data), and C-11 and C-12 (field data), respectively by event. Laboratory analytical reports for all water quality monitoring results are included in Appendix D. Data and analyses conducted by WMU and provided to K&A are included in Appendix E.

3.1 In-lake Water Quality Monitoring Results

In-lake water quality data collected during this study are presented in the following subsections and displayed in tables and figures. Results are generally presented first for Asylum Lake followed by those for Little Asylum Lake.

Temperature and Dissolved Oxygen

Temperature and dissolved oxygen (DO) data collected for each seasonal sampling event are plotted with depth for Asylum Lake in Figures 5-8 and Little Asylum Lake in Figure 9. (Field data are summarized in Appendix C.) The following provides a discussion of these temperature/DO plots.

During the first seasonal sampling on August 9, 2006, the lake was stratified with a pronounced thermocline around 15 feet as evidenced by the sharp decline in temperature and DO concentrations (Figure 5). Temperatures were at or near 25°C above the thermocline then declined sharply to around 6°C below the thermocline. Dissolved oxygen concentrations were roughly 6-7 mg/L above the thermocline, 12 mg/L at the thermocline, and declined drastically to less than 1 mg/L below the thermocline. Anoxic conditions (0.6-0.8 mg/L) were observed at all stations near the bottom. This is commonly observed in eutrophic lakes.

Asylum Lake had undergone fall turnover prior to the November 20, 2006 sampling event evidenced by the near consistent temperature and DO profiles (Figure 6). Temperature at all depths was roughly 6.5°C, while DO levels were roughly 7 mg/L at all depths until a few feet from the bottom. All three sampling locations indicated a significant decline in DO concentrations near the bottom where DO approached 1 mg/L. Anoxic conditions (0.6-0.9 mg/L) were observed at all sites near the bottom in November.

The February 2, 2007 through-the-ice sampling event showed no indication of stratification (Figure 7). The slightly lower temperatures at the surface are indicative of ice cover. The DO profile began at roughly 12-13 mg/L near the surface and declines steadily to around 2 mg/L near the bottom. Stations AS-1 and AS-3 showed signs of anoxic conditions (< 2 mg/L) near the bottom. This suggests there is a strong sediment oxygen demand in Asylum Lake.

By the April 19, 2007 sampling event, Asylum Lake began to show early signs of stratification following spring turnover (Figure 8). A thermocline had not developed at this point, but temperatures were near 7°C at the surface and decreased slightly to between 4-5°C near the bottom. The DO profile indicates high DO concentrations near the surface (>13 mg/L) with a slightly decreasing trend as depth increased. At sites 1 and 2, a marked decreased in DO was observed roughly 10 feet from the bottom where DO concentrations dropped from 13 mg/L to around 5 mg/L. At site 3 there is no marked decrease in DO near the bottom. No anoxic conditions were observed during this sampling event, though the rapid decline in DO during turnover to full temperature stratification supports the suggestion that sediment oxygen demand is high.

In Little Asylum Lake, temperature data from the August 9, 2006 sampling event suggested no signs of stratification with temperature at the surface above 25°C and the same at the bottom (Figure 9). The DO profile decreased from 10 mg/L at the surface to roughly 5 mg/L one foot from the bottom. There was a sharp decrease from 5 mg/L to less than 1 mg/L within the last foot of the water column, indicating some exertion of sediment oxygen demand, though apparently insufficient to create anoxic conditions extending well above the bottom. During the November 20, 2006 sampling event, vertical temperature and DO profiles indicate continued mixing of Little Asylum Lake. Temperature was 5°C and DO was approximately 10 mg/L. On February 2, 2007, the temperature and DO profiles suggested relatively homogenous temperature conditions throughout the water column. Temperature was 1°C at the surface and about 3°C at the bottom. The DO profile shows very low concentrations of 2-3 mg/L down to six feet then an increase to about 7 mg/L at nine feet extending to the bottom. This could be related to plant respiration under ice cover. During the April 19, 2007 sampling event, the temperature profile indicates a developing thermocline between three and six feet (Figure 9). The temperature at the surface was 11°C and below the thermocline 8°C. The DO profile however, shows no indication of a thermocline and is relatively consistent throughout the water column at 13-14 mg/L.

Total Phosphorus, Soluble Reactive Phosphorus and Total Nitrogen

On August 9, 2006, the TP levels in surface waters of Asylum Lake ranged from 13-21.5 µg/L, SRP was very low ranging from 1.9-2.8 µg/L, and TN was recorded at 281-305.8 µg/L (refer to Table C-1 in Appendix C). The representative bottom sample from station AS-2 was very high for TP (565.5 µg/L), SRP (333.9 µg/L), and TN (2,257.3 µg/L). These concentrations strongly suggest sediment release under anoxic conditions and are consistent with the high levels of accumulated phosphorus and nitrogen measured in bottom sediments (see Section 3.2). On November 20, 2006 during fall turnover, the TP level in Asylum Lake was 35.9 µg/L, SRP ranged from 3.6-4 µg/L, and TN ranged from 805-906 µg/L at the surface (Table C-2). Samples collected from the middle of the water column at AS-2 in November were 41.1µg/L for TP, 5.6 µg/L for SRP, and 908 µg/L for TN.

During the February 22, 2007 sampling, the TP level in Asylum Lake ranged from 41.1-60.9 µg/L, SRP was 1.6-5.6 µg/L, and TN was 819-906 µg/L for surface samples (Table C-3). The bottom sample from station AS-2 had a TP concentration of 88.2 µg/L, SRP was 47.7 µg/L, and TN was 1,323 µg/L. Though higher than surface levels, these bottom concentrations did not suggest substantial sediment release as noted under summer temperature stratification in August 2006. This would be expected as fall turnover had likely just occurred and anoxic conditions were not as pronounced in November (Figure 6) compared to August (Figure 5). For April 19, 2007, the TP concentrations in Asylum Lake surface waters were

31.2-32.5 µg/L, SRP was 0.4-0.6 µg/L, and TN was 667-863 µg/L (Table C-4). All samples were taken at mid-depth since the lake appeared generally mixed based on water column temperatures (Figure 8).

During the August 9, 2006 sampling event, the TP concentration in Little Asylum Lake was 50.3 µg/L at the surface and 49.7 µg/L at the bottom; SRP was 7.9 µg/L at the surface and 11.3 µg/L near the bottom; TN was 554.7 µg/L at the surface and 729 µg/L near the bottom (Appendix Table C-1). Temperature data (Figure 9) would suggest that the water column in August was not stratified. This appears to be the case based on similar water quality concentrations at the surface and bottom. On November 20, 2006, the TP concentration measured in Asylum Lake was recorded as 27.6 µg/L, SRP was 0.5 µg/L, and TN was 1,096 µg/L at the surface (Table C-2). During the February 22, 2007 monitoring event, TP was 36.1 µg/L at the surface and 78.1 µg/L near the bottom; SRP was 1.7 µg/L at the surface and 21.2 µg/L near the bottom; TN was 1,380 µg/L at the surface and 1,797 µg/L near the bottom (Table C-3). With ice cover, there is limited vertical mixing. Differences between lower surface water concentrations and higher bottom water concentrations indicate sediment release of phosphorus and nitrogen. On April 19, 2007, the TP concentration was 42.3 µg/L, SRP was 0.7 µg/L, and TN was 832 µg/L at the mid-depth sampling location (Table C-4).

Total Suspended Solids

Total suspended solids (TSS) were detected at low levels below 4 mg/L in surface samples from all sites in Asylum Lake and below 6 mg/L in Little Asylum Lake during this study. These relatively low levels suggest that there is no significant source of sediment loading or re-suspension in the lake. Bottom TSS concentrations were below 6 mg/L for all sites in Asylum and Little Asylum Lakes.

Chlorophyll a

Lake surface chlorophyll *a* levels at open water stations measured for each site in Asylum Lake ranged between 2.4 at AS-3 (August 2006—Appendix Table C-1) and 8.7 µg/L (April 2007—Table C-4). A chlorophyll *a* level of 11.5 µg/L was noted at AS-4 in April of 2007 at the Asylum Lake outlet. These concentrations do not suggest that excessively high levels of algae were present in Asylum Lake during these two sampling periods. Limited field observations confirm that there appeared to be few indications of nuisance algal conditions despite measurable levels of available phosphorus (i.e., SRP).

Chlorophyll *a* levels in Little Asylum Lake were between 3.1 (August 2006) and 4.6 µg/L (April 2007). Even though Little Asylum Lake generally exhibited high concentrations of TP, luxurious rooted plant growth in Little Asylum Lake may out-compete algae for this available phosphorus.

Ammonia-nitrogen and Nitrate-nitrogen

Ammonia-nitrogen was not detected in surface waters of Asylum Lake during August of 2006 (Table C-1). A high level of ammonia-nitrogen was noted in the bottom waters however, at a level of 2.59 mg/L during this same period. This might be expected given the severe anoxia noted during these period of summer stratification and high levels of TN in bottom sediments (see Section 3.2). Ammonia-nitrogen was detected at every surface and bottom water sampling location during the November 2006 (Table C-2) and February 2007 (Table C-3) events at levels ranging from 0.02-0.47 mg/L. Low levels were again noted at all locations sampled in April 2007 (Table C-4) but at a much lower range of concentrations

(0.02-0.09 mg/L). Nitrate-nitrogen was nearly always below the method detection limit of 0.1 mg/L. If detected, it was reported at a level of 0.1 mg/L.

Secchi Depth, Conductivity, and pH

Secchi depth (water clarity) measured on Asylum Lake during the study was generally consistent across sampling sites for each event. The greatest Secchi depth reading was 12.5 feet during the August 9, 2006 sampling (Appendix Table C-5) and the lowest recorded depth was 5.5 feet during the April 19, 2007 spring turnover sampling event (Table C-4). In Little Asylum Lake, the greatest Secchi depth reading was 9.5 feet during the November 20, 2006 sampling and the shallowest depth was 4.5 feet during the August 9, 2006 monitoring.

Conductivity levels in Asylum Lake ranged from 659 to 1,212 µS at all sites and over all sampling occasions. In Little Asylum Lake, conductivity ranged from 669 to 954 µS over all monitoring events. Over all monitoring events and all sites, pH ranged from 6.75 to 8.45 in Asylum Lake. In Little Asylum Lake, pH ranged from 6.4 to 8.08 over all sampling occasions. These pH levels suggest a generally neutral pH of 7.0, or slightly basic condition of pH >7.0.

Major Ions

Sodium and chloride levels in Asylum and Little Asylum Lakes were relatively constant between: a) sampling locations; b) surface and bottom waters; c) both lakes; and, d) over the four seasonal samplings. This suggests that inputs such as road salts in stormwater are relatively minor, and that conditions in both lakes are relatively constant with respect to these ion concentrations. Magnesium and potassium levels were similarly consistent across stations, lakes and seasons. The same was noted for sulfate concentrations, which generally ranged from 12-16 mg/L with one notable exception. For Little Asylum Lake in April 2007, sulfate was measured at a concentration of 38 mg/L. It is uncertain whether this is an invalid result or indicative of some condition associated with organically enriched sediments in this highly productive system (e.g., significant wetlands surrounding open water) manifesting high in-lake levels during or following winter stratification.

Alkalinity levels (as $CaCO_3$) are relatively consistent between the two lakes for individual sampling events with some variability between seasons. Levels suggest a moderately hardwater condition as would be expected from regional geology. Iron was typically below laboratory method detection levels.

Atrazine, Total Petroleum Hydrocarbons, and Mercury

Atrazine and total petroleum hydrocarbons (TPH) were reported as below standard laboratory detection limits during the August and November 2006 sampling events for all samples collected. For this reason, atrazine and TPH were not sampled in subsequent efforts in February and April 2007. More than one-half of the mercury samples collected from Asylum and Little Asylum Lake were reported below the low level laboratory detection limits. Those that were detected ranged from 4.8-27.2 ng/L (parts per trillion). In Asylum Lake, detected mercury concentrations ranged from 4.7-12.5 ng/L; in Little Asylum Lake, these ranged from 12.0-27.2 ng/L. During spring turnover sampling in April 2007, every location sampled in both lakes had a detectable level of mercury.

E. coli

Water quality samples collected in August and November 2006 were tested for *E. coli* bacteria levels. In Asylum Lake, *E. coli* levels ranged from 2.4-3.0 colonies/100 mL in August and 2.0-10.0 colonies/100 mL in November. For Little Asylum Lake, *E. coli* levels ranged from 3.1 colonies/100 mL in August 2006 to 18.0 colonies/100 mL in November 2007. Because of these very low levels, no additional sampling for bacteria counts was undertaken in February or April of 2007.

WMU Water Quality Sampling

Dr. Carla Koretsky of WMU tested water samples collected in August 2006 and April 2007 by K&A for heavy metal concentrations. The water quality report prepared by Dr. Koretsky is included in Appendix E. Results are summarized here. For August 2006, samples were reported as below detections limits for zinc, aluminum, arsenic, molybdenum, lead, selenium, and vanadium (i.e., less than approximately 50 ppb) in all samples. Reported cadmium levels were consistently above the EPA drinking water maximum contaminant level (5 ppb). Dr. Koretsky recommended follow-up analyses to confirm these high levels. Manganese levels were also high in samples collected near the bottom of the lake. Barium levels were slightly above 50 ppb at some sites.

Results for all samples collected in April 2007 were reported as below detection limits for chromium, copper, iron, nickel, cadmium, cobalt, molybdenum and vanadium. All reported concentrations of lead were close to detection limits. Concentrations of barium were higher for filtered samples than unfiltered samples, which Dr. Koretsky concluded might be an artifact from syringe needles or filters used in the field.

3.2 Sediment Sampling Results

Results for sediment nutrient content and mercury sampling are described in this section. These first include data reported by K&A and then by WMU.

Nutrients

High levels of total nitrogen were detected in Asylum Lake sediments at 12,900 mg/kg and in Little Asylum Lake at 54,100 mg/kg. Total phosphorus levels first reported by UFI were deemed unreliable due to laboratory error. Additional samples were necessary for a second analysis. As such, lake bottom sediments were re-sampled on November 20, 2007. Samples were taken at approximately the same locations in Asylum and Little Asylum Lakes as the original samples.

Reported results from UFI showed extremely high TP values for both lakes. These ranged from 0.51-0.59 mg P/g in Asylum Lake and 1.07-1.1 mg P/g in Little Asylum Lake. Confirming that these data were valid, samples sent to the City of Kalamazoo Public Services Laboratory were not substantially different from those reported by UFI. These split samples for Asylum Lake and Little Asylum Lake were 0.44 mg P/g and 1.44 mg P/g, respectively.

Mercury

For the two sites sampled in February 2007 for mercury, these were selected to represent the deepest spot in each lake and to characterize ‘worst case’ conditions. Mercury was detected in both samples at reported levels of 0.08 mg/kg at AS-2 and 0.09 mg/kg at LA-1.

Given these detections, further sediment sampling was conducted in April 2007 at four sites in Asylum Lake and two sites in Little Asylum Lake (stations AS-1 through AS-4, and LA-1 and LA-2 as shown in Figure 3). All sediment samples were reported below detection limits with the exception of one sample collected at AS-1 which had a concentration of 0.09 mg/kg. All sediment mercury sampling results are reported in Table 3.

Table 3. Asylum and Little Asylum Lake Analytical Results for Mercury Concentrations in Sediment Samples.

Site Location	Date Collected	Sample	Mercury (mg/kg)
AS-2	2/22/2007	A	0.082
LA-1	2/22/2007	A	0.091
AS-1	4/19/2007	A	0.092
AS-1	4/19/2007	B	BDL
AS-2	4/19/2007	A	BDL
AS-2	4/19/2007	B	BDL
AS-3	4/19/2007	A	BDL
AS-3	4/19/2007	B	BDL
AS-4	4/19/2007	A	BDL
AS-4	4/19/2007	B	BDL
LA-1	4/19/2007	A	BDL
LA-1	4/19/2007	B	BDL
LA-2	4/19/2007	A	BDL
LA-2	4/19/2007	B	BDL

BDL=Below detection limit (0.001 mg/kg per A&L Great Lakes Laboratories, Inc.)

WMU Sediment Sampling

Dr. Koretsky tested sediment samples collected in August 2006, February 2007, and April 2007 for heavy metal concentrations (see Appendix E). Results from August 2006 showed significant differences in metal concentrations among the three sites sampled. Samples collected in February 2007 and April 2007 were noted to have a high water content and were very rich in organic matter. Due to the condition of the samples, she stated that associated metal concentrations should be regarded as qualitative estimates only. The summary indicated high concentrations of Mg and Ni might have been due to high reagent concentrations in step 1 of the analytical process used.

3.3 Wet Weather Sampling Results

Wet weather sampling results, especially those of particular note that will largely affect water quality conditions, are reported here. For stormwater inlets, all water quality monitoring data are compiled in Appendix Tables C-9 (September 22, 2006) and C-10 (July 17, 2007). This latter Appendix table also includes water quality data for the one event where outflow from Little Asylum Lake was noted at Station

LA-2. No flow was observed from the SW-3 inlet (i.e., subwatershed #7—Figure 2) to Little Asylum Lake; thus, no results are reported here.

Stormwater Inlet #1

This inlet captures surface water runoff from subwatershed 5 and discharges directly to Asylum Lake (refer to Figures 2 and 3). During the September 22, 2006 monitoring, nutrient concentrations were 498.1 µg/L TP, 6.3 µg/L SRP, and 1,794 µg/L TN. On July 17, 2007, nutrient concentrations were 326 µg/L TP, 135 µg/L SRP, and 1,156 µg/L TN. The TSS concentration measured in September 2006 was 68 mg/L; on July 17, 2007, TSS was 46 mg/L. *E. coli* counts were detected during both events with July 2007 notable at 8,500. Mercury was detected at 5.2 ng/L during the September event, though neither atrazine nor TPH were detected.

Stormwater inlet #2

Inlet #2 drains subwatershed 6 and also discharges directly to Asylum Lake. During the September 22, 2006 monitoring, the measured TP concentration was 99.4 µg/L, SRP was 19.5 µg/L, and TN was 997 µg/L. On July 17, 2007, the TP concentration was 299 µg/L, SRP was 121 µg/L, and TN was 3,117 µg/L. The TSS concentration reported for September 2006 was 3 mg/L, and in July 2007 was 76 mg/L. *E. coli* counts, though lower that from inlet #1, were noted.

Stormwater inlet #4

During the September 2006 monitoring, TP concentration was 327.9 µg/L, SRP was 255.2 µg/L, and TN was 1,994 µg/L. During the sampling event on July 17, 2007, TP concentration was 350 µg/L, SRP was 247 µg/L, and TN was 2,357 µg/L. The TSS concentration reported in 2006 was 4 mg/L and in 2007 was 12 mg/L. Mercury was detected in September 2006 at 6.7 ng/L.

Little Asylum Lake Outlet (LA-2)

The outlet from Little Asylum Lake was dry during all other monitoring events except during the July 2007 wet weather event. During this sampling, TP was 203 µg/L, SRP was 55 µg/L, and TN was 1,230 µg/L. The TSS concentration for the Little Asylum Lake outlet was 20 mg/L. These are comparably much higher than noted in the outlet from Asylum Lake at station AS-4.

Stormwater Inlet/Outlet Pollutant Loads

Using the average nutrient concentrations from the K&A monitoring events for wet weather sampling stations and the Asylum Lake outlet, and measured flow volumes (Table 4), annual discharges of TP, TN and TSS are calculated here. It should be noted that these are very coarse estimates whereby the relative magnitude of differences will be illustrative of potential receiving water/downstream impacts.

From Asylum Lake via the outlet structure, annual average discharges to Little Asylum Lake are computed as 102 lbs TP, 1,674 lbs TN, and 2,365 lbs TSS. The annual discharges from Little Asylum Lake via its outlet structure are comparatively small at 1 lb TP, 6 lbs TN, and 96 lbs TSS.

Annual pollutant loads to Asylum Lake from stormwater inlet #1 are estimated to be 105 lbs TP, 376 lbs TN, and 12,497 lbs TSS using available water quality measurements. The pollutant load from stormwater inlet #2 is estimated to be 56 lbs TP, 578 lbs TN, and 21,359 lbs TSS. Annual pollutant loads to Little

Asylum Lake via stormsewer inlet #4 are estimated to be < 1 lb TP, < 1 lb TN, and 1 lb TSS in comparison.

Table 4. Asylum Lake and Little Asylum Lake K&A Stormwater Inlet and Lake Outlet Monitored Flows.

	Flow (cfs)				
	Stormsewer Inlets			Asylum Lake Outlet	Little Asylum Lake Outlet
Date	#1	#2	#4		
8/9/2006	-	-	-	1.088	-
9/22/2006	-	-	-	11.547	-
11/20/2006	-	-	-	0.270	-
2/22/2007	-	-	-	0.375	-
4/19/2007	-	-	-	1.255	-
7/17/2007	0.623	0.687	0.0001	0.0195	0.0052
10/5/2007	-	-	-	0.792	-

3.4 Modeled Watershed Pollutant Loads

Estimated annual runoff volumes and annual phosphorus, nitrogen and sediment loads (pounds per year) from the contributing subwatersheds to Asylum Lake and Little Asylum Lake are presented in Table 6. These are derived from the empirical loading model. Estimated loads to Asylum Lake include subwatershed 1, 3, 4, 5 and 6 (the latter two including stormwater inlets #1 and #2). Areas included in loads to Little Asylum Lake cover subwatersheds 2, 7 and 8.

Table 6. Annual nutrient and sediment loads, and runoff from Asylum Lake and Little Asylum Lake subwatersheds.

	TP (lbs/year)	TN (lbs/year)	TSS (lbs/year)	Runoff (ac-ft/yr)
Asylum Lake Subwatersheds				
1	162	2,387	47,358	355
3	28	271	9,661	30
4	20	146	6,208	20
5	103	1,010	33,877	117
6	21	252	7,746	31
Total	334	4,066	104,850	553
Little Asylum Lake Subwatersheds				
2	21	340	4,229	74
7	7	59	1,672	6
8	2	25	871	4
Total	30	424	6,772	84

A general comparison of the model predictions to the coarsely estimated annual pollutant loads from limited monitoring data presented above in Section 3.3 can be made here. The wet weather estimated phosphorus load from inlet #1 was 105 lbs/yr; from inlet #2, it was 56 lbs/yr. From Table 6, the corresponding model estimated load for subwatershed 5 was 103 lbs/yr. This matches closely with the inlet 1 estimate. The modeled subwatershed 6 load of 21 lbs/yr is less than the wet weather estimate for inlet #2, though combined model loads for these two are 134 lbs/yr compared to the combined wet weather estimate of 161 lbs/yr. These similar approximations led K&A to conclude that the modeled estimates are sufficient for using projected phosphorus and runoff loads for hydraulic and phosphorus mass balance calculations.

Similar comparisons of nitrogen loads suggest that the model may be overestimating loads, or that the wet weather data extrapolation may be underestimating these. This comparison does not, however, suggest that either estimate renders the other useable. The TSS modeled load is likely an overestimate given the low concentrations of TSS measured in Asylum Lake. Differences here can largely be explained by the EMCs used here that are derived from a national database and not necessarily from a comparable local dataset.

A similar model comparison for Little Asylum Lake to wet weather phosphorus load estimates for stormwater inlet #4 suggest that the model prediction is reasonable, though limited model resolution at this small scale hinders meaningful comparisons.

3.5 Hydraulic Mass Balance

Calculations of Asylum Lake volume and surface area estimated from bathymetric data (Sauck et al., 1991) are 1,004 acre-ft and 46.5 acres, respectively. The more recent bathymetric map provided by WMU from 2006 suggests a volume of 976.9 acre-ft and an area of 47 acres. The lake area estimates differ by 1% and the 1991 volume estimate is 2.7% greater than the 2006 volume. These differences are considered relatively minor in this particular application, especially in the context of likely variability in lake volumes and calculation error. Therefore, the original estimates from Sauck et al. (1991) are used here for the hydraulic mass balance. From the 2006 bathymetric map for Little Asylum Lake, the calculated lake surface area is 8.97 acres with a volume of 40.9 acre-ft.

Based on calculated hydraulic loads, the HRT for Asylum Lake was determined to be 0.71 years, or approximately 260 days. The HRT for Little Asylum Lake was determined to have a much shorter residence time of 0.03 years, or approximately 11 days.

A hydraulic mass balance was calculated for Asylum Lake and Little Asylum Lake using these volume estimates. These water balances are presented separately in Figures 10 and 11, respectively. These estimated volumes of water flowing into and out of the lake are summarized in Table 6. Groundwater was the single largest contributor of water to Asylum Lake (732 ac-ft/yr) with the outfall structure constituting the largest loss of water on an annual basis (1,305 ac-ft/yr). Inputs to Little Asylum Lake differ from Asylum Lake in that a significant volume of lakewater is actually lost to the groundwater. A very limited amount of water leaves Little Asylum Lake via the culvert under Parkview Avenue connecting to Cherry Creek.

Table 6. Asylum Lake and Little Asylum Lake Hydraulic Mass Balances.

	Source/Sink	Volume (ac-ft/yr)
Asylum Lake		
Gains	Direct Rainfall	125
	Subwatersheds 5 & 6	148
	Subwatersheds 1, 3 & 4	405
	Groundwater	732
Losses	Evapotranspiration	-105
	Asylum Lake Outlet	-1,305
Little Asylum Lake		
Gains	Direct Rainfall	24
	Subwatersheds 2, 7 & 8	84
	Inlet	1,305
Losses	Evapotranpirtation	-43
	Little Asylum Lake Outlet	-2
	Groundwater	-1,368

3.6 Phosphorus Mass Balance

The phosphorus mass balances for Asylum and Little Asylum Lakes are presented in Figures 12 and 13, respectively; Table 7 summarizes these values. For Asylum Lake, estimates suggest that the largest estimated load to this system is runoff from the immediately surrounding land in subwatershed 1, plus smaller subwatersheds 3 and 4. Because the modeling approach for calculating runoff does not account for storm sewers, the stormwater load from this larger land coverage is model-estimated to be higher than the runoff load from subwatersheds 5 and 6. This difference may be an artifact of the model as coarsely estimated loads from sampling suggest that storm sewered areas likely have a much greater impact on water quality than diffuse overland runoff from remaining drainage areas that are predominantly pervious/vegetated land cover. Regardless, it is obvious that “manageable” stormwater sources in subwatersheds 5 and 6 dominate external loading of phosphorus to the lake. Moreover, much of what enters Asylum Lake appears to be retained in this lake.

In contrast, the phosphorus load that exits Asylum Lake becomes the largest load to Little Asylum Lake. Overland and storm sewered runoff are relatively minor in comparison. Since very little water exits Little Asylum Lake via the outlet, the vast majority of pollutants also appear to be retained despite the short HRT of 11 days.

Table 7. Asylum Lake and Little Asylum Lake TP Mass Balances.

	Source/Sink	Load (lbs/yr)
Asylum Lake		
Gains	Subwatersheds 1, 3 & 4	210
	Subwatersheds 5 & 6	124
	Atmospheric Deposition	20
Losses	Asylum Lake Outlet	-102
	Settling	-252
Little Asylum Lake		
Gains	Subwatersheds 2, 7 & 8	30
	Atmospheric Deposition	7
	Asylum Lake Outlet	102
Losses	Little Asylum Lake Outlet	-1
	Settling	-138

3.7 Aquatic Plant Survey

Survey results for emergent wetland and rooted aquatic plants in Asylum Lake and Little Asylum Lake are summarized here to highlight findings for both native and invasive plant species (submerged and emergent). Results from these surveys are reported here. Relative densities of submergent, floating and emergent plant species observed in these lakes are provided in Appendix F.

<u>*Asylum Lake*</u>

Based on the aquatic plant survey conducted on August 9, 2006 at Asylum Lake, *Chara spp.* (muckgrass) was present at the highest cumulative percent cover of the submergent species (34.1). Other observed submergent vegetation included *Ceratophyllum demersum* (coontail) at 11.3%, *Potamogeton illinoensis* (Illinois pondweed) at 10.5%, *Potamogeton pectinatus* (sago pondweed) at 5.1%, *Naja spp.* at 1.4%, and *Utricularia spp*. (bladderwort) at 0.9%. The aquatic plant that represented the highest cumulative percent cover overall was the floating plant, *Nymphaea spp.* (white water lily) at 43.3. Floating leaf pondweed covered approximately 4.1%.

Several emergent aquatic species were observed around Asylum Lake. *Typha spp.* (cattails) had the highest cumulative percent cover of the emergent species at 35.9, while *Scripus spp.* (bulrushes) had a percent coverage of approximately 25.2. Invasive species identified around Asylum Lake were *Myriophyllum spicatum* (Eurasian water milfoil) and Lythrum salacaria (purple loosestrife) at 5.8% and 0.4% cover, respectively.

Little Asylum Lake

During the aquatic plant survey conducted by K&A on August 9, 2006 at Little Asylum Lake, five submergent aquatic species were identified in the littoral zone of the lake. *Ceratophyllum demersum* (coontail) had the highest cumulative percent cover of the submergent plants at 27.5. The other submergent aquatic species observed during the survey were *Chara spp.* (muckgrass) at 16.1%, *Potamogeton pectinatus* (sago pondweed) at 13.5%, *Naja spp*. at 8.7%, and *Utricularia spp*. (bladderwort) at 2.7% cover. Only two floating aquatic species were identified during the survey, *Nymphaea spp.* (white water lily) at approximately 42.7 cumulative percent cover and *Nuphar spp.* (yellow water lily) at 0.1%.

The emergent aquatic plant *Typha spp*. (cattails) has the highest cumulative percent cover of all identified aquatic macrophytes/wetland plants at 80%. A second emergent aquatic species was observed, *Decodon verticillatus* (swamp loosestrife), at 0.3% cover. Two invasive aquatic species were identified around Little Asylum Lake. Similar to Asylum Lake, *Lythrum salacaria* (purple loosestrife) was identified and had a much higher percent cover of approximately 7%. Unlike Asylum Lake, Eurasian water milfoil was not noted in Little Asylum Lake, though the invasive species *Potamogeton crispus* (curly pondweed) was present and had a cumulative percent cover of approximately 0.9.

Invasive Aquatic Species Coverage

Survey locations where the three exotic species were observed in Asylum Lake and Little Asylum Lake are noted on Figure 4. Around Asylum Lake, Eurasian water milfoil was observed at twelve sites (six sites classified as present, three as sparse, and three as common). Purple loosestrife was observed at Asylum Lake at three sites (two sites classified as present and one as sparse) and Little Asylum Lake at twelve sites (five sites classified as present, six sites as sparse, and one site as common). Curly pondweed was also observed in Little Asylum Lake at five sites (three sites classified present and one as sparse).

CHAPTER 4.0

DISCUSSION

This chapter discusses water quality results and related analyses in the context of overall lake conditions, and introduces issues that should be addressed in the future management efforts for the Asylum and Little Asylum Lake watershed.

4.1 Lake Water Quality Conditions

Several water quality parameters can be used as indicators of lake trophic conditions, pressing water quality issues and for sourcing pollutant contributions to both lakes. Additional descriptions of various water quality indicator parameters relevant to Asylum and Little Asylum Lake applications are inset for reference in this section.

Water Quality Indicators

Biotic productivity within aquatic ecosystems is one of the most common ways to assess the condition of lake systems. Varying levels of primary productivity are used to categorize aquatic ecosystems into separate trophic states. The leading driver behind primary productivity is the availability of key nutrients for biological uptake, mainly phosphorus and nitrogen, although other water quality parameters can be used as indicators of trophic status.

Water quality data collected in this study can assist in better understanding the productivity, and ultimately the trophic status, of Asylum and Little Asylum Lake. The average range of TP values measured in Asylum and Little Asylum Lake were above the 20-37 µg/L range that scientific literature suggests is characteristic of eutrophic systems, (i.e., those systems exhibiting very high levels or primary productivity—refer to tables in Appendix G). Total nitrogen concentrations measured in bottom water samples reported very high values, sometimes between 1,000-2,000 µg/L. These values indicate that primary productivity, or biomass growth, is not likely to be nutrient limited. This can result in nuisance growth of algae and aquatic plants, particularly following spring turnover when bottom waters mix with surface waters.

Other water quality variables have been used in the scientific literature to characterize the trophic state of aquatic ecosystems (Chapra, 1997). Chlorophyll *a* concentrations of less than 10 µg/L characterize ecosystems with low productivity and levels greater than 10 µg/L can indicate high levels of productivity. Similarly, secchi disk

PHOSPHORUS

Both algae and aquatic plants require a wide range of nutrients for growth. The nutrient that is typically in shortest supply with respect to aquatic plant and algal growth is termed the "limiting nutrient". This term implies that the relative availability of this nutrient, in regards to availability of other nutrients, will limit plant growth. In most freshwater ecosystems, phosphorus is the limiting nutrient. Therefore, increases in phosphorus will inevitably lead to increases in nuisance plant and algae growth.

The form of phosphorus most often used for general assessments of lake water quality is total phosphorus (TP). Concentrations of TP in lake water can be used to estimate the trophic status of the lake based on scientific data compiled for other similar inland lakes. The term "trophic state" refers to the level of "primary productivity" (algal growth) in an aquatic system. The three trophic states include "oligotrophic", "mesotrophic", and "eutrophic", which respectively correspond to low, medium, and high levels of productivity. The ranges of TP concentrations in each trophic state, based on various scientific literature, are presented in Appendix G. These can serve as a comparison to concentrations of TP in the lake samples documented in this report.

depths greater than four meters indicate oligotrophic systems (low productivity) and depths less than 2 meters indicate eutrophic systems (high productivity). In Michigan lakes, productivity is often greatest during spring and summer months, when both sunlight and nutrients are available. Chlorophyll *a* samples collected at the Asylum Lake outfall in April 2007 were above 10 µg/L, indicating eutrophic conditions. Little Asylum Lake had much lower concentrations of chlorophyll *a*, indicating a more moderate level of algal productivity. Similarly, secchi depths observed in Asylum and Little Asylum Lakes averaged 1.7-3.5 m, which characterizes the lakes between mesotrophic and eutrophic.

CHLOROPHYLL *a*

Algae concentrations are often measured in terms of chlorophyll a, a pigment used by algae for photosynthesis. The more algae present within a lake system, the higher the measurable chlorophyll a content. Lakes with summer chlorophyll a concentrations less that 7µg/l (or parts per billion) are defined as oligotrophic. Lakes with chlorophyll a between 7 and 12 µg/l are mesotrophic, while lakes with concentrations greater than 12 µg/l are considered eutrophic (Thomann and Mueller, 1987).

Eutrophic conditions, like those found in Asylum and Little Asylum Lake, often produce increased algal growth within the water column. High levels of algae can lead to decreases in available DO through the consumption of oxygen as dead algae (and other aquatic plants) decay. Severely reduced DO levels in aquatic ecosystems can cause problems for other aquatic organisms. DO measured in Asylum Lake shows decreasing levels near the lake bottom throughout the year. This is typical of highly eutrophic lakes. The levels of DO in Little Asylum Lake were greater than Asylum Lake, most likely due to shallow depths and limited temperature stratification in Little Asylum. This temperature stratification precludes mixing of surface and bottom waters in Asylum Lake where well-oxygenated surface waters reaerated by wind, do not mix with oxygen depleted bottom water.

TEMPERATURE & DO

It is important to understand dissolved oxygen (DO) conditions in lakes as they provide a reliable indication of its health. A sufficient supply of DO in lake water is necessary for most forms of aquatic life. Increased algal growth (i.e., suspended microscopic plants in the water column) associated with nutrients added to the lake can lead to severe decreases in DO, especially in the cooler bottom waters of a lake during periods of temperature stratification. This drop in oxygen is due, in part, to dead algae and other organic matter (such as plant material from shoreline areas and leaves, grass, and other plant debris washed in from storm drains) settling to the bottom of the lake and decaying. This process of decay consumes oxygen. As materials accumulate at the bottom of a lake, these new sediments place a continuous demand on oxygen supplies in the overlying waters (referred to as "sediment oxygen demand"). Impacts of DO are most often observed during periods of temperature stratification in warmer summer months, and to a lesser degree, under winter ice cover. Measuring DO concentrations, temperature, and depth through various seasons of the year provides for: 1) an assessment of the general physical conditions in the lake, and 2) a characterization of habitat conditions.

The TP and SRP concentrations observed in bottom waters of both lakes suggest that sediments are releasing large quantities of nutrients back into the water column. This is especially evident in Asylum Lake during periods of stratification when DO levels fall below 2 mg/L. Sediment nutrient release can be several times greater under anoxic conditions. Based on ratios of nitrogen to phosphorus concentrations noted in this study, both Asylum and Little Asylum Lakes may be considered phosphorus-limited. This means that phosphorus will be exhausted first by algae and therefore, reductions in phosphorus should result in decreased biomass and improved trophic conditions. Though sampling conducted during 2006 and 2007 did not reveal nuisance algal conditions (recognized by floating mats and shoreline accumulations), stormwater loads and the obvious internal recycling of phosphorus via sediment release, suggest that opportunities exist for such growing conditions.

Other pollutants detected in these lakes merit attention in terms of management strategies that can be tied to addressing issues such as stormwater loads. Bacteria levels, for example, though very low in the lake (and not exceeding standards for recreational uses), were very high in stormwater runoff. Sources such as waterfowl and pet waste are most often the original source of the bacteria. Educational programs and stormwater controls will be the most effective means to address this issue.

Heavy metals such as mercury may be much more challenging to address. Typically, the single largest source of mercury into lakes is via atmospheric deposition either directly onto the lake surface and via wash-off of accumulated mercury deposits on impervious surfaces. Mercury is a naturally occurring metal in geologic formations. Globally, mercury is released into the environment by both natural and anthropogenic means. Anthropogenic sources of mercury range from various industrial and commercial uses to the bi-product of energy production. One of the most common sources of mercury in the environment is atmospheric deposition, which cycles this pollutant between land and water (McCarty et al., 2004). Atmospheric mercury deposition to waterbodies in the U.S. is a common occurrence in all lakes, but has been showing a decreasing trend in accumulated sediments in recent years (Parsons et al., 2007).

There are few practical management solutions to address atmospheric deposition of mercury at the local level. Regional Clean Air Act programs are unfolding to address this issue as mercury is a ubiquitous problem in the Midwest. Where mercury or other heavy metals enter these lakes via stormwater, control solutions targeting loading of other critical pollutants (i.e., nutrients) will likely address these to some extent.

Hydraulic Conditions and Pollutant Loads

The hydrology of Asylum and Little Asylum Lakes appears to have been modified over time to include inlets from stormsewered areas and constructed outlets. Storm sewers deliver a large volume of runoff with high pollutant concentrations to Asylum Lake during wet weather events. Results from this study suggest that the largest and most manageable source of TP to this lake is stormwater inlet #1. Conversely, a significant source of TN appears to come from runoff entering the lake via stormwater inlet #2. The pollutant load to Little Asylum Lake via stormsewers is minimal, however, there is a significant pollutant load contribution to Little Asylum Lake via the outfall structure from Asylum Lake. This downstream transfer is only manageable over time as nutrient inputs into Asylum Lake, and potentially sediment release are managed.

An important factor to consider when assessing in-lake processes such as sediment release (that can dramatically affect lake water quality) is the amount of time it takes for water to move through the system. This is examined in terms of the hydraulic residence time. The significance of this measurement is that a lake with a very short HRT (10 days or less) is relatively immune to pollutant inputs compared to a lake with a long HRT. Pollutants tend to flush through systems with short HRTs before the nutrients can be assimilated into plant or algae biomass. In contrast, some aquatic herbicides used for managing invasive aquatic species may require a long HRT in order for the treatment to be effective. The HRT for Asylum Lake was determined to have a residence time of approximately 260 days. Hydraulic residence times over 100 days allow time for both an abundant supply of nutrients to accrue and adequate time for algae to assimilate those nutrients (EPA, 1990). Evidence of this is now readily available through bottom water data and mass balance calculations. In contrast, Little Asylum Lake was determined to have a very short HRT of approximately 11 days. However, as hydraulic mass balance computations suggest, the vast majority of water loss in this lake is to groundwater and not through the outlet to Cherry Creek. This dramatically increases the effective HRT whereby pollutant retention (and sediment accumulation) becomes significant. Loading estimates from stormwater inlets and lake outlets suggest that pollutant mass entering these lakes is largely retained.

4.2 Lake Bottom Sediments

The presence of very high levels of phosphorus and nitrogen in Asylum and Little Asylum Lake sediments indicates excessive TP and TN concentrations within the lake system. From the phosphorus mass balance, over 70% of the TP entering the lake is retained. Nearly 100% is retained in Little Asylum Lake, particularly during years of average and below average rainfall. These TP loads are likely assimilated into biomass (primarily as aquatic vegetation and algae) and largely accumulate in bottom sediments. This is evidenced by TP and TN concentrations in bottom sediments that are much higher than those noted in other southern Michigan lakes examined by K&A. Notably, both phosphorus and nitrogen levels are greater in Little Asylum Lake sediments than in Asylum Lake, supporting respective estimates of mass retention.

Data clearly indicate that in-lake processes such as sediment oxygen demand and nutrient release are substantial in these lakes. During spring and fall turnover period, phosphorus released from sediments is remixed with surface waters and becomes available for biological uptake. More biological uptake creates more biomass that settles to the bottom worsening sediment oxygen demand. This is turn, pumps out more nutrients from the sediments. This cycling highlights the importance of first managing and restricting external inputs of phosphorus to the lakes. In-lake treatment efforts will otherwise have limited benefit.

4.3 Aquatic Plant Communities

Aquatic plant communities in both lakes are generally diverse, although Little Asylum Lake does have extensive areas with high cattail density. None of the invasive species found in these lakes were present in dense quantities during this survey, although it should be noted that these species can quickly increase to nuisance levels if not aggressively controlled. Species already present in Asylum Lake (e.g., Eurasian water milfoil) could spread to Little Asylum Lake.

Eurasian water milfoil has the potential to spread through a lake system rapidly and dominate the submergent plant populations. This species can out-compete native plants with its ability to grow when spring water temperatures are still cool. This head start over the native vegetation can allow the Eurasian water milfoil to develop a canopy, shading out other submergent plants. In addition, Eurasian water milfoil can reproduce easily from plant fragments that float to new locations and take root. Curly-leaf pondweed is not as invasive as Eurasian water milfoil, though it does grow in cool water while native vegetation remains dormant. Winter foliage can be produced under a cover of ice. Plant respiration can then deplete oxygen supplies as was noted during February in Little Asylum Lake. Plant die-off in mid-summer will also release nutrients into the water column and organically enrich already heavily laden carbon-rich sediments. The latter condition leads to more severe sediment oxygen demand. Whether chemical treatment or physical plant removal is desired and/or practical here, will likely be a cost-based decision.

Purple loosestrife is a highly invasive species, which can quickly dominate wetland and lakeshore areas. One mature plant (4-5 years old) can produce 2,700,000 seeds annually (USGS, 1999). These seeds can remain viable in the soil for many years and can be transported via wind, water, animals, or humans. For this reason, purple loosestrife presents a potential risk to Asylum and Little Asylum Lake plant diversity.

Generalized plant management guidelines suggest that 20-40% native plant cover should be maintained in a lake for healthy fish and wildlife habitat (Madsen et al., 2002). For this reason, a diverse native plant community should be maintained in Asylum and Little Asylum Lakes. In addition to providing habitat for both lakes, a diverse plant community may also serve to stabilize bottom sediments, buffer shoreline areas from erosion, and absorb in-lake nutrients such as phosphorus and nitrogen that would be utilized for algae growth if not taken up by macrophytes. The Asylum Lake Policy and Management Council should recognize these benefits as they consider efforts for future vegetation management.

CHAPTER 5.0

CONCLUSIONS

Project findings relevant to Asylum Lake Policy and Management Council interests in Asylum and Little Asylum Lakes are presented here. These relate to critical findings and considerations for future management.

- There are nearly 1,633 acres of land surrounding these lakes that are topographically situated to drain to these lakes. However, it appears that US-131 creates a physical barrier to surface drainage such that only 661 acres, all to the east of this highway, drain to the lake via stormsewers, surface channels or direct overland flow.
- Stormwater pollutant inputs from stormsewered areas to the west and north of Asylum Lake constitute the largest source of external loading that can be managed through controls. Large land areas that drain to the lake via overland flow are mostly pervious and covered with vegetation of some type.
- Only four stormwater inlets (two to each lake) appear to be directly discharging stormwater to the lake. Other stormwater outfalls to the east of Asylum Lake and north of Little Asylum Lake appear to be separated by extensive wetland complexes.
- Asylum Lake and Little Asylum Lake are largely isolated from downstream Cherry Creek and Willow Lake. Under normal precipitation conditions, very little water flows out of Little Asylum Lake.
- Groundwater inflow is the predominant source of inflowing water to Asylum Lake. Conversely, nearly all water exits Little Asylum Lake via groundwater.
- Water quality conditions in both lakes suggest these systems can be characterized as eutrophic based on phosphorus, chlorophyll *a* and secchi disk measurements.
- Rapid onset of anoxia (depleted oxygen supplies) even before the onset of temperature stratification is evidenced by field measurements of dissolved oxygen with depth in Asylum Lake. This occurs following both spring and fall turnover. The entire bottom waters of this lake below the thermocline are largely devoid of oxygen in late summer. These conditions are attributable to organically enriched sediments that exert a high sediment oxygen demand on overlying waters. Such conditions are common in highly eutrophic systems.
- Due to its shallow nature, Little Asylum Lake does not tend to thermally stratify during the summer due to complete mixing driven by ambient winds. This limits the extent of anoxic conditions. Under ice cover, however, this shallowness and the extensive shoreline wetlands and rooted aquatic macrophytes appear to deplete oxygen supplies in the upper waters likely via plant respiration.
- High TP and TN concentrations in sediment samples suggest significant retention and accumulation of these materials. This is corroborated by mass balance calculations indicating that more than 70% of the phosphorus that enters Asylum Lake remains within the lake. This is closer to 100% retention in Little Asylum Lake.
- Internal recycling of nutrients via sediment release is evident from bottom sample data in both lakes, but more severe in Asylum Lake during extended periods of temperature stratification. During spring and fall turnover, excess TP and SRP released into the bottom waters in summer become available for uptake and conversion to biomass following seasonal turnover. Future alum treatments could address this condition but not before stormwater loading is corrected.
- Some heavy metals, most notably mercury, are found in lake water and bottom sediments. Those associated with stormwater loading could be addressed via stormwater controls. Mercury is not likely manageable as the greatest source to these lakes is probably atmospheric deposition.

- High counts of *E. coli* bacteria were measured in wet weather stormwater flows into both lakes. Very low counts were noted at in-lake stations during seasonal (non-wet weather) sampling. These observations suggest that stormwater controls established to reduce nutrient loading will likely address concerns with bacterial loads.
- The littoral plant communities of these lakes are moderately diverse. Eurasion water milfoil and purple loosestrife are invasive species in Asylum Lake. Curly leaf pondweed is the predominant invasive aquatic macrophyte in Little Asylum Lake. Cost factors for management will likely dictate decisions made to control these species.
- The most pressing water quality/watershed management issue is controlling stormwater loads from highly developed storm sewered drainage areas, principally for Asylum Lake.

CHAPTER 6.0

RECOMMENDATIONS AND PRELIMINARY STORMWATER TREATMENT CONCEPTS

K&A has conducted a preliminary evaluation of potentially suitable stormwater treatment concepts for runoff entering the west end of Asylum Lake from subwatershed #5 discharging via stormwater inlet #1. All BMPs examined here are widely accepted and utilized for sediment and nutrient removal, though some are more appropriate than others for this setting. Several BMP options are discussed below. Accompanying Tables 8-15 can be found at the end of this chapter. All concepts presented here should be considered conceptual and do not infer commitments on the part of any party or entity associated with land ownership in this subwatershed.

6.1 Evaluation of Potential BMPs

Common pollutant reduction estimates for each BMP are presented in Table 8. It should be noted that these values are median pollutant reduction percentages for design purposes that have been derived from published sampling data, modeling and research. A stormwater BMP design may be capable of exceeding these performances; however, the values in the table are considered median values that can be assumed to be achieved when the stormwater BMP is sized, designed, constructed and maintained in accordance with intended specifications.

Further details regarding relative treatment effectiveness, costs, aesthetics, size requirements and maintenance for common stormwater BMPs are presented in Tables 9, 10 and 11.

<u>*Sediment Forebay*</u>

Sediment forebays are a type of pretreatment BMP used to initially detain stormwater runoff for a short time period to settle out a portion of the suspended material. They are essentially small detention ponds or settling basins, which can be used as stand-alone devices or in combination with other BMPs. Forebays also reduce maintenance needs and maintenance costs by trapping sediment in one small area where it is more easily removed, and further preventing excessive sediment buildup in the other downstream treatment BMPs.

<u>*Retention Pond*</u>

A retention pond is designed to hold a specific amount of water indefinitely. It is designed as a permanent pool of water (Debo & Reese, 1995), which releases water only through infiltration and evaporation processes. Usually the pond is designed to have drainage leading to another location when the water levels reach the pond capacity, but still maintains water at the design capacity.

<u>*Wet Detention Pond*</u>

Wet detention ponds are a variation of retention ponds and are designed to maintain an extended volume above a designed permanent pond elevation, with a gradual release of this additional volume. The depth to groundwater in the project area is quite close to the ground surface (based strictly on observations made during field surveys), therefore, it is expected that evaporation would be the primary mechanism of water removal for the permanent pool volume rather than infiltration.

Dry Detention Pond

These are designed as ponds that hold, or detain, stormwater runoff for a specified time period (typically 6-24 hours) after which the volume drains completely. They are commonly used to remove suspended solids from the stormwater prior to release, and for attenuation of peak flows for downstream flood control. Nutrients, heavy metals, and other stormwater pollutants associated with suspended solids may also be removed to a limited extent. Excessive siltation can result in decreased capacity of detention volume.

Wetlands

Stormwater wetlands are another option for treating stormwater runoff. They utilize shallow, inundated vegetation to remove stormwater sediments and nutrients through biological and naturally occurring chemical processes. For stormwater wetlands to function properly, the hydrologic regime must be closely monitored to ensure that the tolerances of the wetland vegetation are not exceeded, and that adequate retention times are provided. Wetlands can be effective components of stormwater treatment, though land requirements may be fairly intensive and seasonal influences may complicate nutrient removal.

Infiltration Basins

An infiltration basin is a shallow depression area created by excavation or berming that captures and slowly infiltrates stormwater runoff into the soil. Infiltration basins can serve large drainage areas (5-50 acres). In an urban setting, they are best used in conjunction with other BMPs which serve to remove sediments that would otherwise clog the bottom soils. The primary advantage of infiltration basins is that they help to preserve the natural water balance of the site, require low maintenance, and can be integrated into the site landscape. They are best sited in areas where there is sufficient surface area and soil infiltration capacity.

Infiltration Trenches

Other common BMPs are those that focus on infiltration as a means of stormwater treatment. A porous medium (typically coarse sand or gravel) is placed in an excavated trench to promote infiltration. These devices are commonly used as on-site treatment options and they are prone to high maintenance requirements unless sediments are properly removed upstream of their use. Successful implementation of this BMP can be limited in areas of shallow groundwater.

Sand Filters

Sand filters treat stormwater by passing the first flush through a coarse sand filter medium. The filtered water is typically collected in an underdrain system (gravel and perforated pipe) and discharged via a surface outfall rather than infiltrating to the groundwater. Sand filters are effective BMPs for removing solids, but are only moderately effective in treating total phosphorus and other nutrients. Due to hydraulic overloading concerns that can damage the filter bed during intense, peak flows, sand filters are usually installed as an off-line BMP. Most sand filters exhibit diminished operational capacity over time due to surface clogging by organic matter, fine silts, and hydrocarbons resulting in higher than average maintenance considerations. These devices are typically used for smaller applications than those considered necessary for this Asylum Lake drainage area.

Grassed Swales

These are vegetated treatment areas that use bioinfiltration and infiltration to treat stormwater (Debo & Reese, 1995). These vegetative BMPs are effective for TSS and metals removal but have limited effectiveness for phosphorus removal. Depth to groundwater and percentage of impervious surfaces in the watershed may complicate the effectiveness of these practices.

Dry swales are distinguished from a simple grassed swale by the addition of carefully selected, highly permeable soil (usually sandy loam), check dams, and an underdrain system. These additional design features ensure that infiltration of stormwater will not only depend on the infiltration rate of the existing natural soils. Only in special circumstances where natural soil and groundwater conditions consistently provide high infiltration will a traditional grassed swale provide the same water quality benefits as a dry swale design.

Another type of swale, a wet swale, is designed to maintain saturated conditions within soils at the bottom of the swale. The purpose of a wet swale is to create an enlongated wetland treatment system that treats stormwater through physical and biological processes. Unlike dry swales, infiltration of stormwater is an undesirable condition in a wet swale because it would prevent saturated conditions necessary to support wetland vegetation.

Filter/Buffer Strips

Filter strips, also known as vegetated buffer strips, use biological means to filter stormwater runoff. Strategically directed runoff flows in a wide sheet across this vegetated area, and is treated by infiltration into the soil and through uptake by the plants. Small berms may be installed at the downstream edge of the filter strip to ensure that water can be detained and filtered into the underlying soils. Filter strips are not designed to attenuate peak stormwater flows, but can be an effective water quality BMP. A dense vegetative cover, long flow path, and low gradient profile provide the most effective removal rates.

Oil and Grit Separators (e.g., Stormceptor® Units)

Stormceptor® units and similar prefabricated structures are specifically-designed to remove trash, sediment and hydrocarbons from stromwater runoff. While relatively expensive to install and maintain, they are necessary for select urban applications where debris, oil and grease may be more problematic. Depending on the amount of runoff and available prefabricated sizing limitations, these BMPs may require installation of multiple units in parallel operation.

BMP Summary

No single BMP is necessarily adequate for treating stormwater from large drainage areas (i.e., greater than 5-10 acres). For larger drainage areas, stormwater BMPs should be selected using a "treatment-train" concept. A treatment-train is a series of BMPs used in conjunction with one another to provide a more comprehensive treatment of stormwater runoff. Each BMP is chosen for its ability to remove or limit specific pollutants, and/or its ability to help regulate changes in hydrology. Furthermore, all BMPs which are selected for use at a given site should be designed based on the observed site-specific characteristics (i.e., soil type, slope, topography, climate, etc). Wherever possible, stormwater BMPs should be designed to be aesthetically pleasing.

6.2 Preliminary Runoff Design Considerations

The following analysis examines critical factors associated with the physical setting of subwatershed 5 that will influence design considerations to effectively treat runoff.

Curve Number and Runoff Volume Estimates

Existing land use information was evaluated by K&A and used to estimate stormwater runoff characteristics for Asylum Lake subwatershed 5 (Figure 2) and stormwater inlet #1 (Figure 3). Based on available land use information, individual land use curve numbers were calculated and area-weighted to produce a composite runoff curve number (RCN) value of 76.6 for this urban drainage area. This composite RCN value was then used to determine estimated runoff produced by various rainfall events. Stormwater runoff volumes were estimated by K&A for runoff entering the west end of Asylum Lake from subwatershed 5. Runoff curve number calculations and estimated runoff volumes are presented in Tables 12 and 13, respectively.

Storm events of various frequencies were used to estimate runoff volumes from subwatershed 5 (Table 13). Based on the available land area west of Asylum Lake and a design goal of capturing the initial 1-inch of rainfall runoff (i.e., “first flush”), a stormwater capture volume of approximately 4.9 acre-feet is attainable for a single storm event.

Stormwater Loading Estimates

Estimated pollutant loads from stormwater runoff were calculated for Asylum Lake subwatershed 5. (Refer to Section 3.0 of this text for a detailed discussion.) Characterizing the quantity of pollutants entering Asylum Lake from this drainage area identifies the level of impact that stormwater runoff is imparting on the lake, but also aids with defining the requirements and focus of stormwater treatment alternatives. Table 14 provides a summary of estimated annual loads for total suspended solids, total phosphorus and total nitrogen associated with stormwater runoff from subwatershed 5 entering Asylum Lake.

6.3 Recommended Treatment Concept

The former trailer park property located at the southwest corner of Stadium Drive and Drake Road, approximately 6.5 acres in size, is now under the control of the WMU Foundation. The Foundation has recently expressed interest in developing a portion of the site and allowing the remaining unused space to be utilized for stormwater treatment. As a result, the recommended treatment concept proposed by K&A is primarily limited to the southern 2.75 acres of the former trailer park property. The fundamental purpose of the recommended treatment concept is to divert stormwater runoff from subwatershed 5 and infiltrate as much stormwater as possible.

Figure 14 provides a schematic illustration of the key treatment system elements that are included in the recommended treatment concept. Several important discussion items related to the schematic illustration are listed below.

- Size of the flow direction (blue) arrows on this schematic conceptually depicts the volume of stormwater passed through each stage of the treatment system (as less volume is passed and greater cumulative volume is infiltrated).
- Stormwater will be diverted from a manhole, located at the northeast corner of Stadium Drive and Drake Road, toward the west onto the WMU Foundation property.
- Untreated stormwater will be directed through a passive, underground trash collection vault structure specifically designed to remove trash, coarse sediment and hydrocarbons from stromwater runoff. This structure will require periodic maintenance to remove litter.
- Stormwater will then be diverted to a sediment forebay. Sand and some silt would be removed through this open basin, approximately 2-4 feet in depth (below the surrounding grade). Long-term periodic cleanout of accumulated sediments may be needed once every 5-10 years. Retention time for this cell would be on the order of 2-3 hours for typical runoff events.
- A 2-4 feet deep retention/infiltration pond will receive stormwater from the sediment forebay. Fine sediments will be settled here (if a 12-24 hour detention time can be established based on size). Limited infiltration and evaporation is expected from this basin.
- Stormwater will then be directed through two, terraced infiltration basins constructed in series. These basins would be constructed to appear as rain gardens with a wide diversity of native prairie and wetland plants. They would be approximately 1-2 feet deep (below surrounding grade). These would be allowed to fill to no more that about 12-14 inches deep, and be constructed to fully drain between storm events.
- To help ensure the maximum fill depth is not exceeded as both infiltration basins fill under extreme or intense storms, an overflow infiltration trench extending south and then east, wrapping around the existing wetland, is also recommended. Significant infiltration capacities have been observed by K&A in other similar infiltration trenches we've constructed.
- Water flowing through the infiltration basins during typical runoff events (that does not overflow to the south), will pass through a final series of infiltration structures. These would rely on the underlying sand lithology separated by filter fabric overlaid with stone. Over time, perimeter vegetative growth would obscure direct observation of these features.
- If infiltration through these latter infiltration basins is exceeded during high volume events, the final discharge of treated water will be vented to the existing wetland drainage ditches. These existing wetlands (or lowlands) are often dry with only periodic inundation. More frequent wetting might occur with direct discharge and/or recharge from treatment system infiltration basins.
- Some modification of these drainage ditch outlets may be needed on the west side of Drake Road.

Figure 15 provides an aerial overlay and preliminary layout of the conceptual treatment-train system. Several important discussion items related to the conceptual layout sketch are listed below.

- Approximately 60% of the northern portion of the upland areas adjacent to Stadium Drive would accommodate a new building with a footprint of 25,000 ft^2 with up to approximately 70 parking spaces.
- Any future parking lot would have its own stormwater capture with integrated on-site rain gardens. Overflows to the larger system will be possible if needed to meet potential Oshtemo Township requirements.

- The recommended treatment concept would utilize the existing terracing to the south of a potential building/parking lot footprint for a stormwater BMP treatment-train.
- Infiltration will be the primary treatment approach with overflows, if any, entering the existing wetland ditches that are connected to Asylum Lake via culverts beneath Drake Road.
- The treatment-train area would be naturalized, accommodating existing landscaping where possible and appropriate, feature walking paths, and blend into the existing natural terrain. From any future, on-site building, this treatment area would be visually pleasing.

This site-specific stormwater treatment approach, heavily favoring infiltration, appears to be the most efficient and effective way to mitigate loads to Asylum Lake. Existing topography and natural features provide opportunities for a terraced BMP layout with gravity conveyance of stormwater throughout the conceptual treatment-train system.

Diverted stormwater runoff would initially be directed on-site and into a trash, oil and grit separator to remove large litter debris and potential hydrocarbon compounds associated with the nearby commercial and impervious areas (subwatershed 5). Flows exiting the trash separator would be subsequently directed into a sediment forebay for removal of medium-coarse suspended sediments. A small retention/infiltration pond would follow the forebay to provide a combination of fine sediment deposition and nutrient reduction. Limited infiltration and evaporation would also occur in the retention/infiltration pond between storm events. Finally, a series of terraced bioinfiltration basins and infiltration trenches would allow stormwater to be naturally returned to the groundwater to maintain the hydrologic regime via recharge. If necessary, a portion of intense storm flows could be diverted into the nearby existing wetland drainage ditches that are connected to Asylum Lake beneath Drake Road. Some modification of these drainage ditch outlets may be needed on the west side of Drake Road.

Estimated Costs

All stormwater BMPs have economies of scale and their associated costs are variable depending on region and site constraints. Estimated implementation costs (preliminary) for the recommended stormwater BMP treatment concept proposed by K&A for Asylum Lake are summarized in Table 15. Capitol construction costs are estimated to be approximately $303,000. In addition, engineering design and permitting costs are estimated to be approximately $60,600. Contingency costs (%10) amount to approximately $30,300. An estimated total for project development of the recommended treatment concept is $394,000. These estimates are based on recent and local projects of similar materials and scope.

Table 8. Design Pollutant Removal Efficiencies (%) for Stormwater BMPs.

Stormwater BMP	Total Suspended Solids	Total Phosphorus	Total Nitrogen	Pathogens	Metals
Dry Detention Basins	30-65	15-45	15-45	<30	15-45
Retention Basins	50-80	30-65	30-65	<30	50-80
Constructed Wetlands	50-80	15-45	<30	<30	50-80
Infiltration Basins[1]	50-80	50-80	50-80	65-100	50-80
Infiltration Trenches/ Dry Wells	50-80	15-45	50-80	65-100	50-80
Porous Pavement	65-100	30-65	65-100	65-100	65-100
Grassed Swales	30-65	15-45	15-45	<30	15-45
Vegetated Filter Strips	50-80	50-80	50-80	<30	30-65
Surface Sand Filters	50-80	50-80	<30	<30	50-80
Other Media Filters	65-100	<30	15-45	<30	50-80
Trash/Oil/Grit Separator	30-60	<5	<5	---	---

Source: U.S. EPA, 1999

Notes:

1. Infiltration basins can be considered 100 percent effective at removing pollutants in the fraction of water that is infiltrated, if the pollutants found in this volume are not discharged directly to surface waters via an overflow spillway. Since infiltrated water does not leave the BMP as a discrete flow, there is no representative way of collecting a true outflow sample.

--- Insufficient data to provide design removal efficiency.

Additional Considerations:

1. BMP performance should not be based on comparisons using percent removal alone. This finding is illustrated by an example where low total suspended solids in influent might result in a low percent removal calculation for suspended solids. The BMP might be performing as intended, even though the percent removal value is low.
2. The chosen performance-evaluation method can affect reported pollutant removal efficiencies.
3. Wet ponds and wetlands are not well represented by storm-by-storm comparisons because paired inflow and outflow might not be related to the same event.
4. Effluent quality is useful for characterizing the effectiveness of the BMP.
5. Downstream response and biological/habitat assessment might be a better gauge of long-term BMP effectiveness for select sites than pollutant removal efficiencies alone.
6. More data are needed for sound statistical analysis, particularly for BMPs other than ponds and wetlands.

Table 9. Relative treatment effectiveness, costs, aesthetics, and size requirements for various stormwater BMPs.

Stormwater BMP	Stormwater Treatment Effectiveness	Relative Cost	Traditional Aesthetics	Proposed Size Requirements (as percent of total)	Remarks
Wet Retention	High	Low/Med	Med	50-100%	Access limitations may be required
Dry Detention	High	Low	Low	--	Not recommended for large watersheds
Sediment Forebay	High	Low	Low	5-10%	Maintenance access required
Wetlands	Moderate	Med/High	High	0-25%	Low maintenance; high natural habitat
Infiltration Basin	High	Low/Med	Med	50-100%	Low maintenance
Infiltration Trench	Moderate/High	Med	Low	--	Not recommended for large watersheds
Sand Filter	Moderate	High	Low	5-10%	High maintenance; off-line treatment
Grassed Swale	Low/Moderate	Low	High	--	Not recommended for large watersheds
Stormceptor® Units[1]	Moderate	High	Med	--	Not recommended for large watersheds

<u>Notes</u>:

1. Stormceptor® is referenced above as an example manufacturer of structural precast BMP water quality devices that can be installed on-line to remove trash, oil and grit from stormwater runoff. These systems are not necessarily stand-alone BMPs and should be used to pretreat stormwater runoff prior to discharging to other BMPs such as ponds, sand filters, or infiltration/exfiltration trenches whenever possible. The above reference is not necessarily intended to constitute an endorsement of the Stormceptor® product.

Table 10. Estimated implementation costs for various stormwater BMPs.

Stormwater BMP	Conceptual Cost (C) Equation[1] ($)	Conceptual Cost[2] ($/ft^3)	Remarks
Retention/ Detention Basins and Sediment Forebays	C=168.39xV0.69 (where: V is in m^3)	0.50-1.00	Cost range reflects economies of scale in designing this BMP. The lowest unit cost represents approx. 150,000 cubic feet of storage, while the highest is approx. 15,000 cubic feet. Typically, dry detention basins are the least expensive design options among retention and detention practices.
Constructed Wetlands	$18.5(V)^{0.70}$ (where: V is in ft^3)	0.60-1.25	Although little data are available to assess the cost of wetlands, it is assumed that they are approx. 25% more expensive (because of plant selection and sediment forebay requirements) than retention basins.
Infiltration Basin	$C=13.9(V/0.02832)^{0.69}$ (where: V is in m^3)	1.30	Represents typical costs for a 0.25-acre infiltration basin.
Infiltration Trench	C=1317.1xV0.63 (where: V is in m^3)	4.00	Represents typical costs for a 100-foot long trench.
Sand Filter	$10,000-$20,000 /impervious acre	3.00-6.00	The range in costs for sand filter construction is largely due to the different sand filter designs. Of the three most common options available, perimeter sand filters are moderate cost whereas surface sand filters and underground sand filters are the most expensive.
Grass Swale	$5-$15/linear ft	0.50	Swale Based on cost per square foot, and assuming 6 inches of storage in the filter.
Filter Strip	$2,000/drainage acre	0.00-1.30	Based on cost per square foot, and assuming 6 inches of storage in the filter strip. The lowest cost assumes that the buffer uses existing vegetation, and the highest cost assumes that sod was used to establish the filter strip.
Stormceptor® Units[3]	30,000-60,000[4]	30,000-60,000[4]	The expected life of the Stormceptor® is 50 to 100 years (Stormceptor®, 1996).

Source: U.S. EPA, 1999; www.stormceptor.com

<u>Notes</u>:

1. Conceptual costs can be estimated from these equations, where V is the volume of stormwater managed (m^3), unless noted otherwise (Schueler, 1987) and (Wiegand et al., 1986). Base year for these cost equations is 1995. Real estate, design, and contingency costs are not included in these estimates. These are provided for conceptual cost estimating purposes only.
2. Base year for these cost data: 1997. Real estate, design, and contingency costs are not included in these estimates. These are provided for conceptual cost estimating purposes only.
3. Stormceptor® is referenced above as an example manufacturer of structural precast BMP water quality devices that can be installed on-line to remove trash, oil and grit from stormwater runoff. These systems are not necessarily stand-alone BMPs and should be used to pretreat stormwater runoff prior to discharging to other BMPs such as ponds, sand filters, or infiltration/exfiltration trenches whenever possible. The above reference is not necessarily intended to constitute an endorsement of the Stormceptor® product.
4. Estimated implementation costs for structural precast trash/oil/grit separator devices are provided in $/acre. Not recommended for large watersheds.

Table 11. Common BMP Maintenance Considerations.

Stormwater BMP	Activity	Schedule
Retention Pond/ Wetland	• Cleaning and removal of debris after major storm events • Harvest excess vegetation • Repair of embankment and side slopes • Repair of control structure	Annual or as needed
	• Removal of accumulated sediment from main cells of pond once the original volume has been significantly reduced	20-year cycle (although can vary)
Sediment Forebay	• Removal of accumulated sediment from forebays or sediment	5-yr cycle, or as needed
Detention Basin	• Removal of accumulated sediment • Repair of control structure • Repair of embankment and side slopes	Annual or as needed
Infiltration Basin	• Cleaning and removal of debris after major storm events • Mowing[1] and maintenance of upland vegetated areas	Annual or as needed
	• Removal of accumulated sediment from forebays or sediment storage areas	3- to 5-year cycle
Infiltration Trench	• Cleaning and removal of debris after major storm events • Mowing[1] and maintenance of upland vegetated areas • Maintenance of inlets and outlets	Annual or as needed
Sand Filter	• Removal of trash and debris from control openings • Repair of leaks from the sedimentation chamber or deterioration of structural components • Removal of the top few inches of sand and cultivation of the surface when filter bed is clogged (only works for a few cycles) • Clean-out of accumulated sediment from filter bed chamber • Clean out of accumulated sediment from sedimentation chamber	Annual or as needed
Grass Swale	• Mowing[1] and litter and debris removal • Stabilization of eroded side slopes and bottom • Nutrient and pesticide use management	Annual or as needed

Table 11. Common BMP Maintenance Considerations *(continued).*

	• De-thatching swale bottom and removal of thatching • Discing or aeration of swale bottom	
	• Scraping swale bottom, and removal of sediment to restore original cross section and infiltration rate • Seeding or sodding to restore ground cover (use proper erosion and sediment control)	5-year cycle
Filter Strip	• Mowing[1] and litter and debris removal • Nutrient and pesticide use management • Aeration of soil in the filter strip • Repair of eroded or sparse grass areas	Annual or as needed
Stormceptor® Units[2]	• Inspect every six months for the first year to determine the oil and sediment accumulation rate. • Clean out each unit once a year using a conventional vacuum truck, • or when 15 percent of the operating storage volume is filled with solids, • or when oil levels reach 25 mm (1.0 in) or greater (Stormceptor®, 1996) • Sediment capacity of these units generally range from 2.12 to 20.56 m3 (2.77 to 26.87 yd3).	Annual (minimum), or as needed

Source: U.S. EPA, 1999; www.stormceptor.com

Notes:
1. Mowing may be required several times a year, depending on local conditions.
2. Stormceptor® is referenced above as an example manufacturer of structural precast BMP water quality devices that can be installed on-line to remove trash, oil and grit from stormwater runoff. These systems are not necessarily stand-alone BMPs and should be used to pretreat stormwater runoff prior to discharging to other BMPs such as ponds, sand filters, or infiltration/exfiltration trenches whenever possible. The above reference is not necessarily intended to constitute an endorsement of the Stormceptor® product.

Table 12. Asylum Lake Stormwater Treatment Evaluation of Storm Sewer Subwatershed #5.

Storm Sewer Area #5 Land Use	Area (ac)	Percent (%) of Total Area	Landuse RCN	Partial RCN
Low intensity urban	13.566	19.6	81	15.8
High intensity urban	21.794	31.4	89	28.0
Road/parking lot	16.457	23.7	98	23.2
Agriculture	0.000	0.0	59	0.0
Openland/shrub	4.670	6.7	39	2.6
Forest	11.564	16.7	36	6.0
Water	0.000	0.0	100	0.0
Forested Wetlands	0.000	0.0	100	0.0
Sand/soil/bare	1.334	1.9	49	0.9
	69.4	**100.0**		**76.6**

= Composite Runoff Curve Number (RCN) for Storm Sewer Area #5

Table 13. Estimated Rainfall Depths and Runoff Volumes for Storm Sewer Subwatershed #5 of Asylum Lake.

24-Hour Rainfall Frequency[a]	Storm Sewer Area #5 Surface Runoff (inches)	Runoff Volume (ac-ft)
9-mo To 1-yr (2.2")	0.54	3.14
1-yr (2.3")	0.60	3.48
2-yr (2.7")	**0.85**	**4.91**
5-yr (3.3")	1.26	7.28
10-yr (3.9")	1.71	9.86
25-yr (4.5")	2.18	12.60
50-yr (5.1")	2.67	15.45
100-yr (5.7")	3.18	18.39

[a]Precipitation values from "Rainfall Frequency Atlas of the Midwest", Midwestern Climate Center and Illinois State Water Survey, 1992.
Yellow denotes design storm

Table 14. Estimated Annual Stormwater Loading Contribution into Asylum Lake from Storm Sewer Subwatershed #5.

	Total Phosphorus (lbs/yr)	Total Suspended Solids (lbs/yr)	Total Nitrogen (lbs/yr)
Storm Sewer Inlet #1	102	32,620	482
Percent of Total Load to Asylum Lake	38%	43%	33%

Table 15. Estimated Costs for the Asylum Lake Conceptual Treatment-Train System.

Item	Quantity	Unit	Unit Cost	Total Cost
Site Clearing/Prep	3	ac	$4,500	$13,500
Diversion of Storm Sewer	150	ft	$50	$7,500
Drake Road Trench/Resurfacing	1,100	ft2	$12	$13,200
Trash Separators	3	ea	$20,000	$60,000
Storm Manhole Structures	2	ea	$2,500	$5,000
Piping to Forebay	250	ft	$40	$10,000
Sediment Forebay				
Inflow Structure	1	ea	$1,500	$1,500
Excavation	1,300	cyd	$4	$5,200
Berming (2-ft high)	705	ft	$30	$21,150
Outflow Structure	1	ea	$1,500	$1,500
Wet Detention Pond				
Inflow Structure	1	ea	$1,500	$1,500
Excavation	960	cyd	$4	$3,840
Berming (2-ft high)	655	ft	$30	$19,650
Outflow Structure	1	ea	$1,500	$1,500
Infiltration Basins (2)				
Inflow Structure	2	ea	$1,500	$3,000
Excavation	4085	cyd	$4	$16,340
Berming (2-ft high)	1500	ft	$30	$45,000
Outflow Structure	2	ea	$1,500	$3,000
Infiltration Beds (2)				
Inflow Structure	2	ea	$1,500	$3,000
Excavation	890	cyd	$4	$3,560
Berming (2-ft high)	960	ft	$30	$28,800
Outflow Structure	2	ea	$1,500	$3,000
Infiltration Trench	1,150	ft	$15	$17,250
Plantings/Lanscaping	3	ac	$5,000	$15,000

Construction Subtotal	$302,990
10% Contingency	$30,299
20% Engineering/Design	$60,598
Estimated Total Project Development	**$393,887**

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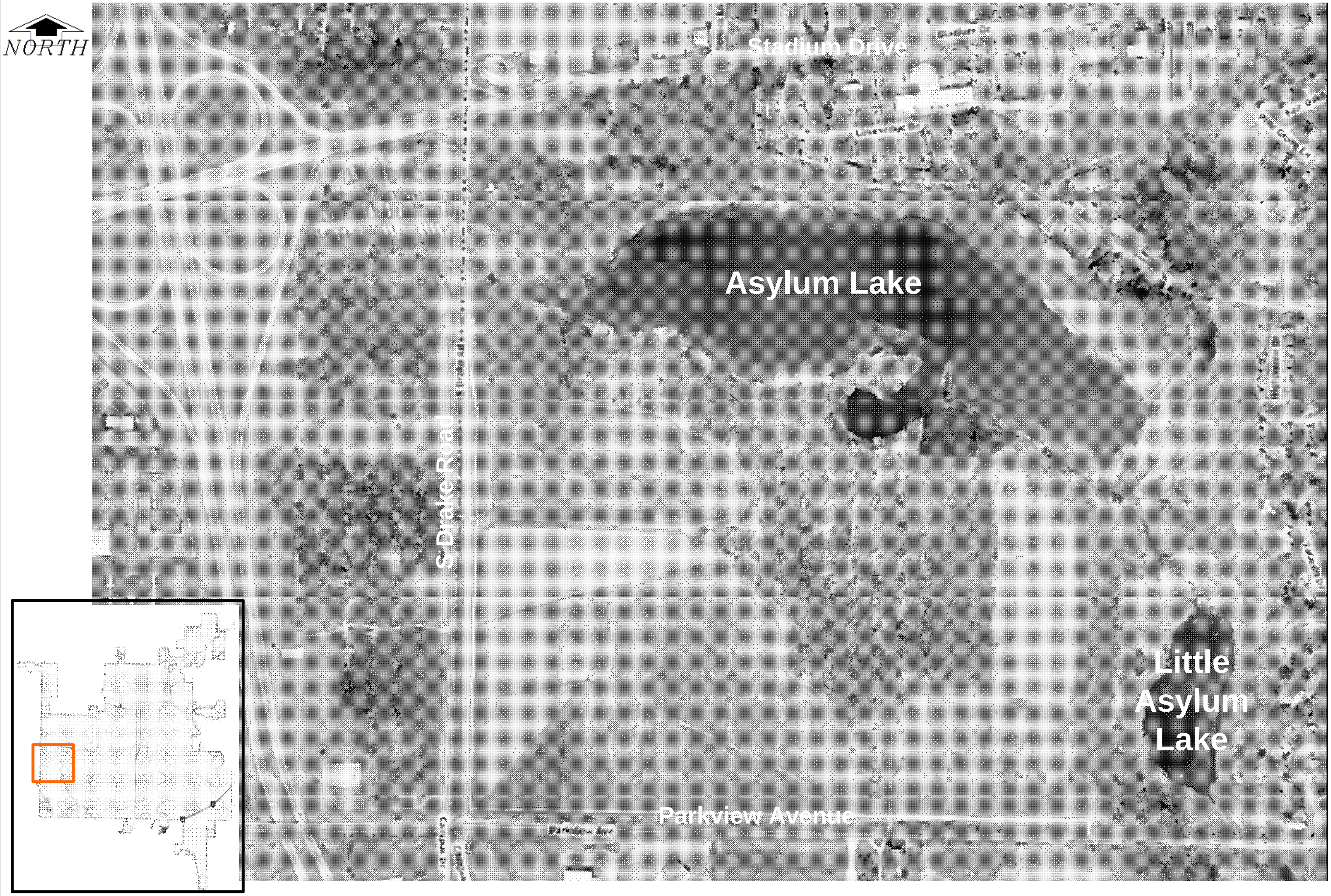

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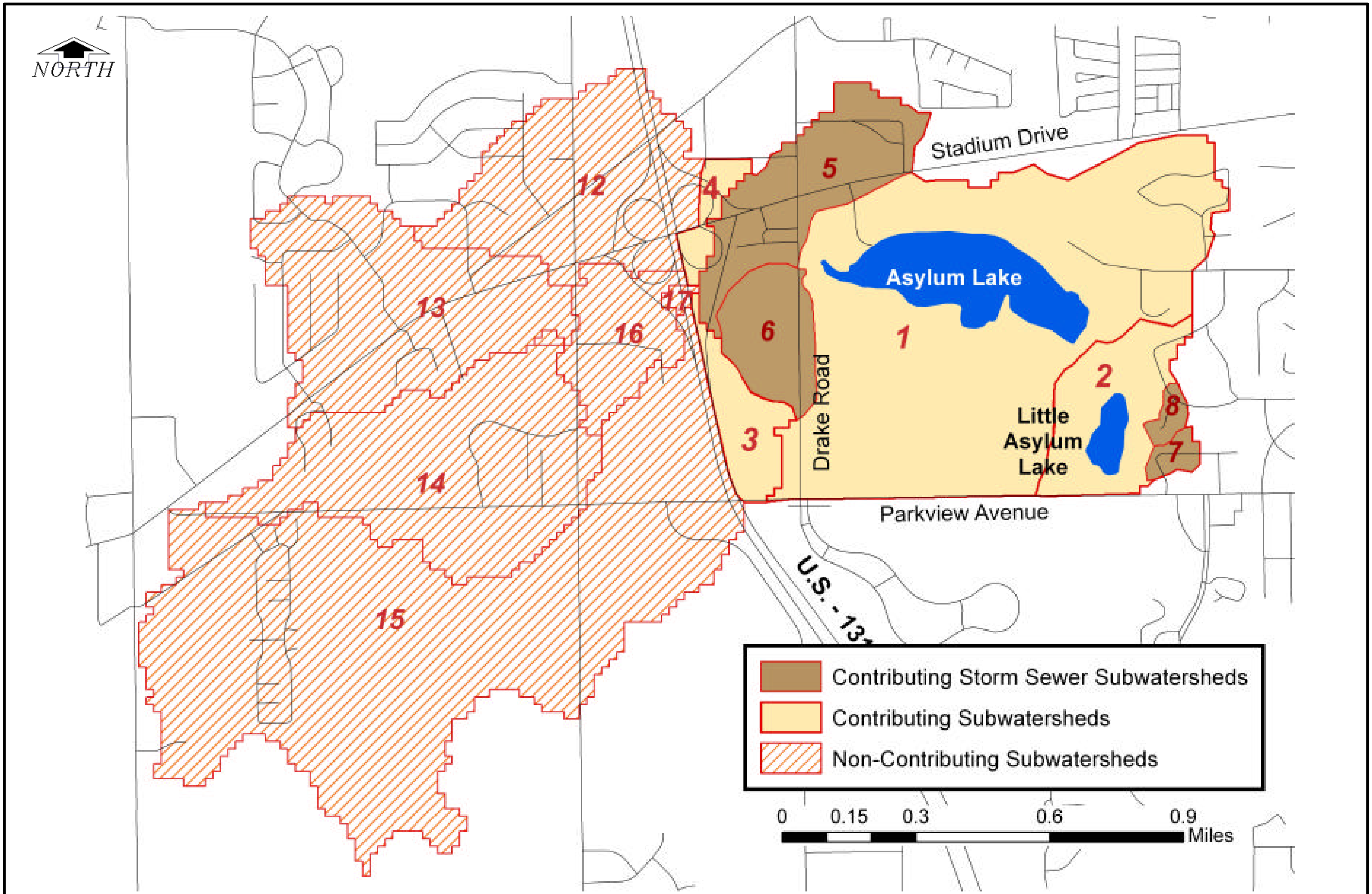
Asylum Lake and Little Asylum Lake project area. Inset map shows project vicinity within the City of Kalamazoo. (Source: City of Kalamazoo, 2007)

FIGURE

1



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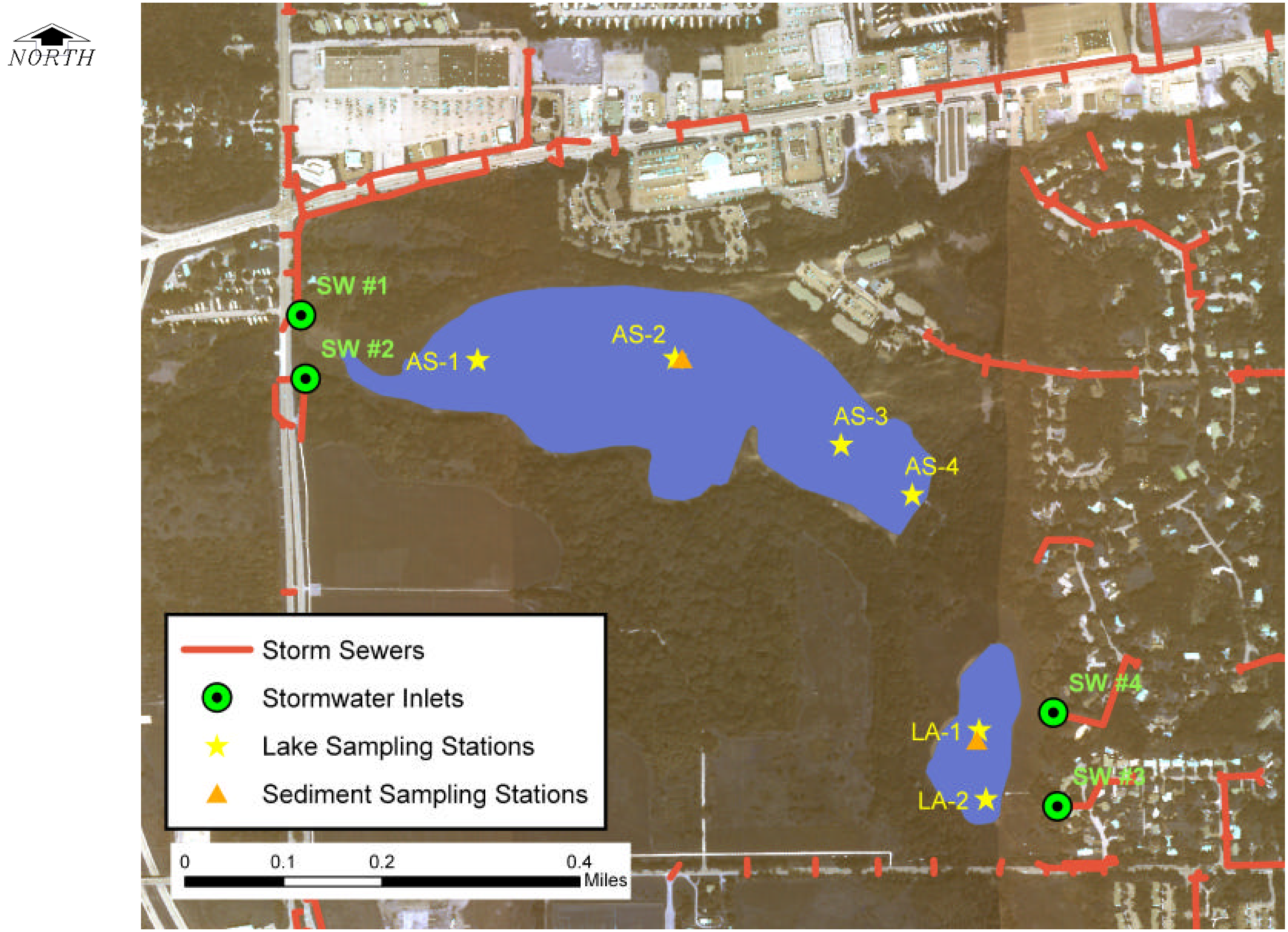
Contributing and non-contributing watershed areas for Asylum Lake and Little Asylum Lake.

FIGURE
2



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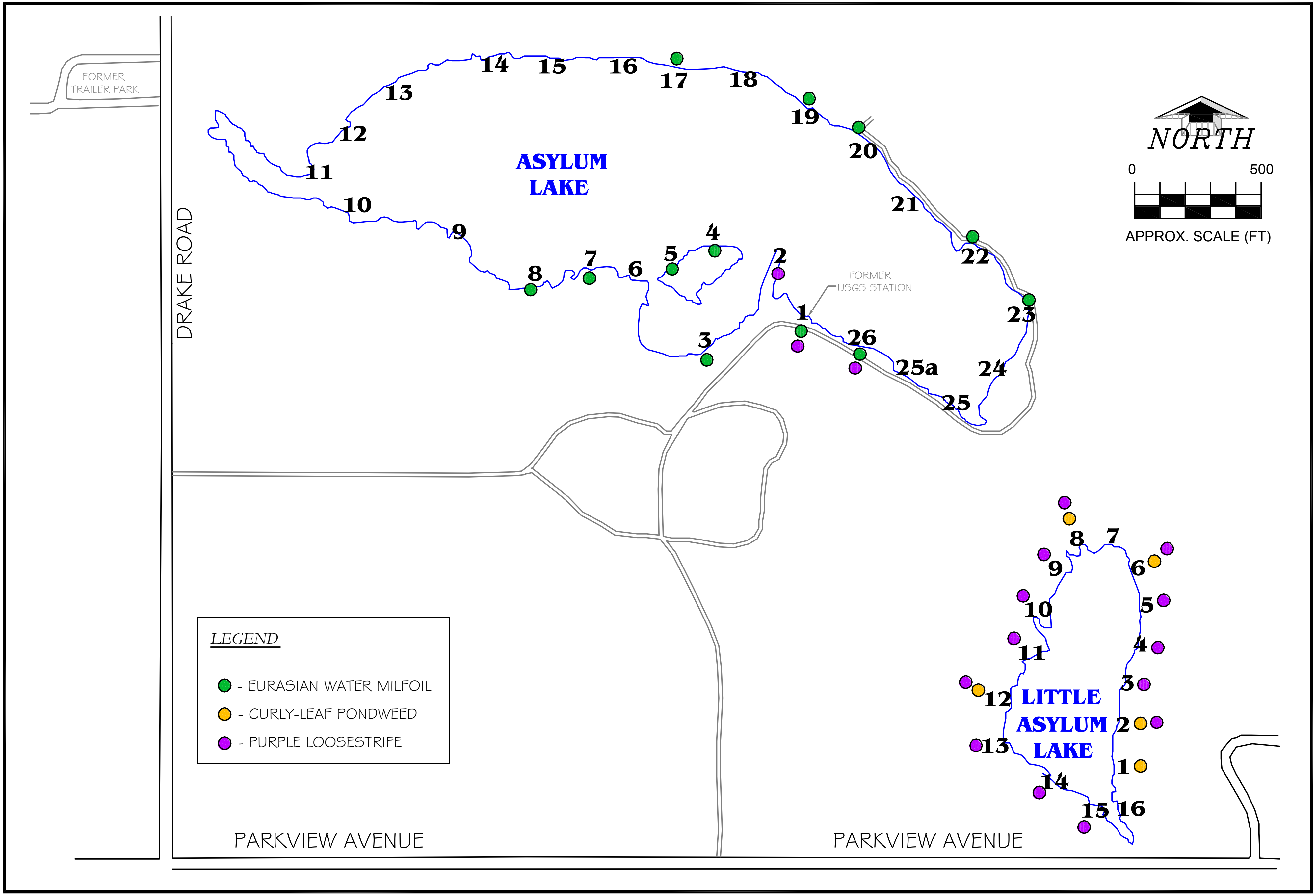
In-lake, stormwater and sediment sampling locations in Asylum Lake and Little Asylum Lake.

FIGURE
3

DRAWN BY: KBB CHECKED BY: MSK REVISED:



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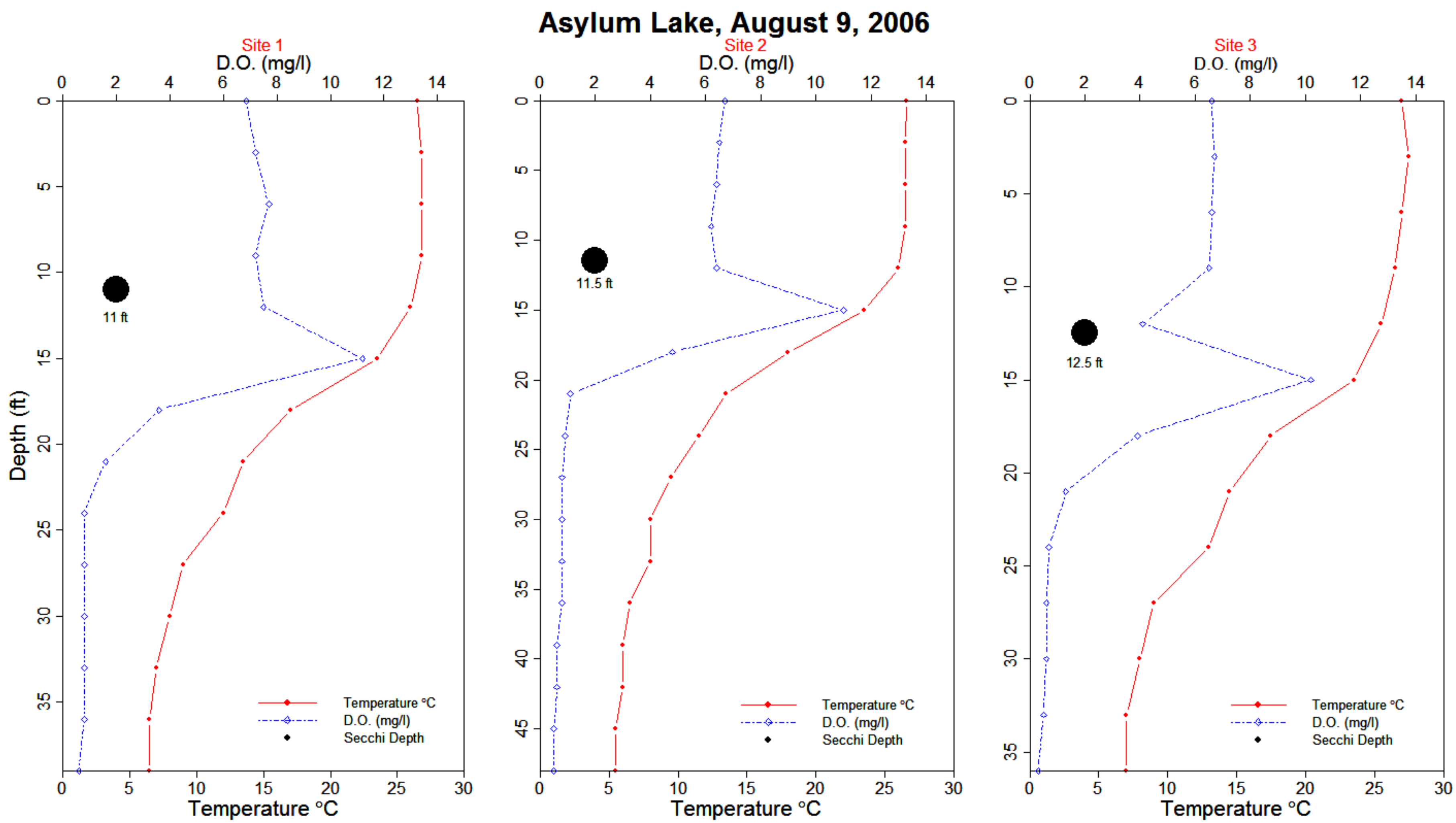
ASYLUM LAKE AND LITTLE ASYLUM LAKE VEGETATION SURVEY LOCATIONS, CONDUCTED AUG-SEP 2006.

FIGURE
4



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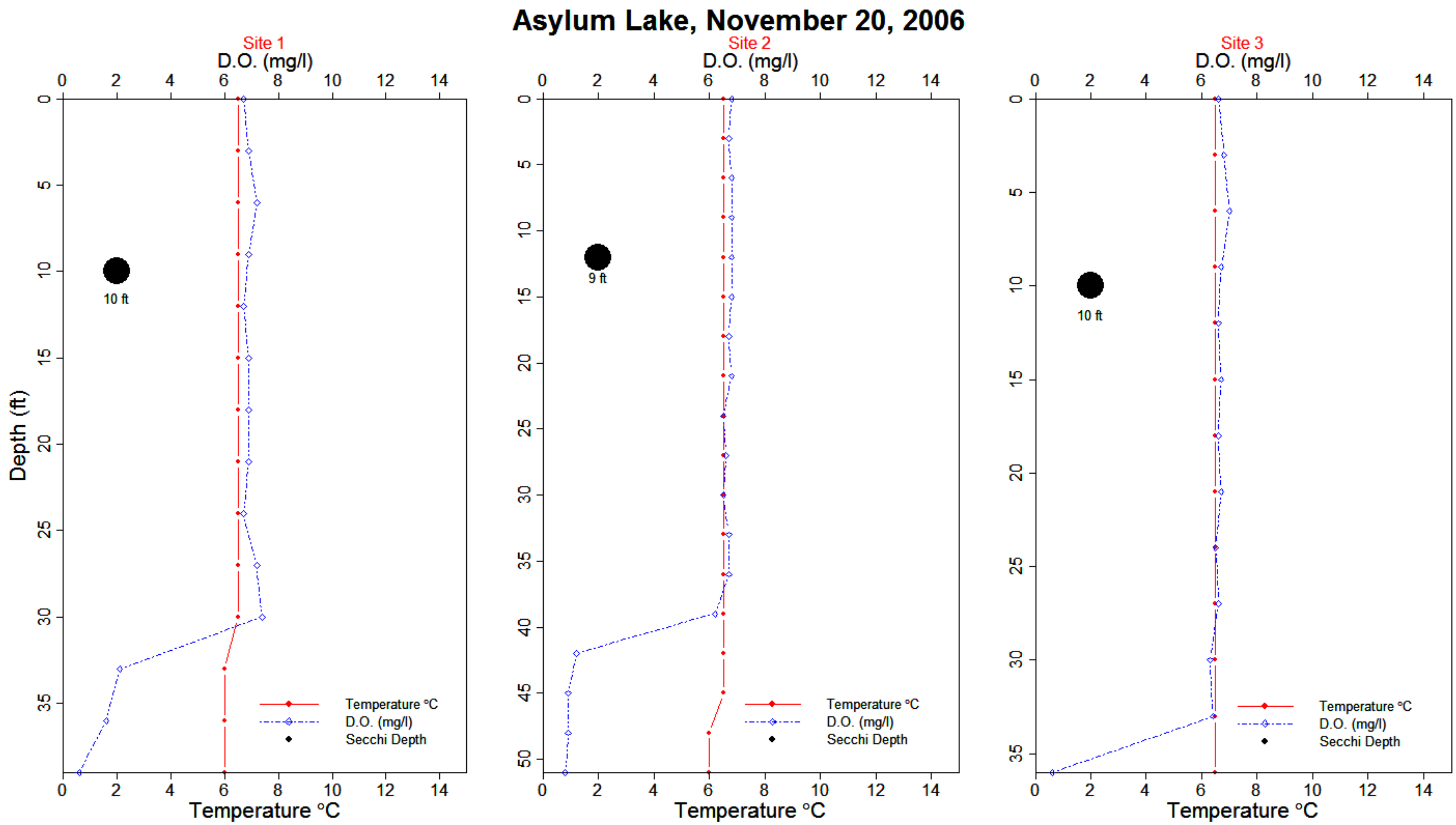
Asylum Lake Sites 1, 2, and 3 Temperature and Dissolved Oxygen Profiles for August 9, 2006.

FIGURE 5



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Asylum Lake Sites 1, 2, and 3 Temperature and Dissolved Oxygen Profiles for November 20, 2006

FIGURE
6

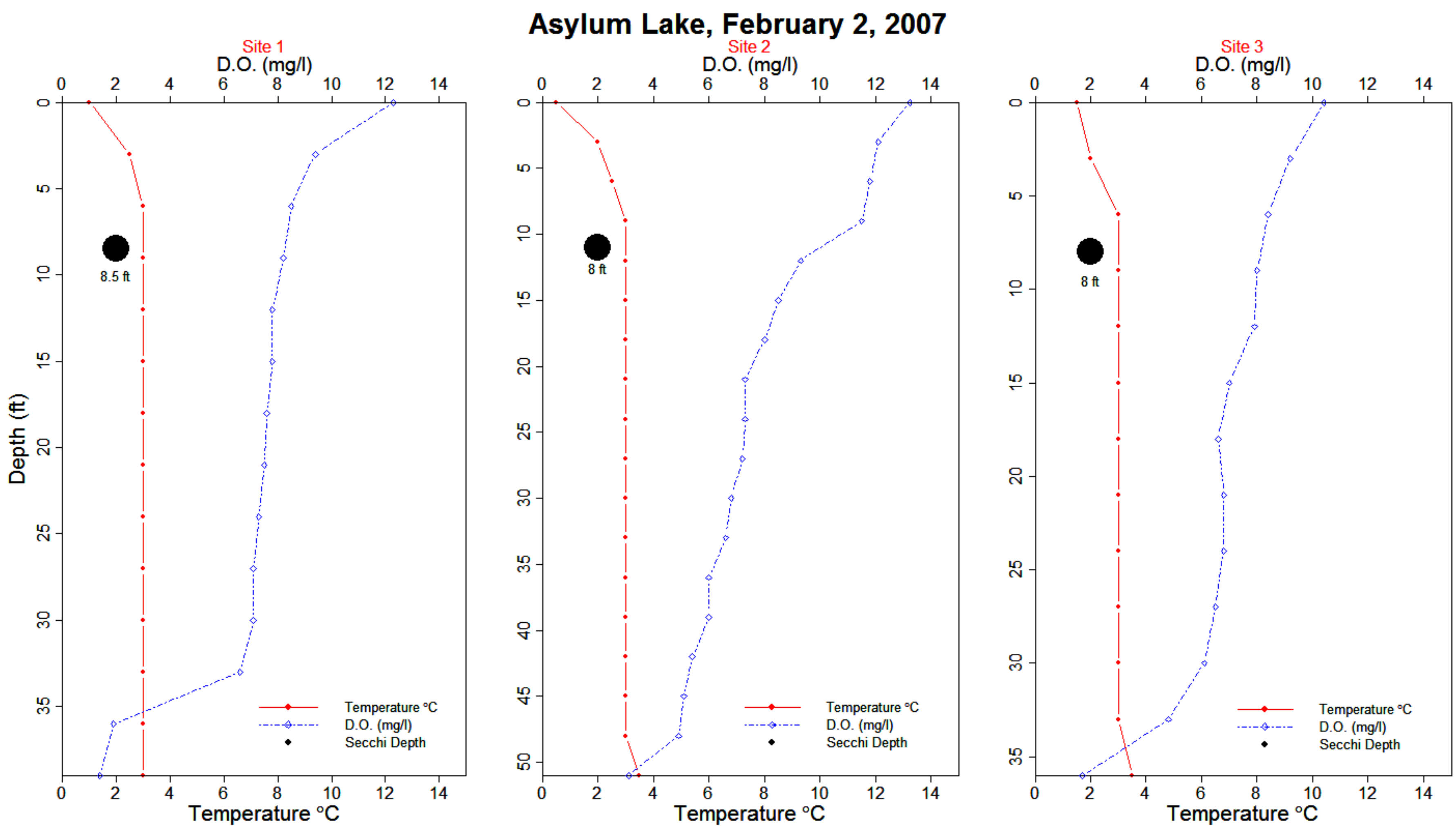

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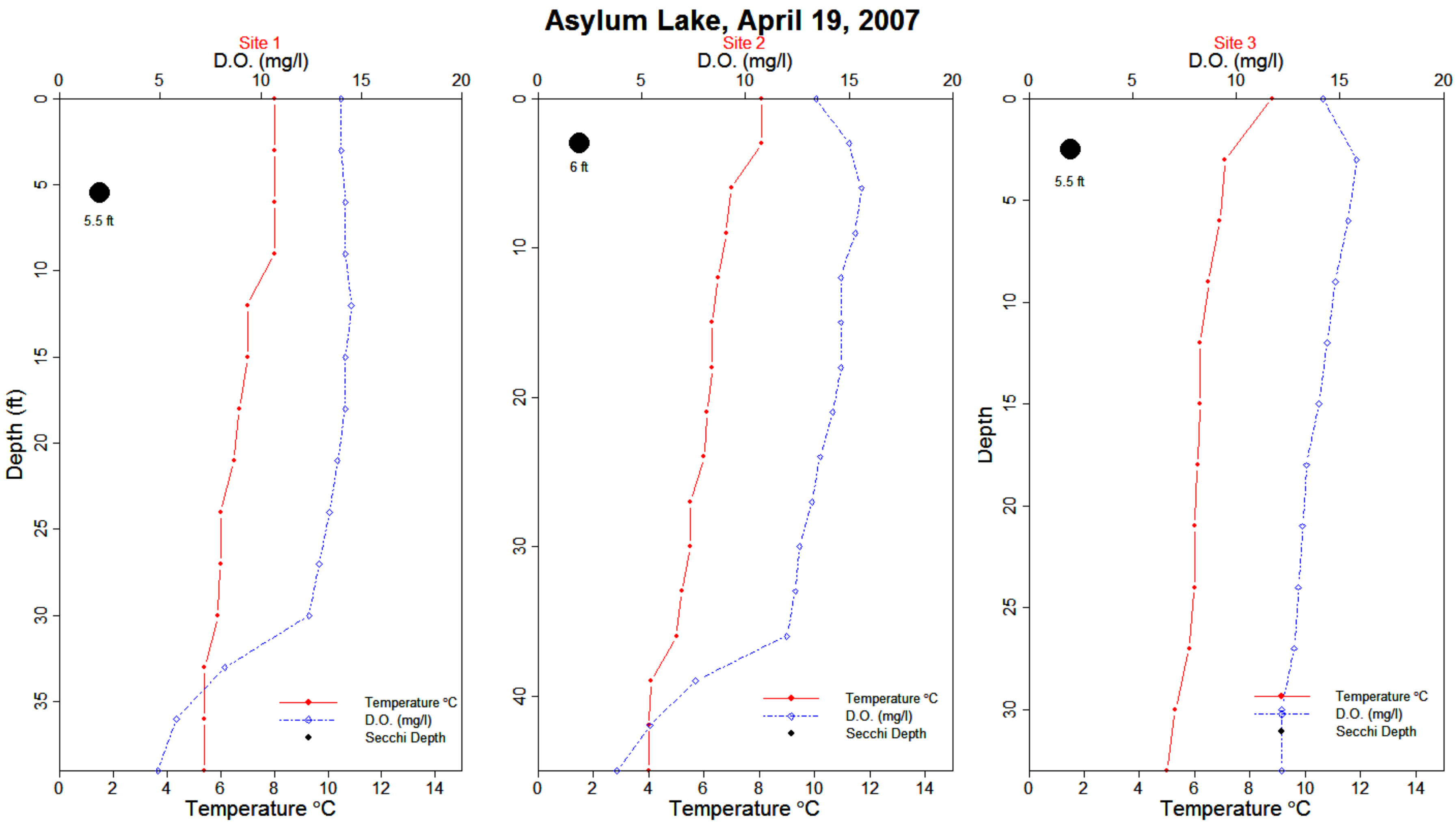
Figure 7. Asylum Lake Sites 1, 2, and 3 Temperature and Dissolved Oxygen Profiles for February 22, 2007.

FIGURE
7



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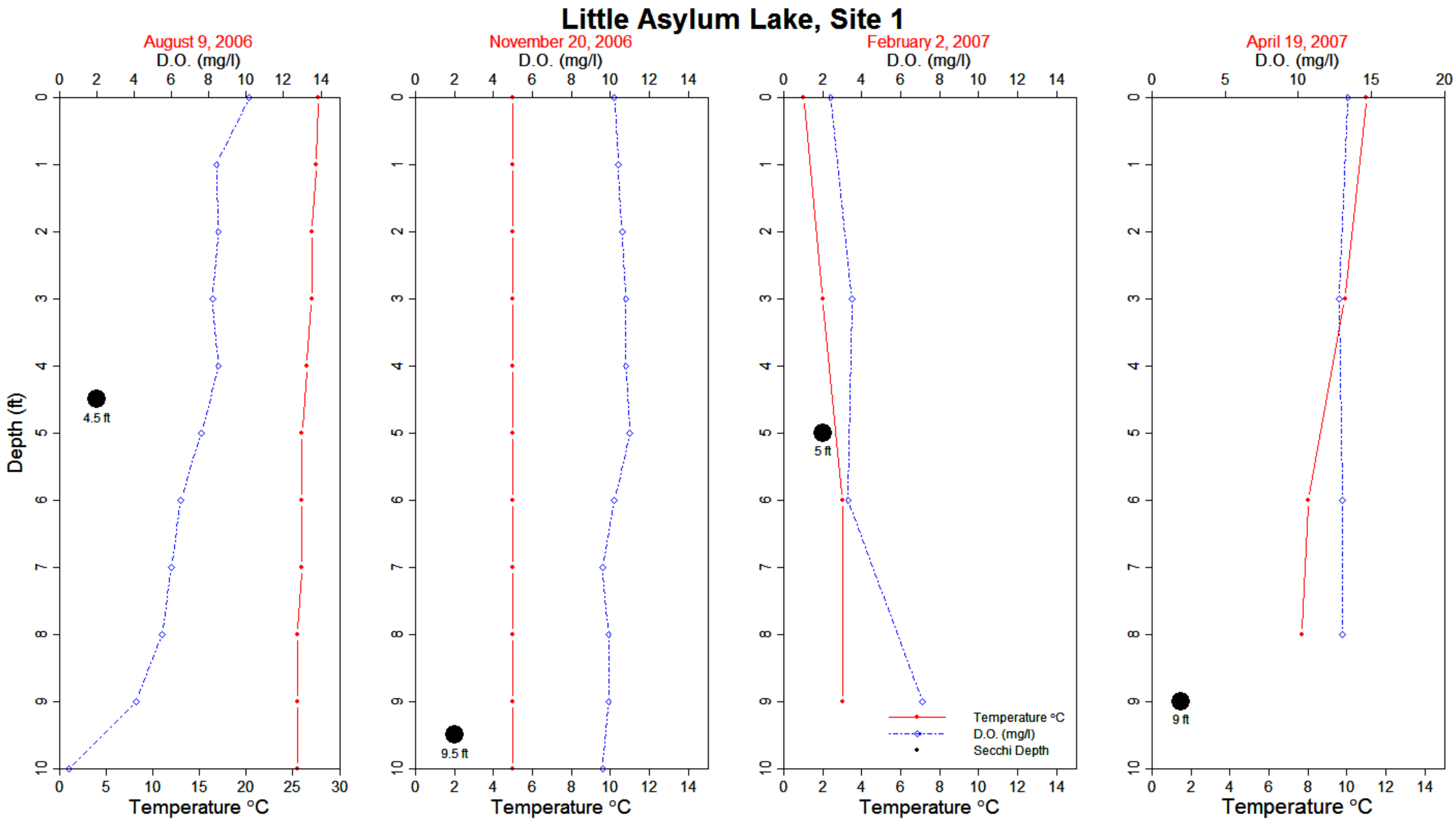
Asylum Lake Sites 1, 2, and 3 Temperature and Dissolved Oxygen Profiles for April 19, 2007.

FIGURE
8



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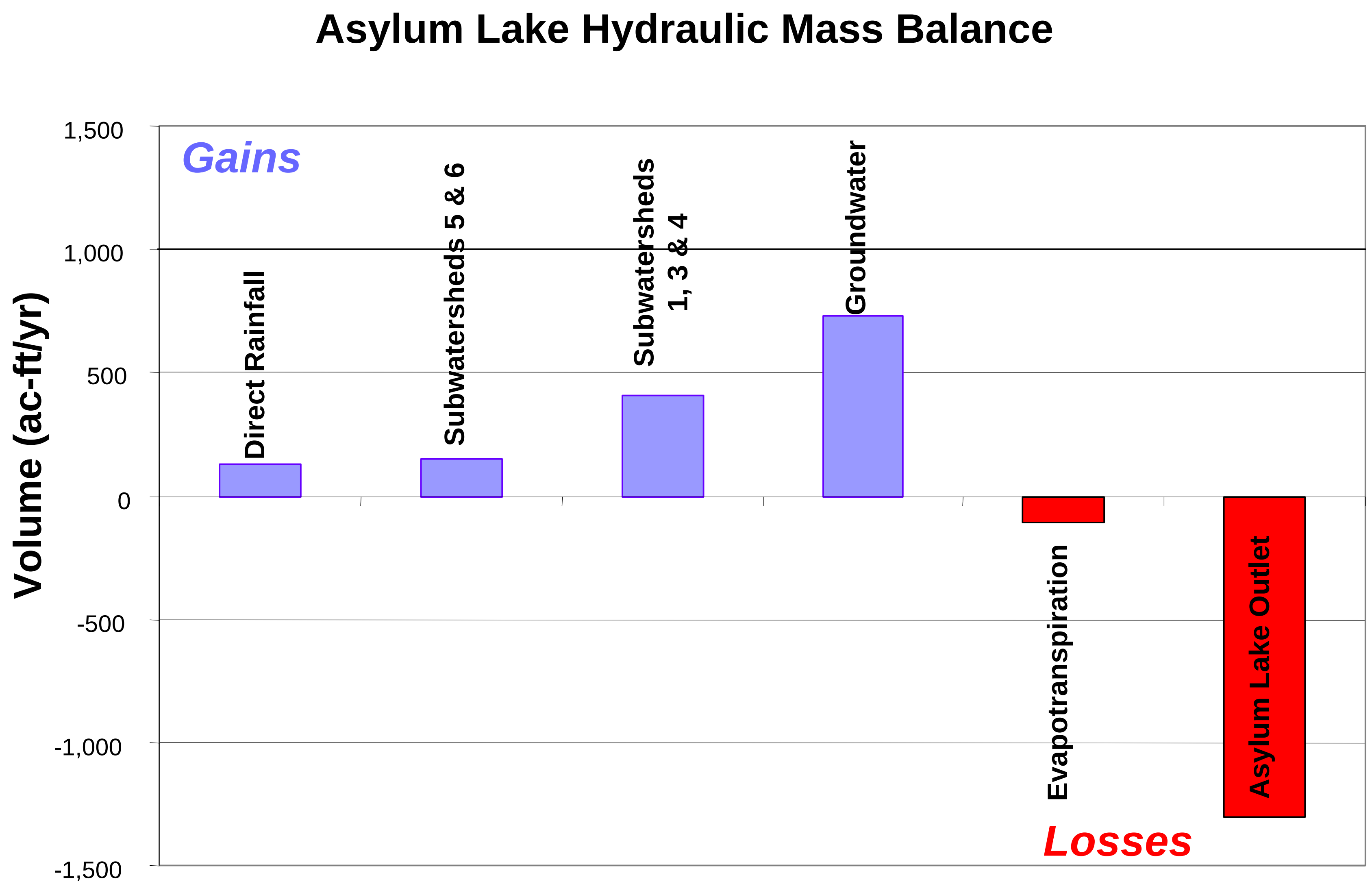
Temperature and Dissolved Oxygen Profiles for Little Asylum Lake Site 1 on August 9, 2006; November 20, 2006; February 22, 2007; and April, 19, 2007.

FIGURE

9



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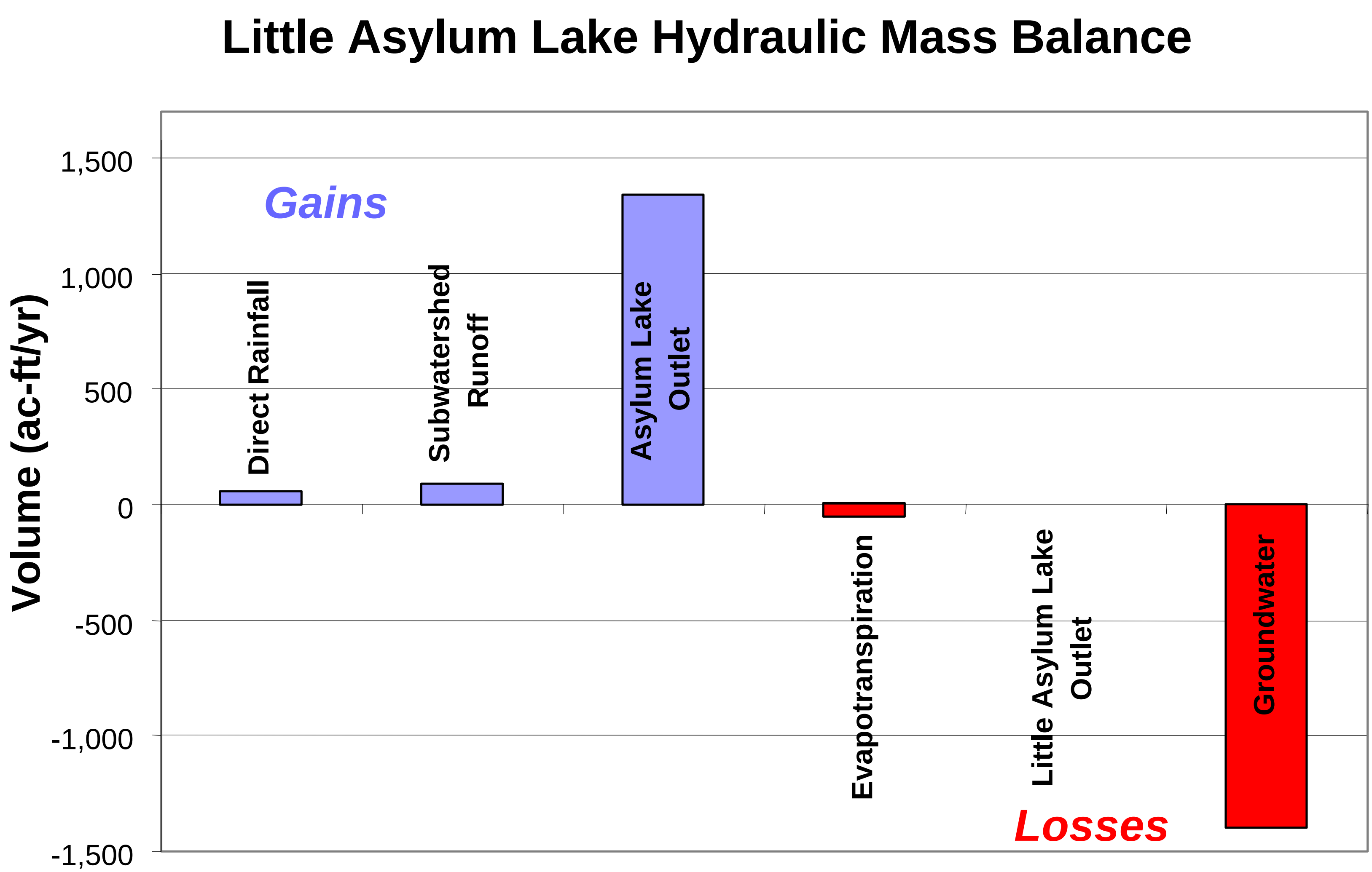
Hydraulic mass balance of Asylum Lake gains and losses by volume.

FIGURE 10



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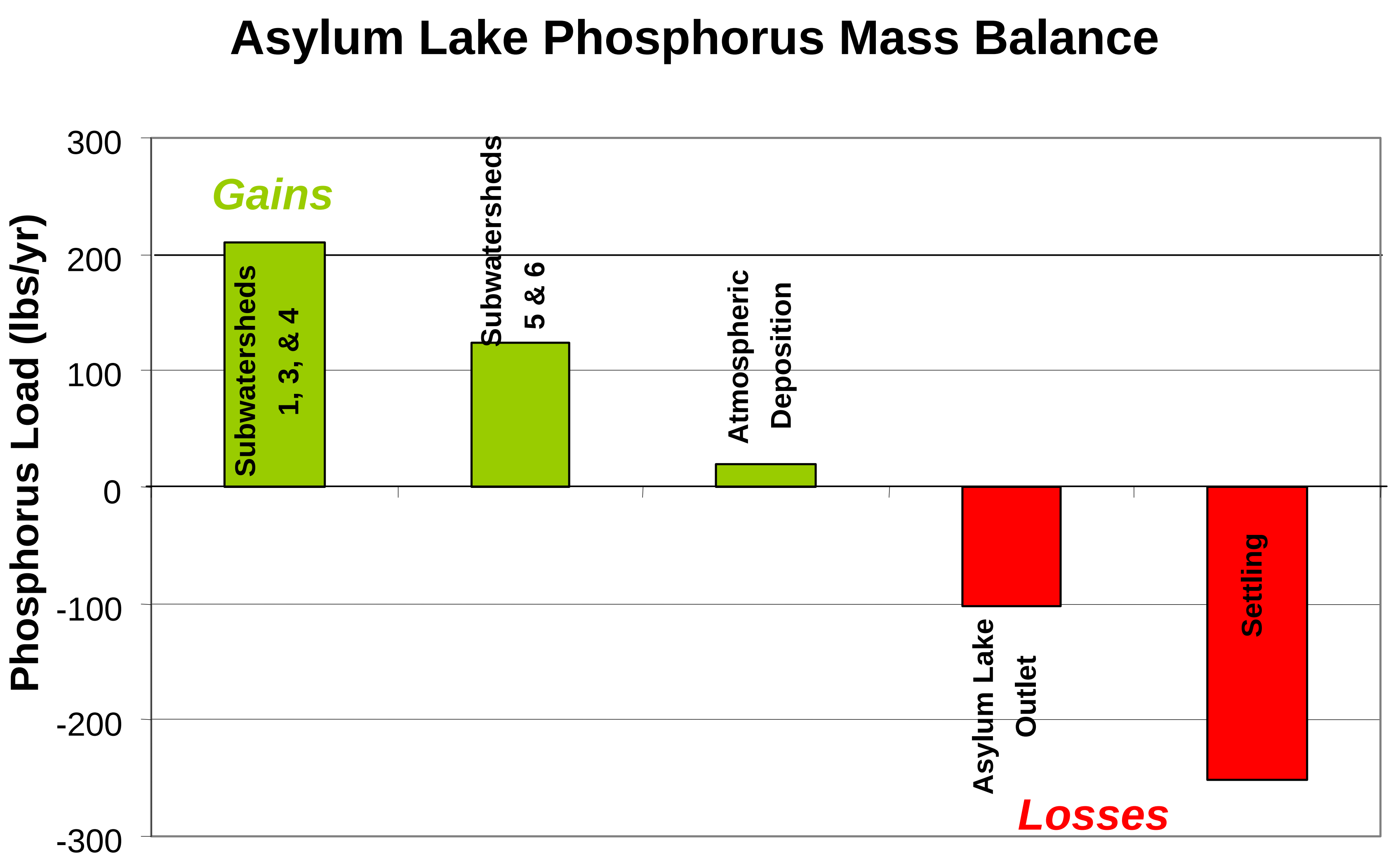
Hydraulic mass balance of Little Asylum Lake gains and losses by volume.

FIGURE 11



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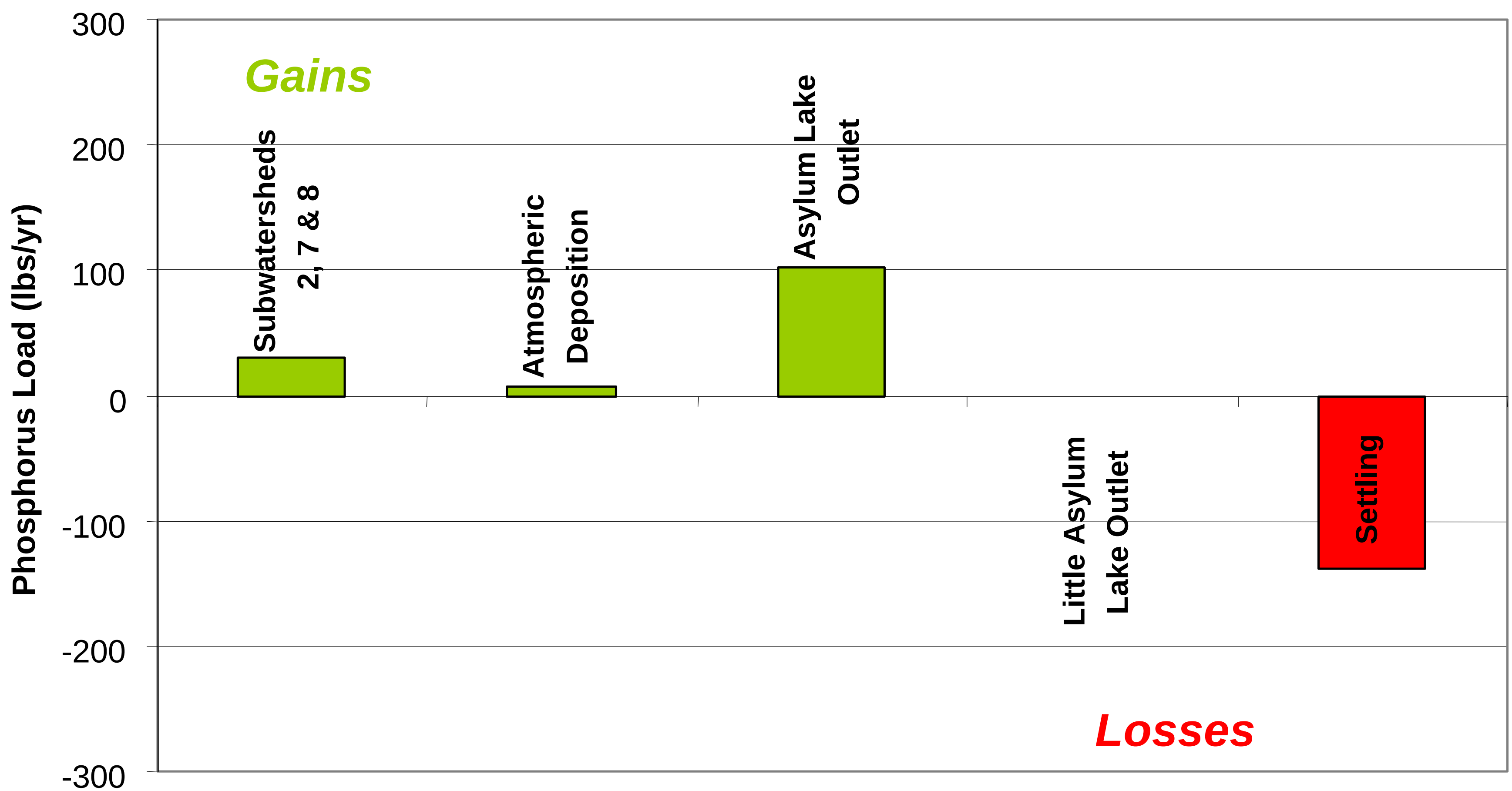
Phosphorus mass balance of Asylum Lake gains and losses by load (lbs/yr).

FIGURE 12

Little Asylum Lake Phosphorus Mass Balance



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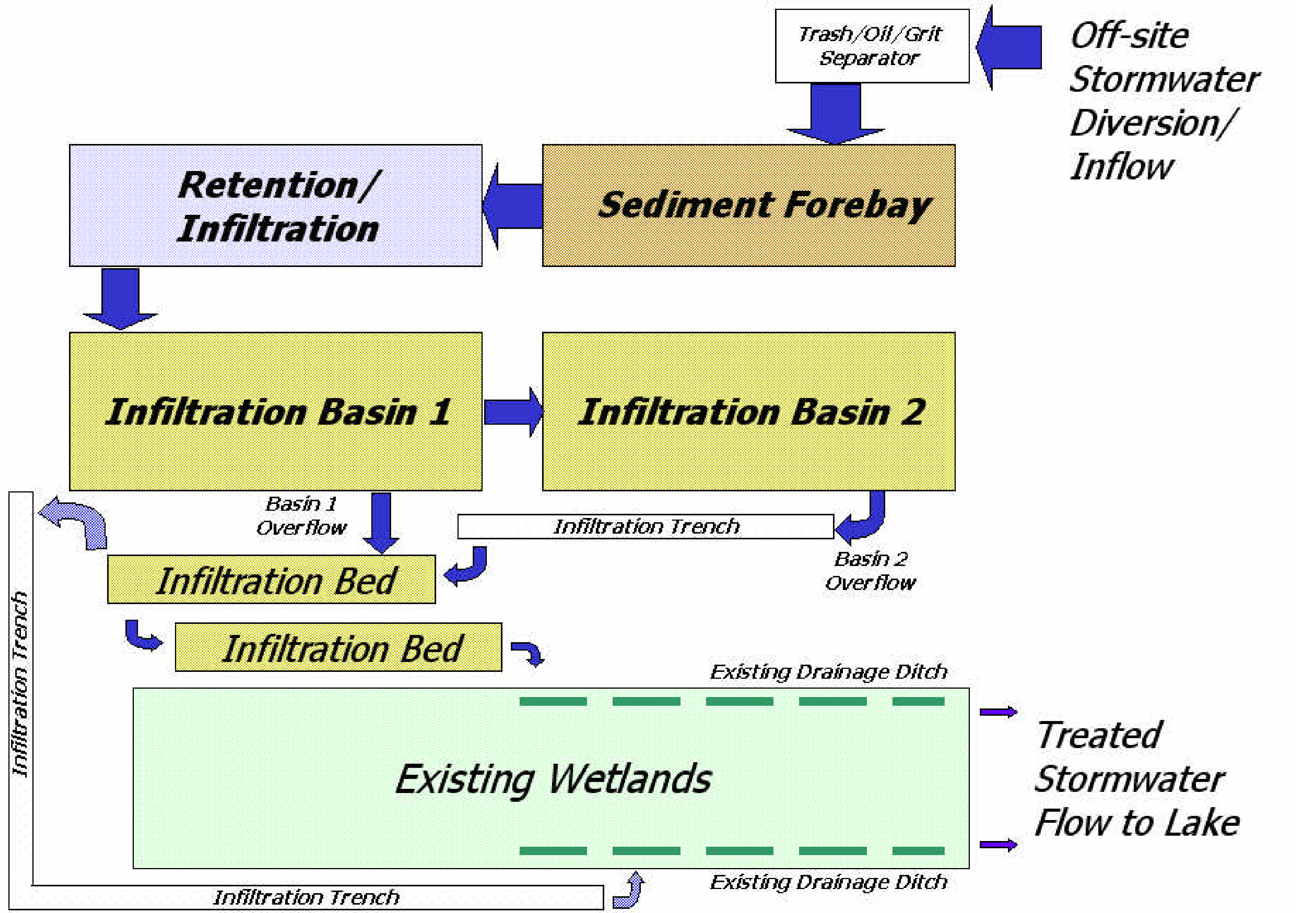
Phosphorus mass balance of Little Asylum Lake gains and losses by load (lbs/yr).

FIGURE 13



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Conceptual Schematic of Recommended Stormwater Treatment Approach for Asylum Lake.

FIGURE 14

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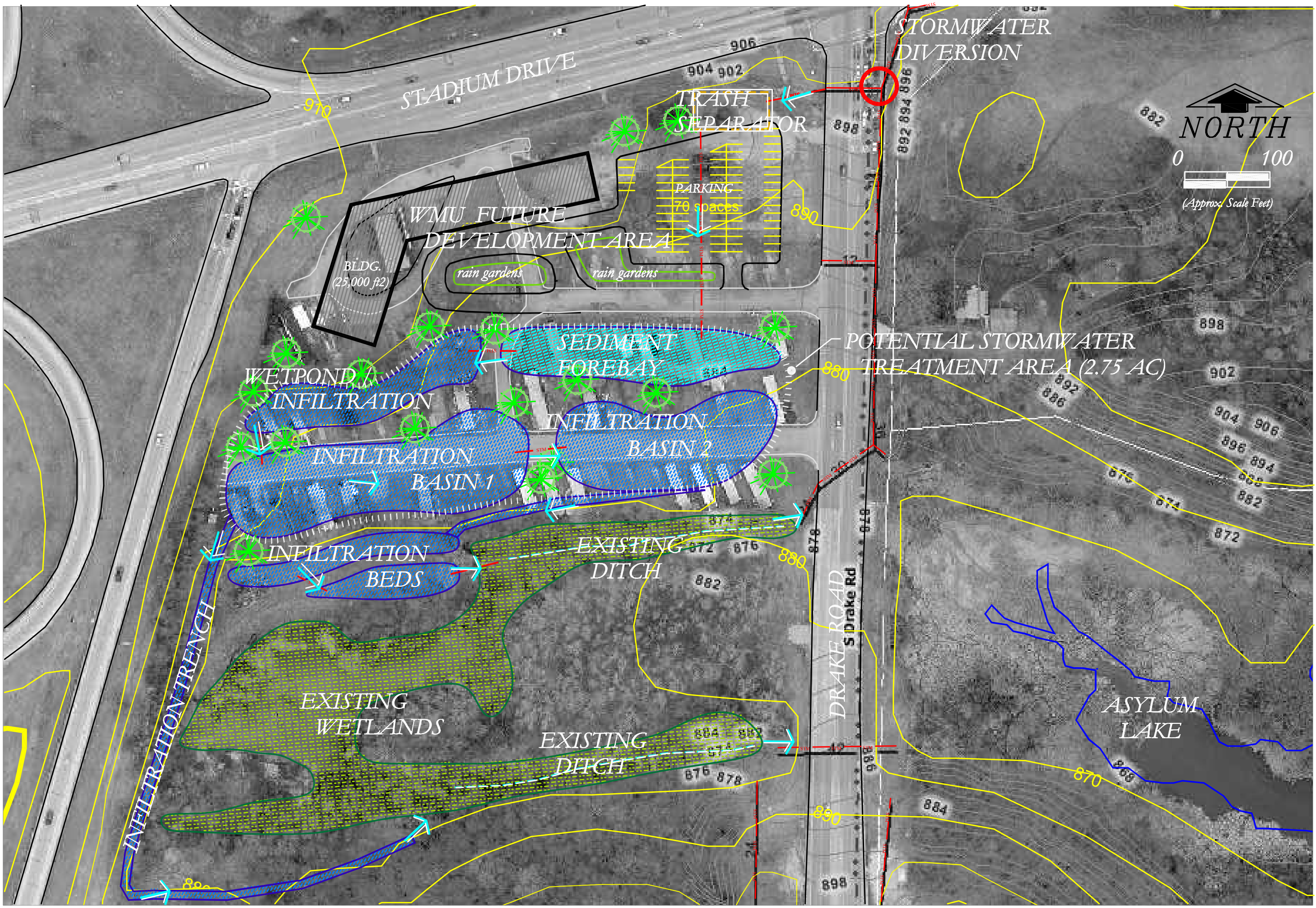

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ASYLUM LAKE STORMWATER TREATMENT

Stormwater Runoff Treatment Concepts
WMU Property, Kalamazoo, MI.

FIGURE
15

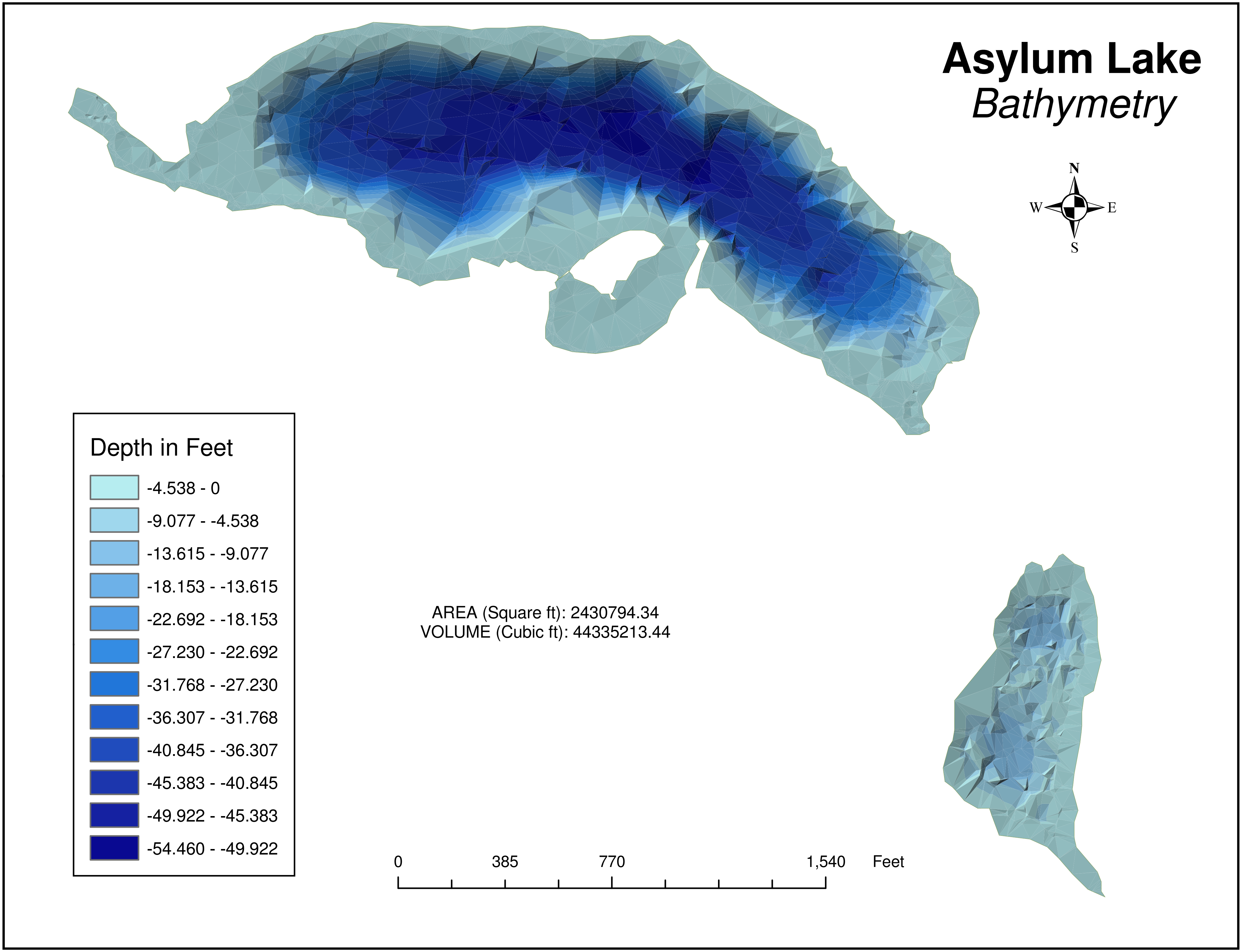
Appendix A

Geographic Coordinates of Sampling Sites

Asylum Lake Location	GPS Coordinates
AS-1S	N 42^0 16' 2.6"
	W 85^0 38' 9.5"
AS-2S	N 42^0 16' 1.7"
	W 85^0 38' 23.4"
AS-2B	(same as AS-2S)
AS-3S	N 42^0 15' 57.5"
	W 85^0 38' 14.2"
AS-4S	N 42^0 15' 86.8"
	W 85^0 38' 16.0"
LA-1S	N 42^0 15' 45.2"
	W 85^0 38' 3.7"
LA-1B	(same as LA-1S)
LA-2S	(out in front of culvert)

Appendix B

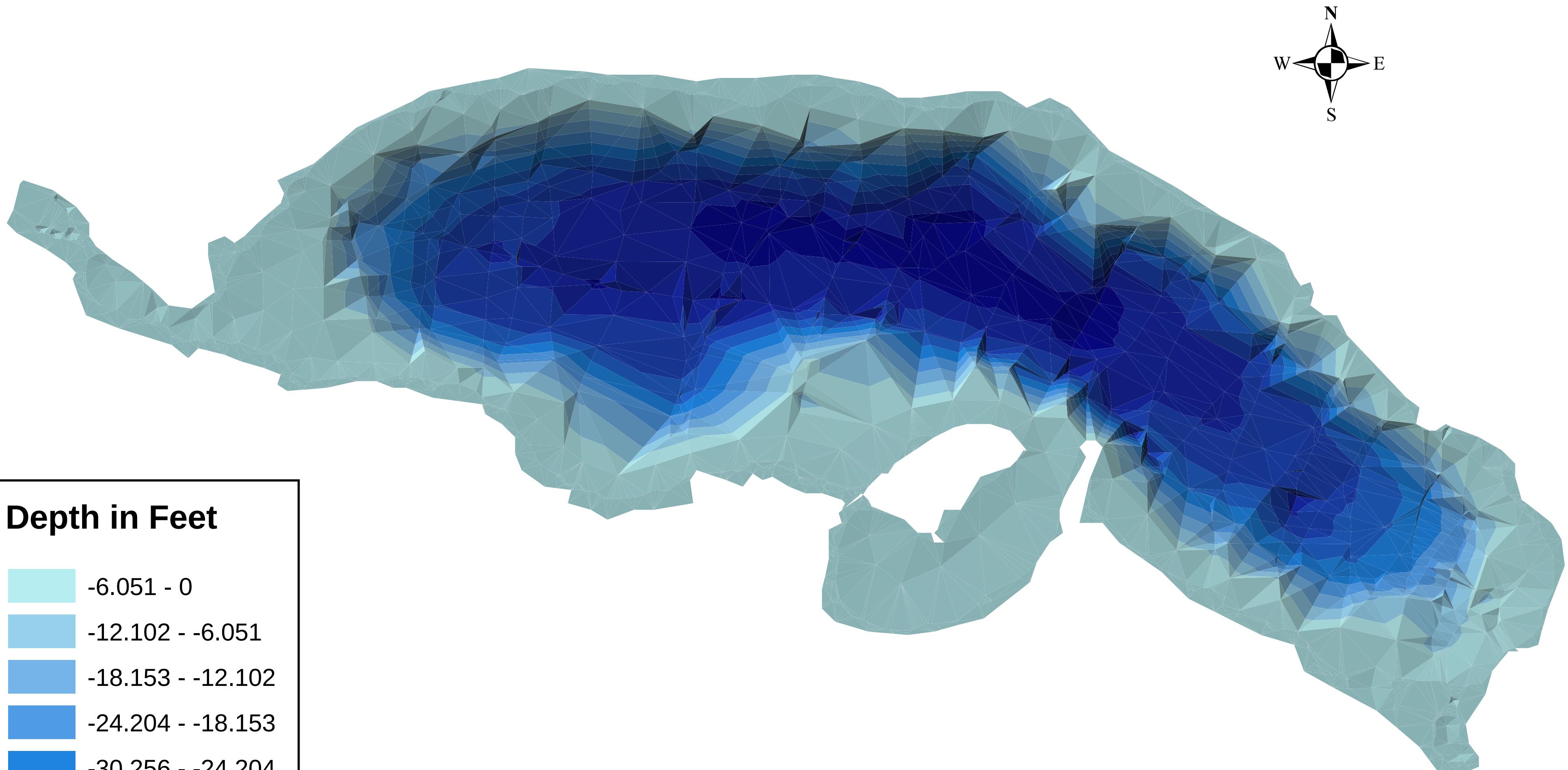
Bathymetric Maps


Asylum Lake
Bathymetry
N
W
E
S
Depth in Feet
-4.538 - 0
-9.077 - -4.538
-13.615 - -9.077
-18.153 - -13.615
-22.692 - -18.153
-27.230 - -22.692
-31.768 - -27.230
-36.307 - -31.768
-40.845 - -36.307
-45.383 - -40.845
-49.922 - -45.383
-54.460 - -49.922
AREA (Square ft): 2430794.34
VOLUME (Cubic ft): 44335213.44
0
385
770
1,540
Feet

Big Asylum Lake

Bathymetry

July 2006



Depth in Feet

- -6.051 - 0
- -12.102 - -6.051
- -18.153 - -12.102
- -24.204 - -18.153
- -30.256 - -24.204
- -36.307 - -30.256
- -42.358 - -36.307
- -48.409 - -42.358
- -54.460 - -48.409

AREA (Square ft): 2042225.70 (47 Acres)
VOLUME (Cubic ft): 42555756.21

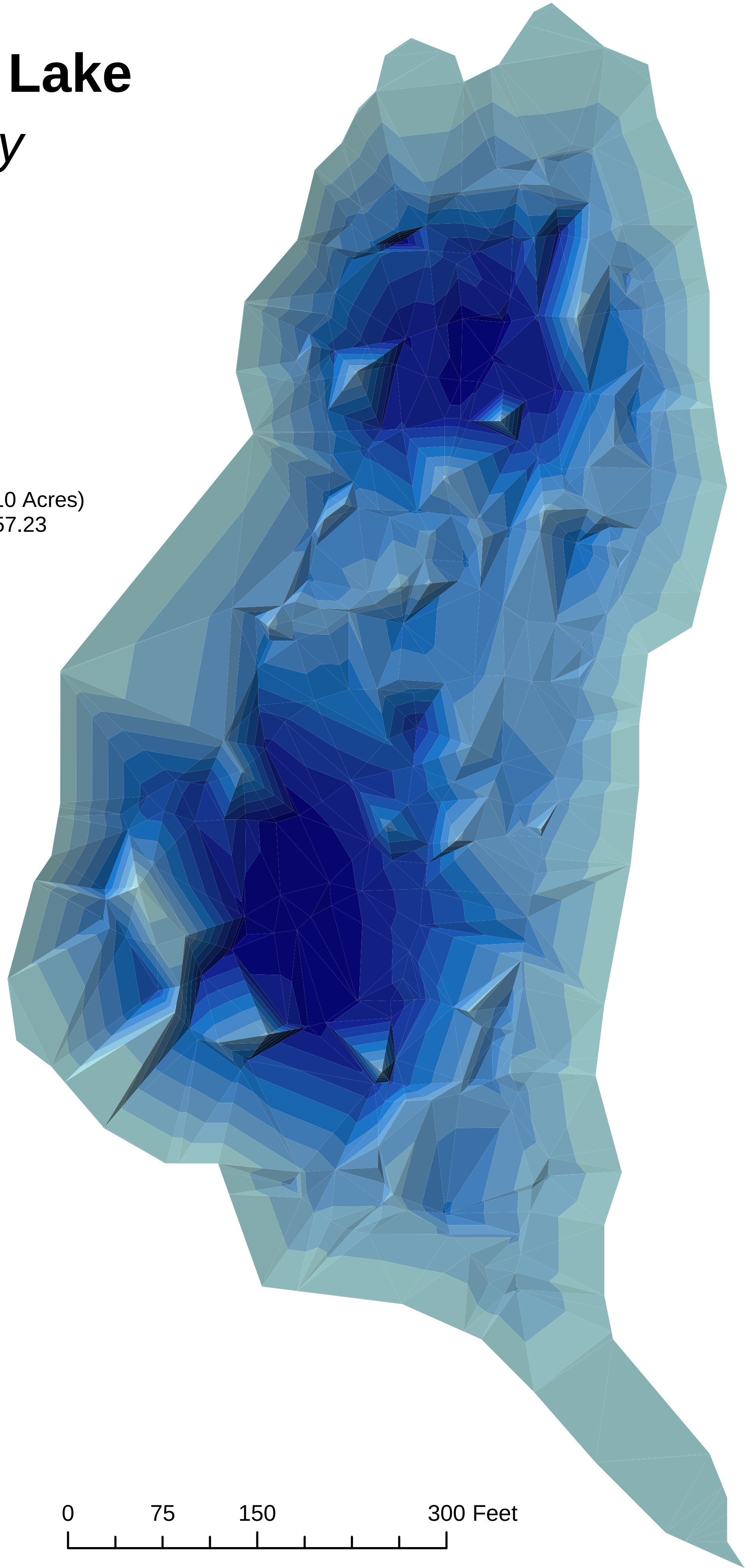
0 315 630 1,260 Feet

Little Asylum Lake

Bathymetry

July 2006

AREA (Square ft): 388568.64 (10 Acres)
VOLUME (Cubic ft): 1779457.23



Depth in Feet

- -1.422 - 0
- -2.844 - -1.422
- -4.267 - -2.844
- -5.689 - -4.267
- -7.111 - -5.689
- -8.533 - -7.111
- -9.956 - -8.533
- -11.378 - -9.956
- -12.800 - -11.378

Appendix C

Water Quality and Field Data

Table C-1 Analytical Results for Asylum and Little Asylum Lake Analytical Aqueous Samples, August 9, 2006.

	AS-1 Surface	AS-2 Surface	AS-2 Bottom	AS-3 Surface	AS-4 Surface	LA-1 Surface	LA-1 Bottom	Units
Alkalinity (as CaCO3)	172	175	260	175	175	170	175	mg/L
Atrazine	BDL	BDL	BDL	BDL	BDL	BDL	BDL	ug/L
Calcium, dissolved	39.5	40.1	62.7	39.1	40.2	38.3	40.8	mg/L
Chloride	175	174	184	174	170	176	175	mg/L
Gravimetric TPH (SGT-HEM)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	mg/L
Iron, dissolved	BDL	BDL	0.02	BDL	BDL	BDL	BDL	mg/L
Magnesium, diss., low level	24.8	25.1	25.0	24.6	25.0	24.6	25.0	mg/L
Mercury by EPA 1631	BDL	BDL	10.8	BDL	BDL	BDL	12.0	ng/L
Nitrogen, ammonia, low-level	BDL	BDL	2.59	BDL	BDL	BDL	0.04	mg/L
Nitrogen, nitrate	BDL	BDL	BDL	BDL	BDL	BDL	BDL	mg/L
Potassium, dissolved	2.3	2.4	2.7	2.7	2.3	2.3	2.4	mg/L
Sodium, dissolved	103	104	106	101	103	105	106	mg/L
Sulfate	14	14	12	14	14	13	13	mg/L
Suspended solids, total	1	2	6	2	1	6	5	mg/L
Total Phosphorus	13	21.5	565.5	13.7	31.2	50.3	49.7	ug/L
Soluble Reactive Phosphorus	1.9	2.8	333.9	2	6	7.9	11.3	ug/L
Total Nitrogen	281.8	305.8	2,257.3	340.5	340.6	554.7	729.4	ug/L
Bacteria, E. coli	2	6	NS	12	NS	60	NS	colonies/100mL
Chlorophyll-a	3	2.9	NS	2.4	NS	3.1	NS	ug/L

NS = Not Sampled
BDL = Below Detection Limits
Dectection limit of Atrazine = 1ug/L
Detection limit of Gravimetric TPC (SGT-HEM) = 5 mg/L
Detectable limit of Iron, dissolved = 0.01 mg/L
Detection limit of Mercury by EPA 1631 = 0.5 ng/L
Detection limit of Nitrogen, ammonia, low-level = 0.01 mg/L
Detection limit of Nitrogen, nitrate = 0.1 mg/L

Table C-2 Preliminary Asylum and Little Asylum Lake Analytical Results, November 20, 2006.

	AS-1 Surface	**AS-2 Middle**	**AS-3 Surface**	**AS-4 Surface**	**LS-1 Surface**	**Units**
Alkalinity (as CaCO3)	202	205	208	202	182	mg/L
Atrazine	BDL	BDL	BDL	BDL	BDL	ug/L
Calcium, dissolved	53.5	53.2	52.9	52.9	44.7	mg/L
Chloride	169	169	168	168	147	mg/L
Gravimetric TPH (SGT-HEM)	BDL	BDL	BDL	BDL	BDL	mg/L
Iron, dissolved	BDL	BDL	BDL	BDL	BDL	mg/L
Magnesium, diss., low level	24.3	24.2	24.1	24.1	22.7	mg/L
Mercury by EPA 1631	BDL	4.8	BDL	BDL	18.5	ng/L
Nitrogen, ammonia, low-level	0.21	0.22	0.19	0.14	0.02	mg/L
Nitrogen, nitrate	BDL	BDL	BDL	BDL	BDL	mg/L
Potassium, dissolved	2.4	2.5	2.4	2.4	2.4	mg/L
Sodium, dissolved	100	99.9	99.5	99.7	93.4	mg/L
Sulfate	14	14	14	14	12	mg/L
Suspended solids, total	1	1	BDL	4	BDL	mg/L
Total Phosphorus	35.9	41.1	35.9	43.4	27.6	ug/L
Soluble Reactive Phosphorus	4	5.6	3.6	2	0.5	ug/L
Total Nitrogen	906	908	805	754	1096	ug/L
Bacteria, E. coli	10	6	2	NS	18	colonies/100mL

NS = Not Sampled

BDL = Below Detectable Limit

Detection limit of Atrazine = 1ug/L

Detection limit of Gravimetric TPC (SGT-HEM) = 5 mg/L

Detectable limit of Iron, dissolved = 0.01 mg/L

Detection limit of Mercury by EPA 1631 = 0.5 ng/L

Detection limit of Nitrogen, nitrate = 0.1 mg/L

Detection limit of Suspended solids, total = 1 mg/L

Table C-3 Analytical Results for Asylum and Little Asylum Lake, February 22, 2007.

	AS-1 Surface	AS-2 Surface	AS-2 Bottom	AS-3 Surface	AS-4 Surface	LA-1 Surface	LA-1 Bottom	Units
Alkalinity (as CaCO3)	210	212	235	210	210	208	215	mg/L
Atrazine*	-	-	-	-	-	-	-	ug/L
Calcium, dissolved	55.7	54.4	60.8	55.3	54.8	55.2	57	mg/L
Chloride	174	174	247	172	171	175	168	mg/L
Gravimetric TPH (SGT-HEM)*	-	-	-	-	-	-	-	mg/L
Iron, dissolved	BDL	BDL	BDL	BDL	BDL	BDL	BDL	mg/L
Magnesium, diss., low level	24.8	24.1	24.4	24.3	24.2	24.4	24.4	mg/L
Mercury by EPA 1631	BDL	3.1	12.1	BDL	BDL	BDL	18	ng/L
Nitrogen, ammonia, low-level	0.11	0.13	0.46	0.14	0.15	0.19	0.47	mg/L
Nitrogen, nitrate	BDL	0.1	0.1	BDL	BDL	0.1	BDL	mg/L
Potassium, dissolved	2.5	2.5	2.6	2.5	2.5	2.5	2.7	mg/L
Sodium, dissolved	101	98.1	138	98.7	98.7	98.9	97.6	mg/L
Sulfate	16	14	16	14	14	14	13	mg/L
Suspended solids, total	4	3	3	3	2	2	3	mg/L
Total Phosphorus	60.9	42.8	88.2	43.7	39	36.1	78.1	ug/L
Soluble Reactive Phosphorus	1.6	1.7	47.7	1.6	1.1	1.7	21.2	ug/L
Total Nitrogen	819	906	1323	1616	1115	1380	1797	ug/L

*Atrazine and Total Petroleum Hydrocarbons (TPH) were reported as below standard laboratory detection limits during Aug. and Nov. 2006 sampling efforts for all samples. These two analytical parameters were therefore removed from the remaining sample events scheduled to occur in 2007.

BDL = Below Detection Limits

Detectable limit of Iron, dissolved = 0.01 mg/L

Detection limit of Mercury by EPA 1631 = 0.5 ng/L

Detection limit of Nitrogen, nitrate = 0.1 mg/L

Table C-4 Analytical Results for Asylum and Little Asylum Lake Aqueous Samples, April 19, 2007.

	AS-1 Middle	AS-2 Middle	AS-3 Middle	AS-4 Surface	LA-1 Middle	Units
Alkalinity (as CaCO3)	210	212	212	208	195	mg/L
Atrazine*	-	-	-	-	-	ug/L
Calcium, dissolved	56.2	50	55.3	54	48.5	mg/L
Chloride	169	167	167	168	157	mg/L
Gravimetric TPH (SGT-HEM)	-	-	-	-	-	mg/L
Iron, dissolved	BDL	BDL	BDL	BDL	BDL	mg/L
Magnesium, diss., low level	23.8	21.4	23.4	23.5	21.6	mg/L
Mercury by EPA 1631	7.5	12.5	11.9	4.7	27.2	ng/L
Nitrogen, ammonia, low-level	0.05	0.09	0.08	0.02	0.02	mg/L
Nitrogen, nitrate	BDL	BDL	BDL	BDL	0.1	mg/L
Potassium, dissolved	2.4	2.1	2.4	2.3	2.1	mg/L
Sodium, dissolved	110	99.4	109	110	98.2	mg/L
Sulfate	14	14	14	14	38	mg/L
Suspended solids, total	2	2	2	5	2	mg/L
Total Phosphorus	31.2	32.5	32.5	60	42.3	ug/L
Soluble Reactive Phosphorus	0.6	0.4	0.6	4.2	0.7	ug/L
Total Nitrogen	847	667	863	622	832	ug/L
Chlorophyll a	8.7	7.7	6.8	11.5	4.5	ug/L

*Atrazine and Total Petroleum Hydrocarbons (TPH) were reported as below standard laboratory detection limits during Aug. and Nov. 2006 sampling efforts for all samples. These two analytical parameters were therefore removed from the remaining sample events scheduled to occur in 2007.

BDL = Below Detection Limits

Detectable limit of Iron, dissolved = 0.01 mg/L

Detection limit of Nitrogen, nitrate = 0.1 mg/L

Table C-5 Asylum and Little Asylum Lake Field Measurements, August 9, 2006.

Site	Depth (meters)	Dissolved Oxygen (mg/L)	Conductivity (uS)	Temperature (degrees C)	pH	Turbidity (NTU)	Secchi (feet)
AS-1	0	6.86	668	26.5	7.63	6.5	11
AS-1	3	7.2		26.8			
AS-1	6	7.7		26.8			
AS-1	9	7.2		26.8			
AS-1	12	7.5		26			
AS-1	15	11.2	702	23.5	7.7		
AS-1	18	3.6	704	17	7.32		
AS-1	21	1.6		13.5			
AS-1	24	0.8		12			
AS-1	27	0.8		9			
AS-1	30	0.8		8			
AS-1	33	0.8		7			
AS-1	36	0.8		6.5			
AS-1	39	0.6	739	6.5	7.29	105.5	
(N42D16.041M W085D38.638M)							
Summer, 8/9/06 9:10 A.M. EDT							
Observation: Bottom sample had a sulfur odor. Depth finder reading 40 feet.							
Site	Depth (meters)	Dissolved Oxygen (mg/L)	Conductivity (uS)	Temperature (degrees C)	pH	Turbidity (NTU)	Secchi (feet)
AS-2	0	6.71	668	26.6	7.75	5.5	11.5
AS-2	3	6.5		26.5			
AS-2	6	6.4		26.5			
AS-2	9	6.2		26.5			
AS-2	12	6.4		26			
AS-2	15	11	697	23.5	7.76		
AS-2	18	4.8	710	18	7.36		
AS-2	21	1.1		13.5			
AS-2	24	0.9		11.5			
AS-2	27	0.8		9.5			
AS-2	30	0.8		8			
AS-2	33	0.8		8			
AS-2	36	0.8		6.5			
AS-2	39	0.6		6			
AS-2	42	0.6		6			
AS-2	45	0.5		5.5			
AS-2	48	0.5	773	5.5	7.08	21.5	
(N42D16.036M W085D38.386M)							
Summer, 8/9/06 10:10 A.M. EDT							
Observation: Bottom sample had a sulfur odor. Depth finder 46 feet.							

Table C-5 (cont.) Asylum and Little Asylum Lake Field Measurements

Site	Depth (meters)	Dissolved Oxygen (mg/L)	Conductivity (uS)	Temperature (degrees C)	pH	Turbidity (NTU)	Secchi (feet)
AS-3	0	6.6	659	27	7.86	5	12.5
AS-3	3	6.7		27.5			
AS-3	6	6.6		27			
AS-3	9	6.5		26.5			
AS-3	12	4.1		25.5			
AS-3	15	10.2	682	23.5	7.79		
AS-3	18	3.9	708	17.5	7.53		
AS-3	21	1.3		14.5			
AS-3	24	0.7		13			
AS-3	27	0.6		9			
AS-3	30	0.6		8			
AS-3	33	0.5		7			
AS-3	36	0.3	736	7	7.52	10.5	
(N42D15.960M W085D38.224M)							
Summer, 8/9/06 11:35 A.M. EDT							
Observation: Bottom sample did not have a sulfur odor. Depth finder 34-35 feet.							
Site	Depth (meters)	Dissolved Oxygen (mg/L)	Conductivity (uS)	Temperature (degrees C)	pH	Turbidity (NTU)	Secchi (feet)
AS-4	0	4.07	660	24.5	7.31	4	
(N42D15.868M W085D38.160M)							
Summer, 8/9/06 12:30 P.M. EDT							
Observation: 6.5 inches from bottom of pipe.							
LA-1	0	10.16	669	27.7	8.05	14.5	4.5
LA-1	1	8.4		27.5			
LA-1	2	8.5		27			
LA-1	3	8.2		27			
LA-1	4	8.5		26.5			
LA-1	5	7.6		26			
LA-1	6	6.5		26			
LA-1	7	6		26			
LA-1	8	5.5		25.5			
LA-1	9	4.1		25.5			
LA-1	10	0.5	676	25.5	7.51	12	
(N42D15.747M W085D38.078M)							
Summer, 8/9/06 2:15 P.M. EDT							
Observation: Samples at 9.5 feet. Bottom sample had rotting organic odor. Consisted of plant material.							
Site	Depth (meters)	Dissolved Oxygen (mg/L)	Conductivity (uS)	Temperature (degrees C)	pH	Turbidity (NTU)	Secchi (feet)
LA-2	Not flowing. No samples taken.						
Summer, 8/9/06 5:45 P.M. EDT							

Table C-6 Asylum and Little Asylum Lake Field Measurements, November 20, 2006.

Site	Depth (feet)	Dissolved Oxygen (mg/L)	Conductivity (uS)	Temperature (degrees C)	pH	Turbidity (NTU)	Secchi (feet)
AS-1	0	6.7	720	6.5	7.66		10
AS-1	3	6.9		6.5			
AS-1	6	7.2		6.5			
AS-1	9	6.9		6.5			
AS-1	12	6.7		6.5			
AS-1	15	6.9		6.5			
AS-1	18	6.9		6.5			
AS-1	21	6.9		6.5			
AS-1	24	6.7		6.5			
AS-1	27	7.2		6.5			
AS-1	30	7.4		6.5			
AS-1	33	2.1		6			
AS-1	36	1.6	709	6	7.52		
AS-1	39	0.6		6			
(N42D16M W085D38M)							
Fall, 11/20/06 8:50 A.M. EDT							
Observation: Collected all samples at the surface in 36 feet of water							
Site	Depth (feet)	Dissolved Oxygen (mg/L)	Conductivity (uS)	Temperature (degrees C)	pH	Turbidity (NTU)	Secchi (feet)
AS-2	0	6.8	821	6.5	7.37		9
AS-2	3	6.7		6.5			
AS-2	6	6.8		6.5			
AS-2	9	6.8		6.5			
AS-2	12	6.8		6.5			
AS-2	15	6.8		6.5			
AS-2	18	6.7		6.5			
AS-2	21	6.8		6.5			
AS-2	24	6.5	819	6.5	7.57		
AS-2	27	6.6		6.5			
AS-2	30	6.5		6.5			
AS-2	33	6.7		6.5			
AS-2	36	6.7		6.5			
AS-2	39	6.2		6.5			
AS-2	42	1.2		6.5			
AS-2	45	0.9		6.5			
AS-2	48	0.9		6			
AS-2	51	0.8	931 (at 50ft)	6	6.93		
(N42D16M W085D38M)							
Fall, 11/20/06 9:33 A.M. EDT							
Observation: Collected all samples at mid-depth of 25 feet							

Table C-6 (cont.) Asylum and Little Asylum Lake Field Measurements

Site	Depth (feet)	Dissolved Oxygen (mg/L)	Conductivity (uS)	Temperature (degrees C)	pH	Turbidity (NTU)	Secchi (feet)
AS-3	0	6.6		6.5	7.74		10
AS-3	3	6.8		6.5			
AS-3	6	7		6.5			
AS-3	9	6.7		6.5			
AS-3	12	6.6		6.5			
AS-3	15	6.7		6.5			
AS-3	18	6.6		6.5			
AS-3	21	6.7		6.5			
AS-3	24	6.5		6.5			
AS-3	27	6.6		6.5			
AS-3	30	6.3		6.5			
AS-3	33	6.4		6.5			
AS-3	36	0.6		6.5	7.72		
(N42D15M W085D38M)							
Fall, 11/20/06 10:20 A.M. EDT							
Observation: Collected all samples at surface, conductivity meter no longer working.							
Site	Depth (feet)	Dissolved Oxygen (mg/L)	Conductivity (uS)	Temperature (degrees C)	pH	Turbidity (NTU)	Secchi (feet)
LA-1S	0	10.2		5	8.08		9.5
LA-1S	1	10.4		5			
LA-1S	2	10.6		5			
LA-1S	3	10.8		5			
LA-1S	4	10.8		5			
LA-1S	5	11		5			
LA-1S	6	10.2		5			
LA-1S	7	9.6		5			
LA-1S	8	9.9		5			
LA-1S	9	9.9		5	8.08		
LA-1S	10	9.6		5			
(N42D15M W085D38M)							
Fall, 11/20/06 12:10 P.M. EDT							
Observation: Collected all samples at 5 feet.							
Site	Depth (inches)	Dissolved Oxygen (mg/L)	Conductivity (uS)	Temperature (degrees C)	pH	Turbidity (NTU)	Secchi (feet)
AS-4	1.5	10.24		4.8	7.78		
Fall, 11/20/06 11:05 A.M. EDT							
Observation: Collected all samples at outlet end of culvert							

Table C-7 Asylum and Little Asylum Lake Field Measurements, February 22, 2007.

Site	Depth (feet)	Dissolved Oxygen (mg/L)	Conductivity (uS)	Temperature (degrees C)	pH	Turbidity (NTU)	Secchi (feet)
AS-1	0	12.3	953	1	8.17	1.5	8.5
AS-1	3	9.4		2.5			
AS-1	6	8.5		3			
AS-1	9	8.2		3			
AS-1	12	7.8		3			
AS-1	15	7.8		3			
AS-1	18	7.6		3			
AS-1	21	7.5		3			
AS-1	24	7.3		3			
AS-1	27	7.1		3			
AS-1	30	7.1		3			
AS-1	33	6.6		3			
AS-1	36	1.9		3			
AS-1	39	1.4	1,070	3	7.74	0	
(N42 16' 02.0"M W085 38' 37.4")							
WINTER 2-22-07 10:15 AM EDT							
Observation: Depth finder reading 43 feet.							
Site	Depth (feet)	Dissolved Oxygen (mg/L)	Conductivity (uS)	Temperature (degrees C)	pH	Turbidity (NTU)	Secchi (feet)
AS-2	0	13.23	958	0.5	8.45	0.5	8
AS-2	3	12.1		2			
AS-2	6	11.8		2.5			
AS-2	9	11.5		3			
AS-2	12	9.3		3			
AS-2	15	8.5		3			
AS-2	18	8		3			
AS-2	21	7.3		3			
AS-2	24	7.3		3			
AS-2	27	7.2		3			
AS-2	30	6.8		3			
AS-2	33	6.6		3			
AS-2	36	6		3			
AS-2	39	6		3			
AS-2	42	5.4		3			
AS-2	45	5.1		3			
AS-2	48	4.9		3			
AS-2	51	3.1	1,212	3.5	8.1	0	
(N42 16' 02.9" W085 38' 28.3")							
WINTER 2-22-07 11:50 AM EDT							
Observation: depth finder 51 feet.							

Table C-7 (cont.) Asylum and Little Asylum Lake Field Measurements

Site	Depth (feet)	Dissolved Oxygen (mg/L)	Conductivity (uS)	Temperature (degrees C)	pH	Turbidity (NTU)	Secchi (feet)
AS-3	0	10.4	937	1.5	8.1	0	8
AS-3	3	9.2		2			
AS-3	6	8.4		3			
AS-3	9	8		3			
AS-3	12	7.9		3			
AS-3	15	7		3			
AS-3	18	6.6		3			
AS-3	21	6.8		3			
AS-3	24	6.8		3			
AS-3	27	6.5		3			
AS-3	30	6.1		3			
AS-3	33	4.8		3			
AS-3	36	1.7	992	3.5	7.91	0	
(N42 15' 57.8" W085 38' 14.3")							
WINTER 2-22-07 2:00 PM EDT							
Observation: Depth finder 36 feet.							
Site	Depth (feet)	Dissolved Oxygen (mg/L)	Conductivity (uS)	Temperature (degrees C)	pH	Turbidity (NTU)	Secchi (feet)
AS-4	0	9.3	918	1.4	8.19	0	
(N42 15' 51.6" W085 38' 09.5")							
WINTER 2-22-07 2:30 PM EDT							
Observation: FLOW DEPTH 1.75", VELOCITY 4.47 FPS							
LA-1	0	7.1	954	1	7.95	0	5
LA-1	3	3.3		2			
LA-1	6	3.5		3			
LA-1	9	2.4	929	3	7.73	0	
(N42 15' 44.6" W085 38' 03.7")							
WINTER 2-22-7 3:335 PM EDT							
Observation: DEPTH 9 FEET, SEDIMENT CONSISTED OF PLANT MATERIAL AND SOIL							
Site	Depth (meters)	Dissolved Oxygen (mg/L)	Conductivity (uS)	Temperature (degrees C)	pH	Turbidity (NTU)	Secchi (feet)
LA-2	Not flowing. No samples taken.						
WINTER 2-22-07 4:30 PM EDT							

Table C-8 Asylum and Little Asylum Lake Field Measurements, April 19, 2007.

Site	Depth (feet)	Dissolved Oxygen (mg/L)	Conductivity (uS)	Temperature (degrees C)	pH	Turbidity (NTU)	Secchi (feet)
AS-1	0	14	871	8	7.3	0	5.75
AS-1	3	14		8			
AS-1	6	14.2		8			
AS-1	9	14.2		8			
AS-1	12	14.5	934	7	7.33		
AS-1	15	14.2		7			
AS-1	18	14.2	922	6.7	7.2		
AS-1	21	13.8		6.5			
AS-1	24	13.4		6			
AS-1	27	12.9		6			
AS-1	30	12.4	937	5.9	7.07		
AS-1	33	8.2		5.4			
AS-1	36	5.8		5.4			
AS-1	39	4.9		5.4		9	
(N 42 16' 2.1" W 085 35' 40.1")							
SPRING 4-19-07 11:45 AM EDT							
Observation: Depth finder reading 41 feet.							
Site	Depth (feet)	Dissolved Oxygen (mg/L)	Conductivity (uS)	Temperature (degrees C)	pH	Turbidity (NTU)	Secchi (feet)
AS-2	0	13.4	917	8.1	7.33	0	6
AS-2	3	15		8.1			
AS-2	6	15.6		7			
AS-2	9	15.3	925	6.8	7.24		
AS-2	12	14.6		6.5			
AS-2	15	14.6		6.3			
AS-2	18	14.6		6.3			
AS-2	21	14.2		6.1			
AS-2	24	13.6	936	6	7.07		
AS-2	27	13.2		5.5			
AS-2	30	12.6		5.5			
AS-2	33	12.4		5.2			
AS-2	36	12		5			
AS-2	39	7.6		4.1			
AS-2	42	5.4	1066	4	6.75		
AS-2	45	3.8		4		11.5	
(N 42 16' 1.8" W 085 38' 25.1")							
SPRING 4-19-07 11:00 AM EDT							
Observation: depth finder 48 feet.							

Table C-8 (cont.) Asylum and Little Asylum Lake Field Measurements

Site	Depth (feet)	Dissolved Oxygen (mg/L)	Conductivity (uS)	Temperature (degrees C)	pH	Turbidity (NTU)	Secchi (feet)
AS-3	0	14.2	912	8.8	7.33	1	5.5
AS-3	3	15.8		7.1			
AS-3	6	15.4		6.9			
AS-3	9	14.8		6.5			
AS-3	12	14.4		6.2			
AS-3	15	14	912	6.2	7.13		
AS-3	18	13.4		6.1			
AS-3	21	13.2		6			
AS-3	24	13		6			
AS-3	27	12.8		5.8			
AS-3	30	12.2		5.3			
AS-3	33	12.2	945	5	6.9	28	
(N 42 15' 57.6" W 085 38' 15.1")							
SPRING 4-19-07 12:35 PM EDT							
Observation: Depth finder 35 feet.							
Site	Depth (feet)	Dissolved Oxygen (mg/L)	Conductivity (uS)	Temperature (degrees C)	pH	Turbidity (NTU)	Secchi (feet)
AS-4	0	15.4	917	13	7.55	7	
(N 42 15' 52.0" W 085 38' 09.2")							
SPRING 4-19-07 1:55 PM EDT							
Observation: VELOCITY 5.35 FPS							
Site	Depth (feet)	Dissolved Oxygen (mg/L)	Conductivity (uS)	Temperature (degrees C)	pH	Turbidity (NTU)	Secchi (feet)
LA-1	0	13	850	11	7.51	0	9
LA-1	3	13		9.9			
LA-1	6	12.8	886	8	6.4		
LA-1	8	13.4		7.7		1,163	
(N 42 15' 45.2" W 085 38' 03.7")							
SPRING 4-19-07 2:55 PM EDT							
Observation: DEPTH 9 FEET, SEDIMENT CONSISTED OF PLANT MATERIAL AND SOIL							
Site	Depth (meters)	Dissolved Oxygen (mg/L)	Conductivity (uS)	Temperature (degrees C)	pH	Turbidity (NTU)	Secchi (feet)
LA-2	Not flowing. No samples taken.						
SPRING 4-19-07 4:00 PM EDT							

Table C-9 Wet Weather Sampling Data, September 22, 2006.

	SW-1	**SW-2**	**SW-4**	**Units**
Alkalinity (as CaCO3)	165	192	50	mg/L
Atrazine	BDL	BDL	BDL	ug/L
Calcium, dissolved	48	52.7	17.1	mg/L
Chloride	82.7	147	2.9	mg/L
Gravimetric TPH (SGT-HEM)	BDL	BDL	BDL	mg/L
Iron, dissolved	0.6	0.04	0.08	mg/L
Magnesium, diss., low level	8.2	15.8	2.4	mg/L
Mercury by EPA 1631	5.2	0.8	6.7	ng/L
Nitrogen, ammonia, low-level	0.66	0.29	0.14	mg/L
Nitrogen, nitrate	0.5	0.2	0.9	mg/L
Potassium, dissolved	4.4	4.4	5.4	mg/L
Sodium, dissolved	62.2	92.8	3.9	mg/L
Sulfate	11	5	3	mg/L
Suspended solids, total	68	3	4	mg/L
Total Phosphorus	498.1	99.4	327.9	ug/L
Soluble Reactive Phosphorus	6.3	19.5	255.2	ug/L
Total Nitrogen	1,794	997	1,994	ug/L
Bacteria, E. coli	400	50	450	colonies/100mL

BDL = Below Detectable Limit

Detection limit of Atrazine = 1ug/L

Detection limit of Gravimetric TPC (SGT-HEM) = 5 mg/L

Table C-10 Wet Weather Sampling Data July 17, 2007.

	SW-1	SW-2	SW-4	LA-2	Units
Suspended solids, total	46	76	12	20	mg/L
Total Phosphorus	203	299	350	203	ug/L
Soluble Reactive Phosphorus	55	121	247	55	ug/L
Total Nitrogen	1,230	3,117	2,357	1,230	ug/L
Bacteria, E. coli	8,500	4,400	10,000	3,100	colonies/100mL

Table C-11 Asylum and Little Asylum Lake Field Measurements, September 22, 2006.

	SW-1	**SW-2**	**SW-4**	**Units**
Dissolved Oxygen	6.50	3.60	7.93	mg/L
Conductivity	473	625	164	uS/cm
Temperature	15.8	14.2	14.5	degrees C
pH	6.73	6.91	6.94	
Turbidity	110.5	23.5	17.5	NTU

*No flow or standing water at SW-3 stormwater outlet

Appendix D

Analytical Laboratory Reports

KAR *Laboratories, Inc.*

4425 Manchester Road
Kalamazoo, MI 49001
Phone 269 381-9666
Fax 269 381-9698
www.karlabs.com

Kieser & Associates
536 E. Michigan Ave. Suite 300
Kalamazoo, MI 49007

Attn : ***Mr. Mark Kieser***

KAR Project No. :	***063441***
Date Reported :	***08/24/06***
Date Activated :	***08/09/06***
Date Due :	***08/24/06***
Date Validated :	***08/23/06***

Project Description : ***Analysis of 14 aqueous samples from Asylum Lake.***

Dear Client,

Your laboratory data is presented to you in this report. Unless otherwise stated under the "Comments" heading, all tests were performed within the maximum allowable holding times, have met or exceeded QC requirements and the result represents the sample as it was received.

If you wish to contact us about this work please mention KAR Project No. 063441. To arrange additional sampling or testing please contact our Client Services Department. If you have any questions regarding quality assurance please contact us.

Thank you for the opportunity to serve you. Please do not hesitate to call if we can provide additional assistance.

Respectfully submitted,

David R. Alkema
Laboratory Manager

KAR Laboratories, Inc. maintains Full Certification status for Bacteriology, Inorganics, Regulated Organics and Synthetic Organics through USEPA, Michigan Department of Public Health and Indiana State Department of Health. This report may only be reproduced in full and not without the written consent of **Kieser & Associates**.

LABORATORY DETAIL REPORT

KAR Project No. : ***063441***

Client: ***Kieser & Associates***

Date Reported : ***08/24/06***

Project Description : ***Analysis of 14 aqueous samples from Asylum Lake.***

Sample ID : ***"AS-1S"***

Sampled By : ***JAS of Kieser & Associates***

Sample Date : ***08/09/06***

Sample Time : ***0910***

Date Received : ***08/09/06***

Sample Type : ***aqueous***

KAR Sample No. : ***063441-01***

Test	Result	Units of Measure	Method	Analyzed	Analyst	Comments
Bacteria, E. coli	*2*	*colonies/100mL*	*EPA 10029*	*08/09/06*	*DMC*	

LABORATORY DETAIL REPORT

KAR Project No. : ***063441***

Client: ***Kieser & Associates*** **Date Reported :** ***08/24/06***

Project Description : ***Analysis of 14 aqueous samples from Asylum Lake.***

Sample ID : ***"AS-2S"***

Sampled By : ***JAS of Kieser & Associates*** **Date Received :** ***08/09/06***

Sample Date : ***08/09/06*** **Sample Type :** ***aqueous***

Sample Time : ***1010*** **KAR Sample No. :** ***063441-02***

Test	Result	Units of Measure	Method	Analyzed	Analyst	Comments
Bacteria, E. coli	*6*	*colonies/100mL*	*EPA 10029*	*08/09/06*	*DMC*	

LABORATORY DETAIL REPORT

KAR Project No. : ***063441***

Client: ***Kieser & Associates***

Date Reported : ***08/24/06***

Project Description : ***Analysis of 14 aqueous samples from Asylum Lake.***

Sample ID : ***"AS-3S"***

Sampled By : ***JAS of Kieser & Associates***

Sample Date : ***08/09/06***

Sample Time : ***1135***

Date Received : ***08/09/06***

Sample Type : ***aqueous***

KAR Sample No. : ***063441-03***

Test	Result	Units of Measure	Method	Analyzed	Analyst	Comments
Bacteria, E. coli	*12*	*colonies/100mL*	*EPA 10029*	*08/09/06*	*DMC*	

LABORATORY DETAIL REPORT

KAR Project No. : ***063441***

Client: ***Kieser & Associates*** **Date Reported :** ***08/24/06***

Project Description : ***Analysis of 14 aqueous samples from Asylum Lake.***

Sample ID : ***"LA-1S"***

Sampled By : ***JAS of Kieser & Associates*** **Date Received :** ***08/09/06***

Sample Date : ***08/09/06*** **Sample Type :** ***aqueous***

Sample Time : ***1415*** **KAR Sample No. :** ***063441-04***

Test	Result	Units of Measure	Method	Analyzed	Analyst	Comments
Bacteria, E. coli	*60*	*colonies/100mL*	*EPA 10029*	*08/09/06*	*DMC*	

LABORATORY DETAIL REPORT

KAR Project No. : ***063441***

Client: ***Kieser & Associates*** **Date Reported :** ***08/24/06***

Project Description : ***Analysis of 14 aqueous samples from Asylum Lake.***

Sample ID : ***"AS-1S"***

Sampled By : ***JAS of Kieser & Associates*** **Date Received :** ***08/10/06***

Sample Date : ***08/09/06*** **Sample Type :** ***aqueous***

Sample Time : ***0910*** **KAR Sample No. :** ***063441-05***

Test	Result	Units of Measure	Method	Analyzed	Analyst	Comments
Prep, 1631	*Completed*		*EPA 1631*	*08/17/06*	*PML*	
Prep, filtration	*Completed*		*EPA 3005,200.x*	*08/10/06*	*GJE*	
Calcium, dissolved	*39.5*	*mg/L*	*EPA 200.7*	*08/11/06*	*DBL*	
Iron, dissolved	*<0.01*	*mg/L*	*EPA 200.7*	*08/11/06*	*DBL*	
Magnesium, diss., low level	*24.8*	*mg/L*	*EPA 200.7*	*08/11/06*	*DBL*	
Mercury by EPA 1631	*<0.5*	*ng/L*	*EPA 1631*	*08/18/06*	*PML*	
Potassium, dissolved	*2.3*	*mg/L*	*EPA 200.7*	*08/11/06*	*DBL*	
Sodium, dissolved	*103*	*mg/L*	*EPA 200.7*	*08/11/06*	*DBL*	
Alkalinity (as CaCO3)	*172*	*mg/L*	*EPA 310.1*	*08/22/06*	*BLF*	
Chloride	*175*	*mg/L*	*SM 4500-Cl- E*	*08/17/06*	*MTW*	
Gravimetric TPH (SGT-HEM)	*<5*	*mg/L*	*EPA 1664*	*08/14/06*	*LPV*	
Nitrogen, ammonia, low-level	*<0.01*	*mg/L*	*EPA 350.1*	*08/18/06*	*DMC*	
Nitrogen, nitrate	*<0.1*	*mg/L*	*EPA 353.2*	*08/10/06*	*MTW*	
Sulfate	*14*	*mg/L*	*EPA 300.0A*	*08/14/06*	*MTW*	
Suspended solids, total	*1*	*mg/L*	*EPA 160.2*	*08/11/06*	*DMC*	
Prep, SV BN	*Completed*		*EPA 3510*	*08/15/06*	*LPV*	
Atrazine	*<1*	*ug/L*	*EPA 8270*	*08/16/06*	*KTL*	

LABORATORY DETAIL REPORT

KAR Project No. : ***063441***

Client: ***Kieser & Associates***

Date Reported : ***08/24/06***

Project Description : ***Analysis of 14 aqueous samples from Asylum Lake.***

Sample ID : ***"AS-2S"***

Sampled By : ***JAS of Kieser & Associates***

Sample Date : ***08/09/06***

Sample Time : ***1010***

Date Received : ***08/10/06***

Sample Type : ***aqueous***

KAR Sample No. : ***063441-06***

Test	Result	Units of Measure	Method	Analyzed	Analyst	Comments
Prep, 1631	Completed		EPA 1631	08/17/06	PML	
Prep, filtration	Completed		EPA 3005,200.x	08/10/06	GJE	
Calcium, dissolved	40.1	mg/L	EPA 200.7	08/11/06	DBL	
Iron, dissolved	<0.01	mg/L	EPA 200.7	08/11/06	DBL	
Magnesium, diss., low level	25.1	mg/L	EPA 200.7	08/11/06	DBL	
Mercury by EPA 1631	<0.5	ng/L	EPA 1631	08/18/06	PML	
Potassium, dissolved	2.4	mg/L	EPA 200.7	08/11/06	DBL	
Sodium, dissolved	104	mg/L	EPA 200.7	08/11/06	DBL	
Alkalinity (as CaCO3)	175	mg/L	EPA 310.1	08/22/06	BLF	
Chloride	174	mg/L	SM 4500-Cl- E	08/17/06	MTW	
Gravimetric TPH (SGT-HEM)	<5	mg/L	EPA 1664	08/14/06	LPV	
Nitrogen, ammonia, low-level	<0.01	mg/L	EPA 350.1	08/18/06	DMC	
Nitrogen, nitrate	<0.1	mg/L	EPA 353.2	08/10/06	MTW	
Sulfate	14	mg/L	EPA 300.0A	08/14/06	MTW	
Suspended solids, total	2	mg/L	EPA 160.2	08/11/06	DMC	
Prep, SV BN	Completed		EPA 3510	08/15/06	LPV	
Atrazine	<1	ug/L	EPA 8270	08/16/06	KTL	

LABORATORY DETAIL REPORT

KAR Project No. : ***063441***

Client: ***Kieser & Associates*** **Date Reported :** ***08/24/06***

Project Description : ***Analysis of 14 aqueous samples from Asylum Lake.***

Sample ID : ***"AS-2B"***

Sampled By : ***JAS of Kieser & Associates*** **Date Received :** ***08/10/06***

Sample Date : ***08/09/06*** **Sample Type :** ***aqueous***

Sample Time : ***1040*** **KAR Sample No. :** ***063441-07***

Test	Result	Units of Measure	Method	Analyzed	Analyst	Comments
Prep, 1631	*Completed*		*EPA 1631*	*08/17/06*	*PML*	
Prep, filtration	*Completed*		*EPA 3005,200.x*	*08/10/06*	*GJE*	
Calcium, dissolved	*62.7*	*mg/L*	*EPA 200.7*	*08/11/06*	*DBL*	
Iron, dissolved	*0.02*	*mg/L*	*EPA 200.7*	*08/11/06*	*DBL*	
Magnesium, diss., low level	*25.0*	*mg/L*	*EPA 200.7*	*08/11/06*	*DBL*	
Mercury by EPA 1631	*10.8*	*ng/L*	*EPA 1631*	*08/18/06*	*PML*	
Potassium, dissolved	*2.7*	*mg/L*	*EPA 200.7*	*08/11/06*	*DBL*	
Sodium, dissolved	*106*	*mg/L*	*EPA 200.7*	*08/11/06*	*DBL*	
Alkalinity (as CaCO3)	*260*	*mg/L*	*EPA 310.1*	*08/22/06*	*BLF*	
Chloride	*184*	*mg/L*	*SM 4500-Cl- E*	*08/17/06*	*MTW*	
Gravimetric TPH (SGT-HEM)	*<5*	*mg/L*	*EPA 1664*	*08/14/06*	*LPV*	
Nitrogen, ammonia, low-level	*2.59*	*mg/L*	*EPA 350.1*	*08/18/06*	*DMC*	
Nitrogen, nitrate	*<0.1*	*mg/L*	*EPA 353.2*	*08/10/06*	*MTW*	
Sulfate	*12*	*mg/L*	*EPA 300.0A*	*08/14/06*	*MTW*	
Suspended solids, total	*6*	*mg/L*	*EPA 160.2*	*08/11/06*	*DMC*	
Prep, SV BN	*Completed*		*EPA 3510*	*08/15/06*	*LPV*	
Atrazine	*<1*	*ug/L*	*EPA 8270*	*08/16/06*	*KTL*	

LABORATORY DETAIL REPORT

KAR Project No. : ***063441***

Client: ***Kieser & Associates***

Date Reported : ***08/24/06***

Project Description : ***Analysis of 14 aqueous samples from Asylum Lake.***

Sample ID : ***"AS-3S"***

Sampled By : ***JAS of Kieser & Associates***
Date Received : ***08/10/06***
Sample Date : ***08/09/06***
Sample Type : ***aqueous***
Sample Time : ***1135***
KAR Sample No. : ***063441-08***

Test	Result	Units of Measure	Method	Analyzed	Analyst	Comments
Prep, 1631	*Completed*		*EPA 1631*	*08/17/06*	*PML*	
Prep, filtration	*Completed*		*EPA 3005,200.x*	*08/10/06*	*GJE*	
Calcium, dissolved	*39.1*	*mg/L*	*EPA 200.7*	*08/11/06*	*DBL*	
Iron, dissolved	*<0.01*	*mg/L*	*EPA 200.7*	*08/11/06*	*DBL*	
Magnesium, diss., low level	*24.6*	*mg/L*	*EPA 200.7*	*08/11/06*	*DBL*	
Mercury by EPA 1631	*<0.5*	*ng/L*	*EPA 1631*	*08/18/06*	*PML*	
Potassium, dissolved	*2.7*	*mg/L*	*EPA 200.7*	*08/11/06*	*DBL*	
Sodium, dissolved	*101*	*mg/L*	*EPA 200.7*	*08/11/06*	*DBL*	
Alkalinity (as CaCO3)	*175*	*mg/L*	*EPA 310.1*	*08/22/06*	*BLF*	
Chloride	*174*	*mg/L*	*SM 4500-Cl- E*	*08/17/06*	*MTW*	
Gravimetric TPH (SGT-HEM)	*<5*	*mg/L*	*EPA 1664*	*08/14/06*	*LPV*	
Nitrogen, ammonia, low-level	*<0.01*	*mg/L*	*EPA 350.1*	*08/18/06*	*DMC*	
Nitrogen, nitrate	*<0.1*	*mg/L*	*EPA 353.2*	*08/10/06*	*MTW*	
Sulfate	*14*	*mg/L*	*EPA 300.0A*	*08/14/06*	*MTW*	
Suspended solids, total	*2*	*mg/L*	*EPA 160.2*	*08/11/06*	*DMC*	
Prep, SV BN	*Completed*		*EPA 3510*	*08/15/06*	*LPV*	
Atrazine	*<1*	*ug/L*	*EPA 8270*	*08/16/06*	*KTL*	

LABORATORY DETAIL REPORT

KAR Project No. : ***063441***

Client: ***Kieser & Associates*** **Date Reported :** ***08/24/06***

Project Description : ***Analysis of 14 aqueous samples from Asylum Lake.***

Sample ID : ***"AS-4S"***

Sampled By : ***JAS of Kieser & Associates*** **Date Received :** ***08/10/06***

Sample Date : ***08/09/06*** **Sample Type :** ***aqueous***

Sample Time : ***1230*** **KAR Sample No. :** ***063441-09***

Test	Result	Units of Measure	Method	Analyzed	Analyst	Comments
Prep, 1631	Completed		EPA 1631	08/17/06	PML	
Prep, filtration	Completed		EPA 3005,200.x	08/10/06	GJE	
Calcium, dissolved	40.2	mg/L	EPA 200.7	08/11/06	DBL	
Iron, dissolved	<0.01	mg/L	EPA 200.7	08/11/06	DBL	
Magnesium, diss., low level	25.0	mg/L	EPA 200.7	08/11/06	DBL	
Mercury by EPA 1631	<0.5	ng/L	EPA 1631	08/18/06	PML	
Potassium, dissolved	2.3	mg/L	EPA 200.7	08/11/06	DBL	
Sodium, dissolved	103	mg/L	EPA 200.7	08/11/06	DBL	
Alkalinity (as CaCO3)	175	mg/L	EPA 310.1	08/22/06	BLF	
Chloride	170	mg/L	SM 4500-Cl- E	08/17/06	MTW	
Gravimetric TPH (SGT-HEM)	<5	mg/L	EPA 1664	08/14/06	LPV	
Nitrogen, ammonia, low-level	<0.01	mg/L	EPA 350.1	08/18/06	DMC	
Nitrogen, nitrate	<0.1	mg/L	EPA 353.2	08/10/06	MTW	
Sulfate	14	mg/L	EPA 300.0A	08/14/06	MTW	
Suspended solids, total	1	mg/L	EPA 160.2	08/11/06	DMC	
Prep, SV BN	Completed		EPA 3510	08/15/06	LPV	
Atrazine	<1	ug/L	EPA 8270	08/16/06	KTL	

LABORATORY DETAIL REPORT

KAR Project No. : ***063441***

Client: ***Kieser & Associates***

Date Reported : ***08/24/06***

Project Description : ***Analysis of 14 aqueous samples from Asylum Lake.***

Sample ID : ***"LA-1S"***

Sampled By : ***JAS of Kieser & Associates***

Sample Date : ***08/09/06***

Sample Time : ***1415***

Date Received : ***08/10/06***

Sample Type : ***aqueous***

KAR Sample No. : ***063441-10***

Test	Result	Units of Measure	Method	Analyzed	Analyst	Comments
Prep, 1631	Completed		EPA 1631	08/17/06	PML	
Prep, filtration	Completed		EPA 3005,200.x	08/10/06	GJE	
Calcium, dissolved	38.3	mg/L	EPA 200.7	08/11/06	DBL	
Iron, dissolved	<0.01	mg/L	EPA 200.7	08/11/06	DBL	
Magnesium, diss., low level	24.6	mg/L	EPA 200.7	08/11/06	DBL	
Mercury by EPA 1631	<0.5	ng/L	EPA 1631	08/18/06	PML	
Potassium, dissolved	2.3	mg/L	EPA 200.7	08/11/06	DBL	
Sodium, dissolved	105	mg/L	EPA 200.7	08/11/06	DBL	
Alkalinity (as CaCO3)	170	mg/L	EPA 310.1	08/22/06	BLF	
Chloride	176	mg/L	SM 4500-Cl- E	08/17/06	MTW	
Gravimetric TPH (SGT-HEM)	<5	mg/L	EPA 1664	08/14/06	LPV	
Nitrogen, ammonia, low-level	<0.01	mg/L	EPA 350.1	08/18/06	DMC	
Nitrogen, nitrate	<0.1	mg/L	EPA 353.2	08/10/06	MTW	
Sulfate	13	mg/L	EPA 300.0A	08/14/06	MTW	
Suspended solids, total	6	mg/L	EPA 160.2	08/11/06	DMC	
Prep, SV BN	Completed		EPA 3510	08/15/06	LPV	
Atrazine	<1	ug/L	EPA 8270	08/16/06	KTL	

LABORATORY DETAIL REPORT

KAR Project No. : ***063441***

Client: ***Kieser & Associates*** **Date Reported :** ***08/24/06***

Project Description : ***Analysis of 14 aqueous samples from Asylum Lake.***

Sample ID : ***"LA-1B"***

Sampled By : ***JAS of Kieser & Associates*** **Date Received :** ***08/10/06***

Sample Date : ***08/09/06*** **Sample Type :** ***aqueous***

Sample Time : ***1440*** **KAR Sample No. :** ***063441-11***

Test	Result	Units of Measure	Method	Analyzed	Analyst	Comments
Prep, 1631	Completed		EPA 1631	08/17/06	PML	
Prep, filtration	Completed		EPA 3005,200.x	08/10/06	GJE	
Calcium, dissolved	40.8	mg/L	EPA 200.7	08/11/06	DBL	
Iron, dissolved	<0.01	mg/L	EPA 200.7	08/11/06	DBL	
Magnesium, diss., low level	25.0	mg/L	EPA 200.7	08/11/06	DBL	
Mercury by EPA 1631	12.0	ng/L	EPA 1631	08/18/06	PML	
Potassium, dissolved	2.4	mg/L	EPA 200.7	08/11/06	DBL	
Sodium, dissolved	106	mg/L	EPA 200.7	08/11/06	DBL	
Alkalinity (as CaCO3)	175	mg/L	EPA 310.1	08/22/06	BLF	
Chloride	175	mg/L	SM 4500-Cl- E	08/17/06	MTW	
Gravimetric TPH (SGT-HEM)	<5	mg/L	EPA 1664	08/14/06	LPV	
Nitrogen, ammonia, low-level	0.04	mg/L	EPA 350.1	08/18/06	DMC	
Nitrogen, nitrate	<0.1	mg/L	EPA 353.2	08/10/06	MTW	
Sulfate	13	mg/L	EPA 300.0A	08/14/06	MTW	
Suspended solids, total	5	mg/L	EPA 160.2	08/11/06	DMC	
Prep, SV BN	Completed		EPA 3510	08/15/06	LPV	
Atrazine	<1	ug/L	EPA 8270	08/16/06	KTL	

LABORATORY DETAIL REPORT

KAR Project No. : ***063441***

Client: ***Kieser & Associates*** **Date Reported :** ***08/24/06***

Project Description : ***Analysis of 14 aqueous samples from Asylum Lake.***

Sample ID : ***"Trip Blank"***

Sampled By :

Sample Date :

Sample Time :

Date Received : *08/10/06*

Sample Type : *aqueous*

KAR Sample No. : *063441-12*

Test	Result	Units of Measure	Method	Analyzed	Analyst	Comments
Prep, 1631	*Completed*		*EPA 1631*	*08/17/06*	*PML*	
Mercury by EPA 1631	*<0.5*	*ng/L*	*EPA 1631*	*08/18/06*	*PML*	

LABORATORY DETAIL REPORT

KAR Project No. : ***063441***

Client: ***Kieser & Associates***

Date Reported : ***08/24/06***

Project Description : ***Analysis of 14 aqueous samples from Asylum Lake.***

Sample ID : ***"AS-2B, Sediment"***

Sampled By : ***JAS of Kieser & Associates***

Sample Date : ***08/09/06***

Sample Time : ***1040***

Date Received : ***08/10/06***

Sample Type : ***soil***

KAR Sample No. : ***063441-13***

Test	Result	Units of Measure	Method	Analyzed	Analyst	Comments
Prep, $25 addn'l	*Completed*			*08/10/06*	*MTW*	
Dry weight solids	*11.81*	*% by weight*	*SM 2540 B mod.*	*08/14/06*	*BLF*	
Nitrogen, total	*12,900*	*mg/kg dry sample*	*EPA 351.2,353.2*	*08/21/06*	*DMC*	*Matrix effect observed; result is approximate.*

LABORATORY DETAIL REPORT

KAR Project No. : ***063441***

Client: ***Kieser & Associates*** **Date Reported :** ***08/24/06***

Project Description : ***Analysis of 14 aqueous samples from Asylum Lake.***

Sample ID : ***"LA-1B, Sediment"***

Sampled By : ***JAS of Kieser & Associates*** **Date Received :** ***08/10/06***

Sample Date : ***08/09/06*** **Sample Type :** ***soil***

Sample Time : ***1440*** **KAR Sample No. :** ***063441-14***

Test	Result	Units of Measure	Method	Analyzed	Analyst	Comments
Prep, $25 addn'l	*Completed*			*08/10/06*	*MTW*	
Dry weight solids	*3.07*	*% by weight*	*SM 2540 B mod.*	*08/14/06*	*BLF*	
Nitrogen, total	*54,100*	*mg/kg dry sample*	*EPA 351.2,353.2*	*08/21/06*	*DMC*	*Matrix effect observed; result is approximate.*

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Kalamazoo, MI 49001
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Fax 269 381-9698
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Kieser & Associates
536 E. Michigan Ave. Suite 300
Kalamazoo, MI 49007

Attn : ***Mr. Mark Kieser***

KAR Project No. :	***064245***
Date Reported :	***10/06/06***
Date Activated :	***09/22/06***
Date Due :	***10/06/06***
Date Validated :	***10/06/06***

Project Description : ***Analysis of four aqueous samples from Asylum Lake.***

Dear Client,

Your laboratory data is presented to you in this report. Unless otherwise stated under the "Comments" heading, all tests were performed within the maximum allowable holding times, have met or exceeded QC requirements and the result represents the sample as it was received.

If you wish to contact us about this work please mention KAR Project No. 064245. To arrange additional sampling or testing please contact our Client Services Department. If you have any questions regarding quality assurance please contact us.

Thank you for the opportunity to serve you. Please do not hesitate to call if we can provide additional assistance.

Respectfully submitted,

David R. Alkema
Laboratory Manager

LABORATORY DETAIL REPORT

KAR Project No. : ***064245***

Client: ***Kieser & Associates*** **Date Reported :** ***10/06/06***

Project Description : ***Analysis of four aqueous samples from Asylum Lake.***

Sample ID : ***"Asylum Lake, SW-1"***

Sampled By : ***JAS of Kieser & Associates*** **Date Received :** ***09/22/06***

Sample Date : ***09/22/06*** **Sample Type :** ***aqueous***

Sample Time : ***1000*** **KAR Sample No. :** ***064245-01***

Test	Result	Units of Measure	Method	Analyzed	Analyst	Comments
Prep, 1631	Completed		EPA 1631	09/25/06	PML	
Prep, filtration	Completed		EPA 3005,200.x	09/22/06	ALD	
Calcium, dissolved	48.0	mg/L	EPA 200.7	09/26/06	DBL	
Iron, dissolved	0.60	mg/L	EPA 200.7	09/26/06	DBL	
Magnesium, diss., low level	8.2	mg/L	EPA 200.7	09/26/06	DBL	
Mercury by EPA 1631	5.2	ng/L	EPA 1631	09/26/06	PML	
Potassium, dissolved	4.4	mg/L	EPA 200.7	09/26/06	DBL	
Sodium, dissolved	62.2	mg/L	EPA 200.7	09/26/06	DBL	
Bacteria, E. coli	400	colonies/100mL	EPA 10029	09/22/06	DMC	
Alkalinity (as CaCO3)	165	mg/L	EPA 310.1	10/03/06	BLF	
Chloride	82.7	mg/L	EPA 300.0A	09/27/06	MTW	
Gravimetric TPH (SGT-HEM)	<5	mg/L	EPA 1664	10/04/06	LPV	
Nitrogen, ammonia, low-level	0.66	mg/L	EPA 350.1	09/29/06	DMC	
Nitrogen, nitrate	0.5	mg/L	EPA 353.2	09/22/06	MTW	
Sulfate	11	mg/L	EPA 300.0A	09/27/06	MTW	
Suspended solids, total	68	mg/L	EPA 160.2	09/27/06	DMC	
Prep, SV BN	Completed		EPA 3510	09/25/06	LPV	
Atrazine	<1	ug/L	EPA 8270	09/28/06	KTL	

LABORATORY DETAIL REPORT

KAR Project No. : ***064245***

Client: ***Kieser & Associates*** **Date Reported :** ***10/06/06***

Project Description : ***Analysis of four aqueous samples from Asylum Lake.***

Sample ID : ***"Asylum Lake, SW-2"***

Sampled By : ***JAS of Kieser & Associates*** **Date Received :** ***09/22/06***

Sample Date : ***09/22/06*** **Sample Type :** ***aqueous***

Sample Time : ***1030*** **KAR Sample No. :** ***064245-02***

Test	Result	Units of Measure	Method	Analyzed	Analyst	Comments
Prep, 1631	*Completed*		*EPA 1631*	*09/25/06*	*PML*	
Prep, filtration	*Completed*		*EPA 3005,200.x*	*09/22/06*	*ALD*	
Calcium, dissolved	*52.7*	*mg/L*	*EPA 200.7*	*09/26/06*	*DBL*	
Iron, dissolved	*0.04*	*mg/L*	*EPA 200.7*	*09/26/06*	*DBL*	
Magnesium, diss., low level	*15.8*	*mg/L*	*EPA 200.7*	*09/26/06*	*DBL*	
Mercury by EPA 1631	*0.8*	*ng/L*	*EPA 1631*	*09/26/06*	*PML*	
Potassium, dissolved	*4.4*	*mg/L*	*EPA 200.7*	*09/26/06*	*DBL*	
Sodium, dissolved	*92.8*	*mg/L*	*EPA 200.7*	*09/26/06*	*DBL*	
Bacteria, E. coli	*50*	*colonies/100mL*	*EPA 10029*	*09/22/06*	*DMC*	
Alkalinity (as CaCO3)	*192*	*mg/L*	*EPA 310.1*	*10/03/06*	*BLF*	
Chloride	*147*	*mg/L*	*EPA 300.0A*	*09/27/06*	*MTW*	
Gravimetric TPH (SGT-HEM)	*<5*	*mg/L*	*EPA 1664*	*10/04/06*	*LPV*	
Nitrogen, ammonia, low-level	*0.29*	*mg/L*	*EPA 350.1*	*09/28/06*	*DMC*	
Nitrogen, nitrate	*0.2*	*mg/L*	*EPA 353.2*	*09/22/06*	*MTW*	
Sulfate	*5*	*mg/L*	*EPA 300.0A*	*09/27/06*	*MTW*	
Suspended solids, total	*3*	*mg/L*	*EPA 160.2*	*09/27/06*	*DMC*	
Prep, SV BN	*Completed*		*EPA 3510*	*09/25/06*	*LPV*	
Atrazine	*<5*	*ug/L*	*EPA 8270*	*09/28/06*	*KTL*	

LABORATORY DETAIL REPORT

KAR Project No. : ***064245***

Client: ***Kieser & Associates*** **Date Reported :** ***10/06/06***

Project Description : ***Analysis of four aqueous samples from Asylum Lake.***

Sample ID : ***"Asylum Lake, SW-4"***

Sampled By : ***JAS of Kieser & Associates*** **Date Received :** ***09/22/06***

Sample Date : ***09/22/06*** **Sample Type :** ***aqueous***

Sample Time : ***1145*** **KAR Sample No. :** ***064245-03***

Test	Result	Units of Measure	Method	Analyzed	Analyst	Comments
Prep, 1631	Completed		EPA 1631	09/25/06	PML	
Prep, filtration	Completed		EPA 3005,200.x	09/22/06	ALD	
Calcium, dissolved	17.1	mg/L	EPA 200.7	09/26/06	DBL	
Iron, dissolved	0.08	mg/L	EPA 200.7	09/26/06	DBL	
Magnesium, diss., low level	2.4	mg/L	EPA 200.7	09/26/06	DBL	
Mercury by EPA 1631	6.7	ng/L	EPA 1631	09/26/06	PML	
Potassium, dissolved	5.4	mg/L	EPA 200.7	09/26/06	DBL	
Sodium, dissolved	3.9	mg/L	EPA 200.7	09/26/06	DBL	
Bacteria, E. coli	450	colonies/100mL	EPA 10029	09/22/06	DMC	
Alkalinity (as CaCO3)	50	mg/L	EPA 310.1	10/03/06	BLF	
Chloride	2.9	mg/L	EPA 300.0A	09/27/06	MTW	
Gravimetric TPH (SGT-HEM)	<5	mg/L	EPA 1664	10/04/06	LPV	
Nitrogen, ammonia, low-level	0.14	mg/L	EPA 350.1	09/28/06	DMC	
Nitrogen, nitrate	0.9	mg/L	EPA 353.2	09/22/06	MTW	
Sulfate	3	mg/L	EPA 300.0A	09/27/06	MTW	
Suspended solids, total	4	mg/L	EPA 160.2	09/27/06	DMC	
Prep, SV BN	Completed		EPA 3510	09/25/06	LPV	
Atrazine	<5	ug/L	EPA 8270	09/28/06	KTL	

LABORATORY DETAIL REPORT

KAR Project No. : ***064245***

Client: ***Kieser & Associates*** **Date Reported :** ***10/06/06***

Project Description : ***Analysis of four aqueous samples from Asylum Lake.***

Sample ID : ***"Trip Blank"***

Sampled By :
Sample Date :
Sample Time :

Date Received : *09/22/06*
Sample Type : *aqueous*
KAR Sample No. : *064245-04*

Test	Result	Units of Measure	Method	Analyzed	Analyst	Comments
Prep, 1631	*Completed*		*EPA 1631*	*09/25/06*	*PML*	
Mercury by EPA 1631	*<0.5*	*ng/L*	*EPA 1631*	*09/26/06*	*PML*	

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Kieser & Associates
536 E. Michigan Ave. Suite 300
Kalamazoo, MI 49007

Attn : ***Mr. Mark Kieser***

KAR Project No. :	***070768***
Date Reported :	***03/09/07***
Date Activated :	***02/23/07***
Date Due :	***03/09/07***
Date Validated :	***03/08/07***

Project Description : ***Analysis of eight aqueous samples from Asylum Lake.***

Dear Client,

Your laboratory data is presented to you in this report. Unless otherwise stated under the "Comments" heading, all tests were performed within the maximum allowable holding times, have met or exceeded QC requirements and the result represents the sample as it was received.

If you wish to contact us about this work please mention KAR Project No. 070768. To arrange additional sampling or testing please contact our Client Services Department. If you have any questions regarding quality assurance please contact us.

Thank you for the opportunity to serve you. Please do not hesitate to call if we can provide additional assistance.

Respectfully submitted,

David R. Alkema
David R. Alkema
Laboratory Manager

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LABORATORY DETAIL REPORT

KAR Project No. : ***070768***

Client: ***Kieser & Associates*** **Date Reported :** ***03/09/07***

Project Description : ***Analysis of eight aqueous samples from Asylum Lake.***

Sample ID : ***"AS-1S"***

Sampled By : ***KBB & SPM of Kieser & Associates*** **Date Received :** ***02/23/07***

Sample Date : ***02/22/07*** **Sample Type :** ***aqueous***

Sample Time : ***1015*** **KAR Sample No. :** ***070768-01***

Test	Result	Units of Measure	Method	Analyzed	Analyst	Comments
Prep, 1631	*Completed*		*EPA 1631*	*02/26/07*	*PML*	
Prep, filtration	*Completed*		*EPA 3005,200.x*	*02/23/07*	*HES*	
Calcium, dissolved	*55.7*	*mg/L*	*EPA 200.7*	*02/26/07*	*DBL*	
Iron, dissolved	*<0.01*	*mg/L*	*EPA 200.7*	*02/26/07*	*DBL*	
Magnesium, diss., low level	*24.8*	*mg/L*	*EPA 200.7*	*02/26/07*	*DBL*	
Mercury by EPA 1631	*<0.5*	*ng/L*	*EPA 1631*	*02/27/07*	*PML*	
Potassium, dissolved	*2.5*	*mg/L*	*EPA 200.7*	*03/06/07*	*DBL*	
Sodium, dissolved	*101*	*mg/L*	*EPA 200.7*	*02/26/07*	*DBL*	
Alkalinity (as CaCO3)	*210*	*mg/L*	*EPA 310.1*	*02/26/07*	*BLF*	
Chloride	*174*	*mg/L*	*EPA 300.0A*	*02/27/07*	*MTW*	
Nitrogen, ammonia, low-level	*0.11*	*mg/L*	*EPA 350.1*	*03/01/07*	*DMC*	
Nitrogen, nitrate	*<0.1*	*mg/L*	*EPA 353.2*	*02/23/07*	*MTW*	
Sulfate	*16*	*mg/L*	*EPA 300.0A*	*02/27/07*	*MTW*	
Suspended solids, total	*4*	*mg/L*	*EPA 160.2*	*02/28/07*	*DMC*	

LABORATORY DETAIL REPORT

KAR Project No. : ***070768***

Client: ***Kieser & Associates***

Date Reported : ***03/09/07***

Project Description : ***Analysis of eight aqueous samples from Asylum Lake.***

Sample ID :	***"AS-2S"***		
Sampled By :	***KBB & SPM of Kieser & Associates***	**Date Received :**	***02/23/07***
Sample Date :	***02/22/07***	**Sample Type :**	***aqueous***
Sample Time :	***1150***	**KAR Sample No. :**	***070768-02***

Test	Result	Units of Measure	Method	Analyzed	Analyst	Comments
Prep, 1631	*Completed*		*EPA 1631*	*02/26/07*	*PML*	
Prep, filtration	*Completed*		*EPA 3005,200.x*	*02/23/07*	*HES*	
Calcium, dissolved	*54.4*	*mg/L*	*EPA 200.7*	*02/26/07*	*DBL*	
Iron, dissolved	*<0.01*	*mg/L*	*EPA 200.7*	*02/26/07*	*DBL*	
Magnesium, diss., low level	*24.1*	*mg/L*	*EPA 200.7*	*02/26/07*	*DBL*	
Mercury by EPA 1631	*3.1*	*ng/L*	*EPA 1631*	*02/27/07*	*PML*	
Potassium, dissolved	*2.5*	*mg/L*	*EPA 200.7*	*03/06/07*	*DBL*	
Sodium, dissolved	*98.1*	*mg/L*	*EPA 200.7*	*02/26/07*	*DBL*	
Alkalinity (as CaCO3)	*212*	*mg/L*	*EPA 310.1*	*02/26/07*	*BLF*	
Chloride	*174*	*mg/L*	*EPA 300.0A*	*02/27/07*	*MTW*	
Nitrogen, ammonia, low-level	*0.13*	*mg/L*	*EPA 350.1*	*03/01/07*	*DMC*	
Nitrogen, nitrate	*0.1*	*mg/L*	*EPA 353.2*	*02/23/07*	*MTW*	
Sulfate	*14*	*mg/L*	*EPA 300.0A*	*02/27/07*	*MTW*	
Suspended solids, total	*3*	*mg/L*	*EPA 160.2*	*02/28/07*	*DMC*	

LABORATORY DETAIL REPORT

KAR Project No. : ***070768***

Client: ***Kieser & Associates*** **Date Reported :** ***03/09/07***

Project Description : ***Analysis of eight aqueous samples from Asylum Lake.***

Sample ID : ***"AS-2B"***

Sampled By : ***KBB & SPM of Kieser & Associates*** **Date Received :** ***02/23/07***

Sample Date : ***02/22/07*** **Sample Type :** ***aqueous***

Sample Time : ***1205*** **KAR Sample No. :** ***070768-03***

Test	Result	Units of Measure	Method	Analyzed	Analyst	Comments
Prep, 1631	*Completed*		*EPA 1631*	*02/26/07*	*PML*	
Prep, filtration	*Completed*		*EPA 3005,200.x*	*02/23/07*	*HES*	
Calcium, dissolved	*60.8*	*mg/L*	*EPA 200.7*	*02/26/07*	*DBL*	
Iron, dissolved	*<0.01*	*mg/L*	*EPA 200.7*	*02/26/07*	*DBL*	
Magnesium, diss., low level	*24.4*	*mg/L*	*EPA 200.7*	*02/26/07*	*DBL*	
Mercury by EPA 1631	*12.1*	*ng/L*	*EPA 1631*	*02/27/07*	*PML*	
Potassium, dissolved	*2.6*	*mg/L*	*EPA 200.7*	*03/06/07*	*DBL*	
Sodium, dissolved	*138*	*mg/L*	*EPA 200.7*	*02/26/07*	*DBL*	
Alkalinity (as CaCO3)	*235*	*mg/L*	*EPA 310.1*	*02/26/07*	*BLF*	
Chloride	*247*	*mg/L*	*EPA 300.0A*	*02/27/07*	*MTW*	
Nitrogen, ammonia, low-level	*0.46*	*mg/L*	*EPA 350.1*	*03/01/07*	*DMC*	
Nitrogen, nitrate	*0.1*	*mg/L*	*EPA 353.2*	*02/23/07*	*MTW*	
Sulfate	*16*	*mg/L*	*EPA 300.0A*	*02/27/07*	*MTW*	
Suspended solids, total	*3*	*mg/L*	*EPA 160.2*	*02/28/07*	*DMC*	

LABORATORY DETAIL REPORT

KAR Project No. : ***070768***

Client: ***Kieser & Associates*** **Date Reported :** ***03/09/07***

Project Description : ***Analysis of eight aqueous samples from Asylum Lake.***

Sample ID : ***"AS-3S"***

Sampled By : ***KBB & SPM of Kieser & Associates*** **Date Received :** ***02/23/07***

Sample Date : ***02/22/07*** **Sample Type :** ***aqueous***

Sample Time : ***1400*** **KAR Sample No. :** ***070768-04***

Test	Result	Units of Measure	Method	Analyzed	Analyst	Comments
Prep, 1631	Completed		EPA 1631	02/26/07	PML	
Prep, filtration	Completed		EPA 3005,200.x	02/23/07	HES	
Calcium, dissolved	55.3	mg/L	EPA 200.7	02/26/07	DBL	
Iron, dissolved	<0.01	mg/L	EPA 200.7	02/26/07	DBL	
Magnesium, diss., low level	24.3	mg/L	EPA 200.7	02/26/07	DBL	
Mercury by EPA 1631	<0.5	ng/L	EPA 1631	02/27/07	PML	
Potassium, dissolved	2.5	mg/L	EPA 200.7	03/06/07	DBL	
Sodium, dissolved	98.7	mg/L	EPA 200.7	02/26/07	DBL	
Alkalinity (as CaCO3)	210	mg/L	EPA 310.1	02/26/07	BLF	
Chloride	172	mg/L	EPA 300.0A	02/27/07	MTW	
Nitrogen, ammonia, low-level	0.14	mg/L	EPA 350.1	03/01/07	DMC	
Nitrogen, nitrate	<0.1	mg/L	EPA 353.2	02/23/07	MTW	
Sulfate	14	mg/L	EPA 300.0A	02/27/07	MTW	
Suspended solids, total	3	mg/L	EPA 160.2	02/28/07	DMC	

LABORATORY DETAIL REPORT

KAR Project No. : ***070768***

Client: ***Kieser & Associates*** **Date Reported :** ***03/09/07***

Project Description : ***Analysis of eight aqueous samples from Asylum Lake.***

Sample ID : ***"AS-4S"***

Sampled By : ***KBB & SPM of Kieser & Associates*** **Date Received :** ***02/23/07***

Sample Date : ***02/22/07*** **Sample Type :** ***aqueous***

Sample Time : ***1430*** **KAR Sample No. :** ***070768-05***

Test	Result	Units of Measure	Method	Analyzed	Analyst	Comments
Prep, 1631	Completed		EPA 1631	02/26/07	PML	
Prep, filtration	Completed		EPA 3005,200.x	02/23/07	HES	
Calcium, dissolved	54.8	mg/L	EPA 200.7	02/26/07	DBL	
Iron, dissolved	<0.01	mg/L	EPA 200.7	02/26/07	DBL	
Magnesium, diss., low level	24.2	mg/L	EPA 200.7	02/26/07	DBL	
Mercury by EPA 1631	<0.5	ng/L	EPA 1631	02/27/07	PML	
Potassium, dissolved	2.5	mg/L	EPA 200.7	03/06/07	DBL	
Sodium, dissolved	98.7	mg/L	EPA 200.7	02/26/07	DBL	
Alkalinity (as CaCO3)	210	mg/L	EPA 310.1	02/26/07	BLF	
Chloride	171	mg/L	EPA 300.0A	02/27/07	MTW	
Nitrogen, ammonia, low-level	0.15	mg/L	EPA 350.1	03/01/07	DMC	
Nitrogen, nitrate	<0.1	mg/L	EPA 353.2	02/23/07	MTW	
Sulfate	14	mg/L	EPA 300.0A	02/27/07	MTW	
Suspended solids, total	2	mg/L	EPA 160.2	02/28/07	DMC	

LABORATORY DETAIL REPORT

KAR Project No. : ***070768***

Client: ***Kieser & Associates***

Date Reported : ***03/09/07***

Project Description : ***Analysis of eight aqueous samples from Asylum Lake.***

Sample ID : ***"LA-1S"***

Sampled By : ***KBB & SPM of Kieser & Associates***

Date Received : ***02/23/07***

Sample Date : ***02/22/07***

Sample Type : ***aqueous***

Sample Time : ***1535***

KAR Sample No. : ***070768-06***

Test	Result	Units of Measure	Method	Analyzed	Analyst	Comments
Prep, 1631	Completed		EPA 1631	02/26/07	PML	
Prep, filtration	Completed		EPA 3005,200.x	02/23/07	HES	
Calcium, dissolved	55.2	mg/L	EPA 200.7	02/26/07	DBL	
Iron, dissolved	<0.01	mg/L	EPA 200.7	02/26/07	DBL	
Magnesium, diss., low level	24.4	mg/L	EPA 200.7	02/26/07	DBL	
Mercury by EPA 1631	<0.5	ng/L	EPA 1631	02/27/07	PML	
Potassium, dissolved	2.5	mg/L	EPA 200.7	03/06/07	DBL	
Sodium, dissolved	98.9	mg/L	EPA 200.7	02/26/07	DBL	
Alkalinity (as CaCO3)	208	mg/L	EPA 310.1	02/26/07	BLF	
Chloride	175	mg/L	EPA 300.0A	02/27/07	MTW	
Nitrogen, ammonia, low-level	0.19	mg/L	EPA 350.1	03/01/07	DMC	
Nitrogen, nitrate	0.1	mg/L	EPA 353.2	02/23/07	MTW	
Sulfate	14	mg/L	EPA 300.0A	02/27/07	MTW	
Suspended solids, total	2	mg/L	EPA 160.2	02/28/07	DMC	

LABORATORY DETAIL REPORT

KAR Project No. : ***070768***

Client: ***Kieser & Associates*** **Date Reported :** ***03/09/07***

Project Description : ***Analysis of eight aqueous samples from Asylum Lake.***

Sample ID : ***"LA-1B"***

Sampled By : ***KBB & SPM of Kieser & Associates*** **Date Received :** ***02/23/07***

Sample Date : ***02/22/07*** **Sample Type :** ***aqueous***

Sample Time : ***1555*** **KAR Sample No. :** ***070768-07***

Test	Result	Units of Measure	Method	Analyzed	Analyst	Comments
Prep, 1631	*Completed*		*EPA 1631*	*02/26/07*	*PML*	
Prep, filtration	*Completed*		*EPA 3005,200.x*	*02/23/07*	*HES*	
Calcium, dissolved	*57.0*	*mg/L*	*EPA 200.7*	*02/26/07*	*DBL*	
Iron, dissolved	*<0.01*	*mg/L*	*EPA 200.7*	*02/26/07*	*DBL*	
Magnesium, diss., low level	*24.4*	*mg/L*	*EPA 200.7*	*02/26/07*	*DBL*	
Mercury by EPA 1631	*18.0*	*ng/L*	*EPA 1631*	*02/27/07*	*PML*	
Potassium, dissolved	*2.7*	*mg/L*	*EPA 200.7*	*03/06/07*	*DBL*	
Sodium, dissolved	*97.6*	*mg/L*	*EPA 200.7*	*02/26/07*	*DBL*	
Alkalinity (as CaCO3)	*215*	*mg/L*	*EPA 310.1*	*02/26/07*	*BLF*	
Chloride	*168*	*mg/L*	*EPA 300.0A*	*02/27/07*	*MTW*	
Nitrogen, ammonia, low-level	*0.47*	*mg/L*	*EPA 350.1*	*03/01/07*	*DMC*	
Nitrogen, nitrate	*<0.1*	*mg/L*	*EPA 353.2*	*02/23/07*	*MTW*	
Sulfate	*13*	*mg/L*	*EPA 300.0A*	*02/27/07*	*MTW*	
Suspended solids, total	*3*	*mg/L*	*EPA 160.2*	*02/28/07*	*DMC*	

LABORATORY DETAIL REPORT

KAR Project No. : ***070768***

Client: ***Kieser & Associates***

Date Reported : ***03/09/07***

Project Description : ***Analysis of eight aqueous samples from Asylum Lake.***

Sample ID : ***"Trip Blank"***

Sampled By :

Sample Date :

Sample Time :

Date Received : ***02/23/07***

Sample Type : ***aqueous***

KAR Sample No. : ***070768-08***

Test	Result	Units of Measure	Method	Analyzed	Analyst	Comments
Prep, 1631	*Completed*		*EPA 1631*	*02/26/07*	*PML*	
Mercury by EPA 1631	*<0.5*	*ng/L*	*EPA 1631*	*02/27/07*	*PML*	

KAR *Laboratories, Inc.*

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Kieser & Associates
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Kalamazoo, MI 49007

Attn : ***Mr. Mark Kieser***

KAR Project No. :	***065186***
Date Reported :	***12/05/06***
Date Activated :	***11/20/06***
Date Due :	***12/06/06***
Date Validated :	***12/04/06***

Project Description : ***Analysis of six aqueous samples from Asylum Lake.***

Dear Client,

Your laboratory data is presented to you in this report. Unless otherwise stated under the "Comments" heading, all tests were performed within the maximum allowable holding times, have met or exceeded QC requirements and the result represents the sample as it was received.

If you wish to contact us about this work please mention KAR Project No. 065186. To arrange additional sampling or testing please contact our Client Services Department. If you have any questions regarding quality assurance please contact us.

Thank you for the opportunity to serve you. Please do not hesitate to call if we can provide additional assistance.

Respectfully submitted,

David R. Alkema
Laboratory Manager

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LABORATORY DETAIL REPORT

KAR Project No. : ***065186***

Client: ***Kieser & Associates*** **Date Reported :** ***12/05/06***

Project Description : ***Analysis of six aqueous samples from Asylum Lake.***

Sample ID : ***"AS-1S"***

Sampled By : ***PHM, KBB, & SM of Kieser & Associates*** **Date Received :** ***11/20/06***
Sample Date : ***11/20/06*** **Sample Type :** ***aqueous***
Sample Time : ***0915*** **KAR Sample No. :** ***065186-01***

Test	Result	Units of Measure	Method	Analyzed	Analyst	Comments
Prep, 1631	Completed		EPA 1631	11/21/06	PML	
Prep, filtration	Completed		EPA 3005,200.x	11/20/06	ALD	
Calcium, dissolved	53.5	mg/L	EPA 200.7	11/22/06	DBL	
Iron, dissolved	<0.01	mg/L	EPA 200.7	11/22/06	DBL	
Magnesium, diss., low level	24.3	mg/L	EPA 200.7	11/22/06	DBL	
Mercury by EPA 1631	<0.5	ng/L	EPA 1631	11/22/06	PML	
Potassium, dissolved	2.4	mg/L	EPA 200.7	11/22/06	DBL	
Sodium, dissolved	100	mg/L	EPA 200.7	11/22/06	DBL	
Bacteria, E. coli	10	colonies/100mL	EPA 10029	11/21/06	EKS	
Alkalinity (as CaCO3)	202	mg/L	EPA 310.1	11/27/06	BLF	
Chloride	169	mg/L	EPA 300.0A	11/21/06	MTW	
Gravimetric TPH (SGT-HEM)	<5	mg/L	EPA 1664	11/21/06	LPV	
Nitrogen, ammonia, low-level	0.21	mg/L	EPA 350.1	12/01/06	DMC	
Nitrogen, nitrate	<0.1	mg/L	EPA 353.2	11/21/06	MTW	
Sulfate	14	mg/L	EPA 300.0A	11/21/06	MTW	
Suspended solids, total	1	mg/L	EPA 160.2	11/21/06	EKS	
Prep, SV BN	Completed		EPA 3510	11/22/06	LPV	
Atrazine	<1	ug/L	EPA 8270	11/30/06	KTL	

LABORATORY DETAIL REPORT

KAR Project No. : ***065186***

Client: ***Kieser & Associates*** **Date Reported :** ***12/05/06***

Project Description : ***Analysis of six aqueous samples from Asylum Lake.***

Sample ID : ***"AS-2M"***

Sampled By : ***PHM, KBB, & SM of Kieser & Associates*** **Date Received :** ***11/20/06***

Sample Date : ***11/20/06*** **Sample Type :** ***aqueous***

Sample Time : ***0950*** **KAR Sample No. :** ***065186-02***

Test	Result	Units of Measure	Method	Analyzed	Analyst	Comments
Prep, 1631	Completed		EPA 1631	11/21/06	PML	
Prep, filtration	Completed		EPA 3005,200.x	11/20/06	ALD	
Calcium, dissolved	53.2	mg/L	EPA 200.7	11/22/06	DBL	
Iron, dissolved	<0.01	mg/L	EPA 200.7	11/22/06	DBL	
Magnesium, diss., low level	24.2	mg/L	EPA 200.7	11/22/06	DBL	
Mercury by EPA 1631	4.8	ng/L	EPA 1631	11/22/06	PML	
Potassium, dissolved	2.5	mg/L	EPA 200.7	11/22/06	DBL	
Sodium, dissolved	99.9	mg/L	EPA 200.7	11/22/06	DBL	
Bacteria, E. coli	6	colonies/100mL	EPA 10029	11/21/06	EKS	
Alkalinity (as CaCO3)	205	mg/L	EPA 310.1	11/27/06	BLF	
Chloride	169	mg/L	EPA 300.0A	11/21/06	MTW	
Gravimetric TPH (SGT-HEM)	<5	mg/L	EPA 1664	11/21/06	LPV	
Nitrogen, ammonia, low-level	0.22	mg/L	EPA 350.1	12/01/06	DMC	
Nitrogen, nitrate	<0.1	mg/L	EPA 353.2	11/21/06	MTW	
Sulfate	14	mg/L	EPA 300.0A	11/21/06	MTW	
Suspended solids, total	1	mg/L	EPA 160.2	11/21/06	EKS	
Prep, SV BN	Completed		EPA 3510	11/22/06	LPV	
Atrazine	<1	ug/L	EPA 8270	11/30/06	KTL	

LABORATORY DETAIL REPORT

KAR Project No. : ***065186***

Client: ***Kieser & Associates*** **Date Reported :** ***12/05/06***

Project Description : ***Analysis of six aqueous samples from Asylum Lake.***

Sample ID : ***"AS-3S"***

Sampled By : ***PHM, KBB, & SM of Kieser & Associates*** **Date Received :** ***11/20/06***

Sample Date : ***11/20/06*** **Sample Type :** ***aqueous***

Sample Time : ***1035*** **KAR Sample No. :** ***065186-03***

Test	Result	Units of Measure	Method	Analyzed	Analyst	Comments
Prep, 1631	*Completed*		*EPA 1631*	*11/21/06*	*PML*	
Prep, filtration	*Completed*		*EPA 3005,200.x*	*11/20/06*	*ALD*	
Calcium, dissolved	*52.9*	*mg/L*	*EPA 200.7*	*11/22/06*	*DBL*	
Iron, dissolved	*<0.01*	*mg/L*	*EPA 200.7*	*11/22/06*	*DBL*	
Magnesium, diss., low level	*24.1*	*mg/L*	*EPA 200.7*	*11/22/06*	*DBL*	
Mercury by EPA 1631	*<0.5*	*ng/L*	*EPA 1631*	*11/22/06*	*PML*	
Potassium, dissolved	*2.4*	*mg/L*	*EPA 200.7*	*11/22/06*	*DBL*	
Sodium, dissolved	*99.5*	*mg/L*	*EPA 200.7*	*11/22/06*	*DBL*	
Bacteria, E. coli	*2*	*colonies/100mL*	*EPA 10029*	*11/21/06*	*EKS*	
Alkalinity (as CaCO3)	*208*	*mg/L*	*EPA 310.1*	*11/27/06*	*BLF*	
Chloride	*168*	*mg/L*	*EPA 300.0A*	*11/21/06*	*MTW*	
Conductivity	*903*	*micromhos/cm*	*EPA 120.1*	*11/27/06*	*ALD*	
Gravimetric TPH (SGT-HEM)	*<5*	*mg/L*	*EPA 1664*	*11/21/06*	*LPV*	
Nitrogen, ammonia, low-level	*0.19*	*mg/L*	*EPA 350.1*	*12/01/06*	*DMC*	
Nitrogen, nitrate	*<0.1*	*mg/L*	*EPA 353.2*	*11/21/06*	*MTW*	
Sulfate	*14*	*mg/L*	*EPA 300.0A*	*11/21/06*	*MTW*	
Suspended solids, total	*<1*	*mg/L*	*EPA 160.2*	*11/21/06*	*EKS*	
Prep, SV BN	*Completed*		*EPA 3510*	*11/22/06*	*LPV*	
Atrazine	*<1*	*ug/L*	*EPA 8270*	*11/30/06*	*KTL*	

LABORATORY DETAIL REPORT

KAR Project No. : ***065186***

Client: ***Kieser & Associates***

Date Reported : ***12/05/06***

Project Description : ***Analysis of six aqueous samples from Asylum Lake.***

Sample ID : ***"AS-4S"***

Sampled By : ***PHM, KBB, & SM of Kieser & Associates***
Date Received : ***11/20/06***
Sample Date : ***11/20/06***
Sample Type : ***aqueous***
Sample Time : ***1110***
KAR Sample No. : ***065186-04***

Test	Result	Units of Measure	Method	Analyzed	Analyst	Comments
Prep, 1631	*Completed*		*EPA 1631*	*11/21/06*	*PML*	
Prep, filtration	*Completed*		*EPA 3005,200.x*	*11/20/06*	*ALD*	
Calcium, dissolved	*52.9*	*mg/L*	*EPA 200.7*	*11/22/06*	*DBL*	
Iron, dissolved	*<0.01*	*mg/L*	*EPA 200.7*	*11/22/06*	*DBL*	
Magnesium, diss., low level	*24.1*	*mg/L*	*EPA 200.7*	*11/22/06*	*DBL*	
Mercury by EPA 1631	*<0.5*	*ng/L*	*EPA 1631*	*11/22/06*	*PML*	
Potassium, dissolved	*2.4*	*mg/L*	*EPA 200.7*	*11/22/06*	*DBL*	
Sodium, dissolved	*99.7*	*mg/L*	*EPA 200.7*	*11/22/06*	*DBL*	
Alkalinity (as CaCO3)	*202*	*mg/L*	*EPA 310.1*	*11/27/06*	*BLF*	
Chloride	*168*	*mg/L*	*EPA 300.0A*	*11/21/06*	*MTW*	
Conductivity	*900*	*micromhos/cm*	*EPA 120.1*	*11/27/06*	*ALD*	
Gravimetric TPH (SGT-HEM)	*<5*	*mg/L*	*EPA 1664*	*11/21/06*	*LPV*	
Nitrogen, ammonia, low-level	*0.14*	*mg/L*	*EPA 350.1*	*12/01/06*	*DMC*	
Nitrogen, nitrate	*<0.1*	*mg/L*	*EPA 353.2*	*11/21/06*	*MTW*	
Sulfate	*14*	*mg/L*	*EPA 300.0A*	*11/21/06*	*MTW*	
Suspended solids, total	*4*	*mg/L*	*EPA 160.2*	*11/21/06*	*EKS*	
Prep, SV BN	*Completed*		*EPA 3510*	*11/22/06*	*LPV*	
Atrazine	*<1*	*ug/L*	*EPA 8270*	*11/30/06*	*KTL*	

LABORATORY DETAIL REPORT

KAR Project No. : ***065186***

Client: ***Kieser & Associates*** **Date Reported :** ***12/05/06***

Project Description : ***Analysis of six aqueous samples from Asylum Lake.***

Sample ID : ***"LS-1S"***

Sampled By : ***PHM, KBB, & SM of Kieser & Associates*** **Date Received :** ***11/20/06***

Sample Date : ***11/20/06*** **Sample Type :** ***aqueous***

Sample Time : ***1225*** **KAR Sample No. :** ***065186-05***

Test	Result	Units of Measure	Method	Analyzed	Analyst	Comments
Prep, 1631	Completed		EPA 1631	11/21/06	PML	
Prep, filtration	Completed		EPA 3005,200.x	11/20/06	ALD	
Calcium, dissolved	44.7	mg/L	EPA 200.7	11/22/06	DBL	
Iron, dissolved	<0.01	mg/L	EPA 200.7	11/22/06	DBL	
Magnesium, diss., low level	22.7	mg/L	EPA 200.7	11/22/06	DBL	
Mercury by EPA 1631	18.5	ng/L	EPA 1631	11/22/06	PML	
Potassium, dissolved	2.4	mg/L	EPA 200.7	11/22/06	DBL	
Sodium, dissolved	93.4	mg/L	EPA 200.7	11/22/06	DBL	
Bacteria, E. coli	18	colonies/100mL	EPA 10029	11/21/06	EKS	
Alkalinity (as CaCO3)	182	mg/L	EPA 310.1	11/27/06	BLF	
Chloride	147	mg/L	EPA 300.0A	11/21/06	MTW	
Conductivity	837	micromhos/cm	EPA 120.1	11/27/06	ALD	
Gravimetric TPH (SGT-HEM)	<5	mg/L	EPA 1664	11/21/06	LPV	
Nitrogen, ammonia, low-level	0.02	mg/L	EPA 350.1	12/01/06	DMC	
Nitrogen, nitrate	<0.1	mg/L	EPA 353.2	11/21/06	MTW	
Sulfate	12	mg/L	EPA 300.0A	11/21/06	MTW	
Suspended solids, total	<1	mg/L	EPA 160.2	11/21/06	EKS	
Prep, SV BN	Completed		EPA 3510	11/22/06	LPV	
Atrazine	<1	ug/L	EPA 8270	11/30/06	KTL	

LABORATORY DETAIL REPORT

KAR Project No. : ***065186***

Client: ***Kieser & Associates*** **Date Reported :** ***12/05/06***

Project Description : ***Analysis of six aqueous samples from Asylum Lake.***

Sample ID : ***"Trip Blank"***

Sampled By :
Sample Date :
Sample Time :

Date Received : *11/20/06*
Sample Type : *aqueous*
KAR Sample No. : *065186-06*

Test	Result	Units of Measure	Method	Analyzed	Analyst	Comments
Prep, 1631	*Completed*		*EPA 1631*	*11/21/06*	*PML*	
Mercury by EPA 1631	*<0.5*	*ng/L*	*EPA 1631*	*11/22/06*	*PML*	

KAR *Laboratories, Inc.*

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Attn : ***Mr. Mark Kieser***

KAR Project No. :	***071605***
Date Reported :	***05/02/07***
Date Activated :	***04/19/07***
Date Due :	***05/03/07***
Date Validated :	***05/01/07***

Project Description : ***Analysis of 11 aqueous samples from Asylum Lake.***

Dear Client,

Your laboratory data is presented to you in this report. Unless otherwise stated under the "Comments" heading, all tests were performed within the maximum allowable holding times, have met or exceeded QC requirements and the result represents the sample as it was received.

If you wish to contact us about this work please mention KAR Project No. 071605. To arrange additional sampling or testing please contact our Client Services Department. If you have any questions regarding quality assurance please contact us.

Thank you for the opportunity to serve you. Please do not hesitate to call if we can provide additional assistance.

Respectfully submitted,

David R. Alkema
Laboratory Manager

LABORATORY DETAIL REPORT

KAR Project No. : ***071605***

Client: ***Kieser & Associates*** **Date Reported :** ***05/02/07***

Project Description : ***Analysis of 11 aqueous samples from Asylum Lake.***

Sample ID :	***"AS-1S, E. coli"***		
Sampled By :	***KBB and SPM of Kieser & Associates***	**Date Received :**	***04/19/07***
Sample Date :	***04/19/07***	**Sample Type :**	***aqueous***
Sample Time :	***1000***	**KAR Sample No. :**	***071605-01***

Test	Result	Units of Measure	Method	Analyzed	Analyst	Comments
Bacteria, E. coli	*<2*	*colonies/100mL*	*EPA 10029*	*04/19/07*	*DMC*	

LABORATORY DETAIL REPORT

KAR Project No. : ***071605***

Client: ***Kieser & Associates*** **Date Reported :** ***05/02/07***

Project Description : ***Analysis of 11 aqueous samples from Asylum Lake.***

Sample ID : ***"AS-2, E. coli"***

Sampled By : ***KBB and SPM of Kieser & Associates*** **Date Received :** ***04/19/07***
Sample Date : ***04/19/07*** **Sample Type :** ***aqueous***
Sample Time : ***1100*** **KAR Sample No. :** ***071605-02***

Test	Result	Units of Measure	Method	Analyzed	Analyst	Comments
Bacteria, E. coli	*<2*	*colonies/100mL*	*EPA 10029*	*04/19/07*	*DMC*	

LABORATORY DETAIL REPORT

KAR Project No. : ***071605***

Client: ***Kieser & Associates*** **Date Reported :** ***05/02/07***

Project Description : ***Analysis of 11 aqueous samples from Asylum Lake.***

Sample ID : ***"AS-3, E. coli"***

Sampled By : ***KBB and SPM of Kieser & Associates*** **Date Received :** ***04/19/07***
Sample Date : ***04/19/07*** **Sample Type :** ***aqueous***
Sample Time : ***1235*** **KAR Sample No. :** ***071605-03***

Test	Result	Units of Measure	Method	Analyzed	Analyst	Comments
Bacteria, E. coli	*<2*	*colonies/100mL*	*EPA 10029*	*04/19/07*	*DMC*	

LABORATORY DETAIL REPORT

KAR Project No. : ***071605***

Client: ***Kieser & Associates***

Date Reported : ***05/02/07***

Project Description : ***Analysis of 11 aqueous samples from Asylum Lake.***

Sample ID : ***"AS-4S, E. coli"***

Sampled By : ***KBB and SPM of Kieser & Associates***

Sample Date : ***04/19/07***

Sample Time : ***1355***

Date Received : ***04/19/07***

Sample Type : ***aqueous***

KAR Sample No. : ***071605-04***

Test	Result	Units of Measure	Method	Analyzed	Analyst	Comments
Bacteria, E. coli	*<2*	*colonies/100mL*	*EPA 10029*	*04/19/07*	*DMC*	

LABORATORY DETAIL REPORT

KAR Project No. : ***071605***

Client: ***Kieser & Associates*** **Date Reported :** ***05/02/07***

Project Description : ***Analysis of 11 aqueous samples from Asylum Lake.***

Sample ID : ***"LA-1M, E. coli"***

Sampled By : ***KBB and SPM of Kieser & Associates*** **Date Received :** ***04/19/07***

Sample Date : ***04/19/07*** **Sample Type :** ***aqueous***

Sample Time : ***1455*** **KAR Sample No. :** ***071605-05***

Test	Result	Units of Measure	Method	Analyzed	Analyst	Comments
Bacteria, E. coli	*<2*	*colonies/100mL*	*EPA 10029*	*04/19/07*	*DMC*	

LABORATORY DETAIL REPORT

KAR Project No. : ***071605***

Client: ***Kieser & Associates*** **Date Reported :** ***05/02/07***

Project Description : ***Analysis of 11 aqueous samples from Asylum Lake.***

Sample ID : ***"AS-1M"***

Sampled By : ***KBB and SPM of Kieser & Associates*** **Date Received :** ***04/20/07***

Sample Date : ***04/19/07*** **Sample Type :** ***aqueous***

Sample Time : ***1145*** **KAR Sample No. :** ***071605-06***

Test	Result	Units of Measure	Method	Analyzed	Analyst	Comments
Prep, 1631	*Completed*		*EPA 1631*	*04/26/07*	*PML*	
Prep, filtration	*Completed*		*EPA 3005,200.x*	*04/20/07*	*ALD*	
Calcium, dissolved	*56.2*	*mg/L*	*EPA 200.7*	*04/23/07*	*DBL*	
Iron, dissolved	*<0.01*	*mg/L*	*EPA 200.7*	*04/23/07*	*DBL*	
Magnesium, diss., low level	*23.8*	*mg/L*	*EPA 200.7*	*04/23/07*	*DBL*	
Mercury by EPA 1631	*7.5*	*ng/L*	*EPA 1631*	*04/30/07*	*PML*	
Potassium, dissolved	*2.4*	*mg/L*	*EPA 200.7*	*04/23/07*	*DBL*	
Sodium, dissolved	*110*	*mg/L*	*EPA 200.7*	*04/23/07*	*DBL*	
Alkalinity (as CaCO3)	*210*	*mg/L*	*SM 2320 B*	*04/26/07*	*BLF*	
Chloride	*169*	*mg/L*	*EPA 300.0A*	*04/26/07*	*MTW*	
Nitrogen, ammonia, low-level	*0.05*	*mg/L*	*EPA 350.1*	*04/24/07*	*DMC*	
Nitrogen, nitrate	*<0.1*	*mg/L*	*EPA 353.2*	*04/20/07*	*MTW*	
Sulfate	*14*	*mg/L*	*EPA 300.0A*	*04/26/07*	*MTW*	
Suspended solids, total	*2*	*mg/L*	*SM 2540 D*	*04/20/07*	*DMC*	

LABORATORY DETAIL REPORT

KAR Project No. : ***071605***

Client: ***Kieser & Associates*** **Date Reported :** ***05/02/07***

Project Description : ***Analysis of 11 aqueous samples from Asylum Lake.***

Sample ID : ***"AS-2M"***

Sampled By : ***KBB and SPM of Kieser & Associates*** **Date Received :** ***04/20/07***

Sample Date : ***04/19/07*** **Sample Type :** ***aqueous***

Sample Time : ***1100*** **KAR Sample No. :** ***071605-07***

Test	Result	Units of Measure	Method	Analyzed	Analyst	Comments
Prep, 1631	*Completed*		*EPA 1631*	*04/26/07*	*PML*	
Prep, filtration	*Completed*		*EPA 3005,200.x*	*04/20/07*	*ALD*	
Calcium, dissolved	*50.0*	*mg/L*	*EPA 200.7*	*04/23/07*	*DBL*	
Iron, dissolved	*<0.01*	*mg/L*	*EPA 200.7*	*04/23/07*	*DBL*	
Magnesium, diss., low level	*21.4*	*mg/L*	*EPA 200.7*	*04/23/07*	*DBL*	
Mercury by EPA 1631	*12.5*	*ng/L*	*EPA 1631*	*04/30/07*	*PML*	
Potassium, dissolved	*2.1*	*mg/L*	*EPA 200.7*	*04/23/07*	*DBL*	
Sodium, dissolved	*99.4*	*mg/L*	*EPA 200.7*	*04/23/07*	*DBL*	
Alkalinity (as CaCO3)	*212*	*mg/L*	*SM 2320 B*	*04/26/07*	*BLF*	
Chloride	*167*	*mg/L*	*EPA 300.0A*	*04/26/07*	*MTW*	
Nitrogen, ammonia, low-level	*0.09*	*mg/L*	*EPA 350.1*	*04/24/07*	*DMC*	
Nitrogen, nitrate	*<0.1*	*mg/L*	*EPA 353.2*	*04/20/07*	*MTW*	
Sulfate	*14*	*mg/L*	*EPA 300.0A*	*04/26/07*	*MTW*	
Suspended solids, total	*2*	*mg/L*	*SM 2540 D*	*04/20/07*	*DMC*	

LABORATORY DETAIL REPORT

KAR Project No. : **071605**

Client: *Kieser & Associates* — Date Reported : *05/02/07*

Project Description : *Analysis of 11 aqueous samples from Asylum Lake.*

Sample ID : ***"AS-3M"***

Sampled By : *KBB and SPM of Kieser & Associates* — **Date Received :** *04/20/07*

Sample Date : *04/19/07* — **Sample Type :** *aqueous*

Sample Time : *1235* — **KAR Sample No. :** *071605-08*

Test	Result	Units of Measure	Method	Analyzed	Analyst	Comments
Prep, 1631	Completed		EPA 1631	04/26/07	PML	
Prep, filtration	Completed		EPA 3005,200.x	04/20/07	ALD	
Calcium, dissolved	55.3	mg/L	EPA 200.7	04/23/07	DBL	
Iron, dissolved	<0.01	mg/L	EPA 200.7	04/23/07	DBL	
Magnesium, diss., low level	23.4	mg/L	EPA 200.7	04/23/07	DBL	
Mercury by EPA 1631	11.9	ng/L	EPA 1631	04/30/07	PML	
Potassium, dissolved	2.4	mg/L	EPA 200.7	04/23/07	DBL	
Sodium, dissolved	109	mg/L	EPA 200.7	04/23/07	DBL	
Alkalinity (as CaCO3)	212	mg/L	SM 2320 B	04/26/07	BLF	
Chloride	167	mg/L	EPA 300.0A	04/26/07	MTW	
Nitrogen, ammonia, low-level	0.08	mg/L	EPA 350.1	04/24/07	DMC	
Nitrogen, nitrate	<0.1	mg/L	EPA 353.2	04/20/07	MTW	
Sulfate	14	mg/L	EPA 300.0A	04/26/07	MTW	
Suspended solids, total	2	mg/L	SM 2540 D	04/20/07	DMC	

LABORATORY DETAIL REPORT

KAR Project No. : ***071605***

Client: ***Kieser & Associates*** **Date Reported :** ***05/02/07***

Project Description : ***Analysis of 11 aqueous samples from Asylum Lake.***

Sample ID : ***"AS-4S"***

Sampled By : ***KBB and SPM of Kieser & Associates*** **Date Received :** ***04/20/07***

Sample Date : ***04/19/07*** **Sample Type :** ***aqueous***

Sample Time : ***1355*** **KAR Sample No. :** ***071605-09***

Test	Result	Units of Measure	Method	Analyzed	Analyst	Comments
Prep, 1631	Completed		EPA 1631	04/26/07	PML	
Prep, filtration	Completed		EPA 3005,200.x	04/20/07	ALD	
Calcium, dissolved	54.0	mg/L	EPA 200.7	04/23/07	DBL	
Iron, dissolved	<0.01	mg/L	EPA 200.7	04/23/07	DBL	
Magnesium, diss., low level	23.5	mg/L	EPA 200.7	04/23/07	DBL	
Mercury by EPA 1631	4.7	ng/L	EPA 1631	04/30/07	PML	
Potassium, dissolved	2.3	mg/L	EPA 200.7	04/23/07	DBL	
Sodium, dissolved	110	mg/L	EPA 200.7	04/23/07	DBL	
Alkalinity (as CaCO3)	208	mg/L	SM 2320 B	04/26/07	BLF	
Chloride	168	mg/L	EPA 300.0A	04/26/07	MTW	
Nitrogen, ammonia, low-level	0.02	mg/L	EPA 350.1	04/24/07	DMC	
Nitrogen, nitrate	<0.1	mg/L	EPA 353.2	04/20/07	MTW	
Sulfate	14	mg/L	EPA 300.0A	04/26/07	MTW	
Suspended solids, total	5	mg/L	SM 2540 D	04/20/07	DMC	

LABORATORY DETAIL REPORT

KAR Project No. : ***071605***

Client: ***Kieser & Associates***

Date Reported : ***05/02/07***

Project Description : ***Analysis of 11 aqueous samples from Asylum Lake.***

Sample ID : ***"LS-1M"***

Sampled By : ***KBB and SPM of Kieser & Associates***

Date Received : ***04/20/07***

Sample Date : ***04/19/07***

Sample Type : ***aqueous***

Sample Time : ***1455***

KAR Sample No. : ***071605-10***

Test	Result	Units of Measure	Method	Analyzed	Analyst	Comments
Prep, 1631	*Completed*		*EPA 1631*	*04/26/07*	*PML*	
Prep, filtration	*Completed*		*EPA 3005,200.x*	*04/20/07*	*ALD*	
Calcium, dissolved	*48.5*	*mg/L*	*EPA 200.7*	*04/23/07*	*DBL*	
Iron, dissolved	*<0.01*	*mg/L*	*EPA 200.7*	*04/23/07*	*DBL*	
Magnesium, diss., low level	*21.6*	*mg/L*	*EPA 200.7*	*04/23/07*	*DBL*	
Mercury by EPA 1631	*27.2*	*ng/L*	*EPA 1631*	*04/30/07*	*PML*	
Potassium, dissolved	*2.1*	*mg/L*	*EPA 200.7*	*04/23/07*	*DBL*	
Sodium, dissolved	*98.2*	*mg/L*	*EPA 200.7*	*04/23/07*	*DBL*	
Alkalinity (as CaCO3)	*195*	*mg/L*	*SM 2320 B*	*04/26/07*	*BLF*	
Chloride	*157*	*mg/L*	*EPA 300.0A*	*04/26/07*	*MTW*	
Nitrogen, ammonia, low-level	*0.02*	*mg/L*	*EPA 350.1*	*04/24/07*	*DMC*	
Nitrogen, nitrate	*0.1*	*mg/L*	*EPA 353.2*	*04/20/07*	*MTW*	
Sulfate	*38*	*mg/L*	*EPA 300.0A*	*04/26/07*	*MTW*	
Suspended solids, total	*2*	*mg/L*	*SM 2540 D*	*04/20/07*	*DMC*	

LABORATORY DETAIL REPORT

KAR Project No. : ***071605***

Client: ***Kieser & Associates*** **Date Reported :** ***05/02/07***

Project Description : ***Analysis of 11 aqueous samples from Asylum Lake.***

Sample ID : ***"Trip Blank"***

Sampled By :
Sample Date :
Sample Time :

Date Received : ***04/20/07***
Sample Type : ***aqueous***
KAR Sample No. : ***071605-11***

Test	Result	Units of Measure	Method	Analyzed	Analyst	Comments
Prep, 1631	*Completed*		*EPA 1631*	*04/26/07*	*PML*	
Mercury by EPA 1631	*<0.5*	*ng/L*	*EPA 1631*	*04/30/07*	*PML*	

KAR Laboratories, Inc.

4425 Manchester Road
Kalamazoo, MI 49001
Phone 269 381-9666
Fax 269 381-9698
www.karlabs.com

Kieser & Associates
536 E. Michigan Ave. Suite 300
Kalamazoo, MI 49007

Attn : ***Mr. Mark Kieser***

KAR Project No. :	***072937***
Date Reported :	***07/24/07***
Date Activated :	***07/17/07***
Date Due :	***07/31/07***
Date Validated :	***07/23/07***

Project Description : ***Analysis of four aqueous samples from Asylum Lake.***

Dear Client,

Your laboratory data is presented to you in this report. Unless otherwise stated under the "Comments" heading, all tests were performed within the maximum allowable holding times, have met or exceeded QC requirements and the result represents the sample as it was received.

If you wish to contact us about this work please mention KAR Project No. 072937. To arrange additional sampling or testing please contact our Client Services Department. If you have any questions regarding quality assurance please contact us.

Thank you for the opportunity to serve you. Please do not hesitate to call if we can provide additional assistance.

Respectfully submitted,

David R. Alkema
Laboratory Manager

LABORATORY DETAIL REPORT

Client: ***Kieser & Associates***

KAR Project No. : ***072937***
Date Reported : ***07/24/07***

Project Description : ***Analysis of four aqueous samples from Asylum Lake.***

Sample ID : ***"SW-1"***

Sampled By : ***SPM & JS of Kieser & Associates***
Sample Date : ***07/17/07***
Sample Time : ***0850***

Date Received : ***07/17/07***
Sample Type : ***aqueous***
KAR Sample No. : ***072937-01***

Test	Result	Units of Measure	Method	Analyzed	Analyst	Comments
Bacteria, E. coli	*8500*	*colonies/100mL*	*EPA 10029*	*07/17/07*	*DMC*	
Suspended solids, total	*49*	*mg/L*	*SM 2540 D*	*07/18/07*	*DMC*	

LABORATORY DETAIL REPORT

KAR Project No. : ***072937***

Client: ***Kieser & Associates***

Date Reported : ***07/24/07***

Project Description : ***Analysis of four aqueous samples from Asylum Lake.***

Sample ID : ***"SW-2"***

Sampled By : ***SPM & JS of Kieser & Associates***

Sample Date : ***07/17/07***

Sample Time : ***0905***

Date Received : ***07/17/07***

Sample Type : ***aqueous***

KAR Sample No. : ***072937-02***

Test	Result	Units of Measure	Method	Analyzed	Analyst	Comments
Bacteria, E. coli	*4400*	*colonies/100mL*	*EPA 10029*	*07/17/07*	*DMC*	
Suspended solids, total	*76*	*mg/L*	*SM 2540 D*	*07/18/07*	*DMC*	

LABORATORY DETAIL REPORT

KAR Project No. : ***072937***

Client: ***Kieser & Associates*** **Date Reported :** ***07/24/07***

Project Description : ***Analysis of four aqueous samples from Asylum Lake.***

Sample ID : ***"SW-4"***

Sampled By : ***SPM & JS of Kieser & Associates*** **Date Received :** ***07/17/07***

Sample Date : ***07/17/07*** **Sample Type :** ***aqueous***

Sample Time : ***1045*** **KAR Sample No. :** ***072937-03***

Test	Result	Units of Measure	Method	Analyzed	Analyst	Comments
Bacteria, E. coli	*10,000*	*colonies/100mL*	*EPA 10029*	*07/17/07*	*DMC*	
Suspended solids, total	*12*	*mg/L*	*SM 2540 D*	*07/18/07*	*DMC*	

LABORATORY DETAIL REPORT

KAR Project No. : ***072937***

Client: ***Kieser & Associates***

Date Reported : ***07/24/07***

Project Description : ***Analysis of four aqueous samples from Asylum Lake.***

Sample ID : ***"PC-1"***

Sampled By : ***SPM & JS of Kieser & Associates***

Sample Date : ***07/17/07***

Sample Time : ***0935***

Date Received : ***07/17/07***

Sample Type : ***aqueous***

KAR Sample No. : ***072937-04***

Test	Result	Units of Measure	Method	Analyzed	Analyst	Comments
Bacteria, E. coli	*3100*	*colonies/100mL*	*EPA 10029*	*07/17/07*	*DMC*	
Suspended solids, total	*20*	*mg/L*	*SM 2540 D*	*07/18/07*	*DMC*	

UPSTATE FRESHWATER INSTITUTE
P.O. Box 506
Syracuse, New York 13214
ELAP ID 11462

UPSTATE FRESHWATER INSTITUTE LABORATORY REPORT

315-431-4962

FOR:
Kieser & Assoc.
536 East Michigan Ave. Suite 300
Kalamazoo, MI 49007
Aslyum Lake

September 15, 2006
Report Number: CHM6011
Contract Number: 252

UFI ID #	Keiser ID	Sampling Date	Sampling Time	Total Phosphorus (ug/L)	Data Flags (TP)	Total Nitrogen (ug/L)	Data Flags (TDN)	Chlorophyll a	Data Flags (chl)	Soluble Reactive Phosphorus	Data Flags (SRP)
Method				SM 18-20 4500 PE		Pyro-chemilumines cence		EPA 445		SM 18-20 4500 PE	
6223001	AS-1S	8/9/2006	9:10:00	13		281.8	F12	3		1.9	
6223002	AS-2S	8/9/2006	10:10:00	21.5		305.8	F12	2.9		2.8	
6223003	AS-3S	8/9/2006	11:35:00	13.7		340.5	F12	2.4		2	
6223004	LA-1S	8/9/2006	14:15:00	50.3		554.7	F12	3.1		7.9	
6223005	AS-4S	8/9/2006	12:30:00	31.2		340.6	F12	NS		6	
6223006	AS-2B	8/9/2006	10:10:00	565.5	F2	2257.3	F12,F3	NS		333.9	F3
6223007	LA-1B	8/9/2006	14:15:00	49.7		729.4	F12	NS		11.3	
6223008	AS-2B	8/9/2006	10:10:00	42600	F2	NS		NS		NS	
6223009	LA-1B	8/9/2006	14:15:00	24188	F2	NS		NS		NS	

Jennifer Aicher, Laboratory Director

The reported results are pertinent to the samples as they were received at the laboratory.
UFI is not responsible for sample handling and storage prior to their receipt.
Fail QC means that a sample has failed our Laboratory's Quality Control Parameters. NS means that no sample was received.
Detection limits are as follows:, Total Phosphorus 0.6 ug/L, Soluble Reactive Phosphorus 0.3 ug/L, and Total Nitrogen 150ug/L.

Data Flag ID	**Meaning of Flag**	**Date Initiated**
~~F1~~	~~Sample analyzed/received past holding time~~ (Retired as of 4/24/2006)	1/3/2006
F2	Sample diluted to run within calibration curve	1/3/2006
F3	Sample outside calibration curve	1/3/2006
F4	Lower than normal volume of sample analyzed	1/3/2006
F5	Sample not digested/prepared properly	1/3/2006
F6	Sample not preserved properly	1/3/2006
F7	Sample received outside "normal" temperature limits	1/3/2006
F8	Sample container inappropriate	1/3/2006
F9	Sample container broken/cracked/leaked	1/3/2006

F10	Sample taken from container other than specified analyte		1/3/2006
F11	Data associated with failed spike/LCS		1/3/2006
F12	Data associated with failed CCV/CCB		1/3/2006
F13	Data associated with failed duplicate		1/3/2006
F14	sample received past holding time		4/24/2006
F15	sample analyzed past holding time		4/24/2006
F16	sample value less then LOQ, *but more than LOD*		4/24/2006 *7/26/2006*
F17	Sample was Q6ed (sample should have been rerun but conditions exist that prevent a rerun)		4/24/2006
F18	Sample likely/possibly contaminated before arrival		4/24/2006
F19	No sample due to lab error		6/3/2006
F20	No sample due to field error		6/3/2006
F21	Reference outside control limits		7/6/2006

F22	Sample value less than LOD		7/26/2006

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UPSTATE FRESHWATER INSTITUTE LABORATORY REPORT

315-431-4962

CHM 7013

FOR:
Kieser & Report Number: CHM7001
536 East Michigan Ave. Suite 300
Kalamazoo, MI 49007

Date Reported 1/26/2007
Contract Number 252

UFI Lab ID	Client ID	Sample Type	Sampling Date	Sampling Time	Received Date	Received Time	Total Phosphorus (ugP/L)	TP Data Flags	Soluble Reactive Phosphorus (ugP/L)	SRP Data Flags	SRP Date Analysis Performed	SRP Time Analysis Performed
6325016	AS-BLANK	grab	11/20/2006	NA	11/21/2006	10:30	0.6	Sample less than the LOQ, but greater than the LOD	0.2	Sample less than the LOD	11/21/2006	11:59
6325011	AS-1S	grab	11/20/2006	9:15	11/21/2006	10:30	35.9		4		11/21/2006	11:27
6325012	AS-2M	grab	11/20/2006	9:50	11/21/2006	10:30	41.1		5.6		11/21/2006	11:33
6325013	AS-3S	grab	11/20/2006	10:35	11/21/2006	10:30	35.9		3.6		11/21/2006	11:40
6325014	AS-4S	grab	11/20/2006	11:10	11/21/2006	10:30	43.4		2		11/21/2006	11:46
6325015	LS-1S	grab	11/20/2006	12:25	11/21/2006	10:30	27.6		0.5	Sample less than the LOQ, but greater than the LOD	11/21/2006	11:52

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UPSTATE FRESHWATER INSTITUTE LABORATORY REPORT

315-431-4962

CHM 7031

FOR:

Kieser & Assoc.

536 East Michigan Ave. Suite 300
Kalamazoo, MI 49007

Date Reported 5/31/2007
Contract Number 280

UFI Lab ID	Client ID	Sample Type	Sampling Date	Sampling Time	Received Date	Received Time	Total Nitrogen (ug N/L)	flags(TN)	Total Phosphorus (ug P/L)	flags(TP)
7054001	AS-1S	grab	2/22/2007	10:15	2/23/2007	10:00	819		60.9	
7054002	AS-2S	grab	2/22/2007	11:50	2/23/2007	10:00	906		42.8	
7054003	AS-2B	grab	2/22/2007	12:05	2/23/2007	10:00	1323	Sample diluted	88.2	
7054004	AS-3S	grab	2/22/2007	14:00	2/23/2007	10:00	1616	Sample diluted	43.7	
7054005	AS-4S	grab	2/22/2007	14:30	2/23/2007	10:00	1115		39	
7054006	LA-1S	grab	2/22/2007	15:35	2/23/2007	10:00	1380	Sample diluted	36.1	
7054007	LA-1B	grab	2/22/2007	15:55	2/23/2007	10:00	1797	Sample diluted	78.1	
7110060	AS-1M	grab	4/19/2007	11:45	4/20/2007	10:30	847		31.2	
7110061	AS-2M	grab	4/19/2007	11:00	4/20/2007	10:30	667		32.5	
7110062	AS-3M	grab	4/19/2007	12:35	4/20/2007	10:30	863		32.5	
7110063	LA-1M	grab	4/19/2007	14:55	4/20/2007	10:30	832		42.3	
7113001	AS-1M	grab	4/19/2007	11:45	4/23/2007	10:30	NS		NS	

7113002	AS-2M	grab	4/19/2007	11:00	4/23/2007	10:30	NS		NS	
7113003	AS-3M	grab	4/19/2007	12:35	4/23/2007	10:30	NS		NS	
7113004	AS-4S	grab	4/19/2007	13:55	4/23/2007	10:30	NS		NS	
7113005	LA-1M	grab	4/19/2007	14:55	4/23/2007	10:30	NS		NS	
7114001	AS-4S	grab	4/19/2007	13:55	4/24/2007	9:25	622		60	

UFI Lab ID	Client ID	Sample Type	Sampling Date	Sampling Time	Received Date	Received Time	Soluble Reactive Phosphorus (ug P/L)	flags (SRP)	Analysis Date (SRP)	Analysis Time (SRP)	Chlorophyll a (ug/L)
7054001	AS-1S	grab	2/22/2007	10:15	2/23/2007	10:00	1.6		2/23/2007	12:11	NS
7054002	AS-2S	grab	2/22/2007	11:50	2/23/2007	10:00	1.7		2/23/2007	12:22	NS
7054003	AS-2B	grab	2/22/2007	12:05	2/23/2007	10:00	47.7		2/23/2007	12:33	NS
7054004	AS-3S	grab	2/22/2007	14:00	2/23/2007	10:00	1.6		2/23/2007	12:45	NS
7054005	AS-4S	grab	2/22/2007	14:30	2/23/2007	10:00	1.1		2/23/2007	12:56	NS
7054006	LA-1S	grab	2/22/2007	15:35	2/23/2007	10:00	1.7		2/23/2007	13:07	NS
7054007	LA-1B	grab	2/22/2007	15:55	2/23/2007	10:00	21.2		2/23/2007	13:30	NS
7110060	AS-1M	grab	4/19/2007	11:45	4/20/2007	10:30	0.6	Sample less than the LOQ, but greater than the LOD	4/20/2007	12:22	NS
7110061	AS-2M	grab	4/19/2007	11:00	4/20/2007	10:30	0.4	Sample less than the LOQ, but greater than the LOD	4/20/2007	12:23	NS

7110062	AS-3M	grab	4/19/2007	12:35	4/20/2007	10:30	0.6	Sample less than the LOQ, but greater than the LOD	4/20/2007	12:24	NS
7110063	LA-1M	grab	4/19/2007	14:55	4/20/2007	10:30	0.7	Sample less than the LOQ, but greater than the LOD	4/20/2007	12:28	NS
7113001	AS-1M	grab	4/19/2007	11:45	4/23/2007	10:30	No Sample				8.7
7113002	AS-2M	grab	4/19/2007	11:00	4/23/2007	10:30	No Sample				7.7
7113003	AS-3M	grab	4/19/2007	12:35	4/23/2007	10:30	No Sample				6.8
7113004	AS-4S	grab	4/19/2007	13:55	4/23/2007	10:30	No Sample				11.5
7113005	LA-1M	grab	4/19/2007	14:55	4/23/2007	10:30	No Sample				4.6
7114001	AS-4S	grab	4/19/2007	13:55	4/24/2007	9:25	4.2	Sample received and analyzed outside of holding time	4/27/2007	13:00	NS

All results meet the requirements of ELAP unless otherwise noted.
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NS means no sample was collected and/or received, data flags may provide further information.
Data Flags indicate deviations from SOPs, if further interpretation of results is required, please contact UFI.

Analyte	LOQ	LOD	units	Method of analysis
Total Nitrogen	100	50	ug N/L	Chemi-pyroluminescence
Total Phosphorus	2.1	0.6	ug P/L	SM 18 20 4500 P E
Soluble Reactive Phosphorus	0.9	0.3	ug P/L	SM 18 20 4500 P E
Chlorophyll a	0.5	0.2	ug/L	EPA 445

5/31/2007

Jennifer Aicher, Laboratory Director
Upstate Freshwater Institute

Date

UPSTATE FRESHWATER INSTITUTE
P.O. Box 506
Syracuse, New York 13214

Data Report Number: CHM 7185

UPSTATE FRESHWATER INSTITUTE LABORATORY REPORT

Asylum Lake: Sampling Date 11/20/2007

Prepared for:

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Submitted by:

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UFI Lab ID	Client ID	Sample Type	Sampling Date	Sampling Time	Received Date	Received Time	Total Nitrogen (ug N/L)	Flags (TN)	Analysis Date	Analysis Time	Total (ug P/L)	Flags (TP)	TSS (mg/L)	Flags (TSS)	Comments
7325001	Asylum Lk (1)	grab	11/20/2007	10:30	11/21/2007	10:00					0.51				TP VALUES ARE mgP/g
7325002	Asylum Lk (2)	grab	11/20/2007	10:30	11/21/2007	10:00					0.59				TP VALUES ARE mgP/g
7325003	Little Asylum Lk (1)	grab	11/20/2007	11:35	11/21/2007	10:00					1.10				TP VALUES ARE mgP/g
7325004	Little Asylum Lk (2)	grab	11/20/2007	11:35	11/21/2007	10:00					1.07				TP VALUES ARE mgP/g

All results meet the requirements of ELAP unless otherwise noted.
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UFI is not responsible for sample handling and storage prior to their receipt.
NS means no sample was collected and/or received, data flags may provide further information.
Data Flags indicate deviations from SOPs, if further interpretation of results is required, please contact UFI.
UFI Contract Number: 280
ELAP ID 11462

Compiled by: ____________________
Christopher Hoy

Reviewed by:____________________
MaryGail Perkins

Date: 12/13/2007

UFI Lab ID	Client ID	Type	Sampling Date	Sampling	Receive Date	Receive Ti	Receive	Chl_fl	flags (chl_fl	TN	flags(TN)
6269006	Asylum Lake - SW1	grab	9/22/2006	10:00:00	9/26/2006	10:30:00		No Sample		1794	Sample diluted
6269007	Asylum Lake - SW2	grab	9/22/2006	10:30:00	9/26/2006	10:30:00		No Sample		997	
6269008	Asylum Lake - SW4	grab	9/22/2006	11:45:00	9/26/2006	10:30:00		No Sample		1994	Sample diluted
6325011	AS-1S	grab	11/20/2006	9:15:00	11/21/2006	10:30:00		No Sample		906	
6325012	AS-2M	grab	11/20/2006	9:50:00	11/21/2006	10:30:00		No Sample		908	
6325013	AS-3S	grab	11/20/2006	10:35:00	11/21/2006	10:30:00		No Sample		805	
6325014	AS-4S	grab	11/20/2006	11:10:00	11/21/2006	10:30:00		No Sample		754	
6325015	LS-1S	grab	11/20/2006	12:25:00	11/21/2006	10:30:00		No Sample		1096	
6325016	AS-BLANK	grab	11/20/2006		11/21/2006	10:30:00		No Sample		48	Sample below limit of detection
7054001	AS-1S	grab	2/22/2007	10:15:00	2/23/2007	10:00:00		No Sample		819	
7054002	AS-2S	grab	2/22/2007	11:50:00	2/23/2007	10:00:00		No Sample		906	
7054003	AS-2B	grab	2/22/2007	12:05:00	2/23/2007	10:00:00		No Sample		1323	Sample diluted
7054004	AS-3S	grab	2/22/2007	14:00:00	2/23/2007	10:00:00		No Sample		1616	Sample diluted
7054005	AS-4S	grab	2/22/2007	14:30:00	2/23/2007	10:00:00		No Sample		1115	
7054006	LA-1S	grab	2/22/2007	15:35:00	2/23/2007	10:00:00		No Sample		1380	Sample diluted
7054007	LA-1B	grab	2/22/2007	15:55:00	2/23/2007	10:00:00		No Sample		1797	Sample diluted
7110060	AS-1M	grab	4/19/2007	11:45:00	4/20/2007	10:30:00	5.9	No Sample		847	
7110061	AS-2M	grab	4/19/2007	11:00:00	4/20/2007	10:30:00	5.9	No Sample		667	
7110062	AS-3M	grab	4/19/2007	12:35:00	4/20/2007	10:30:00	5.9	No Sample		863	
7114001	AS-4S	grab	4/19/2007	13:55:00	4/24/2007	9:25:00	0	No Sample		622	
7110063	LA-1M	grab	4/19/2007	14:55:00	4/20/2007	10:30:00	5.9	No Sample		832	
7113001	AS-1M	grab	4/19/2007	11:45:00	4/23/2007	10:30:00	jla	8.7		No Sample	
7113002	AS-2M	grab	4/19/2007	11:00:00	4/23/2007	10:30:00	jla	7.7		No Sample	
7113003	AS-3M	grab	4/19/2007	12:35:00	4/23/2007	10:30:00	jla	6.8		No Sample	
7113004	AS-4S	grab	4/19/2007	13:55:00	4/23/2007	10:30:00	jla	11.5		No Sample	
7113005	LA-1M	grab	4/19/2007	14:55:00	4/23/2007	10:30:00	jla	4.6		No Sample	

UFI Lab ID	Client ID	Type	Sampling Date	Sampling	Receive Date	Receive Ti	Receive	TP	flags(TP)	SRP	flags(SRP)	Analysis Da	Analysis Time(SRP)
6269006	Asylum Lake - SW1	grab	9/22/2006	10:00:00	9/26/2006	10:30:00		498.1		6.3	Sample analyzed outside of holdin	9/26/2006	13:53:00
6269007	Asylum Lake - SW2	grab	9/22/2006	10:30:00	9/26/2006	10:30:00		99.4		19.5	Sample analyzed outside of holdin	9/26/2006	14:06:00
6269008	Asylum Lake - SW4	grab	9/22/2006	11:45:00	9/26/2006	10:30:00		327.9		255.2	Sample diluted, sample analyzed c	9/26/2006	14:20:00
6325011	AS-1S	grab	11/20/2006	9:15:00	11/21/2006	10:30:00		Already reported		Already reported			
6325012	AS-2M	grab	11/20/2006	9:50:00	11/21/2006	10:30:00		Already reported		Already reported			
6325013	AS-3S	grab	11/20/2006	10:35:00	11/21/2006	10:30:00		Already reported		Already reported			
6325014	AS-4S	grab	11/20/2006	11:10:00	11/21/2006	10:30:00		Already reported		Already reported			
6325015	LS-1S	grab	11/20/2006	12:25:00	11/21/2006	10:30:00		Already reported		Already reported			
6325016	AS-BLANK	grab	11/20/2006		11/21/2006	10:30:00		Already reported		Already reported			
7054001	AS-1S	grab	2/22/2007	10:15:00	2/23/2007	10:00:00		60.9		1.6		2/23/2007	12:11:00
7054002	AS-2S	grab	2/22/2007	11:50:00	2/23/2007	10:00:00		42.8		1.7		2/23/2007	12:22:00
7054003	AS-2B	grab	2/22/2007	12:05:00	2/23/2007	10:00:00		88.2		47.7		2/23/2007	12:33:00
7054004	AS-3S	grab	2/22/2007	14:00:00	2/23/2007	10:00:00		43.7		1.6		2/23/2007	12:45:00
7054005	AS-4S	grab	2/22/2007	14:30:00	2/23/2007	10:00:00		39		1.1		2/23/2007	12:56:00
7054006	LA-1S	grab	2/22/2007	15:35:00	2/23/2007	10:00:00		36.1		1.7		2/23/2007	13:07:00
7054007	LA-1B	grab	2/22/2007	15:55:00	2/23/2007	10:00:00		78.1		21.2		2/23/2007	13:30:00
7110060	AS-1M	grab	4/19/2007	11:45:00	4/20/2007	10:30:00	5.9	31.2		0.6	Sample less than the LOQ, but gre	4/20/2007	12:22:00
7110061	AS-2M	grab	4/19/2007	11:00:00	4/20/2007	10:30:00	5.9	32.5		0.4	Sample less than the LOQ, but gre	4/20/2007	12:23:00
7110062	AS-3M	grab	4/19/2007	12:35:00	4/20/2007	10:30:00	5.9	32.5		0.6	Sample less than the LOQ, but gre	4/20/2007	12:24:00
7114001	AS-4S	grab	4/19/2007	13:55:00	4/24/2007	9:25:00	0	60		4.2	Sample analyzed outside of holdin	4/27/2007	13:00:00
7110063	LA-1M	grab	4/19/2007	14:55:00	4/20/2007	10:30:00	5.9	42.3		0.7	Sample less than the LOQ, but gre	4/20/2007	12:28:00
7113001	AS-1M	grab	4/19/2007	11:45:00	4/23/2007	10:30:00	jla	No Sample		No Sample			
7113002	AS-2M	grab	4/19/2007	11:00:00	4/23/2007	10:30:00	jla	No Sample		No Sample			
7113003	AS-3M	grab	4/19/2007	12:35:00	4/23/2007	10:30:00	jla	No Sample		No Sample			
7113004	AS-4S	grab	4/19/2007	13:55:00	4/23/2007	10:30:00	jla	No Sample		No Sample			
7113005	LA-1M	grab	4/19/2007	14:55:00	4/23/2007	10:30:00	jla	No Sample		No Sample			

CITY OF KALAMAZOO PUBLIC SERVICES
LABORATORY REPORT

Location	Little Asylum Lake (Sediment)	Asylum Lake (Sediment)
Sample Date	11/20/2007	11/20/2007
Sample Time	11:35	10:30
Sampler	JLM/SM	JLM/SM
Method	EPA 365.4, SM4500P-B4,E	EPA 365.4, SM4500P-B4,E
Analyst	JB	JB
Units	g (Phosphorus) / kg (soil)	g (Phosphorus) / kg (soil)
Result	1.440	0.437

Calculations:	Weight of Soil (g)	Conc of dry soil in 20 ml solution g/L	)igested sampl Conc mg/L	)igested sample Conc g/L	Conc g (P)/g soil	Conc g (P)/kg (soil)
Little Asylum Lake	0.1973	9.865	14.21	0.01421	0.001440	1.440
Asylum Lake	0.6934	34.67	15.16	0.01516	0.000437	0.437

Sample Receipt Summary for WESTERN MICHIGAN UNIVERSITY

Report # F07058-8014 **Lab #** 14708 **Sample ID:** SED AS-1 **Matrix:** Soil **Date Sampled:** 2/22/2007 **Date Received:** 2/27/2007

COC Complete? Y
Samples intact / Good condition? Y
Proper containers for analysis requested? Y
Sufficient sample volume for analysis requested? Y
Sample submitted within required holding time? Y
Sample preserved correctly for analysis requested? N/A
Was sufficient ice used? N/A
Temperature: N/A degrees C
Packing material: On/In Ice
Receipt pH: N/A
Shipper: UPS Next Day Air
Tracking #: 1ZR7148F2210000072
Custody seals intact (if applicable): N/A
Other Noted Compliance Issues: NONE

Report # F07058-8014 **Lab #** 14709 **Sample ID:** SED AS-2 **Matrix:** Soil **Date Sampled:** 2/22/2007 **Date Received:** 2/27/2007

COC Complete? Y
Samples intact / Good condition? Y
Proper containers for analysis requested? Y
Sufficient sample volume for analysis requested? Y
Sample submitted within required holding time? Y
Sample preserved correctly for analysis requested? N/A
Was sufficient ice used? N/A
Temperature: N/A degrees C
Packing material: On/In Ice
Receipt pH: N/A
Shipper: UPS Next Day Air
Tracking #: 1ZR7148F2210000072
Custody seals intact (if applicable): N/A
Other Noted Compliance Issues: NONE

REPORT NO.
F07058-8014
ACCOUNT NUMBER
99990

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QUALITY ANALYSES FOR INFORMED DECISIONS

REPORT PRINTED 5/5/2008

TO: WESTERN MICHIGAN UNIVERSITY
WMU-WOOD HALL ROOM 3900
MAILSTOP 5419
KALAMAZOO, MI 49008

RE: ASYLUM LAKE
KALAMAZOO, MI

ATTN: CARI DELONG

DATE RECEIVED: 2/27/2007 12:25 PM
DATE REPORTED: 3/2/2007 **PAGE:** 1

REPORT OF ANALYSIS

LAB NUMBER	DATE SAMPLED	SAMPLE ID	PARAMETER	RESULT	UNIT	DETECTION LIMIT	ANALYST	ANALYSIS DATE	METHOD REFERENCE
14708	2/22/2007	SED AS-1	Mercury	0.082	mg/kg	0.001	CRT	3/2/2007	SW846-6020
14709	2/22/2007	SED AS-2	Mercury	0.091	mg/kg	0.001	CRT	3/2/2007	SW846-6020

Sample Receipt Summary for Western Michigan University

Report # F07110-8018 **Lab #** 16762 **Sample ID:** AS-1 SED A **Matrix:** Sediment **Date Sampled:** 4/19/2007 **Date Received:** 4/20/2007

COC Complete?	Y	Sufficient sample volume for analysis requested?	Y	Was sufficient ice used?	N/A	Shipper:	UPS Next Day Air
Samples intact / Good condition?	Y	Sample submitted within required holding time?	Y	Temperature:	N/A degrees C	Tracking #:	1ZR7148F2210000090
Proper containers for analysis requested?	Y	Sample preserved correctly for analysis requested?	N/A	Packing material:	On/In Ice	Custody seals intact (if applicable):	N/A
Other Noted Compliance Issues:	NONE			Receipt pH:	N/A		

Report # F07110-8018 **Lab #** 16763 **Sample ID:** AS-1 SED B **Matrix:** Sediment **Date Sampled:** 4/19/2007 **Date Received:** 4/20/2007

COC Complete?	Y	Sufficient sample volume for analysis requested?	Y	Was sufficient ice used?	N/A	Shipper:	UPS Next Day Air
Samples intact / Good condition?	Y	Sample submitted within required holding time?	Y	Temperature:	N/A degrees C	Tracking #:	1ZR7148F2210000090
Proper containers for analysis requested?	Y	Sample preserved correctly for analysis requested?	N/A	Packing material:	On/In Ice	Custody seals intact (if applicable):	N/A
Other Noted Compliance Issues:	NONE			Receipt pH:	N/A		

Report # F07110-8018 **Lab #** 16764 **Sample ID:** AS-2 SED A **Matrix:** Sediment **Date Sampled:** 4/19/2007 **Date Received:** 4/20/2007

COC Complete?	Y	Sufficient sample volume for analysis requested?	Y	Was sufficient ice used?	N/A	Shipper:	UPS Next Day Air
Samples intact / Good condition?	Y	Sample submitted within required holding time?	Y	Temperature:	N/A degrees C	Tracking #:	1ZR7148F2210000090
Proper containers for analysis requested?	Y	Sample preserved correctly for analysis requested?	N/A	Packing material:	On/In Ice	Custody seals intact (if applicable):	N/A
Other Noted Compliance Issues:	NONE			Receipt pH:	N/A		

Report # F07110-8018 **Lab #** 16765 **Sample ID:** AS-2 SED B **Matrix:** Sediment **Date Sampled:** 4/19/2007 **Date Received:** 4/20/2007

COC Complete?	Y	Sufficient sample volume for analysis requested?	Y	Was sufficient ice used?	N/A	Shipper:	UPS Next Day Air
Samples intact / Good condition?	Y	Sample submitted within required holding time?	Y	Temperature:	N/A degrees C	Tracking #:	1ZR7148F2210000090
Proper containers for analysis requested?	Y	Sample preserved correctly for analysis requested?	N/A	Packing material:	On/In Ice	Custody seals intact (if applicable):	N/A
Other Noted Compliance Issues:	NONE			Receipt pH:	N/A		

Report # F07110-8018 **Lab #** 16766 **Sample ID:** AS-3 SED A **Matrix:** Sediment **Date Sampled:** 4/19/2007 **Date Received:** 4/20/2007

COC Complete?	Y	Sufficient sample volume for analysis requested?	Y	Was sufficient ice used?	N/A	Shipper:	UPS Next Day Air
Samples intact / Good condition?	Y	Sample submitted within required holding time?	Y	Temperature:	N/A degrees C	Tracking #:	1ZR7148F2210000090
Proper containers for analysis requested?	Y	Sample preserved correctly for analysis requested?	N/A	Packing material:	On/In Ice	Custody seals intact (if applicable):	N/A
Other Noted Compliance Issues:	NONE			Receipt pH:	N/A		

Sample Receipt Summary for Western Michigan University

Report # F07110-8018 **Lab #** 16767 **Sample ID:** AS-3 SED B **Matrix:** Sediment **Date Sampled:** 4/19/2007 **Date Received:** 4/20/2007

COC Complete? Y
Samples intact / Good condition? Y
Proper containers for analysis requested? Y
Sufficient sample volume for analysis requested? Y
Sample submitted within required holding time? Y
Sample preserved correctly for analysis requested? N/A
Was sufficient ice used? N/A
Temperature: N/A degrees C
Packing material: On/In Ice
Receipt pH: N/A
Shipper: UPS Next Day Air
Tracking #: 1ZR7148F2210000090
Custody seals intact (if applicable): N/A
Other Noted Compliance Issues: NONE

Report # F07110-8018 **Lab #** 16768 **Sample ID:** AS-4 SED A **Matrix:** Sediment **Date Sampled:** 4/19/2007 **Date Received:** 4/20/2007

COC Complete? Y
Samples intact / Good condition? Y
Proper containers for analysis requested? Y
Sufficient sample volume for analysis requested? Y
Sample submitted within required holding time? Y
Sample preserved correctly for analysis requested? N/A
Was sufficient ice used? N/A
Temperature: N/A degrees C
Packing material: On/In Ice
Receipt pH: N/A
Shipper: UPS Next Day Air
Tracking #: 1ZR7148F2210000090
Custody seals intact (if applicable): N/A
Other Noted Compliance Issues: NONE

Report # F07110-8018 **Lab #** 16769 **Sample ID:** AS-4 SED B **Matrix:** Sediment **Date Sampled:** 4/19/2007 **Date Received:** 4/20/2007

COC Complete? Y
Samples intact / Good condition? Y
Proper containers for analysis requested? Y
Sufficient sample volume for analysis requested? Y
Sample submitted within required holding time? Y
Sample preserved correctly for analysis requested? N/A
Was sufficient ice used? N/A
Temperature: N/A degrees C
Packing material: On/In Ice
Receipt pH: N/A
Shipper: UPS Next Day Air
Tracking #: 1ZR7148F2210000090
Custody seals intact (if applicable): N/A
Other Noted Compliance Issues: NONE

Report # F07110-8018 **Lab #** 16770 **Sample ID:** LA-1 SED A **Matrix:** Sediment **Date Sampled:** 4/19/2007 **Date Received:** 4/20/2007

COC Complete? Y
Samples intact / Good condition? Y
Proper containers for analysis requested? Y
Sufficient sample volume for analysis requested? Y
Sample submitted within required holding time? Y
Sample preserved correctly for analysis requested? N/A
Was sufficient ice used? N/A
Temperature: N/A degrees C
Packing material: On/In Ice
Receipt pH: N/A
Shipper: UPS Next Day Air
Tracking #: 1ZR7148F2210000090
Custody seals intact (if applicable): N/A
Other Noted Compliance Issues: NONE

Report # F07110-8018 **Lab #** 16771 **Sample ID:** LA-1 SED B **Matrix:** Sediment **Date Sampled:** 4/19/2007 **Date Received:** 4/20/2007

COC Complete? Y
Samples intact / Good condition? Y
Proper containers for analysis requested? Y
Sufficient sample volume for analysis requested? Y
Sample submitted within required holding time? Y
Sample preserved correctly for analysis requested? N/A
Was sufficient ice used? N/A
Temperature: N/A degrees C
Packing material: On/In Ice
Receipt pH: N/A
Shipper: UPS Next Day Air
Tracking #: 1ZR7148F2210000090
Custody seals intact (if applicable): N/A
Other Noted Compliance Issues: NONE

Sample Receipt Summary for Western Michigan University

Report # F07110-8018	**Lab #** 16772	**Sample ID:** LA-2 SED A		**Matrix:** Sediment		**Date Sampled:** 4/19/2007	**Date Received:** 4/20/2007
COC Complete?	Y	Sufficient sample volume for analysis requested?	Y	Was sufficient ice used?	N/A	Shipper:	UPS Next Day Air
Samples intact / Good condition?	Y	Sample submitted within required holding time?	Y	Temperature:	N/A degrees C	Tracking #:	1ZR7148F2210000090
Proper containers for analysis requested?	Y	Sample preserved correctly for analysis requested?	N/A	Packing material:	On/In Ice	Custody seals intact (if applicable):	N/A
Other Noted Compliance Issues:	NONE			Receipt pH:	N/A		

Report # F07110-8018	**Lab #** 16773	**Sample ID:** LA-2 SED B		**Matrix:** Sediment		**Date Sampled:** 4/19/2007	**Date Received:** 4/20/2007
COC Complete?	Y	Sufficient sample volume for analysis requested?	Y	Was sufficient ice used?	N/A	Shipper:	UPS Next Day Air
Samples intact / Good condition?	Y	Sample submitted within required holding time?	Y	Temperature:	N/A degrees C	Tracking #:	1ZR7148F2210000090
Proper containers for analysis requested?	Y	Sample preserved correctly for analysis requested?	N/A	Packing material:	On/In Ice	Custody seals intact (if applicable):	N/A
Other Noted Compliance Issues:	NONE			Receipt pH:	N/A		

REPORT NO.
F07110-8018
ACCOUNT NUMBER
91516

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QUALITY ANALYSES FOR INFORMED DECISIONS

REPORT PRINTED 5/5/2008

TO: WESTERN MICHIGAN UNIVERSITY
WOOD HALL, ROOM 3900 MS 5419
KALAMAZOO, MI 49008-4049

RE: ASYLUM LAKE
KALAMAZOO, MI

ATTN: CARI DELONG

REPORT OF ANALYSIS

DATE RECEIVED: 4/20/2007 10:40 AM
DATE REPORTED: 4/27/2007 **PAGE:** 1

LAB NUMBER	DATE SAMPLED	SAMPLE ID	PARAMETER	RESULT	UNIT	DETECTION LIMIT	ANALYST	ANALYSIS DATE	METHOD REFERENCE
16762	4/19/2007	AS-1 SED A	Sample Digestion-Microwave				DLG	4/23/2007	SW846-3051
	4/19/2007		Mercury	0.092	mg/kg	0.001	CRT	4/23/2007	SW846-6020
16763	4/19/2007	AS-1 SED B	Sample Digestion-Microwave				DLG	4/23/2007	SW846-3051
	4/19/2007		Mercury	BDL*	mg/kg	0.001	CRT	4/23/2007	SW846-6020
16764	4/19/2007	AS-2 SED A	Sample Digestion-Microwave				DLG	4/23/2007	SW846-3051
	4/19/2007		Mercury	BDL*	mg/kg	0.001	CRT	4/23/2007	SW846-6020
16765	4/19/2007	AS-2 SED B	Sample Digestion-Microwave				DLG	4/23/2007	SW846-3051
	4/19/2007		Mercury	BDL*	mg/kg	0.001	CRT	4/23/2007	SW846-6020
16766	4/19/2007	AS-3 SED A	Sample Digestion-Microwave				DLG	4/23/2007	SW846-3051
	4/19/2007		Mercury	BDL*	mg/kg	0.001	CRT	4/23/2007	SW846-6020
16767	4/19/2007	AS-3 SED B	Sample Digestion-Microwave				DLG	4/23/2007	SW846-3051

* BDL - Below detection level of method utilized.

REPORT NO.
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QUALITY ANALYSES FOR INFORMED DECISIONS

REPORT PRINTED 5/5/2008

TO: WESTERN MICHIGAN UNIVERSITY
WOOD HALL, ROOM 3900 MS 5419
KALAMAZOO, MI 49008-4049

RE: ASYLUM LAKE
KALAMAZOO, MI

ATTN: CARI DELONG

REPORT OF ANALYSIS

DATE RECEIVED: 4/20/2007 10:40 AM
DATE REPORTED: 4/27/2007 **PAGE:** 2

LAB NUMBER	DATE SAMPLED	SAMPLE ID	PARAMETER	RESULT	UNIT	DETECTION LIMIT	ANALYST	ANALYSIS DATE	METHOD REFERENCE
16767	4/19/2007	AS-3 SED B	Mercury	BDL*	mg/kg	0.001	CRT	4/23/2007	SW846-6020
16768	4/19/2007	AS-4 SED A	Sample Digestion-Microwave				DLG	4/23/2007	SW846-3051
	4/19/2007		Mercury	BDL*	mg/kg	0.001	CRT	4/23/2007	SW846-6020
16769	4/19/2007	AS-4 SED B	Sample Digestion-Microwave				DLG	4/23/2007	SW846-3051
	4/19/2007		Mercury	BDL*	mg/kg	0.001	CRT	4/23/2007	SW846-6020
16770	4/19/2007	LA-1 SED A	Sample Digestion-Microwave				DLG	4/23/2007	SW846-3051
	4/19/2007		Mercury	BDL*	mg/kg	0.001	CRT	4/23/2007	SW846-6020
16771	4/19/2007	LA-1 SED B	Sample Digestion-Microwave				DLG	4/23/2007	SW846-3051
	4/19/2007		Mercury	BDL*	mg/kg	0.001	CRT	4/23/2007	SW846-6020
16772	4/19/2007	LA-2 SED A	Sample Digestion-Microwave				DLG	4/23/2007	SW846-3051
	4/19/2007		Mercury	BDL*	mg/kg	0.001	CRT	4/23/2007	SW846-6020

* BDL - Below detection level of method utilized.

REPORT NO.
F07110-8018
ACCOUNT NUMBER
91516

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TO: WESTERN MICHIGAN UNIVERSITY
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KALAMAZOO, MI 49008-4049

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KALAMAZOO, MI

ATTN: CARI DELONG

REPORT OF ANALYSIS

DATE RECEIVED: 4/20/2007 10:40 AM
DATE REPORTED: 4/27/2007 **PAGE:** 3

LAB NUMBER	DATE SAMPLED	SAMPLE ID	PARAMETER	RESULT	UNIT	DETECTION LIMIT	ANALYST	ANALYSIS DATE	METHOD REFERENCE
16773	4/19/2007	LA-2 SED B	Sample Digestion-Microwave				DLG	4/23/2007	SW846-3051
	4/19/2007		Mercury	BDL*	mg/kg	0.001	CRT	4/23/2007	SW846-6020

* BDL - Below detection level of method utilized.

Appendix E

Western Michigan University Analytical Report

REPORT: ASYLUM LAKE FEBRUARY AND APRIL 2007 SEDIMENT SAMPLING

Dr. Carla Koretsky & Christopher Landry
Geosciences Dept and Environmental Studies Program
Western Michigan University

II. SEDIMENT SAMPLES

Sediment Sample Collection and Analysis: Two sediment samples were taken on February 22, 2007 and 6 samples were collected on April 19, 2007 by Kieser and Associates. Samples were taken as follows: sediment samples were obtained using a grab sampler; sediment was than mixed in a large bowl, stirred, and placed in 50 mL vials. Samples were digested using a three-step procedure adapted from Tessier et al. (1979; 1982; Koretsky et al., 2006), as follows. Sediment were freeze-dried prior to extraction. Briefly, duplicate subsamples of ~2 g of dry sediment were extracted using four reagents in sequence: (1) 16 mL of 1M MgCl2 (adjusted to pH 7 using NaOH), (2) 16 mL of 1M Na Acetate adjusted to pH 5 with acetic acid for 5 hr at room temperature, (3) 40mL of 0.04M hydroxylamine HCl in 25% acetic acid for 6 hrs at 96°C, and (4) 6 mL of 0.02M nitric acid + 16 mL of 30% hydrogen peroxide (pH = 2_ for 2 hrs at 96°C, add 10 mL of 3.2M ammonium acetate in 20% nitric acid for an additional 30 minutes at room temperature. The first step targets exchangeable or mineral-surface bound metals, the second step carbonate minerals and associated (lattice bound or adsorbed) trace metals. The third step targets minerals that may undergo reductive dissolution, especially Fe and Mn oxides, releasing lattice-bound and adsorbed metals associated with these phases. The last step targets oxidizable fractions, especially organic matter or sulfides, and releases associated lattice-bound, complexed or adsorbed metals. Note: The sum of these four fractions will not, in general, be equivalent to a whole sediment digest. However, these four operationally-defined fractions likely include the most labile metals. Each experiment included a no-sediment control to assess metal concentrations resulting from reagents, acid-washed plastic centrifuge tubes, syringes and filters. After mixing with each extractant solution for the specified time, the sediment slurry was centrifuged at 5300 rpm for 30 min, an aliquot of supernatant was removed and filtered using a 0.2 mm pore size syringe filter and preserved using concentrated trace-metal grade HNO_3. Between each extraction step, the sediment residue was rinsed twice with 8mL of DDI water. Acidified supernatants were spiked with 100ppb of a multielement (Y, Sc) internal standard and analyzed for by ICP-AES (PerkinElmer Optima2100DV) for the following dissolved constituents: Cr, Cu, Fe, Ni, Mn, Zn, Cd, Co, Mo, Pb, V, Ba, Na, K, and Ca.

Koretsky C.M., Haas J.R., Ndenga N.T. and Miller D. (2006) Seasonal variations in vertical redox stratification and potential influence on trace metal speciation in minerotrophic peat sediments. Water Air and Soil Pollution 173, 373-403.

Tessier A., Campbell P.G.C. and Bisson M. (1979) Sequential extraction procedure for the speciation of particulate trace metals. Analytical Chemistry 51, 844-851.

Tessier A., Campbell P.G.C. and Bisson M. (1982) Particulate trace metal speciation in stream sediments and relationships with grain size: implications for geochemical exploration. Journal of Geochemical Exploration 16, 77-104.

Most of the trace elements have similar speciation in the three seasons, with site to site variability at least as great as seasonal variability. Samples collected in April and February were very watery and extremely organic rich. This caused some problems with respect to the organics step. The reaction was extremely energetic, and some sample was lost during this step. The amount of sample lost was estimated. However, organics associated metal concentrations should be regarded as qualitative estimates only.

Elements associated with operationally-defined exchangeable fraction (step 1 of sequential extraction) in micrograms element per g dry weight sediment. % RSD values are for 3 replicates ICP analyses of each sample. Cr, Cu, and Cd <0.08 µg/g and V is < 0.40 µg/g in all samples. Ni not analyzed due to high concentrations in extracting reagent. Values in red are very close to detection limits and have high errors.

SAMPLE	Mn	% RSD	Fe	% RSD	Zn	% RSD	Co	% RSD	Mo	% RSD	Pb	% RSD	Ba	% RSD
4/19/97														
AS-1(1)	72.6	1.4	<0.08		<0.08		<0.08		<0.40		<0.40		19.4	2.0
AS-1(2)	57.3	4.1	0.10	19.6	0.64	1.3	<0.08		<0.40		<0.40		18.2	2.1
AS-2(1)	47.3	1.4	0.11	11.9	0.30	2.7	<0.08		<0.40		<0.40		10.9	2.4
AS-2(2)	53.8	1.9	<0.08		<0.08		<0.08		0.42	9.2	<0.40		12.1	1.2
AS-3(1)	41.1	.8	<0.08		<0.08		<0.08		0.54	6.4	<0.40		9.49	1.1
AS-3(2)	53.5	4.0	<0.08		<0.08		<0.08		0.47	6.9	<0.40		10.3	2.6
AS-4(1)	19.2	3.0	<0.08		0.24	11.1	<0.08		0.47	8.0	<0.40		12.8	1.4
AS-4(2)	31.1	4.1	<0.08		0.20	19.3	<0.08		<0.40		<0.40		13.1	1.9
LS-1(1)	71.1	3.0	0.19	9.2	<0.08		<0.08		<0.40		<0.40		21.3	0.8
LS-1(2)	68.3	3.4	0.24	3.1	<0.08		<0.08		<0.40		<0.40		22.4	1.7
LA-2(1)	24.0	8.4	49.2	1.4	0.82	3.4	0.24	4.4	<0.40		0.91	7.7	18.5	1.5
AS-4(2)	35.7	2.3	64.5	0.5	0.82	3.9	0.22	4.4	<0.40		0.70	6.4	21.1	2.1
2/22/07														
AS-1(1)	114	1.4	0.20	3.7	<0.08		<0.08		0.59	13.1	<0.40		20.5	0.64
AS-1(2)	104	3.6	0.46	3.7	<0.08		<0.08		0.59	8.3	<0.40		20.1	0.37
AS-2(1)	122	2.0	0.11	5.1	<0.08		<0.08		<0.40		<0.40		23.5	0.75

Step 1 (Exchangeables) Cont'd

SAMPLE	Na	% RSD	K	% RSD	Ca	% RSD
4/19/97						
AS-1(1)	**385.9**	3.4	**82.8**	4.3	**4776**	0.58
AS-1(2)	**385.0**	1.4	**77.0**	4.8	**4558**	2.4
AS-2(1)	**202.6**	2.7	**28.1**	4.7	**2386**	2.5
AS-2(2)	**253.8**	1.9	**26.6**	14.6	**2307**	1.9
AS-3(1)	**233.4**	2.1	**25.7**	19.1	**2402**	1.9
AS-3(2)	**212.6**	1.8	**24.1**	10.1	**2310**	1.7
AS-4(1)	**753.0**	2.1	**252.0**	3.4	**4839**	1.7
AS-4(2)	**539.8**	2.2	**117.5**	2.3	**4459**	1.7
LS-1(1)	**731.5**	2.6	**160.8**	2.3	**7023**	1.3
LS-1(2)	**855.2**	4.1	**187.4**	3.5	**7014**	3.5
LA-2(1)	**4438**	1.3	**40.2**	7.5	**1766**	2.9
AS-4(2)	**7506**	0.44	**59.3**	5.6	**2656**	1.1
2/22/07						
AS-1(1)	**504.2**	1.1	**53.0**	3.2	**4124**	2.2
AS-1(2)	**385.3**	1.3	**46.9**	7.3	**3707**	1.2
AS-2(1)	**1247**	1.3	**349.6**	0.5	**7450**	0.30

Elements associated with operationally-defined carbonate fraction (step 2 of sequential extraction) in micrograms element per g dry weight sediment. % RSD values are for 3 replicates ICP analyses of each sample. Mo is <0.40 and V is <0.80 µg/g in all samples. Na not analyzed due to high concentration in extracting reagent. Note: Mg and Ni may be high due to high concentrations in step 1 reagents.

SAMPLE	Cr	% RSD	Cu	% RSD	Fe	% RSD	Ni	% RSD	Mn	% RSD	Zn	% RSD	Cd	% RSD
4/19/97														
AS-1(1)	**<0.08**		**<0.08**		**27.2**	0.12	**2.6**	1.4	**329.4**	13.0	**9.6**	1.8	**<0.08**	
AS-1(2)	**<0.08**		**<0.08**		**60.5**	2.0	**2.5**	1.3	**317.4**	6.4	**5.1**	1.9	**<0.08**	
AS-2(1)	**<0.08**		**<0.08**		**6.6**	2.1	**3.5**	1.6	**420.5**	6.2	**6.3**	3.1	**<0.08**	
AS-2(2)	**<0.08**		**<0.08**		**10.1**	3.3	**3.7**	3.9	**345.0**	1.7	**7.4**	3.4	**<0.08**	
AS-3(1)	**<0.08**		**<0.08**		**2.8**	6.3	**2.8**	1.4	**387.5**	9.2	**3.3**	1.0	**<0.08**	
AS-3(2)	**<0.08**		**0.24**	2.5	**3.7**	1.2	**3.2**	1.9	**419.5**	7.1	**3.2**	1.8	**<0.08**	
AS-4(1)	**<0.08**		**<0.08**		**<0.08**		**1.1**	3.6	**260.8**	4.0	**0.87**	1.4	**<0.08**	
AS-4(2)	**<0.08**		**<0.08**		**<0.08**		**0.97**	1.3	**247.0**	5.4	**2.4**	0.44	**<0.08**	
LS-1(1)	**<0.08**		**<0.08**		**<0.08**		**0.61**	2.4	**215.4**	9.4	**1.9**	1.2	**<0.08**	
LS-1(2)	**<0.08**		**<0.08**		**<0.08**		**0.62**	1.9	**206.4**	6.0	**1.9**	2.3	**<0.08**	
LA-2(1)	**0.43**	1.1	**0.40**	0.87	**>60**		**4.0**	2.4	**36.9**	1.1	**31.0**	1.8	**8.5**	4.1
AS-4(2)	**0.43**	4.2	**0.41**	1.9	**>60**		**3.8**	2.8	**24.2**	2.5	**29.9**	2.0	**7.6**	5.0
2/22/07														
AS-1(1)	**<0.08**		**<0.08**		**46.1**	1.2	**4.3**	0.48	**17.9**	6.7	**4.9**	1.8	**<0.08**	
AS-1(2)	**<0.08**		**<0.08**		**42.5**	1.1	**3.5**	1.4	**16.8**	1.2	**5.0**	0.91	**<0.08**	
AS-2(1)	**<0.08**		**0.12**	2.1	**0.17**	57.0	**0.72**	3.0	**12.5**	5.8	**2.8**	0.56	**<0.08**	

Step 2 (Carbonates) Cont'd

SAMPLE	Co	% RSD	Pb	% RSD	Ba	% RSD	K	% RSD	Ca	% RSD	Mg	% RSD
4/19/97												
AS-1(1)	**0.19**	2.9	**13.4**	2.3	**30.7**	0.99	**31.6**	7.5	**38880**	1.6	**11883**	1.4
AS-1(2)	**0.13**	4.1	**10.5**	2.4	**31.7**	0.63	**29.8**	4.4	**40192**	2.7	**10982**	1.2
AS-2(1)	**0.13**	12.8	**7.9**	3.6	**25.7**	1.8	**20.0**	11.0	**44208**	1.6	**7984**	2.9
AS-2(2)	**0.14**	9.6	**7.8**	4.8	**27.2**	48.6	**12.8**	20.4	**40912**	2.3	**5394**	2.2
AS-3(1)	**0.09**	4.6	**5.9**	0.11	**23.1**	1.6	**17.2**	7.9	**43664**	2.5	**7302**	2.1
AS-3(2)	**0.10**	8.4	**7.8**	1.7	**24.5**	1.5	**17.6**	13.2	**42784**	1.7	**6938**	2.9
AS-4(1)	**<0.08**		**1.2**	9.1	**23.3**	3.0	**23.0**	9.8	**35904**	0.66	**16832**	6.4
AS-4(2)	**<0.08**		**0.94**	6.4	**23.5**	1.3	**44.2**	2.6	**35984**	0.84	**16592**	0.16
LS-1(1)	**<0.08**		**2.6**	2.4	**22.0**	0.69	**45.5**	3.6	**29744**	2.48	**25040**	2.2
LS-1(2)	**<0.08**		**2.7**	3.9	**23.4**	2.4	**35.4**	5.7	**33152**	1.1	**24480**	2.3
LA-2(1)	**0.71**	1.1	**26.21**	2.4	**8.7**	2.3	**15.0**	2.5	**1365.9**	9.8	**7000**	2.0
AS-4(2)	**0.69**	2.2	**37.2**	2.1	**8.1**	3.5	**8.8**	39.8	**1657.6**	14.3	**4317**	0.52
2/22/07												
AS-1(1)	**0.12**	10.6	**6.7**	0.99	**31.0**	1.7	**15.8**	4.7	**46800**	0.45	**12386**	0.5
AS-1(2)	**0.12**	9.2	**6.3**	2.2	**28.9**	1.0	**19.4**	4.9	**44960**	1.8	**10968**	1.1
AS-2(1)	**<0.08**		**2.0**	1.9	**24.6**	2.8	**N/A**	N/A	**31760**	1.6	**23744**	0.9

Elements associated with operationally-defined reducibles fraction (step 3 of sequential extraction) in micrograms element per g dry weight sediment. % RSD values are for 3 replicates ICP analyses of each sample. Cu is <0.08 and Mo <0.40 µg/g in all samples. Note: Ni may be high due to high concentrations in step 1 reagents. Mg not analyzed.

SAMPLE	Cr	% RSD	Fe	% RSD	Ni	% RSD	Mn	% RSD	Zn	% RSD	Cd	% RSD	Co	% RSD
4/19/97														
AS-1(1)	**0.86**	0.4	**1492**	5.0	**2.5**	3.3	**88.8**	2.9	**33.2**	3.1	**0.24**	1.4	**0.34**	3.1
AS-1(2)	**0.90**	2.1	**1646**	2.5	**2.6**	3.5	**96.2**	2.3	**38.5**	2.8	**0.25**	3.3	**0.33**	4.6
AS-2(1)	**0.45**	1.8	**730.2**	5.0	**2.4**	2.4	**78.7**	2.9	**18.4**	0.97	**0.21**	2.7	**0.15**	4.6
AS-2(2)	**0.33**	2.6	**618.6**	2.3	**1.4**	2.8	**60.0**	2.9	**13.4**	0.86	**0.13**	5.9	**0.10**	7.4
AS-3(1)	**0.36**	1.0	**352.2**	8.2	**2.2**	2.3	**102.6**	2.6	**15.2**	2.7	**0.22**	1.8	**0.10**	3.4
AS-3(2)	**0.38**	2.8	**397.5**	4.0	**2.2**	1.8	**104.4**	4.0	**17.5**	2.1	**0.22**	3.5	**0.11**	9.9
AS-4(1)	**0.09**	9.7	**69.2**	13.6	**1.2**	1.7	**82.7**	1.7	**13.3**	1.5	**0.16**	1.7	**<0.08**	
AS-4(2)	**0.07**	3.1	**51.8**	18.0	**1.2**	1.9	**77.3**	2.9	**12.2**	2.1	**0.14**	6.0	**<0.08**	
LS-1(1)	**0.09**	6.0	**112.2**	10.3	**1.1**	2.9	**37.3**	5.4	**25.9**	2.8	**0.24**	5.9	**<0.08**	
LS-1(2)	**0.08**	11.2	**129.4**	15.7	**1.0**	3.3	**37.1**	2.7	**27.3**	3.5	**0.24**	3.5	**<0.08**	
LA-2(1)	**0.66**	1.8	**1650**	1.5	**1.6**	1.8	**36.2**	1.2	**18.4**	0.68	**0.07**	1.6	**0.32**	1.9
AS-4(2)	**0.75**	2.5	**1740**	2.2	**1.8**	3.6	**35.9**	4.1	**22.2**	0.96	**0.10**	6.2	**0.38**	2.1
2/22/07														
AS-1(1)	**0.56**	1.4	**1337**	2.4	**2.5**	1.6	**109.3**	0.61	**18.5**	1.1	**0.19**	1.8	**0.19**	4.9
AS-1(2)	**0.59**	4.1	**1409**	2.5	**2.9**	4.6	**126.8**	2.1	**20.1**	2.2	**0.20**	5.2	**0.20**	0.49
AS-2(1)	**0.08**	6.41	**139.4**	7.8	**1.1**	1.9	**38.6**	6.0	**18.7**	2.4	**0.18**	3.4	**<0.08**	

Step 3 (Reducibles) Cont'd

SAMPLE	Pb	% RSD	V	% RSD	Ba	% RSD	Na	% RSD	K	% RSD	Ca	% RSD
4/19/97												
AS-1(1)	**27.4**	2.4	**2.0**	2.9	**2455.2**	1.9	**2455.2**	3.6	**30.3**	6.5	**28760**	2.6
AS-1(2)	**29.8**	3.2	**2.2**	2.8	**2645.6**	1.8	**2645.6**	1.1	**33.1**	2.5	**30968**	1.6
AS-2(1)	**15.9**	2.7	**1.8**	1.9	**1868.0**	3.1	**1868.0**	0.59	**22.2**	4.0	**49200**	1.3
AS-2(2)	**8.4**	2.8	**1.1**	1.3	**1389.6**	2.6	**1389.6**	3.0	**14.9**	2.3	**33296**	1.5
AS-3(1)	**11.9**	1.6	**1.4**	4.1	**1489.6**	0.34	**1489.6**	1.4	**21.6**	5.6	**63264**	1.8
AS-3(2)	**12.5**	4.1	**1.4**	3.6	**1675.2**	0.61	**1675.2**	3.2	**20.9**	1.1	**67392**	2.5
AS-4(1)	**10.0**	2.3	**<0.40**		**4340.0**	1.0	**4340.0**	1.3	**14.9**	0.50	**75528**	1.4
AS-4(2)	**9.1**	1.6	**<0.40**		**5004.8**	3.5	**5004.8**	1.9	**214**	0.99	**71640**	1.4
LS-1(1)	**16.0**	3.8	**<0.40**		**7030.4**	2.4	**7030.4**	3.3	**N/A**	N/A	**28544**	3.6
LS-1(2)	**14.9**	2.2	**<0.40**		**6175.2**	0.61	**6175.2**	2.4	**26.5**	1.6	**26864**	2.1
LA-2(1)	**12.7**	1.2	**1.3**	1.8	**1596.8**	1.2	**1596.8**	1.8	**11.4**	1.9	**2300**	0.68
AS-4(2)	**20.4**	1.5	**1.3**	1.7	**1312.0**	2.9	**1312.0**	1.1	**11.0**	2.4	**2159.2**	3.6
2/22/07												
AS-1(1)	**13.1**	5.4	**2.3**	1.4	**4642.4**	0.98	**4642.4**	0.41	**31.7**	1.0	**62216**	2.0
AS-1(2)	**15.5**	4.9	**2.5**	2.4	**4331.2**	1.3	**4331.2**	1.3	**34.5**	1.1	**59584**	2.6
AS-2(1)	**9.5**	3.9	**<0.40**	9.6	**8832.0**	0.42	**8832.0**	3.0	**42.7**	1.6	**20472**	0.98

Elements associated with operationally-defined oxidizables fraction (step 4 of sequential extraction) in micrograms element per g dry weight sediment. % RSD values are for 3 replicates ICP analyses of each sample. Cd is <0.08 µg/g in all samples. Note: Ni may be high due to high concentrations in step 1 reagents. V and Mg not analyzed. ***Note: Values are qualitative estimates only.***

SAMPLE	Cr	% RSD	Cu	% RSD	Fe	% RSD	Ni	% RSD	Mn	% RSD	Zn	% RSD	Co	% RSD
4/19/97														
AS-1(1)	**2.3**	1.8	**4.7**	6.2	**2202**	2.6	**1.7**	0.89	**6.6**	0.06	**4.9**	4.0	**0.64**	1.5
AS-1(2)	**3.2**	0.71	**6.6**	0.98	**3411**	2.3	**2.4**	2.4	**2.4**	42.2	**8.0**	1.2	**0.96**	1.9
AS-2(1)	**0.45**	3.2	**1.7**	0.98	**622.1**	4.6	**0.72**	1.3	**4.8**	1.9	**1.7**	0.92	**0.25**	2.7
AS-2(2)	**0.56**	1.5	**2.1**	2.3	**1074**	6.6	**0.73**	1.2	**4.8**	2.2	**2.1**	1.1	**0.30**	3.0
AS-3(1)	**0.93**	3.3	**2.5**	2.3	**1607**	4.6	**1.6**	0.77	**3.4**	36.2	**3.3**	1.0	**0.49**	1.9
AS-3(2)	**N/A**	N/A	**N/A**	N/A	**N/A**	N/A	**N/A**	N/A	**N/A**	N/A	**N/A**	N/A	**N/A**	N/A
AS-4(1)	**1.1**	2.4	**3.2**	2.3	**1006**	2.6	**3.0**	1.6	**1.1**	35.4	**3.5**	2.7	**0.33**	5.4
AS-4(2)	**0.97**	1.7	**2.6**	1.7	**1002**	7.1	**2.8**	0.94	**2.5**	12.4	**0.05**	5.3	**0.29**	2.2
LS-1(1)	**1.4**	1.6	**68.3**	6.4	**2098**	3.4	**3.8**	3.1	**5.7**	20.5	**14.4**	3.8	**0.59**	1.2
LS-1(2)	**1.4**	1.7	**63.6**	3.5	**2009**	1.1	**3.6**	2.8	**5.8**	17.1	**14.1**	3.8	**0.57**	3.0
LA-2(1)	**2.1**	2.0	**9.6**	2.0	**556.8**	3.9	**1.1**	6.4	**2.9**	2.4	**3.1**	2.9	**0.53**	1.2
AS-4(2)	**2.5**	0.91	**10.6**	0.54	**555.5**	0.68	**1.2**	0.35	**3.1**	0.31	**9.9**	2.5	**0.61**	2.1
2/22/07														
AS-1(1)	**0.50**	0.63	**1.9**	0.42	**728.5**	3.7	**0.74**	2.6	**5.7**	2.4	**1.8**	1.2	**0.38**	6.5
AS-1(2)	**0.60**	1.6	**2.4**	2.0	**1006**	5.8	**0.91**	3.5	**<1**		**2.4**	1.2	**0.52**	3.3
AS-2(1)	**1.2**	2.7	**132.9**	0.70	**1725**	3.9	**3.4**	3.1	**7.1**	20.3	**9.9**	2.5	**0.49**	2.9

Step 4 (Oxidizables) Cont'd

SAMPLE	Mo	% RSD	Pb	% RSD	Ba	% RSD	Na	% RSD	K	% RSD	Ca	% RSD
4/19/97												
AS-1(1)	**<0.40**		**<0.40**		**0.55**	2.0	**40.9**	1.6	**4.3**	2.0	**1096**	2.8
AS-1(2)	**<0.40**		**10.1**	1.2	**3.6**	0.72	**62.0**	0.87	**8.7**	1.5	**1760**	2.2
AS-2(1)	**<0.40**		**<0.40**		**0.51**	1.4	**14.6**	7.6	**3.0**	1.1	**753.4**	0.82
AS-2(2)	**<0.40**		**<0.40**		**0.27**	3.0	**14.5**	15.4	**2.2**	2.8	**558.2**	4.5
AS-3(1)	**<0.40**		**1.2**	1.8	**2.0**	1.1	**16.5**	15.5	**5.4**	2.2	**1294**	1.3
AS-3(2)	**N/A**	N/A	**N/A**	N/A	**N/A**	N/A	**N/A**	N/A	**N/A**	N/A	**N/A**	N/A
AS-4(1)	**<0.40**		**1.3**	3,0	**2.9**	1.8	**168.1**	4.0	**3.7**	2.7	**3608**	2.7
AS-4(2)	**<0.40**		**0.65**	2.7	**3.0**	3.0	**210.0**	6.1	**3.7**	5.3	**3572**	4.5
LS-1(1)	**0.54**	5.0	**10.2**	1.0	**3.1**	3.0	**580.8**	4.0	**12.2**	3.2	**3387**	5.3
LS-1(2)	**0.52**	2.4	**7.1**	3.3	**2.6**	1.1	**413.3**	2.9	**8.1**	1.3	**2766**	1.3
LA-2(1)	**<0.40**		**4.2**	1.8	**1.2**	1.6	**15.4**	3.6	**5.9**	0.69	**292.8**	4.3
AS-4(2)	**<0.40**		**11.6**	0.96	**1.2**	1.3	**15.9**	4.6	**4.8**	1.6	**406.6**	2.9
2/22/07												
AS-1(1)	**<0.40**		**<0.40**		**0.11**	7.4	**52.0**	1.9	**2.6**	1.7	**1241**	3.2
AS-1(2)	**<0.40**		**<0.40**		**0.74**	2.1	**66.3**	7.7	**4.8**	1.2	**1549**	2.8
AS-2(1)	**0.57**	5.1	**8.4**	1.8	**3.2**	1.8	**973.6**	4.3	**7.4**	9.8	**3098**	2.6

REPORT: ASYLUM LAKE APRIL 2007 WATER SAMPLING

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I. WATER SAMPLES

Water Sample Collection and Analysis: Ten (10) water samples were collected by Kieser and Associates. Samples were taken as follows: 50 mL plastic vials were rinsed once with sample water then filled. Half of the water was syringe-filtered through an 0.2? nylon filter into a fresh plastic vial. Samples were than acidified with one drop of trace-metal grade nitric acid per 10mL of sample (~1% HNO_3). Each sample was analyzed by ICP-AES (PerkinElmer Optima2100DV) for the following dissolved constituents: Cr, Cu, Fe, Ni, Mn, Zn, Cd, Co, Mo, Pb, V, Ba, Na, Mg, K, Ca (16 elements). Samples were prepared for analyses in 5% nitric acid with 100ppb spikes of internal standards (Sc, Y).

Many elements were found to be below detection limits (DLs) in all samples. These elements are: Cr (<5 ppb), Cu (<5 ppb), Fe (<5 ppb), Ni (<10 ppb), Cd (<5 ppb), Co (<5 ppb), Mo (<10 ppb), and V (<10 ppb).

Dissolved Major Elements in parts per million (ppm). % RSD from 3 replicate ICP analyses on a single sample.

SAMPLE	Ca (ppm)	% RSD	Na (ppm)	% RSD	Mg (ppm)	% RSD	K (ppm)	% RSD
AS-1M U	53.02	1.2	97.77	0.76	22.85	0.91	2.169	10.5
AS-1M F	55.71	2.1	98.06	0.3	23.11	1.6	2.291	4.5
AS-2M U	53.25	2.7	94.69	1.2	21.54	2.2	2.069	9.7
AS-2M F	55.33	5.2	97.89	2.3	22.47	2.5	2.136	10.8
AS-3M U	53.97	3.6	97.96	1.9	22.62	1.6	2.224	18.1
AS-3M F	56.49	2.8	97.88	1.3	22.97	1.7	2.402	13.1
AS-4S U	52.48	2.4	96.5	2.0	22.47	2.6	2.362	8.7
AS-4S F	52.99	1.3	96.29	0.63	22.77	2.4	2.084	1.3
LS-1M U	50.26	3.0	91.99	4.0	22.33	4.4	2.085	8.5
LS-1M F	50.88	0.8	92.08	0.51	21.58	2.1	1.944	3.2

Notes: Potassium numbers have somewhat high % RSD values.

Dissolved Minor or Trace Elements in parts per billion (ppb).
% RSD from 3 replicate ICP analyses on a single sample.

SAMPLE	Mn	% RSD	Ba	% RSD	Zn	% RSD	Pb	% RSD
AS-1M U	30.55	3.0	104.7	0.93	<5		<10	
AS-1M F	<5		111.4	2.1	120.8	5.9	11.8	78.7
AS-2M U	35.74	2.6	116.5	2.4	<5		21.5	31.0
AS-2M F	<5		115.9	2.9	82.0	4.2	23.4	34.2
AS-3M U	35.26	1.12	117.3	1.9	<5		<10	
AS-3M F	<5		114.5	2.6	39.2	6.3	26.4	62.6
AS-4S U	38.64	0.82	102.1	0.67	15.9	13.4	13.4	33.4
AS-4S F	20.18	1.8	105.4	3.0	75.4	4.1	35.8	31.9
LS-1M U	32.35	4.3	95.7	2.4	9.0	13.5	13.1	132.6
LS-1M F	14.85	2.5	105.2	6.9	78.8	3.1	15.3	107.7

Notes: Pb values are close to detection limits for all samples (all have high % RSD values). Ba values are higher for filtered compared to unfiltered samples. This was seen in all other collection periods, and is likely an artifact from the syringe needles or filters used for the filtration,

7887REPORT: ASYLUM LAKE AUGUST 2006 WATER AND SEDIMENT SAMPLING

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I. WATER SAMPLES

Water Sample Collection and Analysis: Twenty-two (22) water samples were taken on August 9, 2006 by Melanie Havemen (MS Geosciences student) working together with Jeff Spoelstra of Kieser and Associates. Samples were taken as follows: 50 mL plastic vials were rinsed once with sample water then filled. Half of the water was syringe-filtered through an 0.2?m nylon filter into a fresh plastic vial. Samples were than acidified with one drop of trace-metal grade nitric acid per 10mL of sample (~1% HNO_3). Each sample was analyzed by ICP-AES (PerkinElmer Optima2100DV) for the following dissolved constituents: Ca, Na, Mg, Mn, Cr, Cu, Fe, Ni, Zn, Al, As, Cd, Co, Mo, Se, V, and Ba (17 elements). Samples were prepared for analyses in 5% nitric acid with 100ppb spikes of internal standards (Sc, Y).

Several elements were found to be below detection limits (DLs) of approximately 50ppb in all samples. These elements are: Zn, Al, As, Mo, Pb, Se, V.

Cadmium (Cd) levels are consistently above the EPA drinking water maximum contaminant level (MCL) of 5ppb. We recommend follow-up analyses, perhaps using ICP-MS, to confirm these high levels. According to the EPA website, “Corrosion of galvanized pipes; erosion of natural deposits; discharge from metal refineries; runoff from waste batteries and paints” are typical contaminant sources for Cd in drinking water supplies.

Sample Key:

AS-1SF: Asylum Lake filtered water taken at the surface from the west side of the lake
AS-1SU: Asylum Lake unfiltered water taken at the surface from the west side of the lake
AS-1F(5m): Asylum Lake filtered water from 5 m deep (just above thermocline): west side of the lake
AS-1U(5m): Asylum Lake unfiltered water from 5 m deep (just above thermocline): west side of the lake
AS-1F(6m): Asylum Lake filtered water from 6 m deep (just below thermocline): west side of the lake
AS-1U(6m): Asylum Lake unfiltered water from 5 m deep (just above thermocline): west side of the lake
AS-1BF: Asylum Lake filtered water from 13 m deep (just above the lake bottom): west side of the lake
AS-1BU: Asylum Lake unfiltered water from 13 m deep (just above the lake bottom): west side of the lake
AS-2SF: Asylum Lake filtered water taken at the surface from the center of the lake
AS-2SU: Asylum Lake unfiltered water taken at the surface from the center of the lake
AS-2BF: Asylum Lake filtered water taken just above the lake bottom (about 15 m deep) at the center of the lake
AS-2BU: Asylum Lake unfiltered water taken just above the lake bottom (about 15 m deep) at the center of the lake
AS-3SF: Asylum Lake filtered water taken at the surface from the east side of the lake
AS-3SU: Asylum Lake unfiltered water taken at the surface from the east side of the lake
AS-3BF: Asylum Lake filtered water from about 9 m deep (just above the lake bottom): east side of the lake
AS-3BU: Asylum Lake unfiltered water from about 9 m deep (just above the lake bottom): east side of the lake
AS-4SF: Asylum Lake filtered water taken from an out flow creek on the southeast edge of the lake
AS-4SU: Asylum Lake unfiltered water taken from an out flow creek on the southeast edge of the lake
LA-1SF: Little Asylum Lake filtered water taken from the surface at the center of the lake
LA-1SU: Little Asylum Lake unfiltered water taken from the surface at the center of the lake
LA-1BF: Little Asylum Lake filtered water taken from just above the lake bottom (about 2.5m) at the center of the lake
LA-1BU: Little Asylum Lake unfiltered water taken from just above the lake bottom (about 2.5m) at the center of the lake

Dissolved Major Elements in parts per million (ppm). % RSD from 3 replicate ICP analyses on a single sample.

SAMPLE	Ca (ppm)	% RSD	Na (ppm)	% RSD	Mg (ppm)	% RSD
AS-1SF	**37.2**	4.4	**91.3**	0.4	**22.9**	0.61
AS-1SU	**36.8**	2.6	**92.6**	3.6	**22.7**	2.2
AS-1F(5m)	**47.6**	2.3	**94.8**	2.2	**22.4**	1
AS-1U(5m)	**48.6**	2.6	**95.6**	1.6	**22.8**	1.2
AS-1F(6m)	**49.3**	3.6	**94.3**	3.1	**22.6**	3.2
AS-1U(6m)	**48.4**	0.59	**93.1**	0.93	**22.6**	2.5
AS-1BF	**57.7**	4.8	**96.1**	1.3	**23.4**	1.9
AS-1BU	**56.6**	0.85	**94.0**	1.9	**22.6**	0.7
AS-2SF	**36.7**	0.84	**93.1**	0.84	**23.3**	1.1
AS-2SU	**35.9**	3	**88.7**	3.2	**22.4**	2
AS-2BF	**65.1**	4.4	**100.3**	0.61	**25.0**	3.3
AS-2BU	**64.9**	1.9	**96.3**	1.6	**24.0**	1.1
AS-3S F	**37.2**	2	**92.7**	2.7	**22.7**	0.91
AS-3SU	**34.9**	0.7	**87.1**	1.2	**22.2**	0.47
AS-3BF	**55.4**	2.3	**95.4**	1	**23.0**	2.7
AS-3BU	**55.2**	2.5	**92.9**	2.9	**22.7**	3
AS-4SF	**36.6**	4.7	**88.5**	3.2	**22.6**	2
AS-4SU	**35.6**	3	**87.7**	1.1	**22.3**	1.4
LA-1SF	**35.8**	5.6	**93.1**	1.1	**21.8**	4.8
LA-1SU	**34.7**	0.74	**92.5**	1.5	**22.4**	1.4
LA-1BF	**36.8**	2.7	**90.8**	3.1	**22.1**	3.7
LA-1BU	**36.4**	3.4	**91.2**	5.8	**21.9**	2.4

Dissolved Minor or Trace Elements in parts per billion (ppb). % RSD from 3 replicate ICP analyses on a single sample.

SAMPLE	Cr	% RSD	Cu	% RSD	Fe	% RSD	Ni	% RSD	Mn	% RSD	Cd	% RSD	Co	% RSD	Ba	% RSD
AS-1SF	<7	8.3	**12.9**	3.8	**9.7**	2.6	**40.2**	5.6	**<2**	27.9	**33.0**	0.81	**<10**	12.4	**45.7**	2.8
AS-1SU	**7.7**	4.0	**<10**	42.9	**19.6**	0.5	**30.4**	6.3	**10.3**	1.3	**29.2**	1.2	**<10**	10.9	**45.9**	5.2
AS-1F (5m)	**8.1**	5.8	**<10**	6.9	**7.0**	3.1	**33.0**	5.9	**<2**	71.5	**28.0**	1.5	**<10**	7.0	**54.7**	2.0
AS-1U (5m)	**8.6**	2.9	**<10**	14.3	**27.0**	1.4	**30.4**	3.6	**15.1**	3.4	**28.7**	2.6	**<10**	15.0	**55.2**	5.6
AS-1F (6m)	**7.8**	1.2	**<10**	7.7	<5	7.5	<25	9.9	**2.6**	1.1	**30.2**	2.1	**<10**	16.8	**57.1**	4.6
AS-1U (6m)	**7.8**	5.0	**<10**	3.3	**18.6**	2.2	**33.4**	4.1	**21.3**	0.71	**28.6**	1.3	**<10**	12.4	**56.3**	2.8
AS-1BF	**8.1**	5.5	**<10**	5.8	<5	8.6	<25	10.2	**~1500**	4.7	**26.3**	0.32	**<10**	12.7	**89.0**	1.4
AS-1BU	**7.8**	1.2	**<10**	3.0	<5	26.2	**35.0**	4.9	**~1500**	0.81	**37.6**	0.74	**<10**	14.3	**87.2**	1.1
AS-2SF	**7.6**	6.5	**<10**	2.9	<5	9.5	**28.82**	2.0	**<2**	29.3	**0.31**	1.0	**<10**	15.7	**46.8**	5.0
AS-2SU	<7	7.4	**<10**	6.4	**18.2**	4.7	**33.0**	5.8	**10.4**	2.0	**28.4**	1.6	**<10**	24.9	**45.6**	3.7
AS-2BF	**9.4**	2.1	**<10**	9.5	**97.0**	5.6	**30.9**	3.9	**~1960**	2.0	**19.0**	1.4	**<10**	19.5	**121.6**	1.7
AS-2BU	**8.0**	4.6	**<10**	4.0	**195.4**	1.6	<25	11.0	**~1920**	1.1	**17.9**	3.5	**8.0**	6.2	**121.0**	3.6
AS-3S F	**7.6**	3.4	**<10**	2.6	<5	9.0	**32.4**	6.4	**1.3**	5.2	**17.9**	2.8	**7.7**	6.6	**45.7**	1.1
AS-3SU	<7	8.1	**<10**	3.8	**17.4**	3.7	<25	11.1	**10.9**	1.7	**17.2**	2.4	**<10**	18.5	**44.6**	3.8
AS-3BF	**7.8**	4.3	**<10**	4.9	**6.4**	0.06	**27.5**	6.2	**145.5**	0.93	**19.1**	2.1	**<10**	7.7	**64.7**	1.3
AS-3BU	**7.6**	4.9	**<10**	2.6	**20.0**	3.3	**29.5**	6.1	**195.7**	1.0	**19.2**	2.8	**7.8**	4.3	**63.0**	4.8
AS-4SF	**7.8**	3.9	**<10**	1.5	<5	10.3	**29.1**	7.7	**14.95**	3.5	**20.6**	2.3	**<10**	12.8	**46.7**	1.7
AS-4SU	**7.7**	0.86	**<10**	8.7	**11.7**	4.6	<25	10.1	**22.54**	2.5	**20.6**	3.8	**7.4**	3.7	**47.1**	3.9
LA-1SF	**7.9**	4.2	**<10**	4.1	**13.4**	2.4	**33.2**	3.6	**180.8**	1.3	**21.9**	2.9	**<10**	7.3	**69.5**	2.9
LA-1SU	**8.2**	3.3	**<10**	4.6	**6.7**	3.7	**34.0**	2.4	**24.71**	1.8	**22.7**	4.2	**8.4**	3.0	**68.2**	2.3
LA-1BF	<7	7.4	**<10**	4.2	<5	9.2	**29.2**	7.0	**102.2**	0.74	**16.1**	2.0	**7.9**	5.1	**69.2**	1.4
LA-1BU	<7	9.3	**<10**	1.6	**7.4**	1.8	<25	10.5	**3.79**	3.2	**18.3**	3.7	**7.8**	2.6	**65.9**	1.6

II. SEDIMENT SAMPLES

Sediment Sample Collection and Analysis: Three (3) sediment samples were taken on August 9, 2006 by Melanie Havemen (MS Geosciences student) working together with Jeff Spoelstra of Kieser and Associates. Samples were taken as follows: sediment samples were obtained using a grab sampler; sediment was than mixed in a large bowl, stirred, and placed in 50 mL vials. Samples were digested using a three-step procedure adapted from Tessier et al. (1979; 1982; Koretsky et al., 2006), as follows. Samples were frozen and freeze-dried, then duplicate or triplicate subsamples (~1 g) of each sample were extracted using three reagents in sequence: (1) 8mL of 1M Na Acetate at pH 5 for 5 hr at room temperature, (2) 20mL of 0.04M hydroxylamine HCl in 25% acetic acid for 6 hrs at 96°C, and (3) 3mL of 0.02M nitric acid + 5mL of 30% hydrogen peroxide for 2 hrs at 96°C, add 5mL of 3.2M ammonium acetate in 20% nitric acid for an additional 30 minutes at room temperature. The first step targets carbonate minerals and associated (lattice bound or adsorbed) trace metals. It likely also releases surface bound (adsorbed metal ions) on other minerals (e.g. oxides or silicates). The second step targets minerals that may undergo reductive dissolution, especially Fe and Mn oxides, releasing lattice-bound and adsorbed metals associated with these phases. The last step targets oxidizable fractions, especially organic matter or sulfides, and releases associated lattice-bound, complexed or adsorbed metals. *Note*: The sum of these three fractions will not, in general, be equivalent to a whole sediment digest. However, these three operationally-defined fractions likely include the most labile metals. Each experiment included a no-sediment control to assess metal concentrations resulting from reagents, acid-washed plastic centrifuge tubes, syringes and filters. After mixing with each extractant solution for the specified time, the sediment slurry was centrifuged at 5300 rpm for 30 min, an aliquot of supernatant was removed and filtered using a 0.2 ?m pore size syringe filter and preserved using concentrated trace-metal grade HNO_3. Between each extraction step, the sediment residue was rinsed twice with 8mL of DDI water. Acidified supernatants were spiked with 100ppb of a multielement (Y, Sc) internal standard and analyzed for by ICP-AES (PerkinElmer Optima2100DV) for the following dissolved constituents: Cr, Fe, Ni, Cu, Zn, As, Cd, Co, Mo, Pb, Mg, V, Ba, Mg, Ca, Se (16 elements)

Koretsky C.M., Haas J.R., Ndenga N.T. and Miller D. (2006) Seasonal variations in vertical redox stratification and potential influence on trace metal speciation in minerotrophic peat sediments. Water Air and Soil Pollution 173, 373-403.

Tessier A., Campbell P.G.C. and Bisson M. (1979) Sequential extraction procedure for the speciation of particulate trace metals. Analytical Chemistry 51, 844-851.

Tessier A., Campbell P.G.C. and Bisson M. (1982) Particulate trace metal speciation in stream sediments and relationships with grain size: implications for geochemical exploration. Journal of Geochemical Exploration 16, 77-104.

Replicate subsamples from the three sites give similar results for nearly all metals. Significant differences in metal concentrations and distributions exist among the three sample sites. Total labile extractable Co, Cr, Fe, Mg, Ni, and Zn concentrations are all considerably larger in the sediment sampled from the drainage pipe as compared to samples from the centers of Asylum Lake or Little Asylum Lake. These elements are all strongly associated with the reducible fraction, which is likely comprised mostly of Fe oxides and hydroxide minerals with co-precipitated Co, Cr, Ni, and Zn. Because Fe oxides typically undergo seasonal cycles of reductive dissolution (typically in summer) and oxidative precipitation (typically in winter) in shallow sediments, the partitioning of these elements among sediment fractions and aqueous solution likely varies considerably with season. Pb, Ba and V are also have significant associated with a reducible fraction, but concentrations of these two elements are not as large in the drainage pipe samples as in samples from the centers of the lakes. The oxidizable portion of the sediments accounts for most of the Cu and Mo and for much of the Cr, Ni, Fe and V. This likely fraction likely consists of both organic-associated trace metals (e.g. Cu) and also trace metals associated with sulfide minerals (e.g. Fe). Sulfides and associated trace metals extracted in the oxidizable pool are also likely to vary considerably with season, as sulfides are oxidized and dissolved (typically in winter) and formed as a byproduct of sulfate reduction (typically in summer).

Sample Key:

AS-2(1): This sediment was sampled from the center of Asylum Lake at about 13 m deep
AS-2(2): Replicate of AS-2(1)
AS-2(3): Replicate of AS-2(1)
LA-1(1): This sediment was sampled from the center of Little Asylum Lake about 2.5 m deep
LA-2(2): Replicate of LA-1(1)
LA-2(1): This sediment was sampled from the drainage pipe on the west edge of Little Asylum Lake near Parkview Rd.
LA-2(2): Replicate of LA-2(1)
LA-2(3): Replicate of LA-2(1)
LA-2(4): Replicate of LA-2(1)

Elements associated with operationally-defined carbonate fraction (step 1 of sequential extraction) in micrograms element per g dry weight sediment. % RSD values are for 3 replicates ICP analyses of each sample.
BDL: Cu (<0.2), As (<0.8), Cd (<0.2), Mo (<0.8), Se (<0.4)

SAMPLE	Cr	% RSD	Fe	% RSD	Ni	% RSD	Zn	% RSD	Mn	% RSD	Ca	% RSD
AS-2(1)	0.07	3.7	425.7	3.5	0.23	4.9	3.1	2.9	613.8	2.2	>30000	
AS-2(2)	0.01	3.2	676.1	3.6	0.26	4.2	2.8	3.1	589.5	2.1	>30000	
AS-2(3)	0.05	1.3	580.3	3.3	0.25	1.7	3.0	1.3	558.0	3.6	>30000	
LA-1(1)	<0.01		<400		0.37	3.3	4.9	3.0	210.6	1.3	12520	1.6
LA-1(2)	<0.01		<400		0.22	6.6	10.3	3.3	387.3	1.4	19583	0.30
LA-2(1)	1.1	5.3	1090	2.3	2.7	3.8	56.9	1.8	140.1	2.3	7719	2.7
LA-2(2)	1.0	1.6	737.4	3.8	2.0	1.7	52.8	1.1	152.4	2.6	7962	1.1
LA-2(3)	0.78	2.7	1123	4.6	2.1	0.11	34.8	2.0	104.0	1.5	31191	0.69
LA-2(4)	0.89	1.9	1382	2.1	1.9	1.6	35.3	3.3	118.9	0.99	36983	1.5

SAMPLE	Co	% RSD	Pb	% RSD	Mg	% RSD	V	% RSD	Ba	% RSD	K	% RSD
AS-2(1)	<0.5		22.0	1.9	1801	1.6	0.27	5.4	31.5	1.0	65.1	3.6
AS-2(2)	<0.5		17.4	2.2	1646	1.2	0.18	9.7	33.2	2.5	65.6	10.2
AS-2(3)	<0.5		23.3	1.6	1594	2.5	0.24	4.5	31.7	1.5	67.2	8.4
LA-1(1)	<0.5		<0.2		590.9	1.6	<0.2		76.5	3.1	166.1	10.3
LA-1(2)	<0.5		1.1	6.2	970.2	2.4	<0.2		79.3	2.0	175.4	12.1
LA-2(1)	0.70	1.7	4.0	4.1	431.9	2.5	0.47	6.2	18.5	2.0	110.5	1.6
LA-2(2)	0.61	4.8	2.6	3.2	427.6	0.42	0.37	2.3	16.3	1.0	116.1	6.2
LA-2(3)	0.58	2.6	0.26	4.1	1018	2.0	0.38	3.9	15.4	3.4	109.9	5.6
LA-2(4)	0.53	3.9	0.71	4.6	1175	1.6	0.33	3.9	14.6	2.7	102.7	5.4

Elements associated with operationally-defined reducible fraction (step 2 of sequential extraction) in micrograms element per g dry weight sediment. % RSD values are for 3 replicates ICP analyses of each sample.

SAMPLE	Cr	% RSD	Fe	% RSD	Ni	% RSD	Cu	% RSD	Zn	% RSD	As	% RSD	Cd	% RSD	Ca	% RSD
AS-2(1)	**1.3**	1.0	**2041**	2.9	**1.8**	2.1	**<0.4**		**121.5**	1.1	**4.4**	4.6	**0.71**	4.4	**>50000**	
AS-2(2)	**1.2**	1.6	**1939**	0.88	**1.7**	4.2	**<0.4**		**125.3**	0.67	**4.0**	2.0	**0.65**	1.1	**>50000**	
AS-2(3)	**1.1**	2.4	**1869**	0.80	**1.6**	1.5	**<0.4**		**114.9**	0.68	**<4**		**0.56**	2.6	**>50000**	
LA-1(1)	**0.12**	5.9	**231.5**	0.19	**1.2**	4.9	**0.36**	3.2	**107.1**	2.3	**<4**		**0.35**	3.2	**22700**	3.8
LA-1(2)	**1.8**	3.2	**979.7**	1.9	**2.0**	1.8	**<0.4**		**129.3**	6.2	**<4**		**<0.4**		**16950**	1.4
LA-2(1)	**10.4**	2.0	**4322**	1.1	**6.2**	0.68	**0.83**	2.7	**616.4**	0.81	**<4**		**0.68**	1.1	**24360**	1.0
LA-2(2)	**15.2**	1.1	**6480**	1.4	**8.6**	0.38	**2.0**	0.91	**695.0**	2.1	**<4**		**0.74**	1.9	**30770**	3.1

SAMPLE	Co	% RSD	Mo	% RSD	Pb	% RSD	Mg	% RSD	V	% RSD	Ba	% RSD	Mn	% RSD	Se	% RSD
AS-2(1)	**<0.8**		**0.84**	3.8	**114.8**	1.5	**3195.0**	1.4	**5.3**	1.8	**63.1**	2.9	**66.6**	1.4	**2.3**	1.6
AS-2(2)	**<0.8**		**0.59**	0.95	**106.3**	4.0	**3002.9**	1.6	**5.1**	1.9	**60.4**	1.5	**66.8**	2.6	**2.1**	0.84
AS-2(3)	**<0.8**		**<0.6**		**98.0**	3.3	**2866.0**	2.3	**4.7**	1.1	**57.1**	1.7	**61.9**	1.1	**2.0**	1.6
LA-1(1)	**<0.8**		**<0.6**		**22.7**	1.3	**1290.4**	2.0	**1.2**	2.6	**18.1**	16.1	**4.3**	6.8	**<1.5**	
LA-1(2)	**<0.8**		**<0.6**		**17.6**	1.9	**1415.0**	1.3	**1.9**	1.8	**10.0**	3.6	**<4**		**4.7**	1.4
LA-2(1)	**0.80**	2.5	**<0.6**		**61.5**	0.56	**12040**	1.5	**2.5**	1.5	**43.9**	0.53	**26.6**	21.9	**<1.5**	
LA-2(2)	**1.13**	1.9	**<0.6**		**50.7**	4.3	**16470**	1.7	**3.6**	0.59	**38.4**	1.9	**32.6**	3.4	**1.6**	2.7

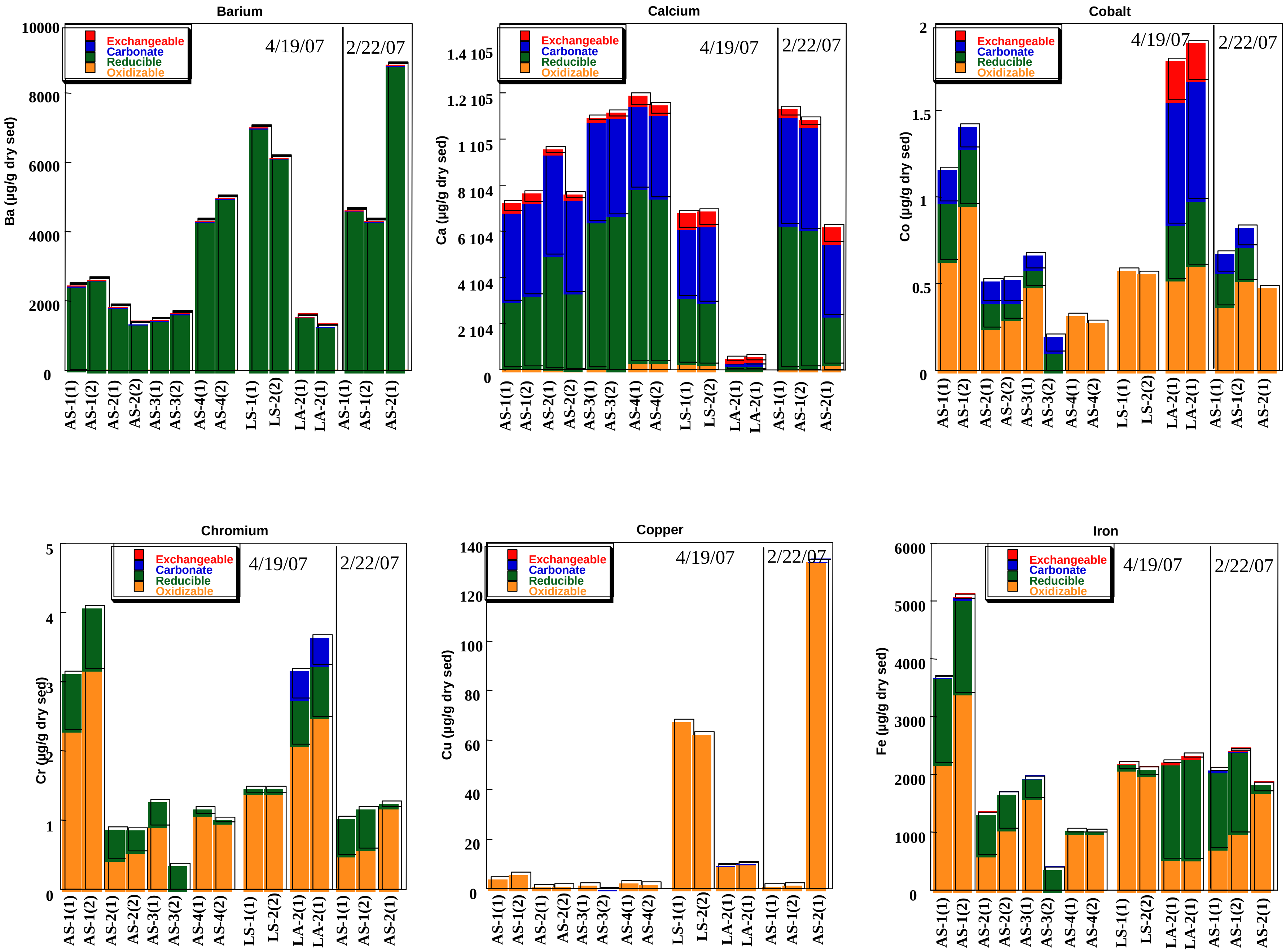
Elements associated with operationally-defined oxidizable fraction (step 3 of sequential extraction) in micrograms element per g dry weight sediment. % RSD values are for 3 replicates ICP analyses of each sample.

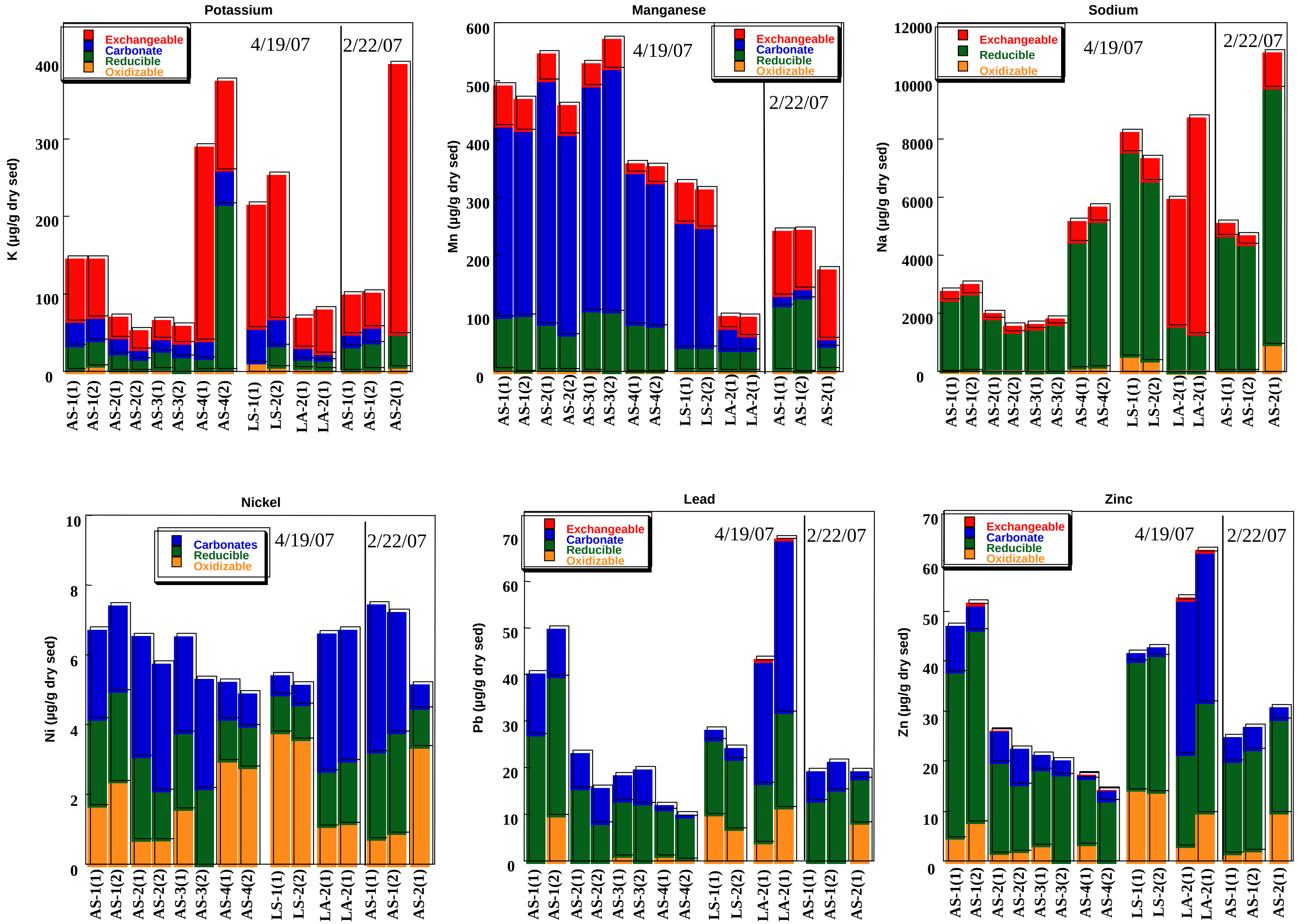
Note: All values are approximate. Due to high organic matter content, some sample material was lost during extraction procedure.

BDL: As (<0.8), Cd (<0.8), Se (<0.8)

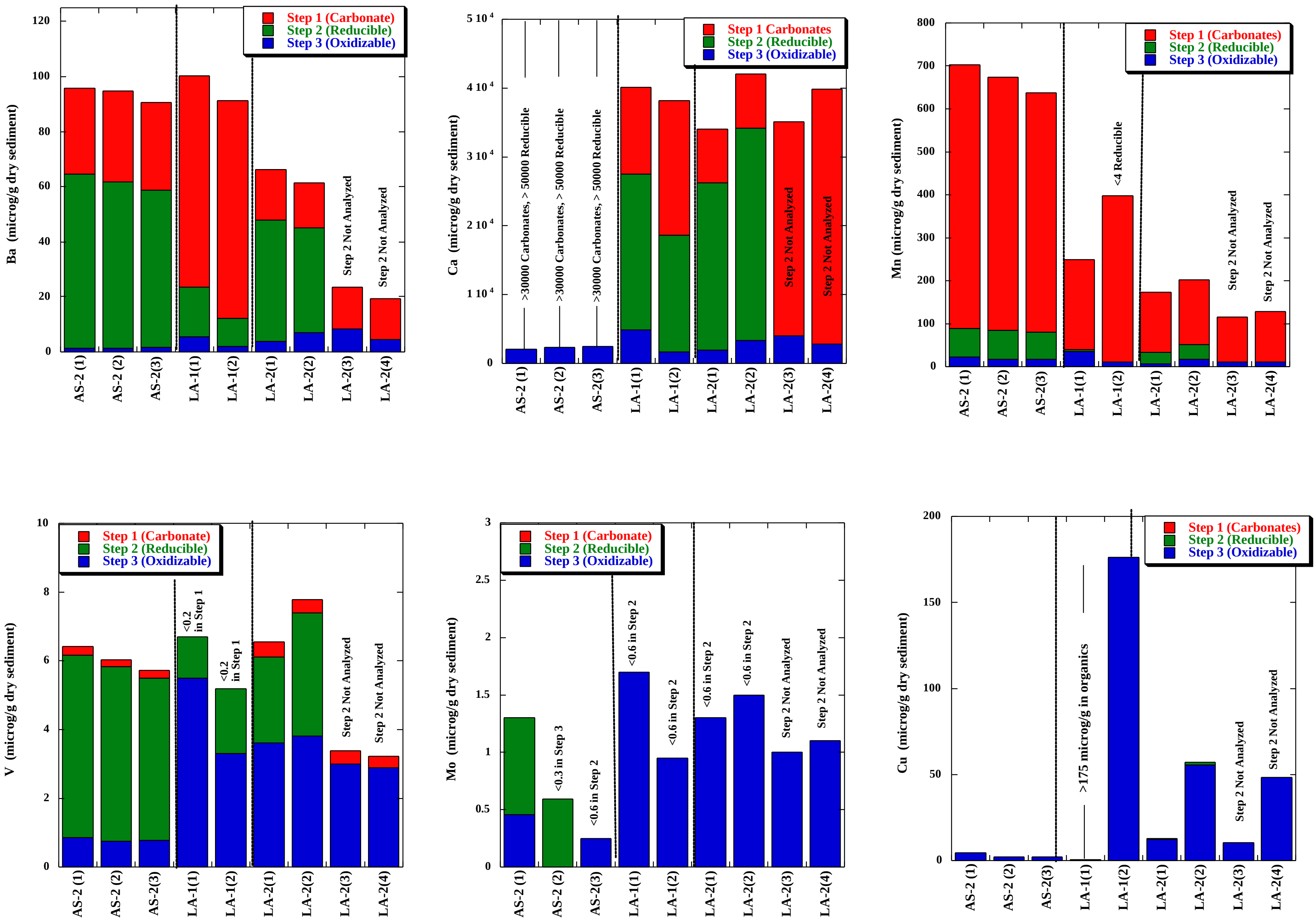
SAMPLE	**Cr**	% RSD	**Fe**	% RSD	**Ni**	% RSD	**Cu**	% RSD	**Zn**	% RSD	**Mn**	% RSD
AS-2(1)	**0.95**	3.1	**2001**	4.5	**1.2**	7.1	**4.6**	2.4	**3.0**	2.0	**22.1**	3.2
AS-2(2)	**0.87**	3.0	**1851**	1.4	**1.0**	4.2	**2.0**	0.27	**2.4**	1.7	**17.0**	0.27
AS-2(3)	**0.93**	1.3	**2134**	3.2	**1.1**	1.7	**2.5**	3.4	**2.8**	1.5	**18.7**	0.39
LA-1(1)	**2.6**	1.7	**4012**	3.5	**4.7**	1.6	**>175**		**15.8**	2.3	**34.9**	1.4
LA-1(2)	**2.1**	3.5	**3154**	1.4	**3.9**	4.4	**176**	2.0	**4.7**	2.8	**10.7**	12.9
LA-2(1)	**25.6**	3.1	**1241**	1.3	**3.4**	3.2	**12.2**	3.3	**46.4**	4.2	**6.6**	0.29
LA-2(2)	**22.6**	1.2	**2129**	1.0	**3.4**	8.5	**55.5**	0.76	**47.0**	2.6	**17.9**	2.5
LA-2(3)	**17.9**	0.61	**2608**	0.53	**3.0**	3.5	**10.7**	2.2	**62.3**	4.5	**12.2**	3.4
LA-2(4)	**18.5**	4.1	**2148**	1.7	**2.8**	1.1	**48.1**	0.88	**36.1**	3.2	**11.0**	3.1

SAMPLE	**Co**	% RSD	**Mo**	% RSD	**Pb**	% RSD	**Mg**	% RSD	**V**	% RSD	**Ba**	% RSD	**Ca**	% RSD
AS-2(1)	**0.32**	5.7	**0.46**	7.0	4.6	5.1	**96.8**	0.75	**0.86**	3.5	**1.4**	4.9	**2024**	2.8
AS-2(2)	**0.30**	2.8	**<0.3**		3.7	2.2	**101.9**	0.72	**0.74**	0.91	**1.3**	4.0	**2356**	2.9
AS-2(3)	**0.31**	4.3	**0.25**	6.5	4.6	1.3	**108.7**	0.26	**0.79**	0.52	**1.7**	2.1	**2446**	1.8
LA-1(1)	**0.57**	8.1	**1.7**	4.1	14.1	4.0	**192.0**	0.81	**5.5**	2.3	**5.6**	4.4	**4867**	0.27
LA-1(2)	**<0.3**		**0.95**	8.6	11.9	2.5	**109.8**	0.22	**3.3**	0.62	**2.0**	1.5	**1723**	2.4
LA-2(1)	**0.27**	8.0	**1.3**	4.9	1.5	3.6	**2375**	1.3	**3.6**	3.1	**4.0**	4.0	**1960**	1.4
LA-2(2)	**0.34**	4.9	**1.5**	1.7	9.4	3.9	**1847**	0.46	**3.8**	1.5	**6.9**	2.5	**3403**	2.9
LA-2(3)	**0.23**	8.3	**1.0**	2.5	9.6	2.5	**2760**	1.2	**3.0**	0.74	**8.2**	0.70	**3982**	1.6
LA-2(4)	**0.26**	3.9	**1.1**	1.2	8.9	0.93	**1163**	0.33	**2.9**	1.1	**4.7**	1.0	**2825**	1.5

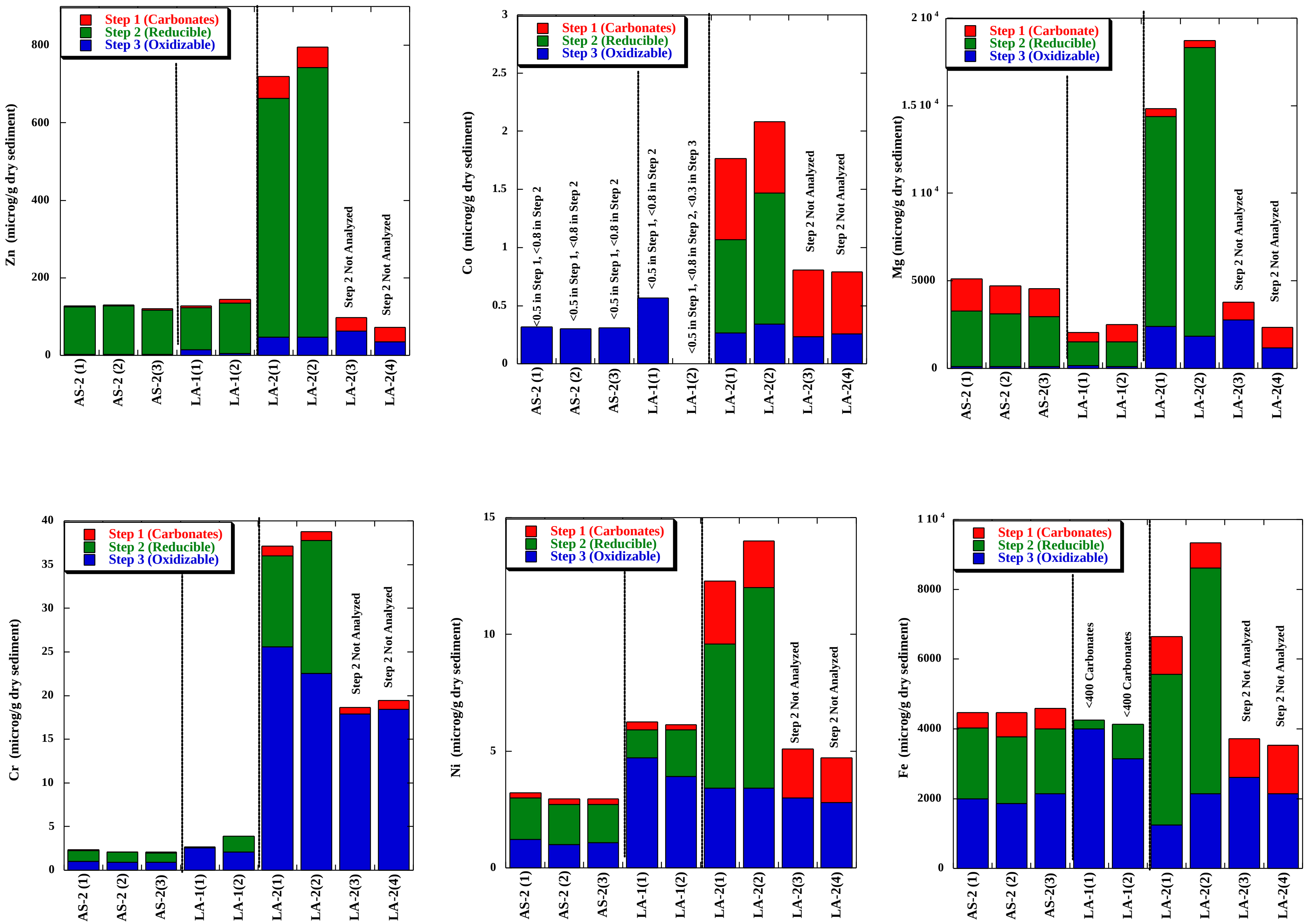

Barium
Ba (µg/g dry sed)
Exchangeable
Carbonate
Reducible
Oxidizable
4/19/07
2/22/07
0
2000
4000
6000
8000
10000
AS-1(1) AS-1(2) AS-2(1) AS-2(2) AS-3(1) AS-3(2) AS-4(1) AS-4(2) LS-1(1) LS-2(2) LA-2(1) LA-2(1) AS-1(1) AS-1(2) AS-2(1)
Calcium
Ca (µg/g dry sed)
0
2 104
4 104
6 104
8 104
1 105
1.2 105
1.4 105
Cobalt
Co (µg/g dry sed)
0
0.5
1
1.5
2
Chromium
Cr (µg/g dry sed)
0
1
2
3
4
5
Copper
Cu (µg/g dry sed)
0
20
40
60
80
100
120
140
Iron
Fe (µg/g dry sed)
0
1000
2000
3000
4000
5000
6000

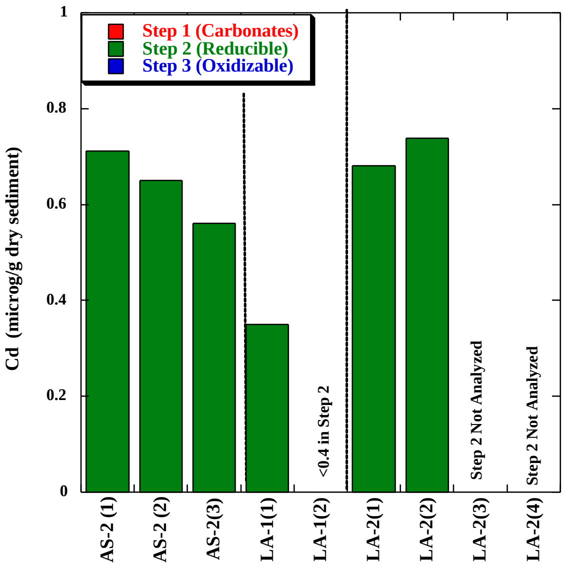


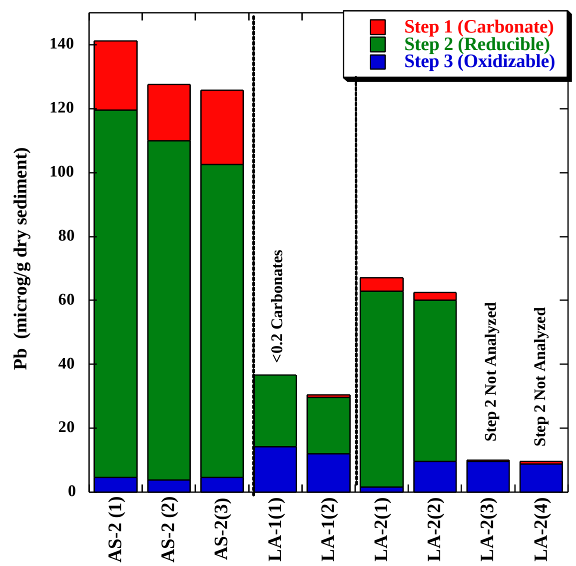
Potassium
K (µg/g dry sed)
Exchangeable
Carbonate
Reducible
Oxidizable
4/19/07
2/22/07
AS-1(1) AS-1(2) AS-2(1) AS-2(2) AS-3(1) AS-3(2) AS-4(1) AS-4(2) LS-1(1) LS-2(2) LA-2(1) LA-2(1) AS-1(1) AS-1(2) AS-2(1)
Manganese
Mn (µg/g dry sed)
Sodium
Na (µg/g dry sed)
Nickel
Ni (µg/g dry sed)
Carbonates
Lead
Pb (µg/g dry sed)
Zinc
Zn (µg/g dry sed)

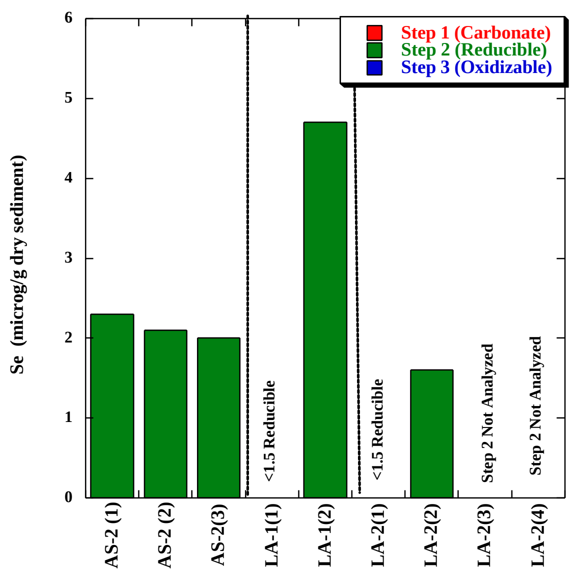


Ba (microg/g dry sediment)
Step 1 (Carbonate)
Step 2 (Reducible)
Step 3 (Oxidizable)
Step 2 Not Analyzed
Step 2 Not Analyzed
Ca (microg/g dry sediment)
Step 1 Carbonates
Step 2 (Reducible)
Step 3 (Oxidizable)
>30000 Carbonates, > 50000 Reducible
>30000 Carbonates, > 50000 Reducible
>30000 Carbonates, > 50000 Reducible
Step 2 Not Analyzed
Step 2 Not Analyzed
Mn (microg/g dry sediment)
Step 1 (Carbonates)
Step 2 (Reducible)
Step 3 (Oxidizable)
<4 Reducible
Step 2 Not Analyzed
Step 2 Not Analyzed
V (microg/g dry sediment)
Step 1 (Carbonate)
Step 2 (Reducible)
Step 3 (Oxidizable)
<0.2 in Step 1
<0.2 in Step 1
Step 2 Not Analyzed
Step 2 Not Analyzed
Mo (microg/g dry sediment)
Step 1 (Carbonate)
Step 2 (Reducible)
Step 3 (Oxidizable)
<0.3 in Step 3
<0.6 in Step 2
<0.6 in Step 2
<0.6 in Step 2
<0.6 in Step 2
<0.6 in Step 2
Step 2 Not Analyzed
Step 2 Not Analyzed
Cu (microg/g dry sediment)
Step 1 (Carbonates)
Step 2 (Reducible)
Step 3 (Oxidizable)
>175 microg/g in organics
Step 2 Not Analyzed
Step 2 Not Analyzed
AS-2 (1)
AS-2 (2)
AS-2(3)
LA-1(1)
LA-1(2)
LA-2(1)
LA-2(2)
LA-2(3)
LA-2(4)


Step 1 (Carbonates)
Step 2 (Reducible)
Step 3 (Oxidizable)
Zn (microg/g dry sediment)
Co (microg/g dry sediment)
Mg (microg/g dry sediment)
Cr (microg/g dry sediment)
Ni (microg/g dry sediment)
Fe (microg/g dry sediment)
AS-2 (1)
AS-2 (2)
AS-2(3)
LA-1(1)
LA-1(2)
LA-2(1)
LA-2(2)
LA-2(3)
LA-2(4)
Step 2 Not Analyzed
<0.5 in Step 1, <0.8 in Step 2
<0.5 in Step 1, <0.8 in Step 2, <0.3 in Step 3
<400 Carbonates
Step 1 (Carbonate)
Step 2 (Reducible)
Step 3 (Oxidizable)


Step 1 (Carbonates)
Step 2 (Reducible)
Step 3 (Oxidizable)
Cd (microg/g dry sediment)
1
0.8
0.6
0.4
0.2
0
<0.4 in Step 2
Step 2 Not Analyzed
Step 2 Not Analyzed
AS-2 (1)
AS-2 (2)
AS-2(3)
LA-1(1)
LA-1(2)
LA-2(1)
LA-2(2)
LA-2(3)
LA-2(4)


Step 1 (Carbonate)
Step 2 (Reducible)
Step 3 (Oxidizable)
Pb (microg/g dry sediment)
140
120
100
80
60
40
20
0
<0.2 Carbonates
Step 2 Not Analyzed
Step 2 Not Analyzed
AS-2 (1)
AS-2 (2)
AS-2(3)
LA-1(1)
LA-1(2)
LA-2(1)
LA-2(2)
LA-2(3)
LA-2(4)


Step 1 (Carbonate)
Step 2 (Reducible)
Step 3 (Oxidizable)
Se (microg/g dry sediment)
6
5
4
3
2
1
0
<1.5 Reducible
<1.5 Reducible
Step 2 Not Analyzed
Step 2 Not Analyzed
AS-2 (1)
AS-2 (2)
AS-2(3)
LA-1(1)
LA-1(2)
LA-2(1)
LA-2(2)
LA-2(3)
LA-2(4)

Appendix F

Aquatic Vegetation Survey Tables

LAKE Asylum Lake COUNTY Kalamazoo SURVEY DATE: 9/25/2006

Standard Aquatic Vegetation Summary Sheet SURVEY BY: PHM, JAS

		Total number of AVAS's for each Density Catagory					Calculations				Sum of Previous Four Columns	Total Number of AVAS's	Quotient of Column 9 divided by Column 10		
							Catagory	Catagory	Catagory	Catagory					
		A	B	C	D		A x 1	B x10	C x 40	D x 80					
Code No	Plant Name	1	2	3	4		5	6	7	8	9	10	11	Code No	Plant Name
1	Eurasian milfoil	6	3	3			6	30	120	0	156	27	5.8	1	Eurasian milfoil
2	Curly leaf pondweed						0	0	0	0	0	27	0.0	2	Curly leaf pondweed
3	Chara	1	4	4	9		1	40	160	720	921	27	34.1	3	Chara
4	Thinleaf pondweed						0	0	0	0	0	27	0.0	4	Thinleaf pondweed
5	Flatstem pondweed						0	0	0	0	0	27	0.0	5	Flatstem pondweed
6	Robbins pondweed						0	0	0	0	0	27	0.0	6	Robbins pondweed
7	Variable pondweed						0	0	0	0	0	27	0.0	7	Variable pondweed
8	Whitestem pondweed						0	0	0	0	0	27	0.0	8	Whitestem pondweed
9	Richardsons pondweed						0	0	0	0	0	27	0.0	9	Richardsons pondweed
10	Illinois pondweed	3	8	5			3	80	200	0	283	27	10.5	10	Illinois pondweed
11	Large leaf pondweed						0	0	0	0	0	27	0.0	11	Large leaf pondweed
12	American pondweed						0	0	0	0	0	27	0.0	12	American pondweed
13	Floating leaf pondweed		3	2			0	30	80	0	110	27	4.1	13	Floating leaf pondweed
14	Water stargrass						0	0	0	0	0	27	0.0	14	Water stargrass
15	Wild Celery						0	0	0	0	0	27	0.0	15	Wild Celery
16	Sagitteria						0	0	0	0	0	27	0.0	16	Sagitteria
17	Northern milfoil						0	0	0	0	0	27	0.0	17	Northern milfoil
18	M. verticillatum						0	0	0	0	0	27	0.0	18	M. verticillatum
19	M. herterophyllum						0	0	0	0	0	27	0.0	19	M. herterophyllum
20	Coontail	4	10	3	1		4	100	120	80	304	27	11.3	20	Coontail
21	Elodea						0	0	0	0	0	27	0.0	21	Elodea
22	Utricularia spp.	4	2				4	20	0	0	24	27	0.9	22	Utricularia spp.
23	Bladderwort-mini						0	0	0	0	0	27	0.0	23	Bladderwort-mini
24	Buttercup						0	0	0	0	0	27	0.0	24	Buttercup
25	Najas spp.	2					2	0	0	0	2	27	0.1	25	Najas spp.
26	Spiny naiad	4	3				4	30	0	0	34	27	1.3	26	Brittle naiad
27	Sago pondweed	9	5	2			9	50	80	0	139	27	5.1	27	Sago pondweed
28							0	0	0	0	0	27	0.0	28	
29							0	0	0	0	0	27	0.0	29	
30	Nymphaea		5	16	6		0	50	640	480	1170	27	43.3	30	Nymphea
31	Nuphar						0	0	0	0	0	27	0.0	31	Nuphar
32	Brasenia						0	0	0	0	0	27	0.0	32	Brasenia
33	Lemna minor						0	0	0	0	0	27	0.0	33	Lemna minor
34	Spirodella						0	0	0	0	0	27	0.0	34	Spirodella
35	Watermeal						0	0	0	0	0	27	0.0	35	Watermeal
36	Arrowhead						0	0	0	0	0	27	0.0	36	Arrowhead
37	Pickerelweed						0	0	0	0	0	27	0.0	37	Pickerelweed
38	Arrow Arum						0	0	0	0	0	27	0.0	38	Arrow Arum
39	Cattails		5	9	7		0	50	360	560	970	27	35.9	39	Cattails
40	Bulrushes	1	4	6	5		1	40	240	400	681	27	25.2	40	Bulrushes
41	Iris						0	0	0	0	0	27	0.0	41	Iris
42	Swamp Loosestrife	3	2				3	20	0	0	23	27	0.9	42	Swamp Loosestrife
43	Purple Loosestrife	2	1				2	10	0	0	12	27	0.4	43	Purple Loosestrife
44							0	0	0	0	0	27	0.0	44	
45							0	0	0	0	0	27	0.0	45	

LAKE Little Asylum Lake COUNTY Kalamazoo SURVEY DATE: 8/9/2006

Standard Aquatic Vegetation Summary Sheet SURVEY BY: PHM, JAS

		Total number of AVAS's for each Density Catagory					Calculations				Sum of Previous Four Columns	Total Number of AVAS's	Quotient of Column 9 divided by Column 10		
		A	B	C	D		Catagory A x 1	Catagory B x10	Catagory C x 40	Catagory D x 80					
Code No	Plant Name	1	2	3	4		5	6	7	8	9	10	11	Code No	Plant Name
1	Eurasian milfoil						0	0	0	0	0	15	0.0	1	Eurasian milfoil
2	Curly leaf pondweed	3	1				3	10	0	0	13	15	0.9	2	Curly leaf pondweed
3	Chara	1		2	2		1	0	80	160	241	15	16.1	3	Chara
4	Thinleaf pondweed						0	0	0	0	0	15	0.0	4	Thinleaf pondweed
5	Flatstem pondweed						0	0	0	0	0	15	0.0	5	Flatstem pondweed
6	Robbins pondweed						0	0	0	0	0	15	0.0	6	Robbins pondweed
7	Variable pondweed						0	0	0	0	0	15	0.0	7	Variable pondweed
8	Whitestem pondweed						0	0	0	0	0	15	0.0	8	Whitestem pondweed
9	Richardsons pondweed						0	0	0	0	0	15	0.0	9	Richardsons pondweed
10	Illinois pondweed						0	0	0	0	0	15	0.0	10	Illinois pondweed
11	Large leaf pondweed						0	0	0	0	0	15	0.0	11	Large leaf pondweed
12	American pondweed						0	0	0	0	0	15	0.0	12	American pondweed
13	Floating leaf pondweed						0	0	0	0	0	15	0.0	13	Floating leaf pondweed
14	Water stargrass						0	0	0	0	0	15	0.0	14	Water stargrass
15	Wild Celery						0	0	0	0	0	15	0.0	15	Wild Celery
16	Sagitteria						0	0	0	0	0	15	0.0	16	Sagitteria
17	Northern milfoil						0	0	0	0	0	15	0.0	17	Northern milfoil
18	M. verticillatum						0	0	0	0	0	15	0.0	18	M. verticillatum
19	M. herterophyllum						0	0	0	0	0	15	0.0	19	M. herterophyllum
20	Coontail	3	5	5	2		3	50	200	160	413	15	27.5	20	Coontail
21	Elodea						0	0	0	0	0	15	0.0	21	Elodea
22	Utricularia spp.	1	4				1	40	0	0	41	15	2.7	22	Utricularia spp.
23	Bladderwort-mini						0	0	0	0	0	15	0.0	23	Bladderwort-mini
24	Buttercup						0	0	0	0	0	15	0.0	24	Buttercup
25	Najas spp.		5		1		0	50	0	80	130	15	8.7	25	Najas spp.
26	Brittle naiad						0	0	0	0	0	15	0.0	26	Brittle naiad
27	Sago pondweed	2	8	3			2	80	120	0	202	15	13.5	27	Sago pondweed
28							0	0	0	0	0	15	0.0	28	
29							0	0	0	0	0	15	0.0	29	
30	Nymphaea			12	2		0	0	480	160	640	15	42.7	30	Nymphea
31	Nuphar	2					2	0	0	0	2	15	0.1	31	Nuphar
32	Brasenia						0	0	0	0	0	15	0.0	32	Brasenia
33	Lemna minor						0	0	0	0	0	15	0.0	33	Lemna minor
34	Spirodella						0	0	0	0	0	15	0.0	34	Spirodella
35	Watermeal						0	0	0	0	0	15	0.0	35	Watermeal
36	Arrowhead						0	0	0	0	0	15	0.0	36	Arrowhead
37	Pickerelweed						0	0	0	0	0	15	0.0	37	Pickerelweed
38	Arrow Arum						0	0	0	0	0	15	0.0	38	Arrow Arum
39	Cattails				15		0	0	0	1200	1200	15	80.0	39	Cattails
40	Bulrushes						0	0	0	0	0	15	0.0	40	Bulrushes
41	Iris						0	0	0	0	0	15	0.0	41	Iris
42	Swamp Loosestrife	5					5	0	0	0	5	15	0.3	42	Swamp Loosestrife
43	Purple Loosestrife	5	6	1			5	60	40	0	105	15	7.0	43	Purple Loosestrife
44							0	0	0	0	0	15	0.0	44	
45							0	0	0	0	0	15	0.0	45	

Appendix G

Trophic State Reference Tables

Total Phosphorus Concentrations for Trophic Status Categories

Trophic State	*Total Phosphorus (?g/L) (by source)*			
Category	(1)	(2)	(3)	(4)
Oligotrophic	4.3-11.5	<10	<10	<9
Mesotrophic	11.5-37.5	10-21.7	10-20	9-35
Eutrophic	>37.5	>21.5	>20	>35

(1) Auer et al., 1986

(2) Chapra and Dobson, 1981

(3) Vollenweider, 1975

(4) Vollenweider, 1982

Chlorophyll a Concentrations and Secchi-Disk Depth for Trophic Status Categories

Variable	*Oligotrophic*	*Mesotrophic*	*Eutrophic*
Chlorophyll a (?g/L)	<4	4-10	>10
Secchi-Disk Depth (m)	>4	2-4	<2

Source: Chapra, S. C., 1997. Surface Water-Quality Modeling. McGraw-Hill, p. 538.

Comparison of Total Phosphorus, Chlorophyll a, and Secchi-Disk Depth Measurements in Four Michigan Lakes

Variable	*Asylum Lake*[1]	*Little Asylum Lake*[1]	*Willow Lake*[2]	*Lake Somerset*[3]	*Woods Lake*[4]
Total Phosphorus (?g/L)	13-60.9	ID	9.9-16.4	23.1-23.4	19-55
Chlorophyll a (?g/L)	2.4-8.7	3.1-4.6	NA	2.6-16.1	37
Secchi-Disk Depth (m)	1.7-3.8	1.4-2.9	NA	1.7-3.3	1.2-7.3

ID – Insuficient data; sampling data collected during wet weather only.
NA – Data not available.
1 – K&A Asylum and Little Asylum Water Quality Evaluation Report, 2008
2 – K&A Willow Lake Water Quality Evaluation Report, 2000
3 – K&A Evaluation of Lake Somerset Water Quality Conditions Report, 2006
4 – K&A Woods Lake Water Quality Study, 1997