

## 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.

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

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:*

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

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.

Land Cover	Pollutant EMC (mg/L)			
	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.