Report

Lake Nebagamon's Water Quality Status – 2004 to 2013

John W (Jack) Arthur
Nebagamon Lake Association

December, 2013

Background

Lake Nebagamon (Wisconsin Waterbody # 2865000) is a light brown-water, a stratified drainage lake, 914 acres in size, having a maximum depth 56 feet, and located in central Douglas County, Wisconsin. The lake is located in the Northwest Wisconsin DNR Geo-Region. The main tributary entering the lake is from Lake Minnesung. The lake is drained by the Nebagamon Creek into the Brule River, and then into Lake Superior. The lake's watershed encompasses 41 square miles, is heavily forested and privately owned (Sand, 2008).

The Nebagamon Lake Association is an active organization, and the primary purpose is an advocate the general public in supporting lake protection. Lake Nebagamon is a popular recreational lake located about 30 miles SE from Superior, Wisconsin on County Road B and P in Douglas County. Water quality summaries assist in identifying lake changes, setting new goals and characterizing potential threats to the lake. Latest water quality summary of Lake Nebagamon was a study by Field (1993, 1994) from samples collected in 1992-1994. Purpose for this report is to provide an up-to-date summary on Lake Nebagamon's water quality.

Procedures

The water quality results were gathered over a ten-year period (2004 to 2013). Lake Nebagamon is a volunteer sampling program conducted with the Wisconsin Department Natural Resources. The sampling site was in the northeast bay (mid-lake point transecting two land points, Fitch Ave, Graves Road), and south from the Nebagamon Creek. The sampling site is called the Big Bay Deep Hole. Each year samples were collected over a 6-month period (April/May, representing approx. 2- weeks after ice-out), in summer months of June, July, August and during the first 2-weeks during the fall in October). During September, additional samples were limited to seicchi disk readings. The April/May and October samplings occurred when lake profile temperatures were similar from top to bottom. Samples collected in June, July and August represented the warm periods of the calendar year, and when the lake was stratified. All surveys were conducted between 1100 to 1400 hours.

Water samples were chemically analyzed for chlorophyll, total phosphorus and using a colorimetric technique for dissolved oxygen. Sampling was also conducted to measure water temperature profiles and water clarity. Lake levels were determined with a staff gauge located in the southeast bay near in the YMCA camp and on private property. All sampling equipment and supplies were furnished by DNR Northern Regional West Office in Spooner, WI. The chlorophyll and phosphorus samples were placed in ice packs, and sent to the DNR Water Hygiene Laboratory, Madison, WI for analysis. All collection and sample procedures, followed WI DNR (2003) protocols.

Lake Nebagamon water quality data is listed by year in the DNR Wisconsin website (dnr.wi.gov/lakes/clmn/station.aspx?id=163394). Results are also reported in an Appendix to this report. Data is also averaged on a yearly basis and using 5-year moving averages. The 5-year running averages were computed using the following year intervals (i.e. 2004-2008, 2005-2009, 2006-2010, 2007-2011, 2008-2012 and 2009-2013). Earliest data reported on the WIDNR web site was in 1986. Lake Nebagamon lake volunteers were Ed Girzi from 1986 to 2001, and Jack Arthur from 2002 to the present-day. Data collected from 1986 through 2003 was limited to seicchi disk readings, and collected during May through October. Beginning in 2004, an expanded water sampling schedule was started with the addition of phosphorus, chlorophyll, dissolved oxygen and temperature. No chlorophyll samples were taken in April/May. Dissolved oxygen sampling was discontinued after 2007. Total phosphorus and chlorophyll analyses were discontinued in October after 2006. Phosphorus and chlorophyll samples were taken using an integrated pipe sampler positioned in the upper 6 feet of the water column. Remaining samples were taken at 3-foot intervals in the water column. Lake stage data is not given on the DNR website, but reported in this report's appendix. A trophic status calculation was also done by the DNR for the phosphorus, chlorophyll and seicchi disk readings.

Results and Discussion

Total Phosphorus

Highest and lowest total phosphorus concentrations were 10 and 37 ug/l (Table 1). In general, lowest phosphorus values occurred in June. The 5-year moving average calculations showed an increasing trend in phosphorus during the years 2011-2012, but not in 2013. Average yearly phosphorus concentrations were the highest in 2012. But a fall-back to lower phosphorus values occurred in 2013. Therefore, more sampling is needed to continue to determine if this increasing trend in phosphorus continues in future years.

Table 1. Total Phosphorus Concentrations (ug/l.) by Sampling Date and Year

Year	Apr/ May	June	July	Aug.	Oct.	Year Av.	5-Yr. Running Av.
2004	21	16	11	15	19	15.8	-
2005	21	10	29	21	11	20.3	-
2006	31	18	18	17	27	21.0	-
2007	14	12	17	19	-	15.5	-
2008	17	20	17	18	-	18.0	18.2
2009	24	17	16	17	-	18.5	18.7
2010	20	16	17	20	-	18.3	18.7
2011	28	19	24	26	-	24.3	18.9
2012	31	37	33	21	-	30.5	21.9
2013	26	15	12	13	-	16.7	21.6
Av.	23.3	18.0	19.4	18.7	19.0	-	-

Chlorophyll

Chlorophyll values varied from 0.9 to 14 ug/l (Table 2). Using 5-yr. average calculations, chlorophyll values have progressively increased from 2009 to 2013. But like phosphorus, a fall-back occurred with the average chlorophyll in 2013. Again, more data is needed to determine if this increasing trend continues.

Table 2. Total Chlorophyll Concentrations (ug/l.) by Month and Year.

Year	June	July	Aug.	Oct.	Yr. Av.	5-Yr. Running Av.
2004	7.2	2.9	2.1	15.4	4.1	-
2005	2.1	3.1	4.4	6.3	3.2	-
2006	4.3	4.2	3.7	12.5	4.1	-
2007	4.0	4.6	8.2	-	4.3	-

2008	0.9	3.0	6.1	-	2.0	5.0
2009	4.8	5.7	9.8	-	5.3	4.8
2010	7.2	9.3	7.4	-	8.3	5.6
2011	8.1	10.6	7.9	-	9.4	6.3
2012	14.8	5.6	6.1	-	10.2	7.2
2013	7.6	6.4	8.0	-	7.0	8.1
Av.	5.5	5.0	5.8	8.6	-	-

Field (1993, 1994) found total phosphorus and chlorophyll values in Lake Nebagamon varying from 12-32 ug/l and 4.2-13.9 ug/l, respectively in 1992 and 1993. His chemical samples were confined to the upper 3 meters of depth. Similar phosphorus concentrations were also found in a 1990-1992 data report (Anonymous, 1990-1992) and varied from 5 to 32 ug./l These previous studies together with this study showed similar total phosphorus profiles. Chlorophyll values were also similar with Fields' studies. Field placed Lake Nebagamon quality somewhere between a mid-tier to top condition based on the phosphorus and chlorophyll profiles. The Wisconsin DNR (2013) in their impairment assessments for drainage lakes would place Lake Nebagamon's phosphorus and chlorophyll values into a non- impairment classification.

Seicchi Disk (Water Clarity)

Seicchi disk readings varied from 4.5 to 9.5 feet (Table 3). Lower readings were recorded in April/May and October samplings. Both the yearly averages and the 5-year running averages showed a progressive decline in water clarity after 2009. Although seicchi disk readings above 10 are found in the DNR website for Lake Nebagamon prior to 2004, no seicchi disk readings >= 10 were recorded in this study.

Table 3. Seicchi Disk Readings (ft.) by Sampling Date and Year.

Year	Apr/ May	June	July	Aug.	Sept.	Oct.	Year Av.	5-Yr. Running Av.
2004	7.0	7.0	8.5	8.5	-	8.5	7.9	-
2005	6.5	9.0	8.5	8.0	7.5	8.5	8.0	-
2006	6.0	9.5	8.0	8.5	8.5	7.5	8.0	-
2007	-	7.5	8.5	6.0	8.0	8.0	7.6	-
2008	5.5	8.0	7.0	6.5	-	9.0	7.2	7.8
2009	7.0	7.0	9.0	8.0	9.0	7.0	7.8	7.8
2010	7.5	8.0	7.0	6.0	-	6.0	6.9	7.5
2011	6.0	6.0	5.5	5.0	-	5.5	5.6	7.1
2012	5.5	6.0	6.5	5.5	7.5	5.5	6.1	6.7
2013	5.5	4.5	5.0	7.0	6.0	6.0	5.7	6.4
Av.	6.3	7.3	7.4	6.9	7.8	7.2	-	-

Field's (1993, 1994) seicchi disk readings varied 5 to 7 feet, and were said to be similar to northwest Wisconsin lake regional results. His seicchi disk values were similar to this study, especially seicchi readings taken after 2010. His conclusion was that seicchi disk readings between 3.3 – 6.6 feet represented a poor condition in northwest Wisconsin lakes.

Trophic Status Index

All trophic lake status indices (TSI) were calculated by the Wisconsin DNR. According to Shaw et al. (2002), trophic status reflects the degree of eutrophication. They defined eutrophication as a mechanism enriching lakes with nutrients and thereby increasing the amounts of aquatic plants and algae. There are three classifications of nutrient status: oligotrophic (nutrient poor), mesotrophic (moderately productive), and eutrophic (highly productive). For the Nebagamon study, average TSI numbers varied from 48.9 to 50.4 units (Table 4). The phosphorus calculation showed the highest average index. A trophic index of 50 represents a borderline between mesotrophic and eutrophic status. Lake Nebagamon's status represents this nutrient status borderline.

Table 4. Calculated Trophic Status based on Phosphorus, Chlorophyll and Seicchi Disk Readings.

	Seicchi Disk		Chlorophyll		Phosphorus	
Year	Av.	5-Yr. Running Av.	Year Av.	5-Yr. Running Av.	Year Av.	5-Yr. Running Av.
2004	47.5	-	44.3	-	49.5	-
2005	47.0	-	43.0	-	51.0	-
2006	47.3	-	45.7	-	51.8	-
2007	48.5	-	46.7	-	49.3	-
2008	49.8	48.0	41.7	45.7	41.7	49.2
2009	45.7	47.9	49.0	45.9	50.8	47.4
2010	49.0	48.1	50.7	47.2	50.5	49.4
2011	51.0	48.3	51.3	47.9	52.8	49.4
2012	50.5	48.9	50.3	48.6	54.5	50.5
2013	54.0	50.1	49.5	50.2	49.5	51.6
Overall Av.	48.9	-	47.7	-	50.4	-

Recommended trophic levels (Wisconsin DNR, 2013) for a "good condition classification" are in the range of 47 – 54 units, and Lake Nebagamon falls into a "good condition". To meet an excellent condition, trophic status values need to be < 47 units. Note that all yearly trophic status values for chlorophyll during 2004-2008 were < 47 units; none of the seicchi disk and phosphorus values were < 47.

Dissolved Oxygen

Dissolved oxygen measurements were confined to the first four study years (2004-2007). Lowest dissolved oxygen concentrations were present in July (Table 5). The June and July surveys showed low levels (< 5.0 mg/l) at depths below 24 feet and in August below 27 feet. Summertime dissolved oxygen values > 5 mg/l occurred in the upper 18 feet of the water column. Hypoxia conditions (<= 2 mg/l) were found below 24 feet in July and below 30 feet in June and August.

Table 5. Dissolved Oxygen during June, July and August by Depth (mg/l).

June (depth in 3 ft. increments)

	0	3	6	9	12	15	18	21	24	27	30	33
2004	8	8	8	8	8	8	-	-	-	-	-	-
2005	-	10	-	-	8	8	6	-	4	-	-	-
2006	8	-	8	8	-	8	-	6	-	4	-	-
2007	-	-	8	-	8	-	8	8	8	4	-	2
Av.	8	9	8	8	8	8	7	7	6	4	-	2
Change	*-1.0*	*1.0*	*0.0*	*0.0*	*0.0*	*1.0*	*0.0*	*1.0*	*2.0*	*-*	*-*	

July (depth in 3 ft. increments)

	0	3	6	9	12	15	18	21	24	27	30	33
2004	10	10	10	8	5	4	3	-	-	-	-	-
2005	-	8	-	8	6	-	5	-	5	-	-	-
2006	-	-	10	-	8	8	8	4	2	2	2	-
2007	-	8	-	8	-	-	8	6	6	2	2	1
Av.	10	8.7	10	8	6.3	6	6	5	4.3	2	2	1
Change	*1.3*	*-1.3*	*2.0*	*1.7*	*0.7*	*0.0*	*1.0*	*0.7*	*2.3*	*0.0*	*1.0*	

August (depth in 3 ft. increments)

	0	3	6	9	12	15	18	21	24	27	30	33
2004	8	8	8	8	8	8	4	-	-	-	-	-
2005	-	8	-	-	8	-	-	6	2	2	-	-
2006	-	-	8	-	-	8	-	8	6	3	-	2
2007	-	-	-	-	-	7	7	7	6	5	3	2
Av.	8	8	8	8	8	7.7	5.5	7	4.7	3.3	3	2
Change		*0.0*	*0.0*	*0.0*	*0.0*	*0.3*	*2.2*	*-1.5*	*2.3*	*1.4*	*0.3*	*1.0*

The EPA (1986) recommends dissolved oxygen values >3.0 mg/l as protective for freshwater fish. In addition, EPA suggests a dissolved oxygen >= 5.0 mg/l for early life fish stages. Field (1993) found dissolved oxygen concentrations <= 3 mg/l in Lake Nebagamon at 24 to 27 feet during June and July surveys. However, summertime stratifications with low dissolved oxygen are said to be a typical in mesotrophic and eutrophic lakes (Shaw et al., 2002.

Water Temperature

Uniform water temperatures only occurred throughout the lake water column in the Apr/May and October surveys (Appendix Table). In the spring and fall surveys, all water temperature measurements were < 55 ^{o}F. in May and < 60 ^{o}F. in October (Table 6). Highest surface water temperatures (confined to the upper 6 feet) were in July and during 2005 and 2012. Greatest temperature changes in water temperature were present during June and July at 12 to 18 foot depths (Table 6). Lake Nebagamon was temperature stratified below 21 feet in August where the temperatures were generally < 55 ^{o}F.

Table 6. Temperature Measurements (in ft.) during June, July and August by Depth (^{o}F).

June (depth in 3 ft. increments)

	0	3	6	9	12	15	18	21	24	27	30	33	36
2004	68	66	66	62	58	-	-	-	-	-	-	-	-
2005	72	72	72	71	70	67	58	58	-	-	-	-	-
2006	70.5	70.0	69.8	67.6	65.3	61.8	58.6	54.3	52.3	51.8	-	-	-
2007	74.6	74.6	74.4	74.1	74.1	73.2	70.5	64.4	59.1	57.2	54.8	52.7	-
2008	62.2	60.2	59.9	59.5	59.3	58.2	58.0	53.9	50.3	49.8	49.4	49.4	-
2009	67.2	65.4	63.6	63.1	59.7	58.6	57.9	57.5	57.2	57.0	57.0	56.6	56.4
2010	70.3	70.1	69.5	66.9	64.9	63.9	59.7	56.4	53.9	53.0	52.3	51.9	51.6
2011	65.3	65.1	64.7	64.5	63.5	60.0	57.0	56.1	55.2	53.0	50.5	50.5	-
2012	69.3	69.6	69.2	69.0	66.3	64.5	62.4	61.5	58.4	56.1	54.6	54.3	54.3
2013	66.0	65.6	64.2	62.9	56.4	50.7	48.0	47.6	47.3	46.5	45.6	45.6	-
Av.	68.6	67.9	67.3	66.1	63.7	61.2	58.9	56.5	54.6	53.1	52.0	51.6	
Change		*0.7*	*0.6*	*1.2*	*2.4*	*2.5*	*2.3*	*2.4*	*1.9*	*1.5*	*1.1*	*0.4*	*-*

July (depth in 3 ft. increments)

	0	3	6	9	12	15	18	21	24	27	30	33	36
2004	78	76	72	68	64	59	55	-	-	-	-	-	-
2005	82	82	82	75	70	67	55	-	53	-	-	-	-
2006	74.6	73.2	72.8	72.6	71.8	56.8	53.7	53.7	53.7	53.0	52.6	-	-
2007	73.2	71.3	70.1	69.6	69.2	69.2	68.0	68.1	68.0	58.4	57.0	53.6	-
2008	73.9	73.7	72.6	72.5	71.9	66.9	65.1	63.5	58.8	55.2	53.8	52.6	51.9
2009	66.0	65.8	65.8	65.8	65.6	65.6	65.6	64.2	58.4	56.6	56.1	54.6	54.6
2010	76.4	76.4	75.9	75.5	72.8	67.4	59.0	56.8	53.6	53.4	52.5	52.1	51.8
2011	78.2	78.0	77.7	76.8	73.2	66.5	62.0	59.1	55.7	53.2	51.8	51.2	51.2
2012	82.4	80.9	79.3	78.2	74.6	67.2	63.3	60.8	57.2	55.2	54.6	53.7	53.7
2013	78.6	78.1	73.4	72.6	71.6	65.1	55.4	48.1	47.1	46.0	45.8	45.6	-
Av.	76.3	75.5	74.1	72.7	70.5	65.3	60.2	59.3	56.2	53.9	53.1	51.9	52.6
Change		*0.8*	*1.4*	*1.5*	*2.2*	*5.2*	*5.1*	*0.9*	*3.1*	*2.3*	*0.8*	*1.2*	*-0.5*

August (depth in 3 ft. increments)

	0	3	6	9	12	15	18	21	24	27	30	33	36
2004	65	65	65	64	64	64	58	55	-	-	-	-	-
2005	74	74	73	73	73	73	72	65	58	54	-	-	-
2006	76.6	-	75.5	-	75.2	75.2	75.0	73.2	-	-	-	-	-
2007	72.3	72.3	72.3	72.1	71.9	71.4	71.4	-	-	-	-	-	-
2008	74.4	73.7	73.4	73.0	70.5	66.5	62.2	-	-	-	-	-	-
2009	76.2	76.2	76.2	75.7	74.6	68.7	68.0	67.4	-	-	-	-	-
2010	73.4	72.6	71.9	71.4	70.5	69.8	69.2	67.8	65.6	55.2	53.4	52.5	52.3
2011	77.5	75.9	74.1	73.4	73.0	71.9	68.3	59.7	56.1	53.7	52.8	52.3	52.1
2012	74.4	74.1	72.8	72.3	71.9	70.8	68.1	61.1	57.7	56.0	55.0	54.3	53.9
2013	72.1	71.9	71.4	69.4	68.9	65.9	59.3	51.0	47.3	46.5	46.2	46.2	-
Av.	73.6	72.8	72.6	71.6	71.5	70.1	67.6	63.4	57.0	53.1	51.9	51.3	52.8
Change		*0.8*	*0.2*	*1.0*	*0.1*	*1.4*	*2.5*	*4.2*	*6.4*	*4.0*	*1.2*	*0.6*	*-1.4*

Highest water temperatures occurred in July, especially during the 2005 and 2011 surveys with temperatures exceeding 80 ^{o}F. in the surface layers (upper 6 feet). This can be a concern since the EPA (1986) suggested water temperatures between 81-82 degrees can impact fish growth of black and white crappie, and northern pike. Sand (1994) reported a diverse fish community existing in Lake Nebagamon comprised of walleye, northern pike, yellow perch, small and largemouth bass, crappie and bluegills. This diverse fish community might be impacted when residing in surface water layers warming into the lower 80's ^{o}F.

Lake Stage Condition

Lake water levels varied from <0.1 to 2.7 feet (Table 7). The lake stage readings were recorded only on sampling days. However, higher and lower water stages were observed at other times during this 10-year period, but not recorded. Highest lake stages were found in April and May, with August and September yielding the lowest lake stage. By October lake levels returning to more normal conditions.

Table 7. Average Lake Stage Readings (ft.) by Month

	Apr.	May	June	July	Aug.	Sept.	Oct.
Av.	1.6	1.6	1.2	0.8	0.7	0.5	0.8
Max.	1.6	2.7	2.1	1.4	2.3	1.0	1.7
Min.	1.3	0.9	0.5	0.2	<0.1	<0.1	0.3

Field (1993, 1994) found lake levels varying about 2 feet from May to September during his Nebagamon studies. Lake levels varied 2.7 feet in this study.

Summary and Conclusions

This report summarizes a 10-year water quality study (2004-2013) conducted in Lake Nebagamon, Douglas County, Wisconsin. Water samples were analyzed for total phosphorus, chlorophyll, water clarity, temperature and dissolved oxygen. The phosphorus and chlorophyll samples were analyzed by the Wisconsin DNR in Madison, WI. Lake stage (water level) was recorded for each sampling period. Phosphorus, chlorophyll and seicchi disk readings proved to be good markers in tracking water quality changes in Lake Nebagamon. With exception of sampling year 2013, increasing concentrations of total phosphorus and chlorophyll samples were found during the later years of the study. Because of 2013 findings, additional sampling is needed to establish if increasing nutrient trends continue. Also, progressive decreases in water clarity are a concern. Thermal and dissolved oxygen lake stratifications occurred below 21 to 24 feet in the summer months. Summertime hypoxia dissolved oxygen conditions (<=2 mg/l) were found at depths below 24 feet. Surface water temperatures exceeded 80 ^{o}F in July on two occasions, and may impace residing fish populations in surface water layers. Stable lake levels were generally present during the sampling activities. Lake Nebagamon appears to have a trophic status at the borderline between mesotrophic and eutrophic conditions. Mesotrophic lake classifications indicate total phosphorus and chlorophyll concentrations in the range of 18-27 and 8-10 ug/l., respectively, and seicchi disk readings of about 6 feet. Guidance supplied by the Wisconsin DNR would rate Lake Nebagamon as mesotrophic. The lake's trophic status appears to be in good condition with a relatively non-impaired status.

Betz and Howard (2005) supply average values for Wisconsin Lake geo-regions. For the northwest lake geo-region, average values were as follows:

Chlorophyll – 13 ug/l
Seicchi Depth – 10.7 ft. (stratified lakes)
Trophic State – 45 units (drainage lakes)

Northwest geo-region phosphorus values were not supplied by Betz and Howard (2005) However, they stated that lakes with total phosphorus concentrations > 20 ug/l can expect algal blooms. Lake Nebagamon phosphorus values were near this threshold level. Although chlorophyll values were about one-half the reported northwest region values, seicchi disk readings revealed worse water quality conditions than reported in northwest lakes. Average TSI indices for Lake Nebagamon varied from 47.7 to 50.4. According to Betz and Howard (1954), when chlorophyll, phosphorus, and secchi TSI indices are equivalent, algae dominate light attenuation. The decreasing water clarity found in Lake Nebagamon might then be due to increasing algal populations, and possibly as a response to increasing phosphorus levels. No Lake Nebagamon algal data was found in the literature.

Increasing phosphorus and chlorophyll concentrations together with declining seicchi disk results represent decreasing water quality, especially during the past 3 to 4 years of this study. However, with the exception of decreasing water clarity, it can be argued that Lake Nebagamon's water quality condition represents a relatively stable condition based on comparisons with Field's (1993, 1994) studies. Additional monitoring with the Wisconsin DNR is needed to determine if water quality continues to decline. Mixed signals were found to rate the lake's present condition, but suggest that Lake Nebagamon is somewhere between a mid to a top-tier condition.

Acknowledgement

Thanks to Wisconsin DNR personnel (in the Spooner and Madison, WI offices) in providing sampling equipment, supplies, and conducting laboratory analyses for total phosphate and chlorophyll.

References Cited

Anonymous 1990-1992. Nebagamon Lake Project Data Reports. Source unknown.

Betz C.R. and P.J. Howard. 2005. Wisconsin Citizen Lake Monitoring Training Manual. Bureau of Integrated Science Services, Wisconsin DNR, P.O. Box 7921, Madison, WI 52707

EPA. 1986. Quality Criteria for Water 1986, EPA 440/5-86-001, Office of Water Regulations and Standards, Washington DC 20460, May

Field, J.F. 1993. Letter to Ms. Swan Herievi., U.S. Dept. Interior, U.S. Geological Survey, Madison, Wisconsin. 53719. June.

Field, J. F. 1994. Letter to Mr. Edward Girzi., U.S. Dept. Interior, U.S. Geological Survey, Madison, Wisconsin. 53719, June.

Sand, C.J. 1994. Fishery Assessments and Managements on Lake Nebagamon. 1933 – Present with Emphasis on a 1994 Treaty Assessment. Unpublished, Brule, Wisconsin.

Sand. C. 2008. Fishery Survey – Lake Nebagamon. Douglas County, 2005-2006, WIBC Code – 2865000, 31 p., April.

Shaw, B., C. Mechenich and L. Klessig. 2002. Understanding Lake Data. Wisconsin Extension Publications, Madison, WI, SR-02/2002-1M-525.

Wickman, S and L. Herman. 2003. Self-help Lake Monitoring Program Training Manual. Lake Chemistry Monitoring, Wisconsin DNR, Madison, Wisconsin, 53707, 64 p., revised from the 1990 PUBL-WR-258, revised 1990 report by Betz and Howard.

Wisconsin Department of Natural Resources. 2013. Wisconsin 2014 Consolidated Assessment and Listing Methodology (WisCALM) Clean Water Act Section 305 (b), 314, and 303 (d) Integrated Reporting. Wisconsin DNR, Madison, Wisconsin 53707-7921, September, 69 p. + Appendices.