**UNITED STATES ENVIRONMENTAL PROTECTION AGENCY**
REGION 5
77 WEST JACKSON BOULEVARD
CHICAGO, IL 60604-3590

SEP 26 2011

REPLY TO THE ATTENTION OF:

Mr. Dan Wyant
Director
Michigan Department of Natural Resources
525 West Allegan
Lansing, Michigan 48909

Dear Mr. Wyant:

Thank you for your September 13, 2011 request to remove the "Eutrophication or Undesirable Algae" Beneficial Use Impairment in the Deer Lake Area of Concern (AOC), Marquette County, Michigan.

The U.S. Environmental Protection Agency approves your removal request based upon a review of your submittal and the supporting data. We share your desire to restore all of the Great Lakes AOCs and to formally delist them. EPA will notify the International Joint Commission of this significant positive change in the environmental health of the Deer Lake AOC.

We congratulate all of the parties involved in this federal/state/local partnership. They have been instrumental in achieving this important environmental improvement, which will benefit people who work and live near the Deer Lake AOC, the State of Michigan, and the Great Lakes basin. We look forward to the continuation of this important and productive relationship with your agency and local coordinating committees as we work together to fully restore all of Michigan's AOCs.

If you have further questions, please contact me at (312) 353-4891 or your staff may contact John Perrecone, Great Lakes National Program Office, at (312) 353-1149.

Sincerely,

Chris Korleski, Director
Great Lakes National Program Office

Cc: Patricia Birkholz, MDEQ, Office of Great Lakes
Frank Ruswick, MDEQ, Office of Great Lakes
Stephanie Swart, MDEQ, Office of Great Lakes
Dr. Saad Jasmin, IJC
Chris Korleski, EPA, GLNPO
Wendy Carney, EPA, GLNPO
John Perrecone, EPA, GLNPO
Marc Tuchman, EPA, GLNPO

RICK SNYDER
GOVERNOR

STATE OF MICHIGAN
OFFICE OF THE GREAT LAKES
LANSING

PATRICIA BIRKHOLZ
DIRECTOR

September 13, 2011

Mr. Chris Korleski, Director
Great Lakes National Program Office
United States Environmental Protection Agency
Region 5
77 West Jackson Boulevard (G-17J)
Chicago, Illinois 60604-3507

Dear Mr. Korleski:

The purpose of this letter is to request the United States Environmental Protection Agency (USEPA), Great Lakes National Program Office's (GLNPO) concurrence with the removal of the Eutrophication or Undesirable Algae Beneficial Use Impairment (BUI) for the Deer Lake Area of Concern (AOC). The Michigan Department of Environmental Quality (MDEQ) has assessed the status of this BUI in accordance with the state's *Guidance for Delisting Michigan's Great Lakes Areas of Concern* and recommends that the BUI be removed from the list of impairments in the Deer Lake AOC.

Enclosed please find documentation to support this recommendation, including the BUI removal Briefing Paper prepared by the MDEQ's technical staff. The Deer Lake AOC Public Advisory Council submitted a letter of support for the removal recommendations on August 15, 2011.

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 need further information concerning this request, please contact Ms. Stephanie Swart, Office of the Great Lakes, MDEQ, at 517-335-6721, or you may contact me.

Sincerely,

Patricia Birkholz
Director
517-335-4056

Enclosures
cc/enc: Mr. Mark Loomis, USEPA
Mr. John Perrecone, USEPA
Mr. Richard Hobrla, MDEQ
Ms. Sharon Baker, MDEQ
Ms. Stephanie Swart, MDEQ

**MICHIGAN DEPARTMENT OF ENVIRONMENTAL QUALITY**

**INTEROFFICE COMMUNICATION**

TO: Patty Birkholz, Director, Office of the Great Lakes

FROM: Rick Hobrla, Chief, Great Lakes Management Unit RMH

DATE: September 13, 2011

SUBJECT: Removal of the Eutrophication and Undesirable Algae Beneficial Use Impairment (BUI) for the Deer Lake Area of Concern (AOC

The Department of Environmental Quality, Great Lakes Management Unit, AOC Program staff request concurrence with the recommendation to remove the Eutrophication or Undesirable Algae BUI in the Deer Lake AOC. This request is made in accordance with the process outlined in the *Guidance for Delisting Michigan's Great Lakes Areas of Concern.*

Attached is a Briefing Paper documenting restoration and justifying removal of this BUI. Also attached is a draft letter to Mr. Chris Korleski, Director, Great Lakes National Program Office, United States Environmental Protection Agency, requesting removal of the BUI. The re-designation was discussed by the Deer Lake AOC Public Advisory Council (PAC) at their regular meeting on September of 2007. A public meeting was held in 2007 to discuss the removal of this BUI with the Deer Lake AOC community. Both the PAC and the local community expressed their support for removal of the BUI. As part of their continued support for this BUI removal recommendation, the PAC submitted a letter on August 15, 2011. Please indicate your approval of this recommendation and we will provide a final letter to Mr. Korleski for your signature.

Approved: Patricia L Birkholz Date: 09/13/11

Attachments

cc: Stephanie Swart, Office of the Great Lakes
Sharon Baker, Office of the Great Lakes

**BRIEFING PAPER**
**REMOVAL RECOMMENDATION**
**EUTROPHICATION OR UNDESIRABLE ALGAE BENEFICIAL USE IMPAIRMENT**
**DEER LAKE AREA OF CONCERN**

## Issue

The Deer Lake Area of Concern (AOC) Technical Committee recommends the removal of the Eutrophication or Undesirable Algae Beneficial Use Impairment (BUI) based on the collective review of the related documentation per the process outlined in the *Guidance for Delisting Michigan's Great Lakes Areas of Concern* (Guidance) (MDEQ, 2008). This recommendation is made by the Deer Lake Technical Committee, comprised of staff from both the United States Environmental Protection Agency (USEPA), and the Michigan Department of Environmental Quality (MDEQ), and members of the Deer Lake Public Advisory Council (PAC).

## Background

Deer Lake is a 1,010-acre impoundment located in central Marquette County near the center of Michigan's Upper Peninsula. The Deer Lake AOC includes a portion of Carp Creek, Deer Lake, and the Carp River (Figure 1). The upstream boundary of the AOC corresponds with the furthest upstream location where a municipal sanitary sewer discharge, Ishpeming Township wastewater treatment plant "A", entered Carp Creek (at the end of Southwood Drive). Carp Creek flows into Deer Lake at the middle of the South Basin. Deer Lake flows into the Carp River via the dam at the North Basin impoundment. The AOC terminates as the Carp River flows into Lake Superior near the City of Marquette, Michigan.

Historic mining practices resulted in mercury contamination to the Deer Lake basin from Ropes Creek and Carp Creek. Three BUIs have been identified for the Deer Lake AOC: Restrictions on Fish and Wildlife Consumption, Eutrophication or Undesirable Algae, and Bird or Animal Deformities or Reproduction Problems (MDEQ, 2008).

The original 1987 Remedial Action Plan (RAP) identified eutrophication as a concern in Deer Lake due to hypereutrophic conditions caused primarily by excessive nutrient loadings Michigan Department of Natural Resources (MDNR, 1987). The major nutrient sources included historic discharges of untreated municipal wastewater from the City of Ishpeming and Ishpeming Township to Carp Creek prior to 1964. These untreated wastewater discharges were replaced by three primary wastewater treatment plants that discharged partially treated municipal wastewater to Carp Creek from both the City of Ishpeming and Ishpeming Township from 1964 until 1985. These historic municipal wastewater discharges resulted in greatly elevated nutrient concentrations in Deer Lake (USEPA, 1975; Bills, 1977; Ludwig, 1981).

## Removal Criteria

According to the Guidance the restoration criteria for the Eutrophication or Undesirable Algae BUI in the Deer Lake AOC requires that:

- 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 USEPA every two years.

The attached excerpt from the Guidance (pages 33-34) includes the rationale for the delisting criteria (Attachment A).

Analysis

In 1975, as part of a national study, the USEPA determined that Deer Lake was eutrophic (USEPA, 1975). A 1977 study by Northern Michigan University determined that Deer Lake was hypereutrophic (Bills, 1977). At that time, the winter dissolved oxygen content of Deer Lake was less than the level recommended for fish survival (USEPA, 1986 and 2000).

In the 1800's the City of Ishpeming discharged untreated wastewater to Carp Creek and Partridge Creek. Beginning in the 1930s, soap manufacturers began using "builders" to improve the cleaning efficiency of soap powders and detergents. The most common "builder" that was used to prevent soap scum was complex phosphate (EAI, 2006). Phosphate (an ionic form of phosphorus) is one of the limiting nutrients in many Michigan water bodies, and was later determined to be an important source of eutrophication (Schindler, 1974). Consequently, phosphate (as part of wash water) was being discharged from the city and contributing to the eutrophication of Deer Lake. Beginning in 1972, the phosphate content of laundry detergents, which had been as great as 15% by weight since the late 1930s, was decreased to 8.7% by weight and by 1977, based on eutrophication concerns; the State of Michigan decreased the maximum phosphate content of laundry detergents to 0.5% by weight (EAI, 2006). In 1973, Michigan promulgated Administrative Rules to enforce water quality standards, which required a maximum monthly effluent concentration for total phosphorus and limits on nutrients to prevent excess plant growth which may become injurious to the designated uses of the surface waters of the state (DEQ, 1994).

In 1964, three primary wastewater treatment plants (WWTPs) were built in the City of Ishpeming and Ishpeming Township. An enhanced secondary municipal wastewater treatment plant replaced the three primary treatment plants in 1985, and nutrient loading to Carp Creek and Deer Lake decreased significantly. By 1995, after the plant upgrade, Deer Lake was described as mesotrophic or moderately nutrient-enriched and the annual loading of nutrients to Deer Lake decreased, see

Table 1 (Kerfoot, 1995). The WWTPs National Pollutant Discharge Elimination System (NPDES) permit discharge point is to Carp Creek near the intersection of Washington Street and North Washington Street in Ishpeming. The WWTP has a limit (0.8 mg/l and 8.8 lbs/day) for total phosphorus as part of its NPDES discharge permit.

Table 1: Nutrient loading change after Ishpeming WWTP upgrades.

| Nutrient | 1975 Annual loading data from Primary WWTPs | 1998 Annual loading data from Enhanced Secondary WWTP | % Change |
|---|---|---|---|
| Phosphorus | 15,960 lbs/yr[1] | 1,711 lbs/yr[2] | 89% decrease[3] |
| Nitrogen | 69,090 lbs/yr[1] | 3,051 lbs/yr[4] | 95% decrease |

[1] Data from USEPA (1975)

[2] Data from Kotajarvi (1998)

[3] The USEPA (1975) estimated that an 80% decrease in phosphorus loading from the municipal wastewater treatment plants would reduce the incidence and severity of nuisance algal blooms as well as provide additional protection for downstream Lake Superior.

[4] Data are from D'Itri *et al.* (1993)

In 1989, winter monitoring by the MDNR demonstrated that Deer Lake had begun recovering from eutrophication. Dissolved oxygen concentrations below the ice were sufficient to support fish growth and survival (USEPA, 1989) to a depth of 12 feet. Additional monitoring by Cliffs Natural Resources in 1999 and 2000 documented further recovery where dissolved oxygen concentrations were sufficient to support fish growth and survival (USEPA, 1986 and 2000) to a depth of 18 feet.

Deer Lake is not on the Category 5 list of impaired waters in the 2010 Water Quality and Pollution Control in Michigan: Section 303(d) and 305(b) Integrated Report (DNRE, 2010) due to nutrients or excessive algal growths thereby meeting the restoration criteria outlined in the Guidance.

A timeline of Deer Lake AOC eutrophication and recovery as well as additional technical support documents can be found in Attachments C and D.

The removal of the Eutrophication or Undesirable Algae BUI was discussed with the Deer Lake PAC at their regular meeting in September 2007. The PAC passed a motion supporting the removal of the Eutrophication or Undesirable Algae BUI at that meeting. A public meeting was held in September 2007 to discuss the removal of this BUI with the community. The community expressed their support for removal of this BUI. In recognition of their continued support for this BUI removal, the PAC unanimously passed a motion at their August 11, 2011, meeting and also submitted a letter (Attachment E).

## Recommendation

Based upon review of the data and input from the MDEQ, USEPA project staff, and the PAC, including the Technical Committee members, we recommend removal of the Eutrophication or Undesirable Algae BUI in the Deer Lake AOC.

Prepared by: Stephanie Swart, Deer Lake AOC Coordinator
Great Lakes Management Unit
Office of the Great Lakes
Michigan Department of Environmental Quality

Sharon Baker, AOC Coordinator
Great Lakes Management Unit
Office of the Great Lakes
Michigan Department of Environmental Quality

## Attachments

A – Eutrophication or Undesirable Algae; pages 33-34 of the Guidance for Delisting Michigan's Great Lakes AOCs
B – Deer Lake AOC Timeline of Eutrophication and Recovery.
C – Technical Information on the Recovery of Deer Lake from Hypereutrophication. Deer Lake PAC Technical Committee.
D – Deer Lake AOC Historical Background
E – Deer Lake PAC letter supporting BUI removal.

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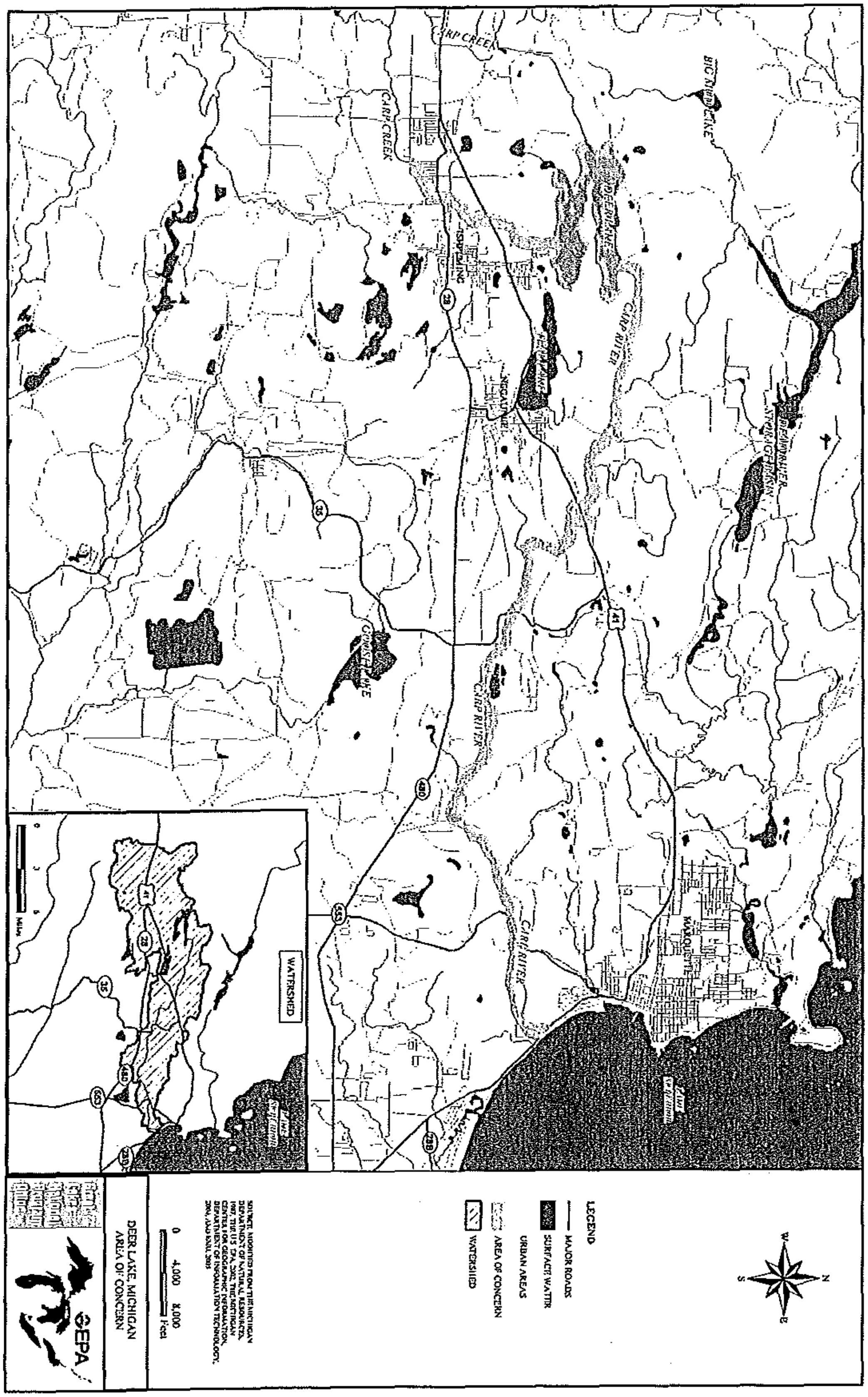
Figure 1. The Deer Lake Area of Concern



**Attachment A
2008 Guidance for Delisting
Michigan's Great Lakes Areas of Concern**

***Eutrophication or Undesirable Algae***

**Significance in Michigan's Areas of Concern (AOC)**

Eight of Michigan's AOCs are listed as impaired due to eutrophication, including: River Raisin, Rouge River, Clinton River, Saginaw River/Bay, St. Marys River, Deer Lake, Muskegon Lake, and White Lake.

**Michigan Restoration Criteria and Assessment**

This Beneficial Use Impairment 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 United States Environmental Protection Agency (USEPA) every two years.

In addition, the MDEQ is in the process of developing nutrient criteria for state surface waters which will be adopted into Michigan's WQS. The MDEQ will evaluate restoration of this BUI consistent with the nutrient criteria when the nutrient criteria are approved by the USEPA and adopted into rule.

**Rationale**

Practical Application in Michigan

The MDEQ regulates water pollution under the authority of Part 31 of the Natural Resources Environment Protection Agency (NREPA), P.A. 451 of 1994. The AOC restoration criteria are consistent with the state's WQS, and how the State identifies waters for inclusion on the Clean Water Act section 303(d) list, which is submitted to USEPA every two years. If a waterbody exhibits growths of undesirable algae in quantities which interfere with a water body's "designated uses" as identified in rules R323.1060 and R323.1100 of the Michigan WQS (e.g., inhibits swimming due to the physical presence of algal mats and/or associated odor; inhibits the growth and production of warm water fisheries, and/or other indigenous aquatic life and wildlife), the waterbody is included on Michigan's Section 303(d) list.

1991 International Joint Commission (IJC) General Delisting Guideline

*When there are no 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 IJC general delisting guideline is presented here for reference. The Practical Application in Michigan subsection above describes application of specific criteria for restoration based on existing Michigan programs and authorities.

**State of Michigan Programs/Authorities for Evaluating Restoration**

Michigan assesses water bodies throughout the state on a 5-year basin rotation cycle according to the MDEQ's "Strategic Environmental Quality Monitoring Program for Michigan's Surface Waters" (MDEQ, 1997) and "Michigan Water Quality Strategy Update" (MDEQ, 2005). Each year, a set of targeted watersheds are sampled at selected sites for conventional and toxic pollutants, and biological and physical habitat/morphology indicators. The set of watersheds sampled rotates each year, with each major watershed in the state revisited every 5 years. Two particularly relevant elements of the strategy are expanded and improved water chemistry monitoring and the lake monitoring program. One of the specific objectives of these programs is to determine whether nutrients are present in surface waters at levels capable of stimulating the growth of nuisance aquatic plants/algae/slimes.

Under the water chemistry monitoring program, water samples generally are analyzed for nutrients, conventional parameters (i.e., temperature, conductivity, suspended solids, pH, dissolved oxygen), total mercury, and trace metals (i.e., cadmium, chromium, copper, lead, nickel, zinc). A much smaller number of samples are analyzed for organic contaminants such as PCBs and base neutrals. Other parameters may be included as appropriate at specific locations, including observations of nuisance algae in AOCs with this impairment. Nutrients and conventional parameters may also be monitored at sites where biological data are collected during routine watershed assessments. Data are reviewed each year to determine whether additional parameters should be added, removed, or analyzed at a greater or lesser frequency.

Some local AOC communities also have programs for monitoring water quality and related parameters which may be applicable to this BUI. If an AOC chooses to use local monitoring data for the assessment of BUI restoration, the data can be submitted to the MDEQ for review. If the MDEQ determines that the data appropriately address the restoration criteria and meet quality assurance and control requirements, they may be used to demonstrate restoration success.

## Attachment B

### Deer Lake AOC Timeline of Eutrophication and Recovery

Summary of activities within the Deer Lake watershed which either contributed to the degradation of or improvements in water quality:

- 1869 – Untreated sewage entered Partridge Creek, which historically flowed through what is now the City of Ishpeming, and was transported to Carp Creek.
- 1881 – Partridge Creek was dredged and widened between Main and First Streets in the City of Ishpeming to reduce flooding during heavy rains.
- April, 1890-1964 – The City of Ishpeming purchased the Carp Creek dam from the Deer Lake Iron and Lumber Company and removed it to allow floodwater and sewage that accumulated in Carp Creek during heavy rains to enter Deer Lake (LaFayette, 1977).
- 1896 – The falls on Carp Creek were blasted to lower the channel six feet and prevent sewage in the stream from "backing up" into the City of Ishpeming during high flows (Dobson, 2005).
- 1900 – Partridge Creek had been diverted into a sewer pipe beneath Third, Bank, and Front Streets in the City of Ishpeming. Brick caissons were build in the ground along the creek channel to drain surface water and lateral sewers. The creek channel was filled and a school was built in a filled portion of the old creek just west of Pine Street. (Dobson, 2005).
- 1900 and 1929 – Ishpeming constructed combined (sanitary and storm) sewers which discharged to Carp Creek. Sewage eventually flowed into the Deer Lake reservoir.
- 1929 – The City of Ishpeming constructed a large (78 inch diameter) sewer main from Front Street (beneath Division Street) to the Carp River.
- 1930s – Soap manufacturers began using "builders" to improve the cleaning efficiency of soap powders and detergents.
- 1947 – The laundry detergent "Tide," which contained the "builder" sodium tripolyphosphate was introduced throughout the United States. Tide and other "built" detergents gained widespread acceptance, and by 1953, the amount of detergent sold exceeded the amount of soap that was sold (EAI, 2006).
- 1963 – Sanitary sewers were constructed in the primary residential area of Ishpeming Township.
- 1964 – Three primary (solids removal) WWTPs with chlorination were built.
  - Ishpeming Township "A" Plant discharged to Carp Creek near the intersection of Copper Street and Southwood Drive in West Ishpeming.
  - The City of Ishpeming WWTP discharged to Carp Creek near the intersection of Poplar Street and North Road in Ishpeming.
  - Ishpeming Township "B" Plant discharged to Carp Creek near the west end of Elm Street in Ishpeming.
- 1970 – The Michigan Water Pollution Control Board determined that the three primary WWTPs were inadequate, and recommended replacement.
- 1970 – At approximately this time, Partridge Creek was re-routed from the sewer main into mine workings (Cliffs Shaft Mine and others) beneath the City of Ishpeming, and back into Carp Creek.

- 1972 – The phosphate content of laundry detergents, which had been as great as 15% by weight since the late 1930s, had gradually decreased to 8.7% by weight.
- 1973 – The State of Michigan promulgated Administrative Rules to enforce water quality standards.
- 1975 – As part of a national study, USEPA determined that the Deer Lake reservoir was eutrophic (USEPA, 1975).
- 1977 – A study by Northern Michigan University determined that Deer Lake was hypereutrophic (Bills, 1977). During the winter the dissolved oxygen content of the entire reservoir was less than the level recommended for fish survival (USEPA, 1986 and 2000).
- 1977 – Based on eutrophication concerns, the State of Michigan decreased the maximum phosphate content of laundry detergents to 0.5% by weight.
- 1984 – Construction began on a new enhanced secondary (removal of solids, organic carbon, nitrogen and phosphorus) WWTP to replace the three primary WWTPs.
- 1986 – The new Ishpeming Area Joint WWTP, which is an enhanced secondary WWTP, began treating sanitary wastewater from the City of Ishpeming and Ishpeming Township (DNR, 1987). The enhanced secondary WWTP discharges to Carp Creek near the intersection of Washington Street and North Washington Street in Ishpeming.
- 1986 – The City of Ishpeming completed separation of storm and sanitary sewers. Storm and sanitary sewers in Ishpeming Township were not combined, and did not need to be separated.
- 1989 – Winter monitoring by the DNR demonstrated that Deer Lake had begun recovering from eutrophication. Dissolved oxygen concentrations below the ice were sufficient to support fish growth and survival (USEPA, 1986 and 2000) to a depth of 12 feet.
- 1993 – A study by Michigan State University, the DNR and the Tokyo University of Agriculture determined that The Enhanced Secondary WWTP significantly decreased nutrient loading to the Deer Lake AOC, relative to the three Primary WWTPs that were replaced (D'Itri *et al.*, 1993).
- 1995 – A study by Michigan Technological University determined that Deer Lake was mesotrophic (Kerfoot and Harting, 1995).
- 1999 and 2000 – Winter monitoring by Cleveland-Cliffs Iron Company documented additional recovery from eutrophication since 1989. Dissolved oxygen concentrations were sufficient to support fish growth and survival (USEPA, 1986 and 2000) to a depth of 18 feet.

## Attachment C

## Technical Information on the Recovery of Deer Lake from Hypereutrophication
## Deer Lake PAC Technical Committee

### What is eutrophication?

Eutrophication is the process of nutrient enrichment in a water body. The main nutrients involved are phosphorus, nitrogen and sometimes carbon. For many lakes, phosphorus is the key nutrient involved in eutrophication (MDEQ, 2004). The amount of nutrients typically determines the biological productivity of a water body. Oligotrophic lakes have low concentrations of nutrients and have relatively low productivity. Mesotrophic lakes contain moderate amounts of nutrients and have moderate productivity. Eutrophic lakes contain high concentrations of nutrients, are highly productive, and can have water quality problems from the high productivity. Hypereutrophic lakes contain excessive amounts of nutrients that diminish water quality, aquatic habitat and aesthetic values.

### Why is hypereutrophication a problem?

Hypereutrophication can result in several water quality problems that impair beneficial uses of the affected water body, including:

- Nuisance plant growth. Weeds in shallow water; algae blooms decrease
- water clarity. Some cyanobacteria blooms can produce potent toxins.
- Sand and gravel sediments are covered with muck (decaying algae).
- Dissolved oxygen is depleted as the excessive plant growth dies and sinks and is consumed by bacteria. Dissolved oxygen depletion can occur in the bottom water during summer in eutrophic lakes. In hypereutrophic lakes, the dissolved oxygen depletion can occur through the entire water column, especially during the winter months beneath ice cover; and.
- Changes to fishery and other aquatic communities. Sensitive coldwater species such as trout, walleye and mayflies decline or even disappear, while tolerant warm-water species such as catfish, bass and sludge worms increase until they dominate the aquatic community.

### What are the nutrient sources for the Deer Lake AOC?

The watershed is primarily forested. The main sources of phosphorus, which is a key nutrient enrichment in aquatic systems, include:

- Municipal sewage.
- weathering soils and bedrock in the watershed, and.
- storm water runoff.
- Historically, phosphorus resulted from the widespread use of phosphate "builders" to enhance the performance of laundry detergents from the 1930s into the 1970s likely contributed large amounts of phosphorus to local municipal sewage systems. Also, the primary wastewater treatment plants of that time were not efficient at removing phosphorus, so significant amounts of that nutrient entered the Deer Lake reservoir from municipal wastewater.

**What measures have been taken to address nutrient sources?**

- Phosphorus regulations for laundry detergents. Starting in the 1930s, the phosphate content of "built" laundry detergents was 15% by weight. In 1972, the phosphate content of laundry detergents had gradually decreased to 8.7% by weight. Based on eutrophication concerns, the State of Michigan passed legislation decreasing the maximum phosphate content of "built" laundry detergents to 0.5% by weight on October 1, 1977.

- Enhanced Secondary wastewater treatment. The original three municipal wastewater treatment plants (WWTPs) in the Deer Lake AOC used Primary treatment. Primary treatment typically involves the use of a bar screen and a grit chamber to remove large and small debris, respectively. A primary clarifier is also used to remove small particles and scum. Secondary treatment adds a biological process that uses bacteria to remove organic material that would create a significant biochemical oxygen demand (BOD) in the receiving water body if it were not removed. Enhanced Secondary treatment adds a process for removal of nitrogen and phosphorus as well as BOD removal. The current Ishpeming Area Joint WWTP uses enhanced secondary treatment for municipal wastewater.

- Separation of storm and sanitary sewers. In older cities such as Ishpeming, it was common to combine sanitary and storm sewers and treat all wastewater prior to discharge. During storm events the large amount of storm water could overwhelm the WWTPs and needed to be diverted. Municipal wastewater was also diverted during these storm events, so untreated sanitary wastewater entered Carp Creek during storms. The City of Ishpeming separated the sanitary and storm sewers in the early 1980s. Municipal wastewater is no longer diverted around the WWTP during storm events so nutrients are removed from sanitary sewage at all times.

**What changes in the Deer Lake AOC demonstrate that these remedies have been successful?**

- Nutrient loading from municipal wastewater sources decreased significantly when the new enhanced secondary WWTP replaced the three primary WWTPs in 1986 (Table B-1). Phosphorus loading from the three primary WWTPs was calculated to be 15,960 lbs per year (USEPA, 1975). Phosphorus loading from the enhanced secondary WWTP has been measured at a yearly average of 1,711 lbs between 1987 and 1997 (Kotajarvi, 1998). Nitrogen loading from the three primary WWTPS was 69,090 lbs per year (USEPA, 1975). Current nitrogen loading from the enhanced secondary WWTP is 3,051 lbs per year. The improvements in wastewater treatment, combined with phosphorus regulation of laundry detergents, have decreased phosphorus (89%) and nitrogen (95%) loading to the Deer Lake AOC.

**Table C-1. Historic and current phosphorus budgets for the Deer Lake reservoir.**

| Phosphorous Sources for Deer Lake | Early 1970s loading (lbs/yr) | Current loading (lbs/yr) |
|---|---|---|
| Precipitation[1] | 140 | 140 |
| Watershed[1] | 2,770 | 2,770 |
| City of Ishpeming WWTP | 11,300[1] | 1,711[2] |
| Ishpeming Twp. WWTP "A" | 3,660[1] | 0 |
| Ishpeming Twp. WWTP "B" | 1,000[1] | 0 |
| Turnover | > 1,279[3] | ≤ 400[4] |
| Total | > 20,149 | ≤ 5,021 |

[1] Data from USEPA (1975)

[2] Data from the Ishpeming Area WWTP, which receives municipal wastewater from the City of Ishpeming and Ishpeming Township (Kotajarvi, 1998)

[3] Data for the South Basin of Deer Lake from Bills (1977) were used to calculate the amount of phosphorus that was released from sediments during anoxic (oxygen-depleted) conditions in late summer and late winter. No data for the North Basin are available; hence, this value represents a minimum estimate.

[4] Data from the PAC monitoring program were used to calculate the amount of phosphorus that was released from sediments during anoxic (oxygen-depleted) conditions in late summer (anoxic conditions no longer occur during the winter). Phosphorus concentrations vary with local weather and seasons. This value represents the maximum value that was measured, which occurred in 2004 following an unusually long, hot summer that resulted in atypically large phosphorus releases, and cyanobacteria blooms in several Michigan lakes (Alexander, 2004).

Based on work by Vollenweider (1968, 1975) the USEPA has acknowledged that excessive phosphorus loading can lead to eutrophication in the current *Quality Criteria for Water* (USEPA, 1986). However, the USEPA has not promulgated a national criterion for phosphorus. Vollenweider (1975) has calculated phosphorus loading thresholds that are based on the ratio of mean depth to hydraulic residence time. The Deer Lake reservoir has a mean depth of 3.84 meters and a hydraulic residence time of 0.377 years, which equals a value of 10.19 m/year. For lakes with a mean depth to residence time of 10 m/year, Vollenweider predicts that eutrophic conditions will occur when the phosphorus load exceeds 0.63 $g/m^2/yr$. In the early 1970s, phosphorus loading was greater than 20,149 pounds per year and the average size of the Deer Lake reservoir at that time was 906 acres. These values equaled a loading rate greater than 2.50 $g/m^2/yr$, which was more than four times greater than the eutrophic threshold. In the early 1970s, the Deer Lake reservoir was clearly hypereutrophic.

The State of Michigan Water Quality Standard Rule 323.1060 for plant nutrients has set a maximum monthly average effluent concentration of 1.0 mg phosphorus per liter for point sources. The National Pollutant Discharge Elimination System (NPDES) permit (MI0044423) for the Ishpeming Area Joint WWTP has a phosphorus limit of 0.08 mg/L, which is slightly more restrictive than R 323.1060. The Ishpeming Area Joint WWTP has remained in compliance with its NPDES permit since April 1986; therefore, it is also meeting the State Standard set by R 323.1060.

The current phosphorus load of ≤5,021 pounds per year for the 1,010-acre Deer Lake (Table B-1) equals a loading rate ≤0.56 $g/m^2/yr$. The current phosphorus budget for the Deer Lake AOC is less than Vollenweider's eutrophic threshold of 0.63 $g/m^2/yr$, but is greater than the oligotrophic rate of 0.32 $g/m^2/yr$. Based on the phosphorus budget, the Deer Lake reservoir should become mesotrophic when the reservoir reaches equilibrium with the current loading. A study by Michigan Technological University described the Deer Lake reservoir as mesotrophic nine years after the new enhanced secondary WWTP became operational (Kerfoot and Harting, 1995).

Water clarity has increased, as shown by deeper secchi depths. Water clarity is affected by the amount of algae in lakes. Shallow secchi depths occur during algae blooms. The USEPA (1975) estimated that an 80% decrease in phosphorus loading from the municipal wastewater treatment plants would reduce the incidence and severity of nuisance algal blooms as well as provide additional protection for downstream Lake Superior. Secchi depth data are available from the 1970s (USEPA, 1975; Bills, 1977) and the PAC has measured secchi depths on a weekly basis through the summer months during 2002-2006. These secchi depths are presented in Figures C-1 and C-2 below. Secchi depths in both basins have improved (are deeper) since the 1970s. Water clarity in Deer Lake has increased, which indicates that algal blooms have decreased in response to lower nutrient loads.

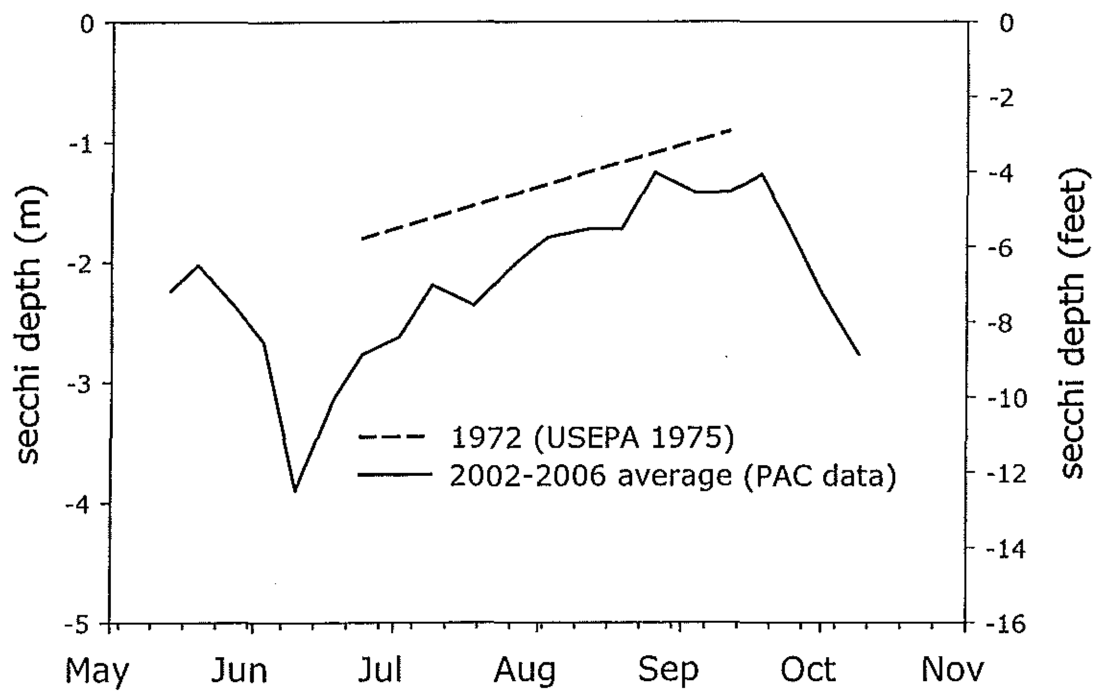



**Figure C-1. Historic and current water clarity in the North Basin of the Deer Lake reservoir. The deeper position of the solid line is indicative of greater water clarity.**

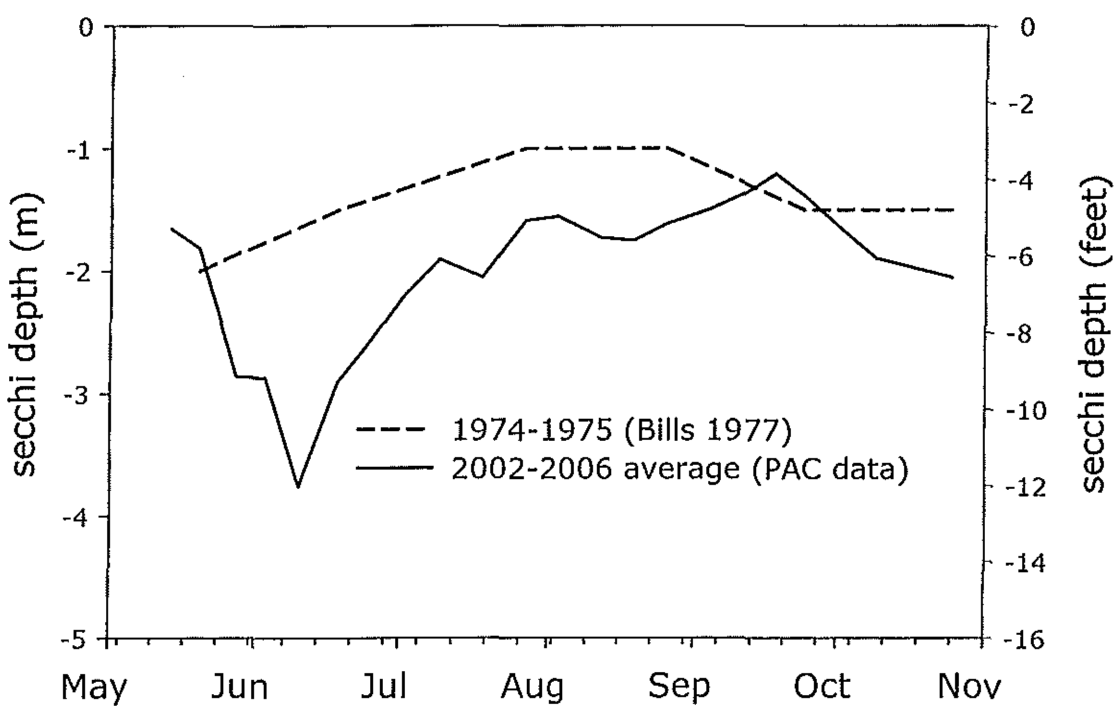



**Figure C-2. Historic and current water clarity in the South Basin of the Deer Lake reservoir. The deeper position of the solid line is indicative of greater water clarity.**

- One of the methods to determine the trophic status of a lake is the Trophic State Index (TSI). The TSI is based on the amount of plant material that exists in a water body (Carlson, 1977). TSI "scores" range from 0 to 100, and can be calculated from several factors, including: phosphorus, weight of algae, *chlorophyll a* (an algae pigment) or secchi depth. TSI "scores "are interpreted as summarized in Table B-2 (Carlson and Simpson, 1996).

One common method for calculating TSI "scores" is to use *Chlorophyll a* concentrations in the water body. *Chlorophyll a* is the primary pigment that algae use to capture sunlight for photosynthesis. Therefore, *Chlorophyll a* concentrations are directly related with of algal biomass and primary productivity. The original equation for calculating a TSI based on *Chlorophyll a* (Carlson, 1977), which is used in the DEQ Cooperative Lake Monitoring Program (Bednarz, 2007) is:

$$TSI(Chl_a) = 10\left[6 - \frac{2.04 - 0.68 * \ln Chl_a}{\ln 2}\right]$$

**Table C-2. Expected conditions in north temperate lakes, and corresponding Trophic State Index (TSI) values from Carlson and Simpson (1996).**

| TSI | Attributes | Fisheries |
|---|---|---|
| 0-30 | *Oligotrophic*: Clear water, oxygen throughout the year in the hypolimnion. | Salmonid fisheries. |
| 30-40 | Hypolimnia of shallower lakes may become anoxic. | Salmonid fisheries in deep lakes only. |
| 40-50 | *Mesotrophic:* Water moderately clear; increasing probability of hypolimnetic anoxia during summer. | Hypolimnetic anoxia results in loss of salmonids. Walleye may predominate. |
| 50-70 | *Eutrophic:* Anoxic hypolimnia, macrophyte problems possible. Blue-green algae dominate; low water transparency; algal scums | Warm-water fisheries only. Bass may predominate. |
| 70-100 | *Hypereurophic* (light-limited productivity): Dense algae and macrophytes. Algal scums block sunlight, few macrophytes survive | "Rough" fish (carp and bullheads) dominate; summer fish kills possible. |

*Chlorophyll a* concentrations in the Deer Lake reservoir have decreased since the 1970s (Table B-3). The TSI "scores" that are based on *Chlorophyll a* have also decreased. In 1972, the TSI "scores" based on *Chlorophyll a* were 62 (eutrophic) for the North Basin and 65 (eutrophic) for the South Basin. In 2002, the TSI "scores" based on *Chlorophyll a* were 44 (mesotrophic) for the North Basin and 36 (between oligotrophic and mesotrophic) for the South Basin.

**Table C-3. Historic and recent *Chlorophyll a* concentrations and TSI (*Chl a*) scores for the Deer Lake reservoir.**

| Data/Test | North Basin | South Basin |
|---|---|---|
| June 24, 1972 *Chlorophyll a*[1] | 31.6 µg/L | 54.5 µg/L |
| June 24, 1972 TSI (*Chl a*) | 62 | 65 |
| June 18-21, 2002 *Chlorophyll a*[2] | 4.1 µg/L | 1.8 µg/L |
| June 18-21, 2002 TSI (*Chl a*) | 44 | 36 |

[1] Data are mean values from two depth-integrated water samples (USEPA, 1975).

[2] Data are volume-weighted means from Table 7. of Manolopoulos and Hurley (2005).

Another common method for calculating TSI "scores" is to use secchi depth data. As discussed above, secchi depth is a measure of water clarity. Algae growth will create turbidity, and decrease secchi depth. Therefore, low secchi depths are indicative of algal biomass and primary productivity. The original equation for calculating a TSI based on secchi depth (Carlson, 1977) is:

$$TSI(SD_a) = 10\left[6 - \frac{\ln SD}{\ln 2}\right]$$

Secchi depths in the Deer Lake reservoir have increased since the 1970s (Table C-4). The TSI "scores" based on secchi depth have decreased. In 1972, the TSI "scores" based on late June secchi depth were 51 (eutrophic) for both basins of the Deer Lake reservoir. The TSI "scores" based on late June secchi depths for 2002 through 2006 were 41 (mesotrophic) for the North Basin and 40 (between oligotrophic and mesotrophic) for the South Basin. The TSI "scores" vary slightly between the *Chlorophyll a* and secchi depth methods, however, the conclusions

(eutrophic in the past, mesotrophic in the present) are the same regardless of which technique is used.

**Table C-4. Historic and recent Secchi depths and TSI (SD) scores for the Deer Lake reservoir.**

| Date/Test | North Basin | South Basin |
|---|---|---|
| June 24, 1972[1] | 1.8 m | 1.8 m |
| June 24, 1972 TSI (SD) | 51 | 51 |
| June 24, 2002-2006[2] | 2.8 m | 2.5 m |
| June 24, 2002-2006 TSI (SD) | 41 | 40 |

[1] Data from USEPA (1975).

[2] Data are mean values for secchi depths measured between June 20 and 28 of the years 2002-2006 in the PAC monitoring program. These dates are within four days of June 24.

- Dissolved oxygen concentrations in Deer Lake during late winter have improved significantly since the 1970s. The end of winter is a time when dissolved oxygen conditions can be diminished in hypereutrophic lakes because: 1) there has been no direct contact between the water column and the atmosphere for five months. Oxygen has been delivered with tributary waters but there has been no diffusion from the atmosphere; and, 2) snow cover on the lake blocks much of the sunlight penetration, so in-lake production of oxygen from photosynthesis has been minimal for several months. Therefore, by late winter, respiration and other processes that consume oxygen have continued under the ice and snow, while the processes that produce oxygen have been minimal.

In 1975 and 1982 dissolved oxygen concentrations were depleted throughout the entire Deer Lake reservoir (Figures C-3 and C-4). Based on the data collected by Bills (1977), there was insufficient oxygen for fish survival in the water column in much of Deer Lake; however, the reservoir supported a perch and pike fishery. The dissolved oxygen profile for 1989 showed a significant improvement in comparison with the 1975 and 1982 profiles. Most of the water column in the South Basin contained enough oxygen for fish survival. In 1999 and 2001 there was continued improvement in the dissolved oxygen content of the lower part of the water column of the South Basin. In the North Basin most of the water column contained sufficient oxygen for fish survival (Figure C-3). In 2005 and 2006 dissolved oxygen concentrations had increased even more in the deep waters of both basins.

Both the MDEQ (1994) and the USEPA (1986) have promulgated water quality standards for dissolved oxygen in fresh waters (USEPA, 1986). The State of Michigan Water Quality Standard supersedes the USEPA criteria. The USEPA criteria are based on worst-case scenarios for waste load allocation, and are included here for reference purposes because they contain information about how dissolved oxygen concentrations affect aquatic communities. The three water quality standards presented in this document are:

- The Michigan Water Quality Standard for dissolved oxygen in inland, non-trout lakes is 5.0 mg/L throughout the epilimnion during stratification (R 323.1065). This standard will protect fish survival and productivity (growth) as described by USEPA (1986, 2000). Like most north temperate lakes, the Deer Lake reservoir is stratified during the summer (typically mid-June through early October) and during the winter (late October through late April). In the winter, the lake is stratified, but there is no defined epilimnion (upper, wave-mixed layer) so the interpretation of the 5.0 mg/L standard in the deep water of winter-stratified lakes is unclear.

- The 7-day mean minimum USEPA Criterion for dissolved oxygen in freshwater is 4.0 mg/L, which will protect fish survival, but the growth of sensitive species of fish and invertebrates may be impaired (USEPA, 1986); and.

- The one-day minimum USEPA Criterion for dissolved oxygen in freshwater is 3.0 mg/L. The 3.0 mg/L criterion is based on protecting the survival of sensitive fish species during brief exposures to low dissolved oxygen. Dissolved oxygen concentrations less than 3.0 mg/L can be lethal to sensitive species of fish and invertebrates (USEPA, 1986). In lakes and reservoirs, fish will typically avoid areas that have low dissolved oxygen, and will survive.

The dissolved oxygen profiles in Figures C-3 and C-4 document the improvements in winter conditions in the Deer Lake reservoir over a thirty-year period. Currently, the Michigan dissolved oxygen Standard of 5.0 mg/L is met in all but the deepest areas of the reservoir even during the extreme conditions of late winter stratification. Most of the volume of Deer Lake is favorable for the survival and growth of aquatic life during worst-case conditions.

The current dissolved oxygen profiles in the Deer Lake reservoir are very similar to those observed in other central Upper Peninsula lakes (Figures C-5 and C-6). Michigan and other States commonly use information from other water bodies within an ecoregion as reference information regarding the condition of a subject water body. With specific reference to the AOC process, the Michigan Guidance (MDEQ, 2008) recommends using water bodies within the same USEPA Level III Ecoregion. The Deer Lake reservoir lies within *Ecoregion 50. Northern Lakes and Forests* (USEPA, 2003), which covers all of Northern Michigan and Wisconsin, and most of Northern Minnesota (Omernik, 1987). The geographic scale of the Level III Ecoregions is too large to be practical for the purpose of selecting lakes that are very similar to the Deer Lake reservoir. Therefore, the much smaller scale Ecoregion Subsection that is described by the US Forest Service (Albert, 1995) and is used for wetland mitigation banking in Michigan (MDEQ, 2003) was used to identify lakes to compare with the Deer Lake reservoir for this document.

The Deer Lake Reservoir is within the Michigamme Highland (IX.2) Ecoregion Subsection, which is characterized by: large areas of exposed Precambrian bedrock; acidic, sandy soils; hardwood or coniferous forests in upland areas and coniferous forests in wetland areas (Albert, 1995). DO profiles were measured in selected Michigamme Highland lakes during the peak of stratification in winter (Figure C-5) and summer (Figure C-6). Of the selected Mighigamme Highland lakes, only Goose Lake (and Deer Lake) received nutrients from municipal sewage. Craig Lake is located within a wilderness area. The remaining Michigamme Highland lakes have typical lakeshore development and watershed land use for the region, and represent typical (reference) conditions for the Deer Lake reservoir.

Currently, dissolved oxygen profiles during peak winter and summer stratification are similar in Deer Lake reservoir and other Michigamme Highlands lakes (Figures C-5 and C-6). At the peak of winter stratification, nearly all Michigamme Highland lakes have some dissolved oxygen depletion below a depth of 4 meters (13 feet); only Lake Michigamme maintains dissolved oxygen concentrations above 5 mg/L throughout the full water column.

Lake Michigamme is much larger and deeper than the other lakes, which provides greater nutrient absorption capacity. The most oxygen depletion in both summer and winter occurred in Craig Lake, which is a wilderness lake.

At the peak of summer stratification, the epilimnia of four Michigamme Highland lakes (plus both basins of Deer Lake) showed some oxygen depletion, while the epilimnia for the other five lakes maintained dissolved oxygen concentrations above 5 mg/L (Figure C-6). The eiplimnia of Beaufort Lake, Craig Lake, both basins of Deer Lake, Greenwood Reservoir, and Lake Independence (which were not stratified) maintained 5 mg/L dissolved oxygen concentrations in at least the upper 4 meters (13 feet) of the water column. Teal Lake and Fish Lake exhibited the most consistent dissolved oxygen concentrations throughout the epilimnia, which indicates they were very well-mixed. Teal and Fish Lakes are among the smallest lakes sampled, and would have been most easily mixed by wind-driven waves.

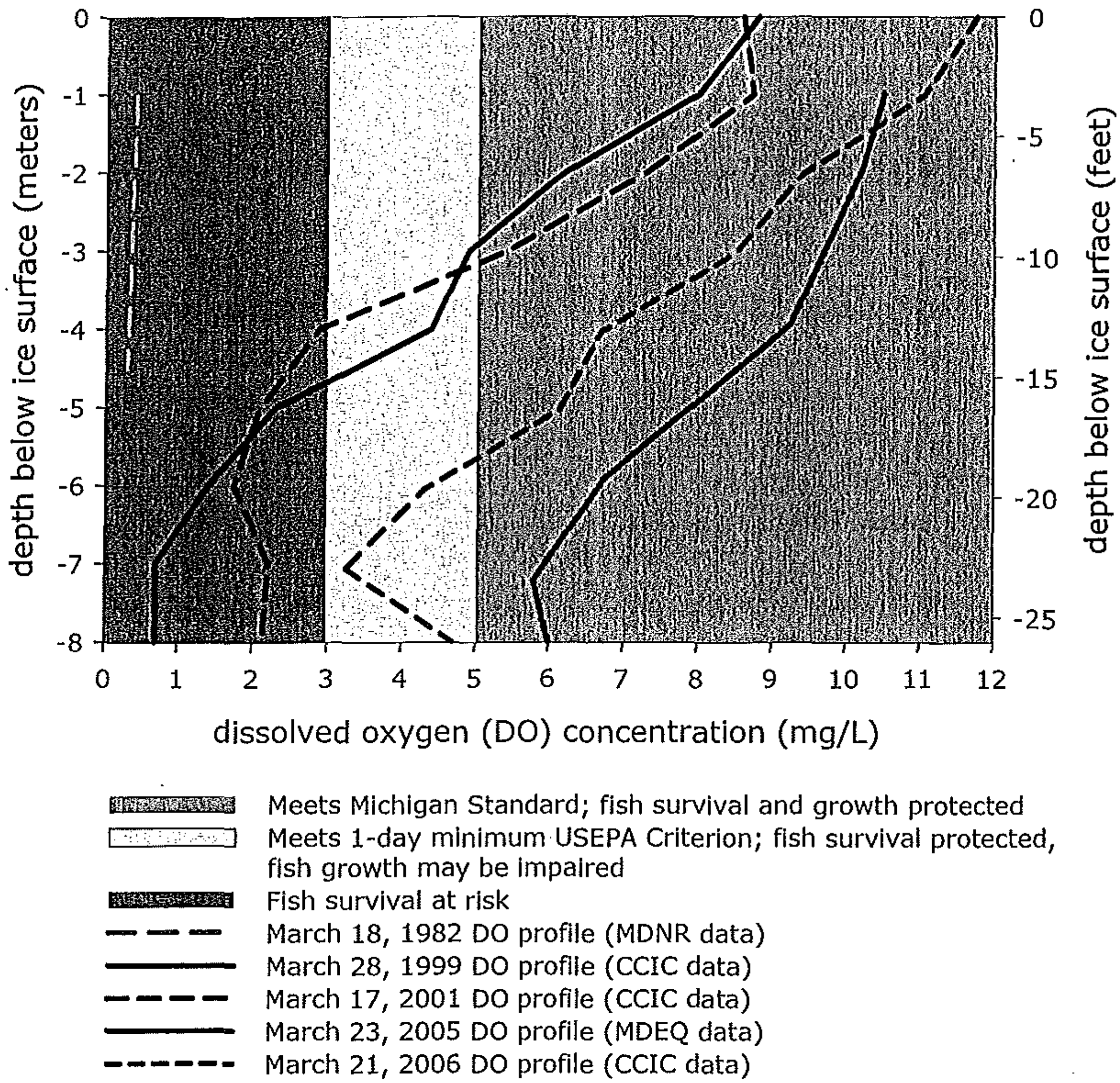



**Figure C-3. Historic and recent winter dissolved oxygen profiles in the North basin of the Deer Lake reservoir.**

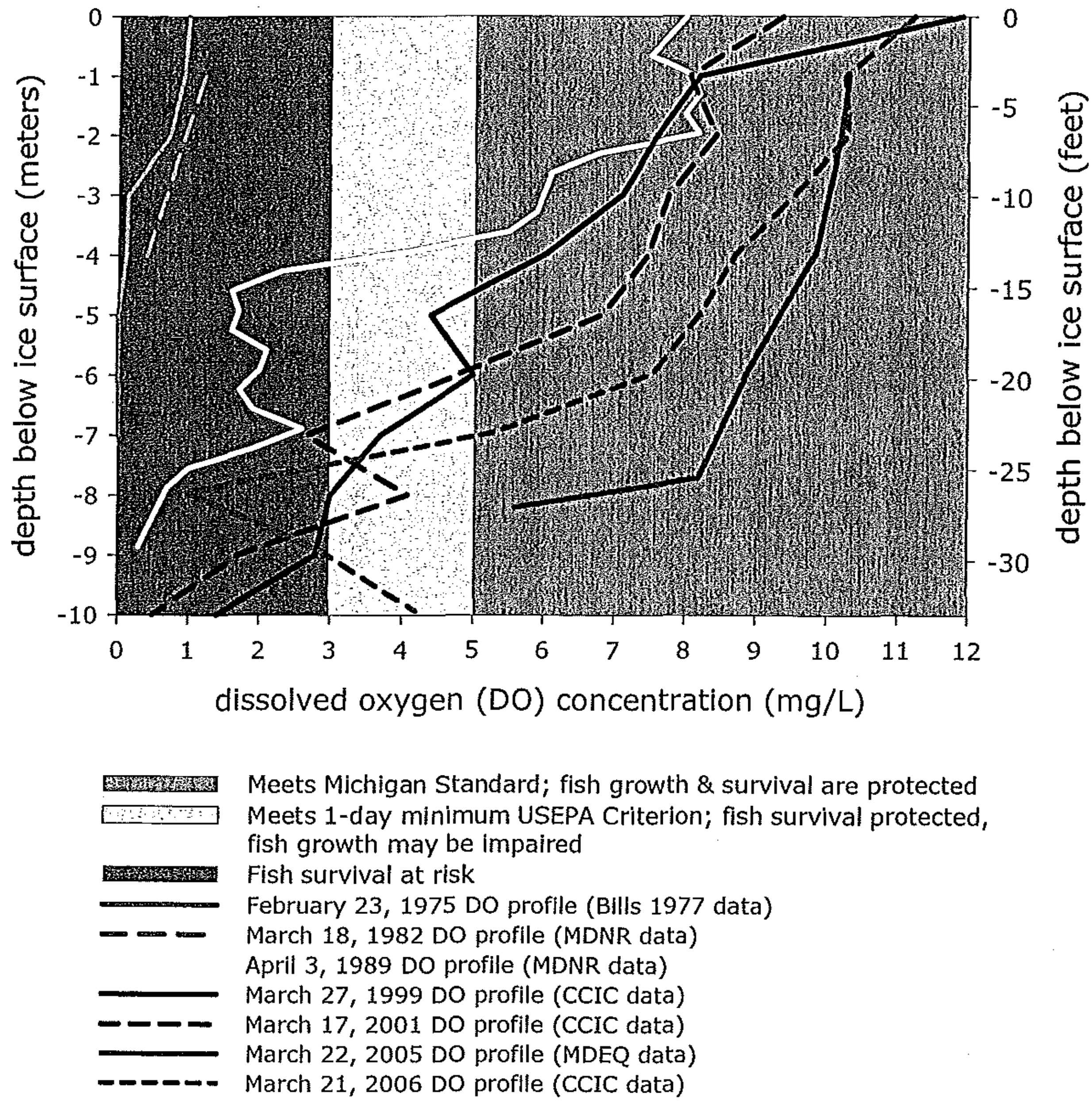



**Figure C-4. Historic and recent winter dissolved oxygen profiles in the South basin of the Deer Lake reservoir.**

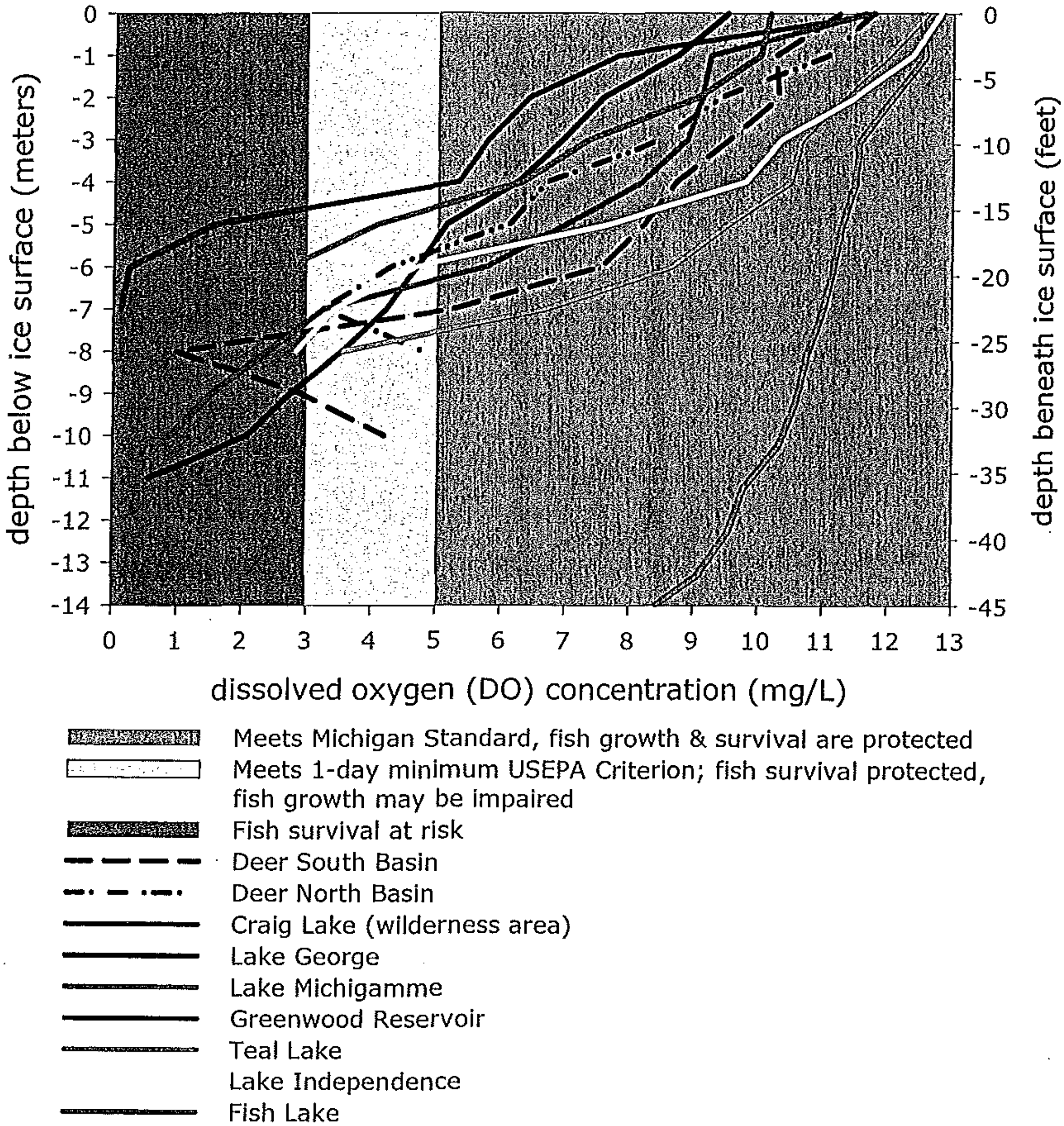



**Figure C-5. Dissolved oxygen profiles in March 2006 for the Deer Lake reservoir and other large lakes in the Michigamme Highland (IX.2) Ecoregion Subsection.**

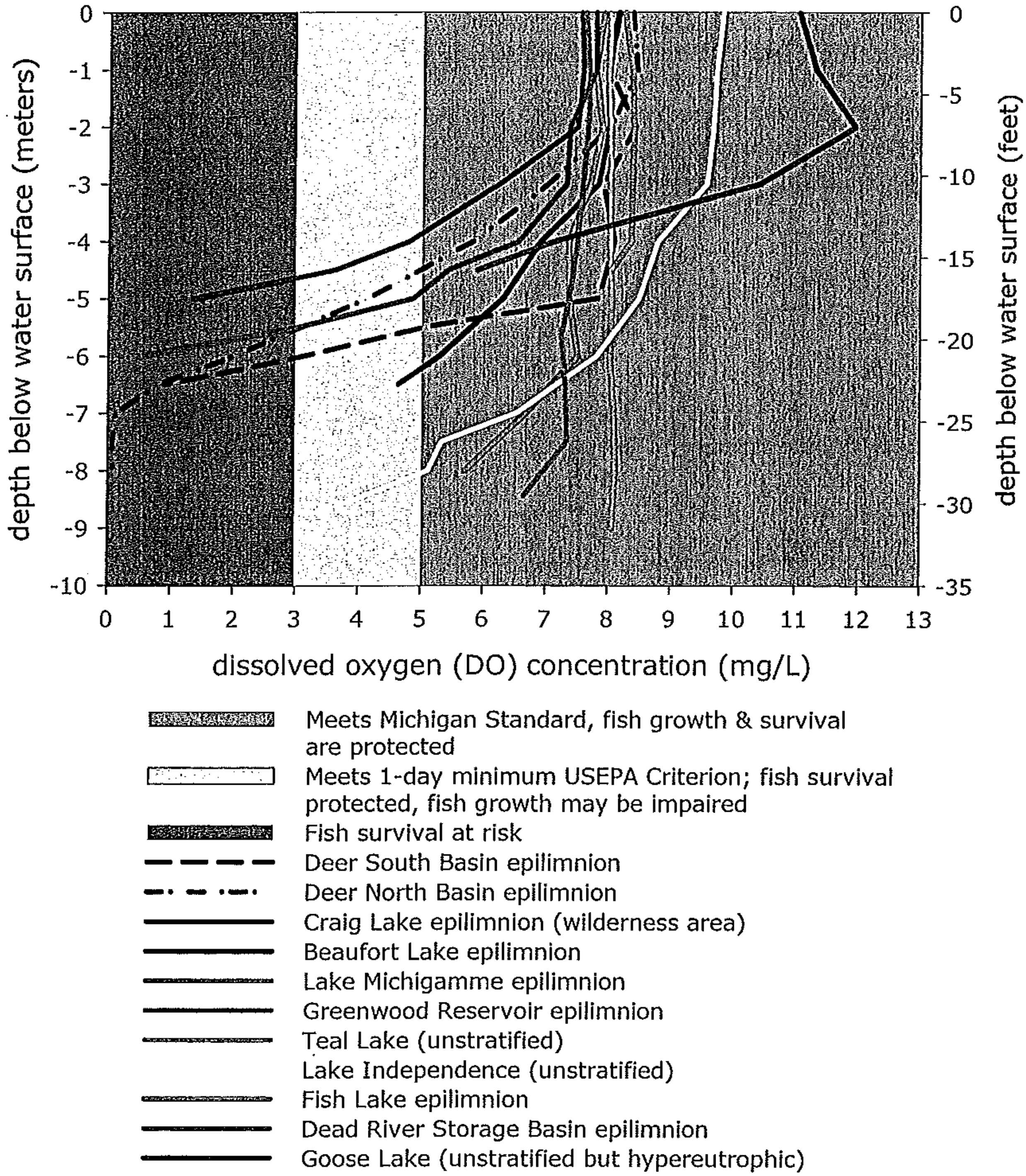



**Figure C-6. Epilimnetic dissolved oxygen profiles in September 2006 for the Deer Lake reservoir and other large lakes in the Michigamme Highland (IX.2) Ecogegion Subsection.**

## Attachment D

## Deer Lake Historical Background

Historic mining practices resulted in mercury contamination to Deer Lake basin from Ropes Creek, and Carp Creek. The "Ropes" Goldmine operated at various times from 1882 through 1991 along Ropes Creek. Gold recovery in the Ropes Mine from 1882-1897 used a mercury amalgamation process to concentrate the gold mined there. Gold processed from the Ropes Mine from 1900-1901 used a cyanide leaching process and additional gold was recovered from scraps of mercury amalgam recovered throughout the Ropes Mill buildings. Mining activity resumed from 1983-1991, but the ore was trucked off site and out of the basin, to the Humboldt Iron Mine for extraction. Throughout the earlier activities, the gold mine tailings from the Ropes Mine were deposited into Ropes Creek watershed. The mine closed in 1979. During the course of investigations by Ecological Research Services, Inc. for the Callahan Mining Company pursuant to the reopening of the Ropes Gold Mine in 1983, high levels of mercury were discovered in fish tissue, sediments, and the water column in Deer Lake Michigan Department of Natural Resources (MDNR),1987).

Investigations by the MDNR determined that Cleveland-Cliffs Iron Company, now Cliffs Natural Resources (Cliffs) assay labs disposed down the lab drains mercury reagent laden wastewater. These wastewaters drained through the Ishpeming Wastewater Treatment Plant (WWTP) to Carp Creek. Cliffs immediately stopped the practice in 1981 when it was determined that their labs were the major continuing mercury source. The 1984 Consent Judgment (CJ) committed both the State of Michigan and Cliffs to a restoration plan which included drawing down the level of the Deer Lake Reservoir, eliminating the contaminated fish, slowly refilling the reservoir, and monitored recovery. The 1984 CJ is Appendix B of in the *1987 Remedial Action Plan for Deer Lake Area of Concern* (MDNR, 1987). The 2006 amendments to the 1984 CJ are intended to facilitate the long term maintenance of the completed remedial measures, provide funding for any additional remedial measures, and minimize discharges from Cliffs Shaft Mine to Carp Creek.

The natural Deer Lake basin covered approximately 90 acres. The original impoundment was formed in 1887 to provide a steady source of water for the Ropes Goldmine operations and did little to change the size of the lake. The second higher dam was built in 1912 by the Cliffs Electric Services Company (CESC) as a hydropower storage reservoir increasing the reservoir to approximately 602 acres to provide energy and to augment winter water flows to the Cliffs iron ore processing operations in Marquette. A third, higher dam was built just below the second in 1942 by the CESC, inundating the second dam, creating the current reservoir to enhance the reservoir's operational capacity. This dam remains in place and is the operating outlet for the Deer Lake reservoir. A large butterfly valve was installed for water flow control at the base of this dam. This valve now helps to control anoxic conditions in the north basin by operating as a bottom draw on the dam. Opening the valve as the lake begins to thermally stratify allows anoxic waters in the north basin flow out the lake bottom keeping dissolved oxygen levels in the hypolimnion higher, instead of allowing all of the flow to exit through the notch at the top of the dam. The notch at the top of the dam is set to maintain the water level in the lake at a minimum of 1,385 feet above sea level. The water level was agreed to between the state and the Cliffs in the 2006 amendments to the CJ.

This level was agreed to be the optimal level needed to minimize the mercury methylation from the contaminated sediments remaining within the lake.

## AOC Designation

In 1985, the Great Lakes Water Quality Board recommended an AOC designation for Deer Lake to the International Joint Commission. This recommendation was based on the fish consumption advisory issued by the Michigan Department of Community Health in 1981 for the Deer Lake reservoir that was expanded in 1982 to include Carp Creek and the Carp River. The fish consumption advisory was driven by high levels of mercury in fish tissues, water and sediment as described in the 1987 Deer Lake RAP (MDNR, 1987).

Elevated levels of mercury in fish were discovered by Ecological Research Services, Inc. through work for the Callahan Mining Company as part of the investigation into the feasibility of reopening of the Ropes Gold Mine. The elevated levels of mercury in the fish were believed to have been primarily caused by discharges of mercury originating from the Cliffs assay labs. These labs discharged wastewater through the old Ishpeming WWTP (MDNR, 1987). Mercury discharges were curtailed in 1981 when the problem was identified (MDNR, 1987).

**Deer Lake Area of Concern**
**Public Advisory Council**
**490 Deer Lake Road**
**Ishpeming, Michigan 49849**

**August 15, 2011**

Ms. Stephanie Swart, AOC Coordinator
Office of the Great Lakes
Michigan Department of Environmental Quality
525 West Allegan Street
Lansing, Michigan 48909

Re: Support for BUI Removals – Eutrophication or Undesirable Algae and Bird or Animal Deformities or Reproduction Problems

Dear Ms. Swart:

The purpose of this letter is to indicate the continued support of the Deer Lake Public Advisory Council (PAC) for the removal of the Eutrophication or Undesirable Algae and the Bird or Animal Deformities or Reproduction Problems Beneficial Use Impairments (BUIs) for the Deer Lake Area of Concern (AOC). At a meeting on August 11, 2011 the PAC unanimously passed a motion supporting the removal of these BUIs. The Deer Lake PAC has been involved in the review of the available information for both BUIs and is in agreement with the July 18, 2011 Bird or Animal Deformities or Reproduction Problems BUI document and the August 2, 2011 Eutrophication or Undesirable Algae BUI document.

If you have any questions regarding our support of the removal of these BUIs please do not hesitate to contact us. We value our partnership with the AOC Program and look forward to continuing good work at Deer Lake and hearing the good news on the BUI removals.

Sincerely,

Diane K Feller

Diane Feller, PAC Chair
Deer Lake Area of Concern
(906) 486-9967

cc: Mr. Pete Nault, Vice Chair, Deer Lake PAC
Ms. Michelle Jarvie, Secretary, Deer Lake PAC