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ENVIRONMENTAL SCIENCE & ENGINEERING

TECHNICAL MEMORANDUM

To:	Lauren Koloski Environmental Supervisor Washtenaw County Water Resources Commissioner's Office	**Date:**	August 27, 2021
From:	Mark Kieser, Senior Scientist Mike Foster, Environmental Engineer Josh Kieser, Field Services Manager	**cc:**	Project files
RE:	**North Lake Watershed Loading Analysis, Washtenaw County**		

1.0 Introduction & Background

North Lake is situated in the upper reaches of Subwatershed 6 of the Portage Creek Watershed in Washtenaw County, Michigan. The Portage Creek Watershed Management Plan (WMP) considers North Lake a priority waterbody for protecting important aquatic habitat threatened by habitat fragmentation and nonpoint sources (NPS) pollution resulting from residential and commercial developments. The lake is hydrologically connected to a chain of wetlands to the north, with the lake contributing flows to a downstream creek and chain of lakes in the Portage Creek watershed through an outlet on the lake's west side.[1]

The WMP listed subwatershed NPS pollutants of concern relevant to North Lake including:

1) Excess nutrients caused by runoff from residential areas and lakefront homes maintaining turfgrass to shorelines (overapplication of fertilizers and erosion from overland runoff).
2) Sedimentation caused by residential areas and lakefront homes with developed shorelines lacking deep-rooted shoreline vegetation, by large wakes causing shoreline erosion, by gravel roads contributing runoff to the lake, and by construction and new development that removes wetland and woodland buffers that intercept and mitigate NPS pollutants.
3) Salt, organic compounds, and heavy metals contributed from roads transporting runoff to the lake, and potentially from leaking gas tanks on recreational boats.
4) Pathogens caused by runoff carrying goose droppings from turfgrass lawns into the lake. [2]

2.0 Watershed Assessment

In order to estimate pollutant source contributions to North Lake for future watershed management planning needs, a series of modeling and surveying efforts were undertaken. These included the following analyses:

[1] Portage Creek Watershed Advisory Group. 2010. *Portage Creek Watershed Management Plan: Section IV Watershed Conditions*. Accessible online here: https://www.hrwc.org/wp-content/uploads/SecIV_ShedConditions.pdf
[2] Portage Creek Watershed Advisory Group. 2010.

- Delineation of watershed draining to the lake
- Land-use analysis of delineated drainage area
- Preliminary empirical watershed modeling focused on a loading assessment of sediment and phosphorus
- Wet-weather "windshield" survey of potential nonpoint sources

These efforts are described in this technical memorandum and supplemented with additional details in appendices.

K&A conducted the NPS pollutant "windshield" survey of the North Lake contributing area on July 16, 2021, by driving or walking the contributing areas during a wet-weather event when runoff pathways of potential NPS pollutants could be clearly identified. The purpose of the survey was to assess load reduction opportunities (Section 1.4) and better define modeled outcomes by directly identifying the NPS pollutant-contributing areas. Appendix B provides GPS locations and corresponding photographs highlighting potential NPS contribution areas and existing buffers and best practices.

2.1 Watershed Delineation and Land Use Analysis

K&A assessed drainage boundaries using geographical information system (GIS) software and electronically-available land elevation data and land use data.[3] This watershed delineation is illustrated in Figure 1. A summary of the land use within the delineated watershed is presented in Table 1.

Table 1 - Watershed Land Use Data

Land Cover Type	North Lake Watershed Area (acres)
Open Water	217.3
Developed, Open Space	183.7
Developed, Low Intensity	81.0
Developed, Medium Intensity	5.6
Developed, High Intensity	0.9
Barren Land	2.4
Deciduous Forest	208.8
Evergreen Forest	2.4
Mixed Forest	14.2
Shrub/Scrub	1.1
Herbaceous	12.2
Hay/Pasture	121.0
Cultivated Crops	50.3
Woody Wetlands	70.3
Emergent Herbaceous Wetlands	18.5
Total Area	989.7

[3] United States Geological Survey (USGS). 2019. National Elevation Dataset (NED). GeoTIFF Digital Elevation Model of USGS 13 arc-second n42w086 1 x 1 degree. 2019-04-23. Available online at: https://viewer.nationalmap.gov/basic/#productSearch.

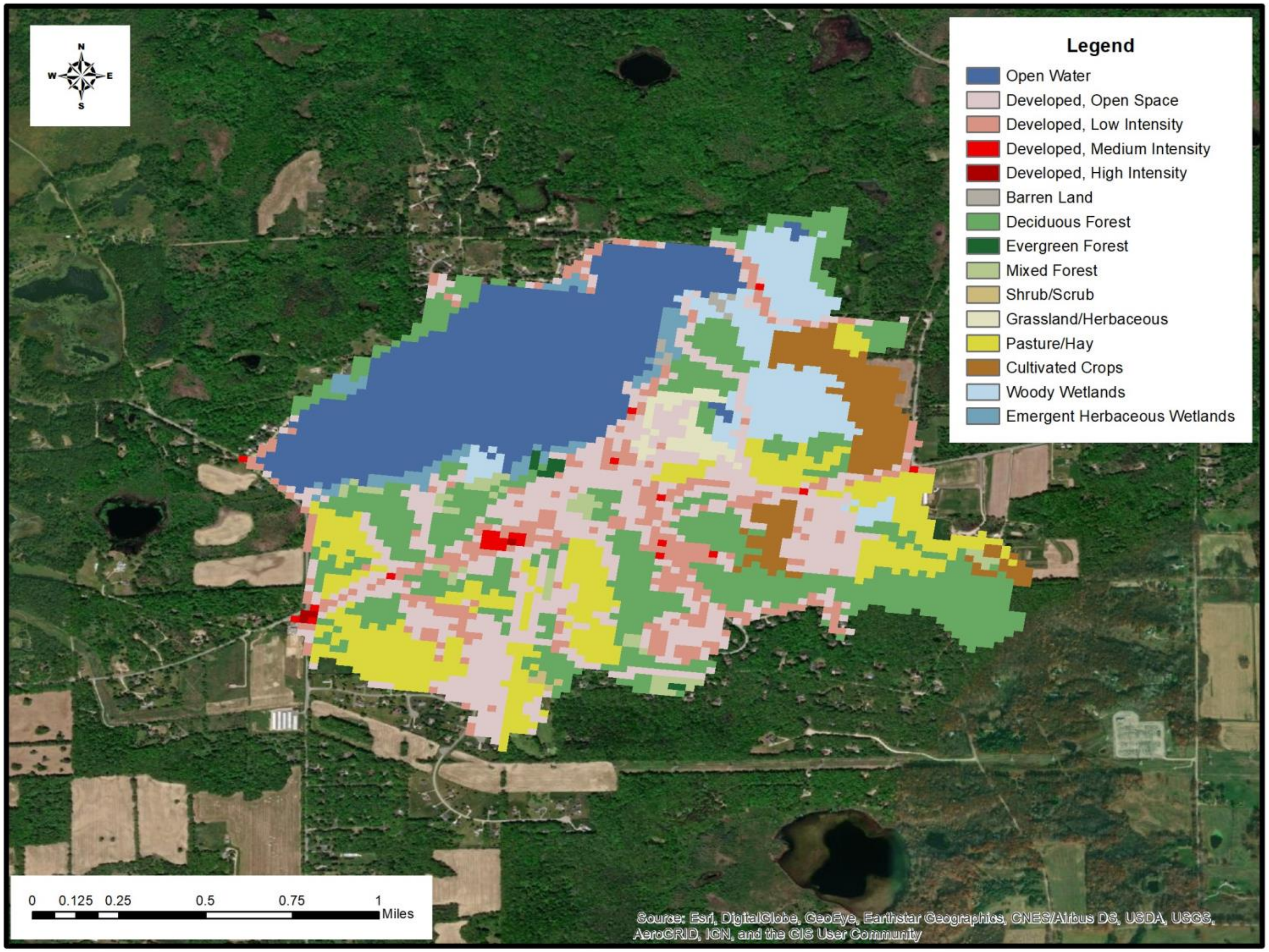

Figure 1 - North Lake Watershed Delineation and Landcover.

2.2 Event Mean Concentration Watershed Loading Assessment

The watershed loading assessment was carried out using an event mean concentration (EMC) analysis, also known as the "Watershed Management Model" (WMM). WMM originated from an EPA-funded study on the Rouge River watershed in Southeast Michigan.[4] This model has since been used in a number of similar watershed assessments in other southern Michigan watersheds.[5, 6]

Average annual precipitation is used in the WMM as the basis for computing runoff volumes. Phosphorus and sediment loads from stormwater runoff are calculated by applying EMC values to calculated runoff volumes. EMC values were determined in the EPA-funded Rouge River National Wet Weather Demonstration Project from which the WMM was derived.[7] This past demonstration project conducted an extensive assessment of stormwater pollutant loading factors by land cover classes and recommended EMC values for ten broad land-cover classes. Water quality monitoring data from other southern Michigan areas were used to refine EMC values.[8] All EMC values and WMM equations can be viewed in Appendix A.

3.0 Event Mean Concentration Loading Analysis Results

The EMC land-use categories along with their associated areas and calculated sediment and phosphorus loads can be seen in Table 2. The watershed is not dominated by any one category of land use, with developed, forested/herbaceous, agricultural, and water/wetlands each accounting for 17%-31% of the total watershed land cover. The majority of the phosphorus load comes from developed land (92 lbs/yr, 49% of the total load) and agricultural land (75 lbs/yr, 39% of the total load). Phosphorus concentrations from forested land are much lower than those from agricultural land, so forested land contributes a relatively small amount of phosphorus to the lake annually (15 lbs) relative to its acreage. Developed and residential land contribute a relatively high amount of runoff given the impermeable surfaces typical with such land uses. This results in developed land uses contributing 49% of the annual phosphorus load despite comprising only 27% of the watershed acreage.

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[4] Wayne County. 1996. Technical Report Preliminary Pollution Loading Projections for Rouge River Watershed and Interim Nonpoint Source Pollution Control Plan, February 1996.

[5] Kieser & Associates. 2001. "Non-Point Source Modeling of Phosphorus Loads in the Kalamazoo River/Lake Allegan Watershed for a Total Maximum Daily Load." Final Report prepared for the Kalamazoo Conservation District and the Kalamazoo River/Lake Allegan TMDL Implementation Planning Group.

[6] Kieser & Associates. 2011. "Western Michigan University TMDL Compliance Planning Project # 8635-0006." Final Report prepared for Western Michigan University and the Michigan Dept. of Environmental Quality, October 28, 2011.

[7] Cave, K., Quarsebarth, T. and E. Harold. 1994. "Selection of Storm Water Pollutant Loading Factors. Rouge River National Wet Weather Demonstration Project Technical Memorandum RPO-MOD-TM34.00". Detroit, Michigan.

[8] Kieser & Associates. 2014. "Portage Creek Water Quality Monitoring Project, DEQ # 481190-10." Final Report prepared for The Forum of Greater Kalamazoo and the Michigan Dept. of Environmental Quality, September 14, 2014.

Watershed land use areas and their annual phosphorus contributions to North Lake are illustrated in Figure 2 and Figure 3.

Table 2 - EMC Analysis-predicted Loads from the North Lake Watershed.

Land Use	Area (ac)	TSS (tons/yr)	TP (lbs/yr)
Commercial	0.9	0.1	1.2
Low Density Residential	183.7	6.9	47.6
Medium Density Residential	81.0	5.5	38.3
High Density Residential	5.6	1.0	5.1
Forest/Rural Open	238.9	3.4	14.8
Agricultural	306.0	14.6	74.7
Water/Wetlands	171.2	0.3	7.5
Total	989.7	32.0	189.3

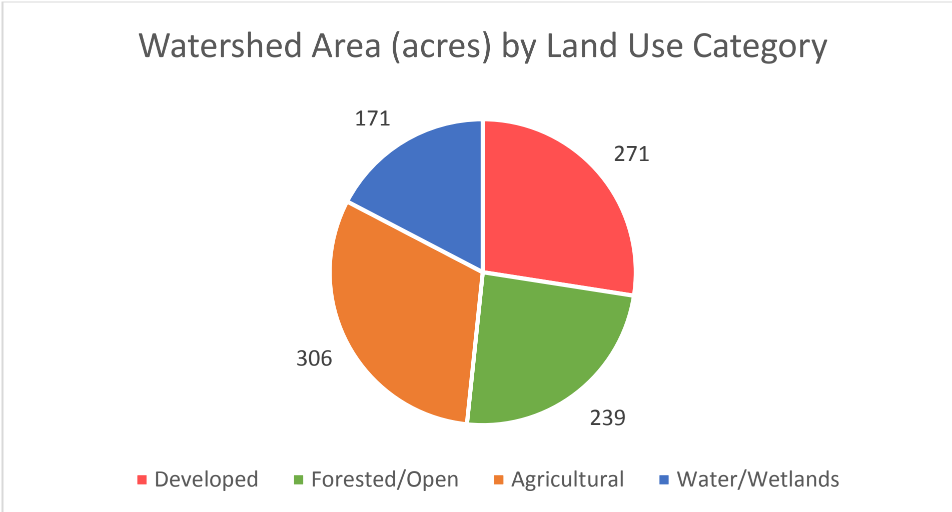


Figure 2 - Watershed Area (acres) by Land Use Category. The "Developed" land use category includes Commercial and Residential EMC land uses.

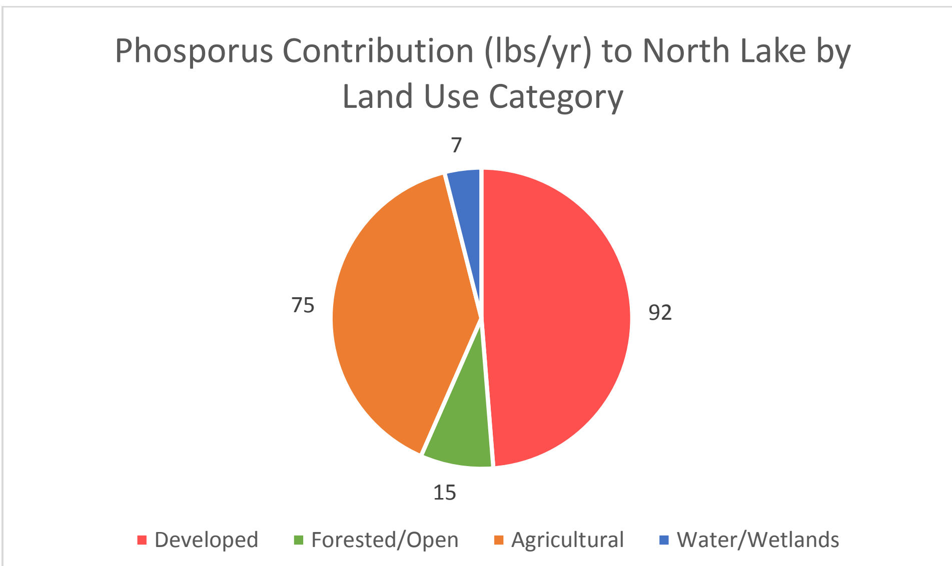


Figure 3 - Phosphorus contribution (lbs/yr) to North Lake by land use category. The "Developed" land use category includes Commercial and Residential land uses.

3.1 Algal Bloom Risk

K&A calculates an algal bloom risk level for lakes based on the characteristics of their watershed. Agricultural and urban land uses contribute more phosphorus to receiving waters than grassland or forested land uses. As phosphorus is typically the limiting nutrient that drives algal blooms, lakes with watersheds that have high proportions of land in agricultural and urban land uses are more likely to be at higher risk of algal blooms. Though not all algal blooms contain cyanobacteria and their associated toxins (Harmful Algal Blooms or HABs), it is important to note that the risk factor reported here is supported by K&A watershed modeling. Lakes at high risk of algal blooms should consider more in-depth studies that can identify possible watershed improvements to

mitigate the risk of HABs as well as prepare strategic responses to such blooms when and if they occur. Herein again, these are efforts that K&A can provide if requested.
The algal bloom risk for North Lake is assessed by K&A as: **Moderate.**

4.0 Load Reduction Opportunities

While modeling shows that agricultural land is potentially responsible for about 39% of the NPS nutrient contribution in the North Lake watershed contributing area, no direct pathways of agricultural runoff to the lake were identified during the windshield survey. The majority of agricultural runoff may be intercepted and partially mitigated by the forest and wetland buffers which currently exist between agricultural areas and the lake. Protecting these undeveloped wetland and wet forest areas is the most important measure on the lake itself for mitigating this potential agricultural loading.

Improving management practices utilized by agricultural producers could further reduce NPS pollutant contributions within the watershed. Coordination with the county conservation district could benefit the lake association in this regard, as the district may help to identify potential problem areas and administer conservation practice funding and best practice implementation with farmers. A more detailed assessment of agricultural fields by K&A was not a part of the limited scope of work for 2021.

Modeling indicates that the majority (49%) of the NPS nutrient contribution to North Lake is being contributed by runoff from developed lands at various densities of development. This includes residential landowners along the lake shoreline, landowners within the direct-runoff areas adjacent to the lake, and the roads, driveways, and lawns through which stormwater is transported. Additionally, several of these residential areas receive stormwater runoff from higher elevation gravel roadways and other residences, and in a few areas this stormwater is likely piped to the lake through storm sewers. Maps with corresponding photographs in Appendix B show the direction and fate of surface water runoff transporting NPS pollutants from developed areas toward North Lake, highlighting areas where NPS load-reducing practices or protective natural buffers already exist, and where such opportunities could potentially be implemented. These areas could be reviewed with Washtenaw County representatives to consider if and where improvements to reduce runoff from gravel roads could be made.

Readily implementable opportunities for reducing phosphorus loading to the lake rests with the residential landowners directly adjacent to the lakeshore. Many of these lots have manicured lawns and armored sea walls. Non- or limited-vegetation riparian areas suffer increased stormwater runoff and nutrient loading as compared to more natural vegetation along shorelines. "Green" infrastructure projects such as shoreline naturalization and transitioning portions of manicured lawns to native plants including taller grasses, flowers, sedges, or shrubs could reduce the volume of stormwater that enters the lake, and reduce the nutrient loads that stormwater carries.

Naturalized shorelines can be designed in a number of ways and can be both aesthetically pleasing and protective of shorelines, while maintaining desired view-scapes for riparian landowners. Natural shorelines and rain gardens with tall plants also tend to deter geese, whose droppings can also contribute substantial nutrient loads when washed into the lake during rain events. Upland vegetated buffers designed to intercept stormwater runoff from roadways and mitigate NPS pollutant contributions through infiltration are another NPS reduction opportunity for reducing roadway.

A detailed assessment of implementation opportunities in these regards can be included in a 2022 K&A scope of services if requested. The Portage Creek WMP also includes more community-planning, maintenance, and standards-based implementation opportunities for reducing NPS pollutants that are relevant to North Lake.[9] Additionally, as part of the separate LakeScan™ Aquatic Vegetation Survey Final Report for North Lake, K&A will include initial shoreline survey assessment results gathered during the late-season 2021 vegetation survey, which may further identify potential NPS load reduction opportunities along the North Lake shoreline.

Lastly, assessment of in-lake sediment phosphorus release should be undertaken to provide context with these estimates of external watershed loading. If, for example, the majority of in-lake phosphorus is attributable to sediment release under periods of temperature stratification and low dissolved oxygen, sediment treatment could bring more immediate and beneficial outcomes than long-term implementation of watershed controls. Such watershed controls can take years to fund and properly address.

Evaluating this balance of internal versus external phosphorus loading is necessary to ensure future source control expenditures are appropriately targeted for providing best returns on investment. This would involve sampling of inflowing streams and the outlet, as well as sediment and lake water quality sampling for phosphorus. This would not need to be extensive and/or expensive, but rather, specifically targeted to quantitatively assess this balance of internal versus external sourcing of phosphorus.

[9] Portage Creek Watershed Advisory Group. 2010.

Appendix A: Pollutant Load Calculations

The following information outlines the calculations utilized to estimate annual pollutant loads within the North Lake watershed. This loading estimation technique is based on the former State of Michigan Water Quality Trading Rules - Part 30.[10] Phosphorus loads from stormwater runoff were calculated by coupling estimated runoff volumes with event mean concentrations (EMCs). Modifications to this calculation were incorporated to utilize regional site-specific monitoring data to further fine tune loading estimates. The pollutant load estimation methods are described in detail below.

A combination of regionally-recognized EMC values and K&A monitoring data were used in the analysis to determine pollutant loading. The majority of the applied EMC values were calculated through the Rouge River National Wet Weather Demonstration Project.[11] This past demonstration project conducted an extensive assessment of stormwater pollutant loading factors by land cover classes and recommended EMC values for ten broad land cover classes. These EMC values were previously incorporated into the former State of Michigan Water Quality Trading Rules - Part 30 to calculate pollutant loads from urban stormwater non-point sources. Michigan was one of the first states to formally enact these rules as flexible compliance options, however these rules were rescinded by the Michigan legislature on August 27, 2013. Despite the rescinding of these rules, the load quantification methods utilized and identified within them are still scientifically sound and professionally valid. More recent data from the Kalamazoo area reported in the Arcadia Creek Water Quality Monitoring Project[12] were used to refine the *low density residential* and *medium density residential* EMC values. All EMC values used in this analysis are presented in Table A1.

Table A1. Land Cover Categories and Event Mean Concentrations

MI Trading Rules Land Cover Category	% Imperviousness	Event Mean Concentration (mg/L)	
		TSS	TP
Commercial	0.9	77	0.33
Low Density Residential	0.1	81	0.28
Medium Density Residential	0.3	81	0.28
High Density Residential	0.85	97	0.24
Urban Open	0.005	51	0.11
Forest/Rural Open	0.005	51	0.11
Water/Wetlands	0	6	0.08
Agricultural	0.03	145	0.37

[10] Michigan Department of Environmental Quality (MDEQ), 2002. Michigan Water Quality Trading Rules. Part 30 of 1994 Part 451, MCL 324.3103 and 324.3106.
[11] Cave, K., T. Quarsebarth, and E. Harold. 1994. "Selection of Storm Water Pollutant Loading Factors. Rouge River National Wet Weather Demonstration Project Technical Memorandum RPO-MOD-TM34.00". Detroit, Michigan.
[12] Kieser & Associates. October 7, 2014. "Arcadia Creek Water Quality Monitoring Project, DEQ #2012-0502." Prepared for Western Michigan University.

With the EMC method, stormwater pollutant loads are also based on pollutant loading factors that vary by land cover type and percent imperviousness. Loads are then computed using Equations 1 and 2 as follows:

$$M_L = EMC_L \times R_L \times K \qquad \textit{(Eq. 1)}$$

Where:

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

Runoff Equation:

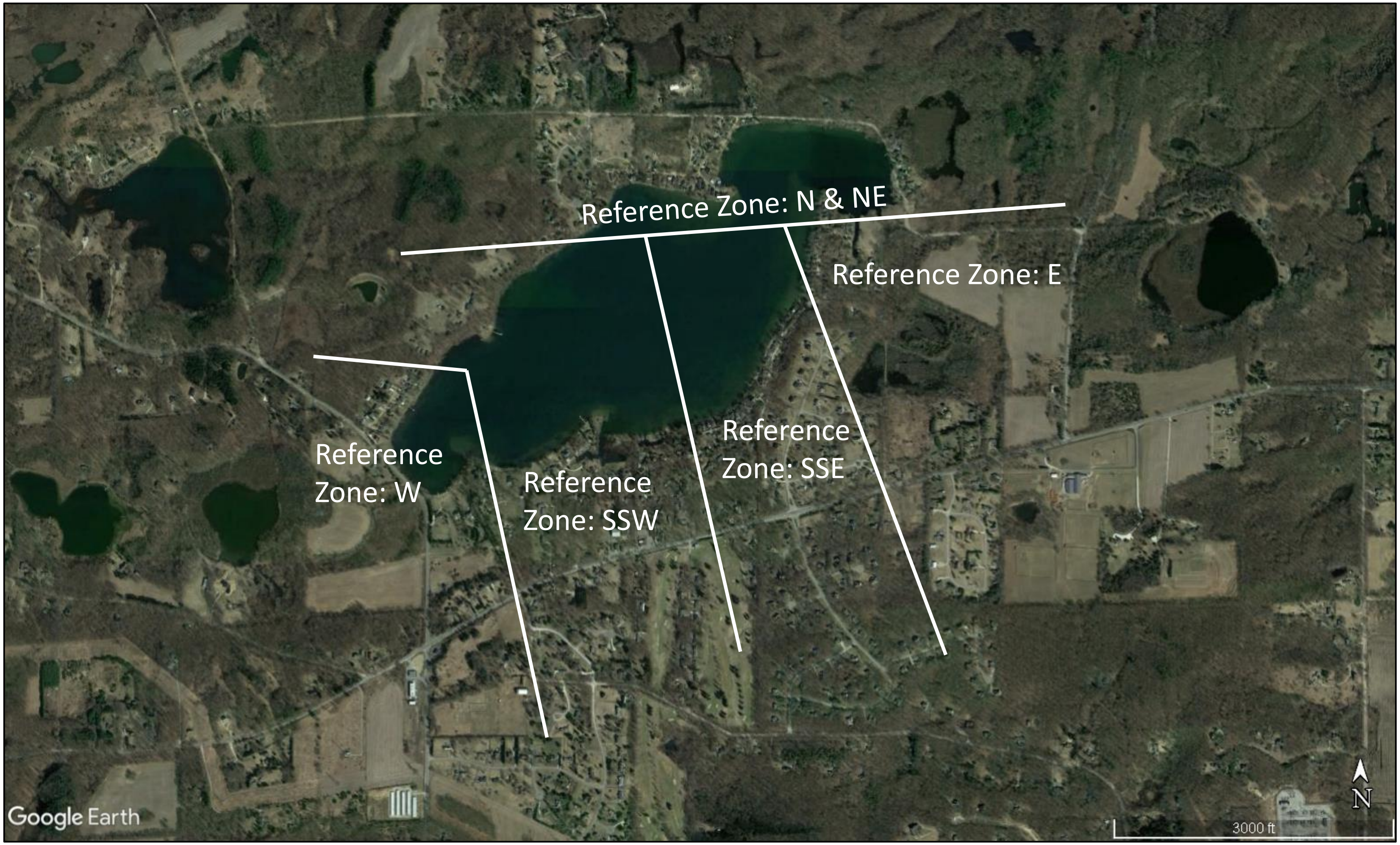
$$R_L = [C_P + (C_I - C_P) \times DCIA_f \times IMP_L] \times A_L \times I \qquad \textit{(Eq. 2)}$$

Where:

- R_L = Total average annual surface runoff from land cover L (ac-in/year)
- C_P = Pervious area runoff coefficient (0.06)
- C_i = Impervious area runoff coefficient (0.9)
- $DCIA_f$ = fraction of impervious area that is directly contributing (0.5)
- IMP_L = Fractional imperviousness of land cover L
- A_L = Area of land cover L (acres)
- I = Long term average annual precipitation (40.08 inches/year)

Equation 1 shows that the loading factor (ML) for land cover L is the product of the EMC for land cover L, the annual runoff for land cover 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 and the percent imperviousness of land cover L, with the tuning coefficients C_P and C_i. The loading factor, M_L, is multiplied by the area of land cover L to obtain a total annual loading for that land cover. Loads for each land cover category were then totaled.

Appendix B: Windshield Survey Supporting Information



North Lake Nonpoint Source (NPS) Pollutant Assessment Appendix B Legend:

Observed direction of roadway stormwater surface runoff (blue arrows)

Areas accepting stormwater surface runoff (red circles)

Existing buffers or areas identified for protection (green circles)

Areas of potential stormwater improvements (yellow circles)

(*Note: All corresponding photographs taken during K&A survey on 7/16/21*)

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Appendix B

North Lake N & NE zones: Direction of roadway stormwater surface runoff (blue arrows), areas accepting stormwater surface runoff (red circles), existing buffers or areas identified for protection (green circles), and areas of potential stormwater improvements (yellow circles).

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Appendix B

North Lake E zone: Direction of roadway stormwater surface runoff (blue arrows), areas accepting stormwater surface runoff (red circles), existing buffers or areas identified for protection (green circles), and areas of potential stormwater improvements (yellow circles).

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Appendix B

North Lake SSE zone: Direction of roadway stormwater surface runoff (blue arrows), areas accepting stormwater surface runoff (red circles), existing buffers or areas identified for protection (green circles), and areas of potential stormwater improvements (yellow circles).

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Appendix B

North Lake SSW zone: Direction of roadway stormwater surface runoff (blue arrows), areas accepting stormwater surface runoff (red circles), existing buffers or areas identified for protection (green circles), and areas of potential stormwater improvements (yellow circles).

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Appendix B

North Lake W zone (lake outlet area): Direction of roadway stormwater surface runoff (blue arrows), areas accepting stormwater surface runoff (red circles), existing buffers or areas identified for protection (green circles), and areas of potential stormwater improvements (yellow circles).

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