REGION 5
CHICAGO, IL 60604

March 28, 2024

Phil Argiroff, Acting Director
Water Resources Division
Michigan Department of Environment, Great Lakes, and Energy
525 W Allegan St.
P.O. Box 30028
Lansing, Michigan 48909-7528

Dear Mr. Argiroff:

Thank you for your March 5, 2024, request to remove the *Eutrophication or Undesirable Algae* Beneficial Use Impairment (BUI) from the Muskegon Lake Area of Concern (AOC) located in Muskegon, Michigan. As you know, we share your desire to restore all the Great Lakes AOCs and to formally delist them.

Based upon a review of your submittal and supporting information, the U.S. Environmental Protection Agency (EPA) hereby approves your request to remove this BUI from the Muskegon Lake AOC. EPA will notify the International Joint Commission of this significant positive environmental change at this AOC.

We congratulate you and your staff as well as the many federal, state, and local partners who have been instrumental in achieving this environmental improvement. Removal of these BUIs will benefit not only the people who live and work in the AOC, but all the residents of Michigan and the Great Lakes basin as well.

We look forward to the continuation of this productive relationship with your agency and the Muskegon Lake Watershed Partnership Public Advisory Council as we work together to delist this AOC in the years to come. If you have any further questions, please contact me at (312) 886-0124 or your staff can contact Leah Medley at (312) 886-1307.

Sincerely,

Teresa Seidel, Director
Great Lakes National Program Office

cc: Mike Alexander, EGLE
Melanie Foose, EGLE
Stephanie Swart, EGLE
Raj Bejankiwar, IJC

STATE OF MICHIGAN
DEPARTMENT OF
ENVIRONMENT, GREAT LAKES, AND ENERGY
LANSING

GRETCHEN WHITMER
GOVERNOR

PHILLIP D. ROOS
DIRECTOR

March 5, 2024

VIA EMAIL

Teresa Seidel, Director
Great Lakes National Program Office
United States Environmental Protection Agency, Region 5
77 West Jackson Boulevard (G-9J)
Chicago, Illinois 60604-3507

Dear Teresa Seidel:

The Michigan Department of Environment, Great Lakes, and Energy's (EGLE) Water Resources Division (WRD) requests concurrence of the United States Environmental Protection Agency's (USEPA) Great Lakes National Program Office (GLNPO) with the removal of the Eutrophication and Undesirable Algae Beneficial Use Impairment (BUI) from the Muskegon Lake Area of Concern (AOC). The WRD has assessed the status of the BUI in accordance with the *Guidance for Delisting Michigan's Great Lakes Areas of Concern* and recommends that the BUI be removed from the list of impairments in the Muskegon Lake AOC.

Attached please find documentation to support this recommendation, including the BUI removal recommendation prepared by WRD's technical staff. The Muskegon Lake Watershed Partnership passed a motion supporting this recommendation on December 20, 2023, which is included as Attachment B.

We value our continuing partnership in the AOC Program and look forward to working with the GLNPO in the removal of BUIs and the delisting of AOCs. If you would like further information concerning this request, please contact Stephanie Swart, Muskegon Lake AOC Coordinator, Great Lakes Management Unit, Great Lakes Watersheds Assessment, Restoration, and Monitoring Section, WRD, at 517-331-3779; SwartS@Michigan.gov; or EGLE, P.O. Box 30458, Lansing, Michigan 48909-7958; or you may contact me.

Sincerely,

Phil Argiroff, Acting Director
Water Resources Division
517-284-5470

Attachment

cc/att: Andrea Schaller, USEPA, Region 5
Amy Pelka, USEPA, Region 5
Leah Medley, USEPA, Region 5
Mark Loomis, USEPA, Region 5
Mike Alexander, EGLE
Melanie Foose, EGLE
Stephanie Swart, EGLE

Removal Recommendation
Eutrophication and Undesirable Algae Beneficial Use Impairment
Muskegon Lake Area of Concern

Issue

The Michigan Department of Environment, Great Lakes, and Energy (EGLE), Water Resources Division (WRD), Areas of Concern (AOC) Program, recommends removal of the *Eutrophication and Undesirable Algae* Beneficial Use Impairment (BUI) for the Muskegon Lake AOC. The recommendation is made with the support of the Muskegon Lake Watershed Partnership (MLWP), which serves as the Public Advisory Council for the AOC. This request is made in accordance with the process and criteria set forth in the *Guidance for Delisting Michigan's Great Lakes Areas of Concern* (*Guidance*) (Michigan Department of Natural Resources [DNR], 2018) and the locally approved criteria.

Background

Muskegon Lake is a 4,150-acre drowned river mouth located in Muskegon County. The Muskegon Lake AOC includes Muskegon Lake and portions of its tributaries: the Muskegon River, Ruddiman Creek, Ryerson Creek, Green Creek, Four Mile Creek, Little Bear Creek (including an unnamed tributary), and Bear Lake. Muskegon Lake was listed as an AOC primarily due to historic discharges of industrial process wastewater, municipal wastewater treatment plant effluent, combined storm sewer overflows, alterations of shoreline, excessive shoreline filling, and urban runoff. These discharges introduced elevated levels of polychlorinated biphenyls, heavy metals, nutrients, oils, and other contaminants into the AOC (DNR, 1987).

There are two BUIs, out of the nine originals, that remain for the Muskegon Lake AOC: *Degradation of Benthos and Eutrophication and Undesirable Algae*. This document pertains only to the *Eutrophication and Undesirable Algae* BUI.

At the time of the 1987 Remedial Action Plan (RAP), this BUI was not included as an impairment to the AOC. However, historical water quality degradation was mentioned (DNR, 1987). The Muskegon Lake Public Advisory Council ([MLPAC] now MLWP) counted the BUI as part of a 2002 RAP Update as they felt that “although progress was made to restore impaired uses between 1994 and 2002…four additional BUIs [were identified] during that period” (Muskegon Conservation District, 2002). The *Eutrophication and Undesirable Algae* BUI was added because of concerns related to historical non-point source pollution in the Muskegon Lake watershed and the water quality of Bear Lake (Public Sector Consultants, 1994; Muskegon Conservation District, 2002).

Removal Criteria

In 2007, the Department of Environmental Quality ([DEQ] now EGLE) accepted a locally developed target for the *Eutrophication and Undesirable Algae* BUI that is functionally equivalent to the criteria outlined in the *Guidance* (DNR, 2018; Attachment A). The target is outlined as such:

The *Eutrophication and Undesirable Algae* BUI will be considered restored when: (1) no waterbodies within the AOC are included on the list of impaired waters due to nutrients or excessive algal growths in the current Clean Water Act Water Quality and Pollution Control in Michigan: Section 303(d) and 305(b) Integrated Report and (2) the following average annual concentrations/values are achieved in Muskegon Lake for two consecutive annual monitoring events:

Indicator	Target	Reasoning
Surface Total Phosphorus Concentration	30 µg/l	MDNR Recommendation for the 1987 RAP[1]
Chlorophyll *a*	10 µg/l	U.S. Environmental Protection Agency[2] (EPA)
Secchi Disk depth	~ 2.0 m	Pentwater Lake as reference
Trophic Status Index	50-55	Pentwater Lake as reference

[1] A total phosphorus concentration of 30 µg/l (during spring and fall turnover) was recommended to maintain water quality at levels that will not produce nuisance algal blooms.

[2] A Chlorophyll *a* target of 10 µg/l (during the summer) was recommended to maintain water quality at levels that will not produce nuisance algal blooms.

Additionally, the targets for Bear Lake will be consistent with the Total Maximum Daily Load (TMDL) and the established local target criteria. The overall objective of the TMDL is to reduce total phosphorus loads to levels that are expected to achieve water quality standards, and specifically, reduce excessive algal growth and increase water transparency (DEQ, 2008a; DEQ, 2011).

Supporting Data and Analysis

Activities

Projects

Projects have been implemented throughout the Muskegon Lake AOC region to reduce non-point source pollution and nutrient runoff in the form of storm water and watershed management and green infrastructure implementation. The Bear Creek Watershed Management Plan was completed in 2004. The plan specifically addresses non-point source water quality concerns. A 319 grant from the state of Michigan allowed the

Muskegon Conservation District and partners to involve stakeholders, update the watershed management plan, address external loading, and study internal phosphorus loading. From 2004-2007, funding provided for stabilization of 1,284 linear feet of streambank, installation of a storm water filter swale, and conversion of 75 feet of Bear Lake shoreline to native buffer. During that time these changes provided an annual reduction in sediment, phosphorus, and nitrogen at 204 tons, 1,599 pounds, and 320 pounds, respectively (Muskegon River Watershed Assembly [MRWA], 2007). From 2010-2014, funds allowed for 370 linear feet of riparian filter strips, an animal waste facility, 790 linear feet of exclusion fencing, and a livestock crossing installation. These changes provided an annual reduction in sediment, phosphorus, and nitrogen loading at 5.78 tons, 30.22 pounds, and 225.4 pounds respectively (MRWA, 2014).

Best Management Practices

To reduce nutrient inputs in the Bear Lake watershed, a coalition of community organizations encouraged landowners to install best management practices to reduce sediment and nutrient loadings in the upper watershed, such as filter strips and conservation cover. These best management practices are maintained by the landowners. This effort eliminated about 100 tons of sediment into the watershed as a one-time impact (Renas, 2016). Also, as part of this work, an area near the upper watershed was identified as highly impacted by septic systems. A 0.75-acre wetland was created near four lakes and Ribe Drain for the purposes of filtering excess nutrients (DEQ, 2017). In 2013, the West Michigan Shoreline Regional Development Commission (WMSRDC) worked with four of the local governments to identify the status of water quality measures in their existing plans and ordinances and developed a set of recommendations (WMSRDC). In 2012, as part of a different project, the city of Muskegon and WMSRDC implemented a green infrastructure and storm water management project from Seaway to Shoreline Drives (Golder Associates, 2016). The project removed foundry fill and replaced it with clean soil and native plantings to treat storm water runoff.

Watershed Management Plans

Both Muskegon Lake and Muskegon River have watershed management plans, which will eventually be updated to a sub watershed format (Grand Valley State University Annis Water Resources Institute [GVSU AWRI], 2002; Fishbeck, 2005). The existing plans outline the sources of nutrient pollution to the watersheds, such as storm water runoff and agricultural runoff. They rank the streams that are sensitive to surface water runoff, which in turn, allows advocacy in those areas for best management practices (GVSU AWRI, 2002; Fishbeck, 2005). The plans lay out goals for each of the sub watersheds along with recommendations for implementation as well as potential pilot project locations. In 2017, a sub watershed management plan was written for Ruddiman Creek, Division Street Outfall, and Muskegon Lake direct drainage (Golder). Like the full watershed plans, this sub watershed plan seeks to minimize non-point source pollution

and storm water runoff, among other objectives. The sub watershed management plan outlines solutions and provides recommendations, such as rain gardens and bioswales, for 15 sites (Golder, 2017). Additionally, each of the sites has a management plan with as built site drawings for implementation.

Municipal Separate Storm Sewer Permits

The cities of Muskegon, Muskegon Heights, Norton Shores, and Roosevelt Park and Muskegon County have Municipal Separate Storm Sewer System (MS4) permits. Under the jurisdiction of the MS4 permits, permittees are required to reduce the discharge of pollutants from their MS4 to the maximum extent practicable through the development of several plans. One such requirement is the cities and the county have developed Storm Water Pollution Prevention Initiatives (SWPPI). The SWPPI provides a "description of watershed characteristics, identif[ies] watershed pollutants, and make[s] recommendations for the treatment, prevention, and reduction of pollution in the Muskegon Lake watershed" (Fishbeck, 2006). A specific goal of each of the SWPPIs is to "prevent soil erosion and reduce sedimentation" and "reduce nutrient loading to Muskegon Lake and its tributaries, giving particular attention to sources of phosphorus" (Fishbeck, 2006 a-e). The SWPPIs assess the best methods to reduce nutrients to the watershed, develop short term objectives, and set methods to assess progress for the goals.

Habitat Restoration

In addition to the watershed efforts and plans to address phosphorus issues in the Bear Lake watershed as well as achieve *Loss of Fish and Wildlife Habitat* BUI targets, a site adjacent to and just south of Bear Creek and northeast of Bear Lake was purchased in 2012 and restored from 2016-2018 with National Oceanic and Atmospheric Administration habitat acquisition and restoration funding (Bear Creek hydrologic reconnection project). Bear Creek had been historically straightened and separated from two ponded areas for celery farming. The ponds contained a significant amount of phosphorus in the sediments and water column, which required remediation prior to restoration as they could have become a large source of total phosphorus to Bear Lake (Steinman et al., 2016). The ponds were drained and water treated at the Muskegon County Wastewater Treatment Plant to remove much of the phosphorus as part of the site restoration work. The project hydrologically reconnected and restored 36.4 acres of floodplain wetlands, removed 148,608 metric tons of phosphorous-laden sediment, and restored 2,015 linear feet of streambank with native vegetation and woody habitat. Following restoration, total phosphorus concentrations in the west pond declined from ~900 µg/l to ~20 µg/l (Hassett and Steinman, 2022).

Figure 1. Former celery field East and West Ponds pre-restoration, aerial view with Bear Creek just to the north of the ponds.

Figure 2. Site construction in the West Pond, looking south at Bear Lake.

Figure 3. Final grade and habitat islands in the East Pond, looking northeast.

Figure 4. Earth work complete in the West Pond, including berm removal, looking west.

The Lower Muskegon River habitat restoration site is a former celery farm on the north side of the Muskegon River, just east of Muskegon Lake. Extensive soil and water sampling for contaminants and nutrients took place during the design phase as well as 2-dimensional hydrologic monitoring to determine how water would flow through the restored wetland. The site restoration included hydrologic reconnection of 54 acres of wetlands to the Muskegon River as well as reshaping and planting. Excavation of 101,850 cubic yards of sediment took place to remove high-phosphorus soils while creating an emergent, southern wet meadow, southern shrub-carr, and floodplain forested wetlands from 2020-2021. After restoration, post restoration monitoring took place in 2021 with water samples and sediment cores in locations similar to where pre-restoration samples took place. The sediments were sampled for organic matter, ash-free dry mass, total phosphorus, and phosphorus isotherm (Steinman and Hassett, 2022). The results indicated that total phosphorus sediment concentrations declined substantially thereby decreasing additional phosphorus load to Muskegon Lake (Steinman and Hassett, 2022).

Figure 5. Lower Muskegon River aerials during Muskegon River restoration on the upper right (left) and after restoration Muskegon River on the left (right).

Assessment of Target Achievement

The removal target for the *Eutrophication and Undesirable Algae* BUI is based on presence of sites in the Integrated Report, sampling results for Muskegon Lake, and consistency with the TMDL for Bear Lake. A review of the 2022 Integrated Report provides that Bear Lake in the Muskegon Lake AOC remains impaired due to nutrients or excessive algal growths (EGLE, 2022; EPA, 2022). Bear Lake is on the 305(b) list (Category 4a), which means available information indicates that at least one designated use is not being supported or is threatened, but a TMDL to address the impairment-causing pollutant has been approved by the EPA. An assessment of Muskegon Lake indicates that the eutrophication issues in Muskegon Lake are no different than other non-AOCs in the region.

Muskegon Lake Sampling Results

Prior to the time of the 1987 RAP, surface water total phosphorus concentrations in Muskegon Lake averaged nearly 70 µg/l in 1972, chlorophyll *a* averaged 25 µg/l, and Secchi disk transparencies were below 1.5 meters (Freedman et al., 1979). Muskegon Lake was in the middle of the eutrophic range as provided by the Carlson Index (Carlson, 1977). Improvements to non-point source runoff, habitat, and water treatment plant upgrades have in turn resulted in successes for Muskegon Lake. GVSU AWRI has been sampling the water quality in Muskegon Lake since 2003. The lake is sampled three times a year at six sites (Figure 6). The information is retained on a website (gvsu.edu/wri/steinman/muskegon-lake-water-quality-dashboard-78.htm) which keeps a running tabulation of the results (GVSU AWRI, 2022). It should be reiterated that the removal criteria were established using the Secchi disk depths during 2007 and the phosphorus numbers were based on spring data and fall turnover and chlorophyll *a* on summer results.

Figure 6. GVSU AWRI Muskegon Lake sampling locations.

The average for total phosphorus (2018-2022) has been 15 µg/l in the spring, 31 µg/l in the summer, and 38 µg/l in the fall. As of late, sampling in the fall has been taking place before turnover since the boats are pulled in late fall and turnover is happening later and later in the year due to climate change. Chlorophyll *a* fluctuates throughout the year with lower concentrations in spring than in fall. Overall, as of 2022, the lake is meeting goals in some seasons, but the increase in blooms in the fall warrants further study (GVSU AWRI, 2022). The most recent data from fall 2023 (Table 1) reveal the influence of

internal phosphorus loading at the two deepest sampling sites (DEEP and BEAR) prior to turnover (September). Once the lake turns over (October), the high total phosphorus concentrations from these sites mix throughout the water column and result in elevated total phosphorus concentrations. The magnitude of internal phosphorus loading worldwide has increased with increasing lake temperatures (O'Reilly et al., 2015), as the duration of stratification has increased (starting earlier, ending later), resulting in longer periods of potential hypoxia and anoxia, which stimulates the internal loading process (Markelov et al., 2019).

		Total Phosphorus (µg/L)			
Site	**Depth**	**9/27/2023**	**10/11/2023**	**10/17/2023**	**10/23/2023**
AWRI	Surface	18.7	33.7	32.4	30.4
	Bottom	15.8	32.7	29.8	29.6
MUSR	Surface	18.8	53.7	27.3	23.7
	Bottom	20.1	31.8	20.8	25.3
BEAR	Surface	13.3	32.3	32.2	33.5
	Bottom	56.5	34.9	48.1	29.9
CHAN	Surface	19.4	33.9	39.7	37.5
	Bottom	13.4	16.2	37.7	39.1
DEEP	Surface	25.0	38.5	35.7	33.0
	Bottom	56.3	43.8	37.6	33.0
RUDD	Surface	14.4	39.1	38.0	31.6
	Bottom	13.6	34.1	31.2	37.7
Grand Mean	Surface	18.3 (4.1)	38.5 (7.9)	34.2 (4.5)	31.6 (4.5)
	Bottom	29.3 (21.1)	32.3 (8.9)	34.2 (9.2)	32.4 (5.2)

Table 1. Muskegon Lake total phosphorus concentrations at surface and near-bottom depths throughout fall 2023 sampling period and lake-wide grand means (±SD) for each sampling date.

Just like with chlorophyll *a*, Secchi disk depth, a measure of water clarity, varies throughout the year, with the 2022 spring and summer results meeting criteria and fall Secchi disk depth greater than the two-meter target threshold (GVSU AWRI, 2022). In fall 2023, Secchi disk depths ranged from 2.1 meters (September) to 3.2 meters (October) (Steinman, unpublished data). The trophic status of Muskegon Lake as of 2021 is mesotrophic or around 51 on the Trophic Status Index. It is important to note, that while the fall target numbers for Muskegon Lake often lean into the undesirable category, Muskegon Lake has greatly improved since the 1979 study and continues to improve as results are better than the 2019 sampling (GVSU AWRI, 2022). Comparatively, Pentwater Lake, a non-AOC just north of Muskegon has similar total phosphorus concentrations (mean of 45 µg/l) and Secchi disk depths (1.7 meters) (Progressive AE, 2018).

Indicator	Target	2021 Status Spring	2021 Status Summer	2021 Status Fall	2022 Status Spring	2022 Status Summer	2022 Status Fall	Pentwater Lake Fall
Surface Total Phosphorus Concentration	30 µg/l	8 µg/l	28 µg/l	38 µg/l	20 µg/l	32 µg/l	40 µg/l	45 µg/l
Chlorophyll *a*	10 µg/l	4 µg/l	9 µg/l	15 µg/l	6 µg/l	10 µg/l	10 µg/l	3 µg/l
Secchi Disk depth	~ 2.0 m	2.6 m	2.3 m	2 m	2.1 m	2.3 m	2.4 m	1.7 m
Trophic Status Index	50-55	50	51	51	51	51	52	NA

Table 2. BUI target criteria for Muskegon Lake as compared to the current status of those targets and a similar drowned river mouth, Pentwater Lake.

Muskegon Lake met the target for total phosphorus for consecutive years, using an average concentration for spring-fall, until 2018 when the numbers began creeping up (GVSU AWRI). And Muskegon Lake met the target for chlorophyll *a* for two consecutive years until 2015 (GVSU AWRI). These results are consistent with other drowned river mouth lakes in the region, some of which have far higher phosphorus numbers leading into the fall. In fact, both the TMDLs for Lake Allegan and Lake Macatawa have a higher in-lake total phosphorous concentration target than Muskegon Lake (Heaton, 2001; Walterhouse, 1999). When looking at water quality and land cover in 12 drowned river mouths along Lake Michigan, researchers determined that there was a latitudinal gradient from south to north and that the southern lakes were experiencing greater climate and anthropogenic stresses than the northern lakes (Mader et al., 2023). The results also indicated that anthropogenic stressors along with natural influences can lead to increased cultural eutrophication (Mader et al., 2023) Since drowned river mouths along the southern coast of eastern Lake Michigan experience different latitudinal impacts, one could infer that the target of 30 µg/l total phosphorus may no longer be an achievable goal. Because Muskegon Lake is in the southern portion of the lower peninsula, it is currently experiencing these climate induced changes like other lakes in the latitude. Thus, Muskegon Lake is seeing conditions that are not limited to the AOC and are typical of the region.

Indeed, Muskegon Lake's water quality (specific conductivity, Secchi disk depth, chlorophyll *a*, and total phosphorus) compares favorably with most of the drowned river mouth lakes sampled in this region, as shown in Mader et al. (2023). Briefly, three sites per drowned river mouth (DRM) were sampled in June and August. To examine how these drowned river mouth lakes compared along the eastern shoreline of Lake Michigan, we ran a hierarchical cluster analysis using group-average linkage based on Euclidean distances of the water quality variables (Figure 7). The cluster analysis showed several distinct groupings, although the overall DRM orientation did not conform

to a clear latitudinal gradient due to some outliers. The Kalamazoo and Macatawa DRMs, which are located at the southern end of the DRM complex (42º N), tend to have the poorest water quality, and were grouped to the far left of the cluster with the deep hole sites in both DRMs particularly separated. The next grouping to the right included mostly the DRMs at the north end of the gradient (44ºN), including Arcadia, Betsie, and Portage. This group included a few outliers (e.g., Pere Marquette and the deep hole sites in Muskegon). The next grouping to the right includes Muskegon Lake channel and river mouth, which is clustered in a large group of DRMs that are in the middle section of the gradient (~43ºN) including Pere Marquette, Pentwater, White, Muskegon, and Mona Lakes. This clustering provides additional support that the water quality issues facing Muskegon Lake are a regional concern.

To examine in more detail the water quality results across the DRMs, we have plotted the key water quality variables from Mader et al. (2023) in Figure 8 below). Muskegon Lake (S4 in Figure 8) water quality groups with other DRMs in the region; this is evident for both chlorophyll *a* (Fig. 8d) and TP (Fig. 8e), where Muskegon Lake (symbol 4th from the left) concentrations are very similar to other DRMs in their region.

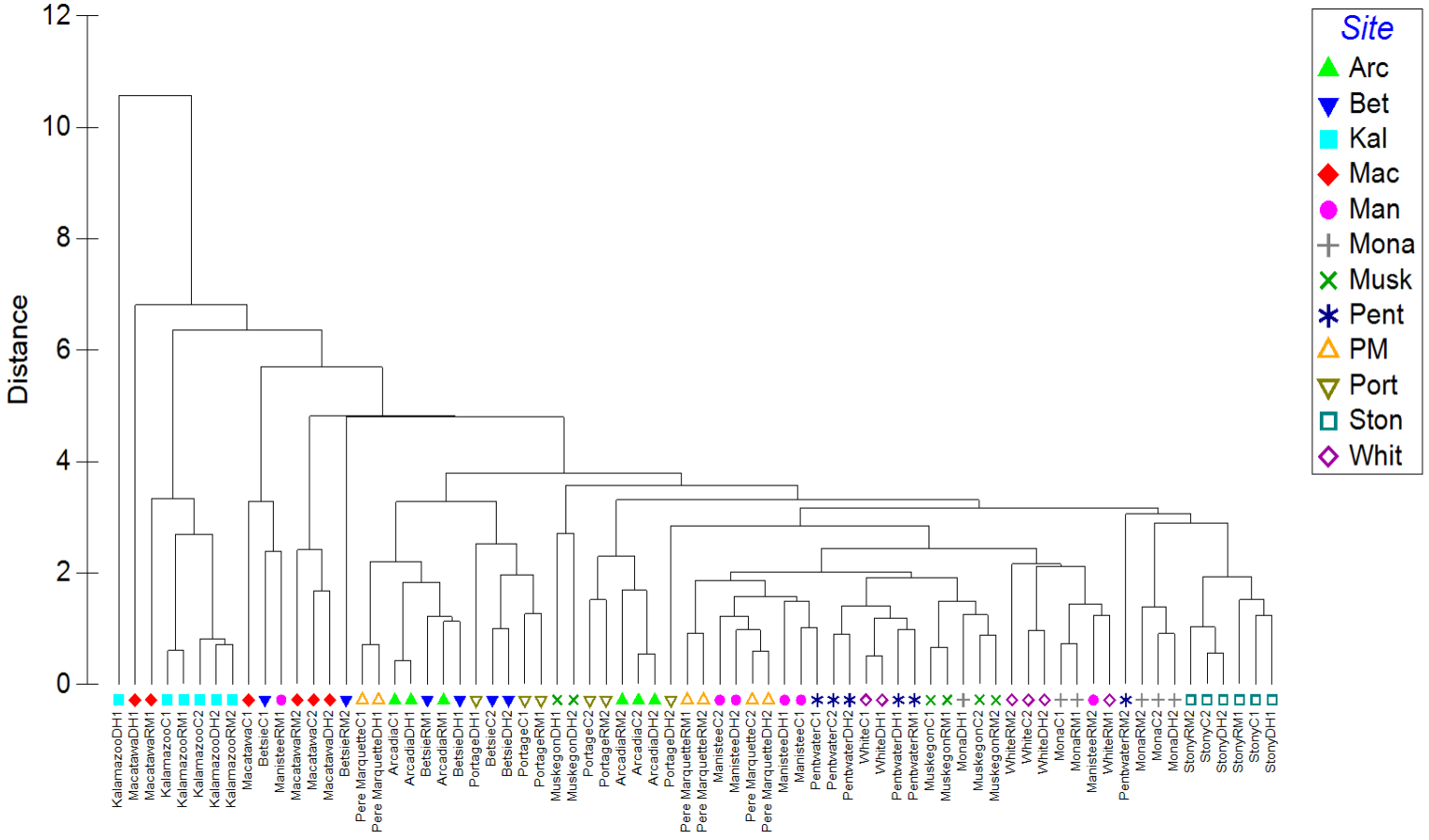

Figure 7. Cluster analysis of all sampling sites in the 12 DRMs during June and August. X-axis labels: C = channel; DH = deep hole; RM = river mouth 1 = June; 2 = August.

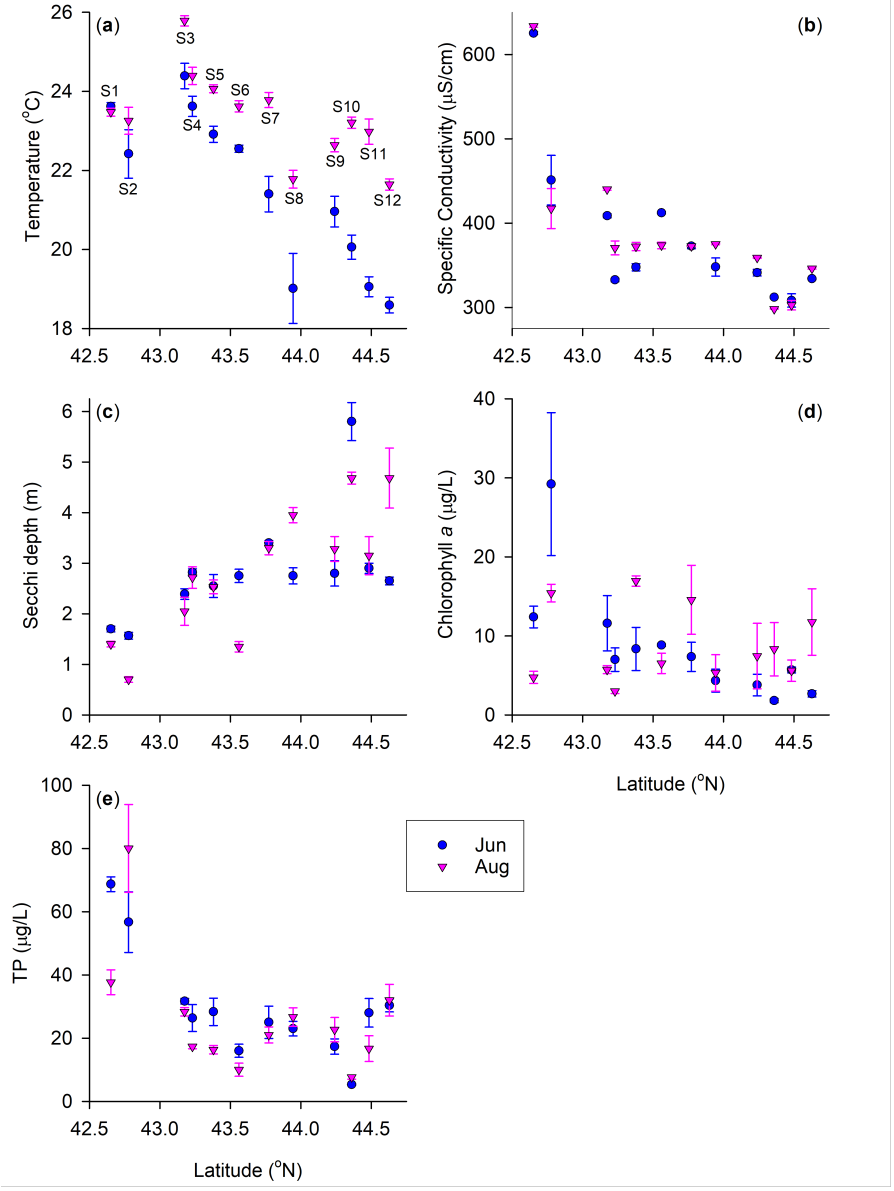

Figure 8. Surface water quality variables for June and August 2020 with latitude: (a) water temperature, (b) specific conductivity, (c) Secchi disk depth, (d) chlorophyll a concentration, and (e) total phosphorus concentration. Points represent the mean (n=3 sites) for a DRM lake (n=12 DRMs) with error bars representing one standard error. Lakes are labeled in the first panel (S1 = Kalamazoo Lake, S2 = Lake Macatawa, S3 = Mona Lake, S4= Muskegon Lake, S5 = White Lake, S6 = Stony Lake, S7 = Pentwater Lake, S8 = Pere Marquette Lake, S9 = Manistee Lake, S10 = Portage Lake, S11 = Arcadia Lake, and S12 = Betsie Lake) with the order of lakes the same in each panel (i.e., listed from south to north).

Muskegon Lake has experienced late summer blooms of cyanobacteria, even before the *Eutrophication and Undesirable Algae* BUI was listed for the AOC. Now the blooms

frequently occur during the fall, but public concern remains as the blooms now produce microcystin, a toxin released by cyanobacteria. Cyanobacteria blooms are becoming more frequent in the Great Lakes basin due to non-point source pollution, cultural eutrophication, and the selective feeding of zebra mussels. Bear Lake and Muskegon Lake are regularly monitored for the presence of cyanobacteria via the Cyanobacteria Assessment Network (CyAN). Many other lakes in the region are also monitored in this way and Figure 8 shows chlorophyll data from June and August among the DRMs. The Muskegon Community has also rallied to the cause in learning about these blooms and ways to prevent them from recurring, while recognizing that the situation in Muskegon is like those in other lakes. A community meeting was held on February 23, 2023, to raise awareness about algal blooms and was attended by over 400 people.

Bear Lake TMDL

Bear Lake is a shallow hypereutrophic/eutrophic lake in the Muskegon Lake AOC (Cadmus et al., 2007; Hassett and Steinman, 2022). Because of elevated total phosphorus concentrations and excessive algal growth, a TMDL was written in 2008 (DEQ, 2008b). The TMDL requires 50 percent external and 79 percent internal load reductions to achieve a target total phosphorus concentration of 30 µg/l for Bear Lake (DEQ, 2008b; Hassett and Steinman, 2022). However, a study by Steinman and Ogdahl (2015) revealed that the internal load estimate was too high. This study provided that internal phosphorus loads were likely less of a factor due to low release rates of phosphorus from the sediment, a well-mixed water column, and iron rich sediments (Steinman and Ogdahl, 2015). Analysis of the scenario results indicates that Bear Lake is already meeting the internal phosphorus load reduction goal without any management action. Given that internal phosphorus loads were overestimated in the TMDL, the focus shifted to external loading management actions. Some of those actions are mentioned in the *Activities* section, specifically the work to restore the former celery farm near Bear Creek. The work at the former celery farm removed 148,608 metric tons of phosphorus-laden sediment from the Bear Lake watershed and has already resulted in a 15-fold reduction in total phosphorus concentration, which is further reducing total phosphorus loads to Bear Lake (Hassett and Steinman, 2022).

The overall objective of the TMDL is to reduce total phosphorus loads to levels that are expected to achieve water quality standards, and specifically, reduce excessive algal growth and increase water transparency (DEQ, 2008a). And, given that internal phosphorus loading in Bear Lake is meeting the TMDL reduction goal, target efforts to reduce phosphorus must shift to external phosphorus sources. While not all lakes have a phosphorus TMDL, many small nutrient rich lakes throughout Michigan face a similar problem, reducing external loading. The TMDL is part of the regulatory process for addressing impairments in the Bear Lake watershed along with the MS4 permits for the surrounding communities, and the continued work by the MLWP and other local jurisdictions to reduce nutrient inputs are the existing mechanism to achieve phosphorus reductions. The TMDL for Bear Lake and the MS4 permits will continue to

provide the means for oversight regardless of the status of the Eutrophication BUI. The same mechanism is used throughout the state of Michigan in other non-AOCs to achieve reductions in phosphorus in shallow lakes. The phosphorus exceedances occurring at Bear Lake are very similar to the Strawberry Lake (Livingston County) and Morrison Lake (Ionia County) TMDLs (DEQ, 2000; DEQ, 2008c). There are 13 phosphorus TMDLs across the state in non-AOCs and even more listed for phosphorus and nutrients in the 2022 Integrated Report (EGLE). The ongoing work by the MLWP and surrounding communities will take time, but it is an effort that is taking place across the state not just in AOCs.

The Muskegon Lake Action Plan (Plan) is a “community-based plan, designed to facilitate the continuation of coordinated, natural resources stewardship of Muskegon Lake and Lower Muskegon Watershed” (WMSRDC, 2019). The Plan is intended to guide the community’s preservation, protection, and improvement of Muskegon Lake and its resources and replace the RAP. The Plan includes implementation recommendations for water quality, green infrastructure, and storm water, including “work with the agricultural community to address nutrient runoff into surface drains”. The habitat sites in the AOC, which provide buffers to nutrient enrichment have monitoring and maintenance plans and a local volunteer coordinator. Long term planning efforts like the Action Plan for the Muskegon Lake watershed will continue to improve upon the successes already seen in the non-point source work. Additionally, there are four SWPPIs, a TMDL, and two watershed management plans, along with a motivated volunteer base that can use these other plans as references for future work to reduce nutrients to Muskegon Lake and Bear Lake.

Conclusion

The status of the *Eutrophication and Undesirable Algae* BUI was assessed by reviewing the data associated with the local targets, the requirements noted in the Bear Lake TMDL, and the work completed in the AOC. The eutrophication and undesirable algae impairments in the Muskegon Lake AOC were largely the result of historical non-point source pollution and water quality issues.

Based on the studies conducted in Muskegon Lake and Bear Lake, as well as the extensive non-point source improvements, eutrophication in the Muskegon Lake AOC has improved especially when compared to original observations (DNR, 1987). Muskegon Lake has started seeing increased total phosphorus after several consecutive years of meeting targets, but these results are no different than other drowned river mouths in lower Michigan and may be a result of climate-induced anthropogenic stressors. Bear Lake remains on the list of impaired waterbodies, but an established regulatory process is in place, recent restoration activities have substantially reduced phosphorus concentrations, and the issues are no different than a non-AOC. The Technical Team (EGLE, GVSU, and MLWP) for this BUI is confident that Bear Lake site will be addressed by applicable state programs and local community efforts and that

the local BUI criteria is satisfied. EGLE's AOC Program staff recommend the removal of the *Eutrophication and Undesirable Algae BUI* because the impairment is not limited to the AOC and is typical of regional conditions.

Recommendation

EGLE recommends removal of the *Eutrophication and Undesirable Algae* BUI in the Muskegon Lake AOC.

The MLWP Technical Committee reviewed the documentation on July 22, 2023, then the removal recommendation was discussed with the MLWP at their regular meeting on November 4, 2023. The MLWP submitted a formal letter of support for removal of the BUI dated December 20, 2023 (Attachment B). This proposed action was public noticed for 30 days via EGLE's Environmental Calendar and postings to the Mich-RAP listserv and MLWP email list. One written comment was received during the comment period and was addressed via email.

Prepared by: Stephanie Swart, Muskegon Lake AOC Coordinator
Great Lakes Management Unit
Surface Water Assessment Section
Water Resources Division
Michigan Department of Environment, Great Lakes, and Energy
February 20, 2024

Attachments:

A – Target for the Delisting of the Eutrophication and Undesirable Algae Beneficial Use Impairment in the Muskegon Lake Area of Concern

B – Muskegon Lake Watershed Partnership letter supporting BUI removal, December 20, 2023

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Attachment A

Target for the Delisting of the Eutrophication and Undesirable Algae Beneficial Use Impairment in the Muskegon Lake Area of Concern

Introduction

Improvements in the water quality of Muskegon Lake have resulted in increased public usage of the resource and community interest in sustaining the progress of restoration and preventing future adverse environmental impacts. At the time of AOC listing, the Michigan Department of Environmental Quality (MDEQ) did not include the Eutrophication or Undesirable Algae Beneficial Use Impairment (BUI) however mentioned historical water quality degradation. Surface water total phosphorus (TP) concentrations averaged nearly 70 µg/L in 1972, chlorophyll *a* averaged 25 µg/L, and Secchi disk transparencies were below 1.5 m (Freedman et al 1979). The lake also experienced frequent, late summer, blooms of cyanobacteria.5 The BUI for the AOC was listed by the PAC in 2002 because of concerns related to historical non-point source pollution in the Muskegon Lake watershed and the water quality of Bear Lake. Current water quality data for Muskegon Lake and Bear Lake was not available at the time of the BUI listing. Due to the establishment of an endowment by the community for the monitoring of Muskegon Lake in 2003, recent water quality data are available (AWRI 2006). Muskegon Lake was in the middle of the eutrophic range as listed by the Carlson Index (Carlson 1977). The lake also experienced frequent, late summer blooms of cyanobacteria. Surface water TP concentrations in 2003-05 averaged < 30 µg/L, chlorophyll *a* averaged 5 µg/L, and Secchi disk transparency was greater than 2 m, indicating that water quality had improved in the lake. Transparency in Muskegon Lake during 2003-05 exceeded that of nearby Pentwater Lake while total phosphorus and chlorophyll *a* concentrations were similar. Pentwater is a drowned river mouth lake with a rural watershed that can be considered as a reference site. Based on the above data, Muskegon Lake is currently at the mesotrophic/eutrophic border line based on the Carlson index (Carlson 1977). The preliminary results of water quality sampling by the MDEQ in 2006 indicated that surface water total phosphorus concentrations averaged 48 µg/l (range 33 µg/l –76 µg/l).

Available Guidance

The IJC criteria for listing the Eutrophication or Undesirable Algae is provided below:

> "When there are persistent water quality problems (e.g. dissolved oxygen depletion of bottom waters, nuisance algal blooms or accumulation, decreased water clarity, etc.) attributed to cultural eutrophication."

The MDEQ provides the following guidance for delisting:

"This BUI will be considered restored when:

• no waterbodies within the AOC are included on the list of impaired waters due to nutrients or excessive algal growths in the most recent Clean Water Act *Water Quality and Pollution Control in Michigan: Section 303(d) and 305(b) Integrated Report* (Integrated Report), which is submitted to U.S. EPA every two years."

Delisting Target

Muskegon Lake is currently not included on the 303(d) listing as requiring a TMDL or on the 305(b) lists for nutrient pollution or algal growths. Bear Lake, however, is included on the 303(d) listing as not meeting standards due to elevated phosphorus concentrations and nuisance algal growths. Because of the importance of Muskegon Lake as a recreational resource and public concern related to sustaining the current trend of improving water quality, the Muskegon Lake Public Advisory Council (MLPAC) voted to adopt targets for delisting the Eutrophication and Undesirable Algae BUI that exceed the State of Michigan Delisting Guidance. The target is presented below:

The **Eutrophication and Undesirable Algae BUI** will be considered restored when will be considered restored when: (1) no waterbodies within the AOC are included on the list of impaired waters due to nutrients or excessive algal growths in the current Clean Water Act Water Quality and Pollution Control in Michigan: Section 303(d) and 305(b) Integrated Report and (2) the following average annual concentrations/values are achieved in Muskegon Lake for two consecutive annual monitoring events:

Indicator	Target	Reasoning
Surface Total Phosphorus Concentration	**30 µg/l**	**MDNR Recommendation for the 1987 RAP[1]**
Chlorophyll *a*	**10 µg/l**	**U.S. EPA[2]**
Secchi Disk depth	**~ 2.0 m**	**Pentwater Lake as reference**
Trophic Status Index	**50-55**	**Pentwater Lake as reference**

[1] A total phosphorus concentration of 30 µg/l (during spring and fall turnover) was recommended to maintain water quality at levels that will not produce nuisance algal blooms.

[2] A Chlorophyll *a* target of 10 µg/l (during the summer) was recommended to maintain water quality at levels that will not produce nuisance algal blooms.

Bear Lake is the only waterbody listed in the AOC on the 2006 303(d) and 305(b) Integrated Report for nutrients or excessive algal growths. The MLPAC will use the 2006 Integrated Report as the reference document to determine which waterbodies require restoration to meet the MDEQ delisting guidance.

- The proposed locations of water quality monitoring sites are shown in Figure 2. The sites in Muskegon Lake currently are monitored by the Annis Water Resources Institute (AWRI) in May, July, and late September (since 2003) as part of program supported by the Muskegon Lake Monitoring Endowment Fund. The MLPAC will work with the MDEQ to develop the monitoring and assessment program for Bear Lake as part of the TMDL process. Targets for Bear Lake will be established to be consistent with the TMDL. Suggested monitoring locations for Bear Lake are shown in Figure 2.

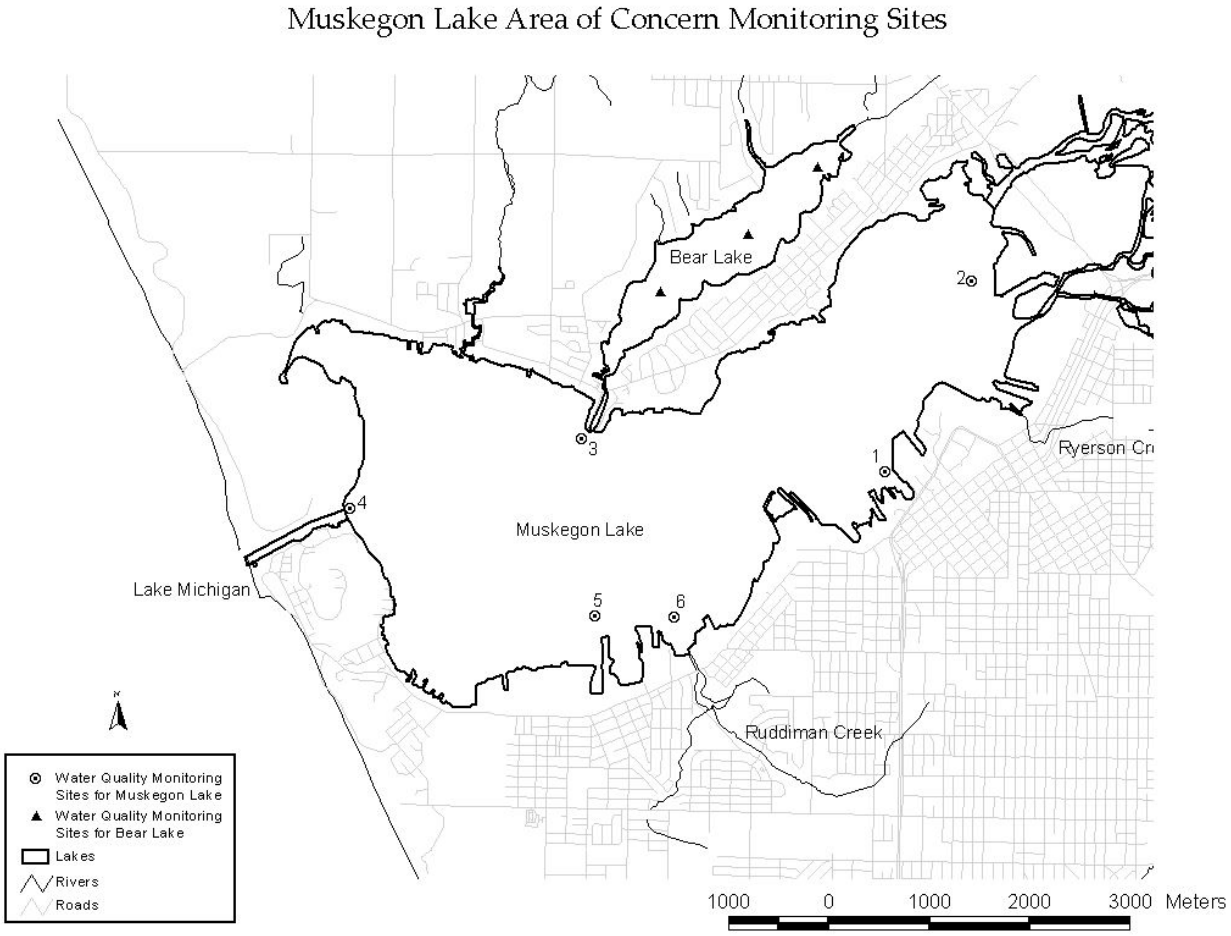

Figure 2. Proposed Water Quality Monitoring Sites in Muskegon Lake and Bear Lake.

Public concerns were expressed regarding the recent occurrence of late summer cyanobacteria blooms and the presence of the toxin, microcystin. Cyanobacteria blooms are becoming more frequent in the Great Lakes basin due to nonpoint source pollution, cultural eutrophication, and the selective feeding of zebra mussels. A detailed

investigation of cyanobacteria and their toxins will be conducted by AWRI in 2006 as part of a MDEQ Grant. The MLPAC will review these data and determine if numerical targets for cyanobacteria and their toxins are necessary.

Functional Equivalence

The proposed targets for the Muskegon Lake AOC are functionally equivalent to the MDEQ guidance in that it requires the removal of Bear Lake from the 303(d) list as a condition for delisting. No other waterbodies in the AOC are included in the 2006 Integrated Report for phosphorus and/or excessive algal growth. The targets exceed the MDEQ guidance as they require specific concentrations/values for water quality parameters to be achieved in Muskegon Lake, which is not included on the 303(d) list.

Programs for Monitoring and Assessing Restoration Success

The MLPAC and/or the Annis Water Resources Institute (AWRI) will obtain funding for the monitoring program for the delisting targets by the submission of grants and requests for assistance from the following sources:

- Muskegon Lake Monitoring Endowment Fund
- Michigan Department of Environmental Quality Clean Michigan Initiative (CMI) Fund Local Monitoring Grants

Environmental Protection Agency Great Lakes National Program Office (GLNPO)
The Annis Water Resources Institute (AWRI) will conduct the monitoring and assessment of Muskegon Lake as part of the program developed for the Muskegon Lake Monitoring Endowment Fund. AWRI will prepare a Quality Assurance Project Plan (QAPP) for Muskegon Lake monitoring activities and obtain MDEQ approval for the methods and data quality objectives associated with the program. Funding for the monitoring and assessment of Bear Lake will be provided by the MDEQ as part of the TMDL process. If necessary, additional funds will be solicited by the MLPAC and/or AWRI from the MDEQ CMI Program and GLNPO for supplemental monitoring and outreach programs. Quality Assurance Project Plans will be prepared for all supplemental assessment activities and agency approval will be obtained for all monitoring programs.

After two successive years of monitoring data meet the above targets for Muskegon Lake, the MLPAC will submit a summary report to the MDEQ along with the acknowledgement that the BUI no longer applies to Muskegon Lake. The report will include monitoring and quality assurance data demonstrating that the data quality objectives of the QAPP and the delisting targets were achieved. The MLPAC will submit a request for formal delisting of the Eutrophication and Undesirable Algae BUI to the MDEQ when the TMDL process results in the removal of Bear Lake from the 303(d) list and the targets for Muskegon Lake are achieved.

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Attachment B

316 Morris Ave., Suite 340 – Muskegon, MI 49440
Website: www.muskegonlake.org

December 20, 2023

Ms. Stephanie Swart
Great Lakes Management Unit
Water Resources Division
Michigan Department of Environment, Great Lakes, and Energy
Lansing, Michigan

Dear Ms. Swart,

The Muskegon Lake Watershed Partnership (MLWP), as the Public Advisory Council (PAC) for the Muskegon Lake Area of Concern (AOC), has reviewed the attached, Michigan Department of Environment, Great Lakes, and Energy (EGLE) Eutrophication and Undesirable Algae BUI Removal Document during our November 14, 2023, meeting.

A draft document was reviewed by the Technical Committee and emailed to the MLWP's officers prior to the November meeting. Following the November meeting, the final document was emailed to the MLWP's list of interested stakeholders and its voting membership for additional review. No additional comments were received.

The MLWP (Muskegon Lake PAC) is pleased to provide this letter in support of EGLE's recommendation to remove the Eutrophication and Undesirable Algae BUI. We look forward to the 30-day public notice via the EGLE Calendar and postings to the Mich-RAP listserv.

Sincerely,

Dennis Kirksey, Chair
Muskegon Lake Watershed Partnership

CC: Mark Loomis, U.S. EPA GLNPO
Fallon Chabala, PAC Support Staff, WMSRD