Nutrient and Dissolved Oxygen TMDL for Matejcek Dam, Walsh County, North Dakota

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List of Figures

List of Tables

Appendices

1.0 INTRODUCTION AND DESCRIPTION OF THE WATERSHED

Matejcek Dam is located on Middle Branch of the Forest River in southeastern North Dakota. The watershed lies almost entirely within Walsh County, with just a small portion crossing the boundaries into Cavalier County on the north and Nelson County on the south. Completed in 1966, Matejcek Dam is a 130.4-acre reservoir designed for flood control, recreation, and a farm to market road. The reservoir has a contributing watershed of 88,572 acres (Figure 1).

Matejcek Dam's fishery consists mainly of walleye, with some northern pike, perch and crappie present. White suckers are abundant. The reservoir is stocked by the ND Game and Fish, most recently in 2015 with walleye and northern pike.

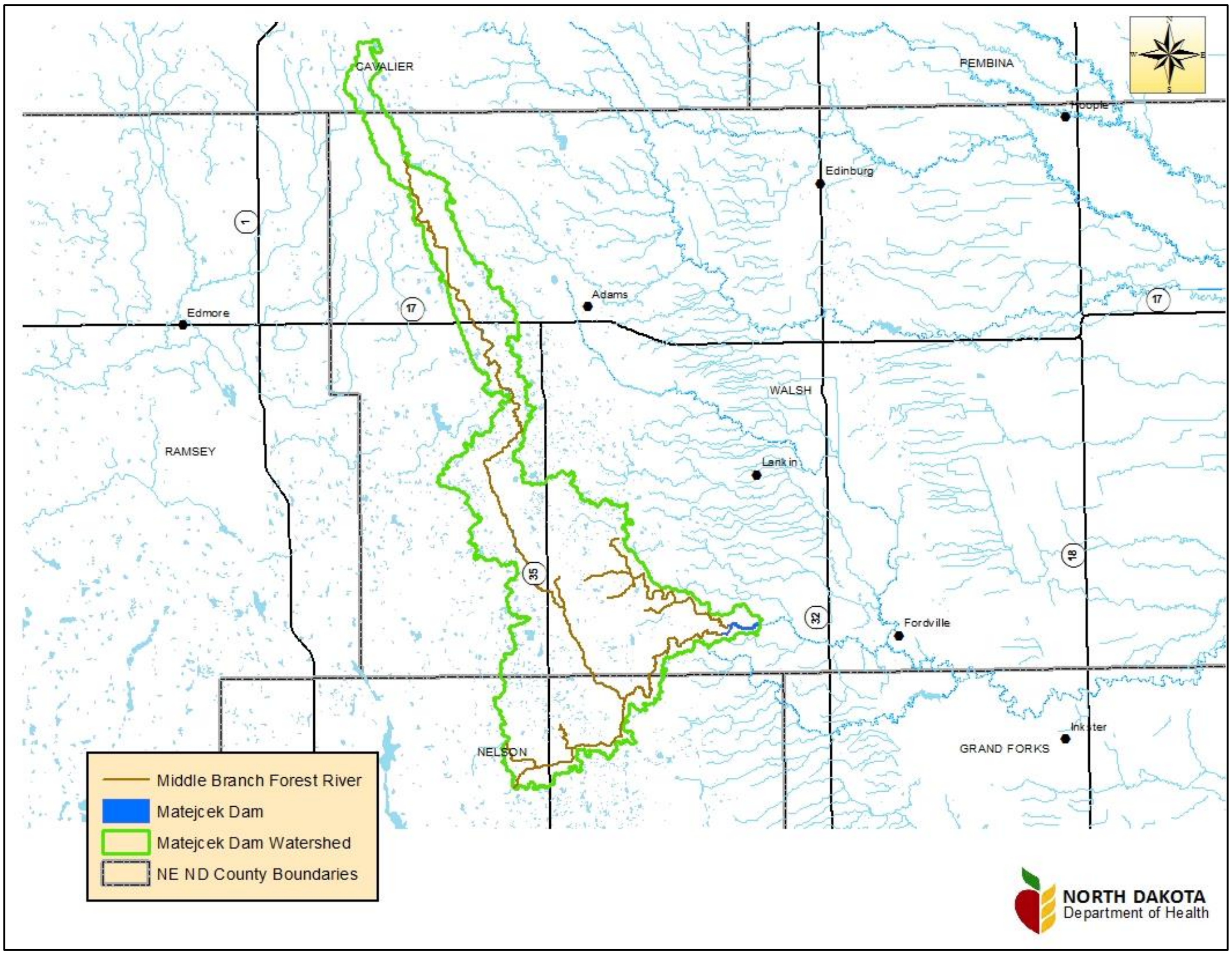

Figure 1. Location of Matejcek Dam and Its Watershed.

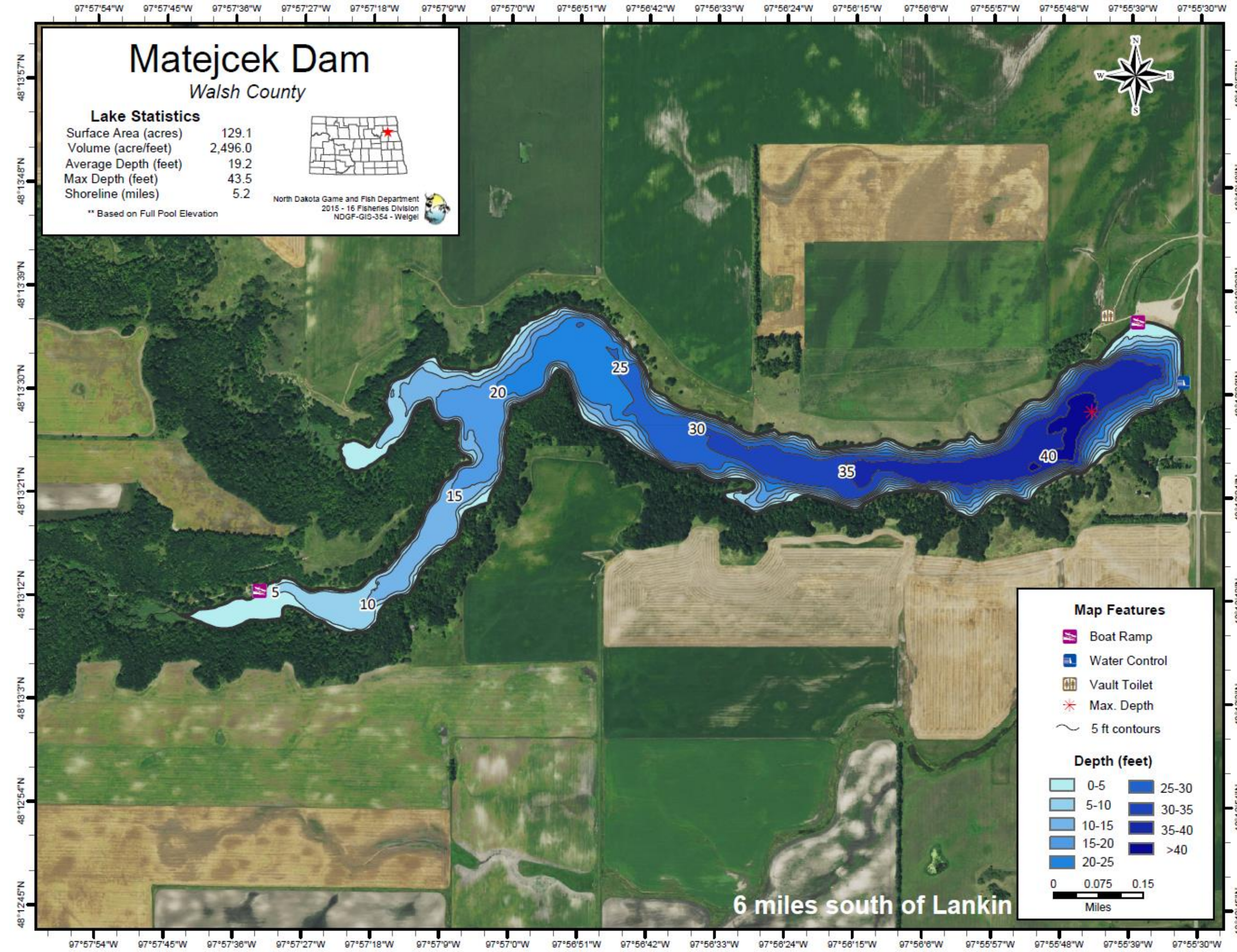

Figure 2. North Dakota Game and Fish Contour Map of Matejcek Dam.

Table 1. General Characteristics of Matejcek Dam and the Matejcek Dam Watershed.

Legal Name	Matejcek Dam
Major Drainage Basin	Forest River into Red River Basin
Nearest Municipality	Fordville, North Dakota
Assessment Unit ID	ND-09020308-003-L_00
County Location	Walsh, Cavalier, and Nelson Counties
Physiographic Region	Northern Great Plains
Latitude	48.2256
Longitude	-97.9277
Watershed Area	88,572 acres
Surface Area	129.1 acres
Average Depth	19.2 feet
Maximum Depth	43.5 feet
Volume	2,496 acre/feet
Type of Waterbody	Reservoir
Dam Type	Earthen Dam
Fishery Type	Walleye, Northern Pike and Yellow Perch

1.1 Clean Water Act Section 303(d) Listing Information

Based on the 2014 Section 303(d) list of impaired waters needing total maximum daily loads (TMDLs), the North Dakota Department of Health (NDDoH) has assessed Matejcek Dam as fully supporting, but threatened for fish and other aquatic biota and recreation uses. The impairments are listed as dissolved oxygen and nutrients/eutrophication/biological indicators. This TMDL report addresses both the aquatic life and recreation impairments caused by low dissolved oxygen and nutrient/eutrophication/biological indicators. The pollutants of concern addressed in this TMDL is nutrients, specifically nitrogen and phosphorus.

Matejcek Dam has been classified as a Class 3 warm-water fishery, "capable of supporting natural reproduction and growth of warm-water fishes (i.e., largemouth bass and bluegill) and associated aquatic biota and marginal growth. Some cool water species may also be present." (NDDoH, 2014b).

Table 2. Matejcek Dam Section 303(d) Listing Information (NDDoH, 2014a).

Assessment Unit ID	**ND-09020308-003-L_00**
Waterbody Name	**Matejcek Dam**
Class	**Class 3 Warm-water fishery**
Impaired Designated Uses	**Fish and Other Aquatic Biota and Recreation**
Use Support	**Fully Supporting, but Threatened**
Impairment	**Nutrient/Eutrophication Biological Indicators; Dissolved Oxygen**
TMDL Priority	**High**

1.2 Topography

The Matejcek Dam watershed is characterized as a subtle undulating topography with a thick mantle of glacial till left behind by retreating Wisconsinan glaciers. A greater proportion of temporary and seasonal wetlands are found on the drift plains than in the coteau areas. Because of the productive soil and level topography, this ecoregion is almost entirely cultivated, with many wetlands drained or simply tilled and planted. The soils present belong to the Order Mollisols, and are typically Haploborolls, Calciaquolls, Natriborolls, Calciborolls and Argiaquolls.

1.3 Land Use and Ecoregions in the Watershed

The Matejcek Dam watershed lies entirely within the Drift Plains IV ecoregion (46i), which is part of the larger Northern Glaciated Plains level III ecoregion (46) (Figure 3).

In the Northern Glaciated Plains level IV ecoregion, drift plains, large glacial lake basins, and shallow river valleys, with level to undulating surfaces and deep soils, provide the basis for crop agriculture. Where the glaciers left heavy deposits of rock, gravel, and sand, grasslands remained generally more intact and their use because grazing land for livestock (USGS, 2006).

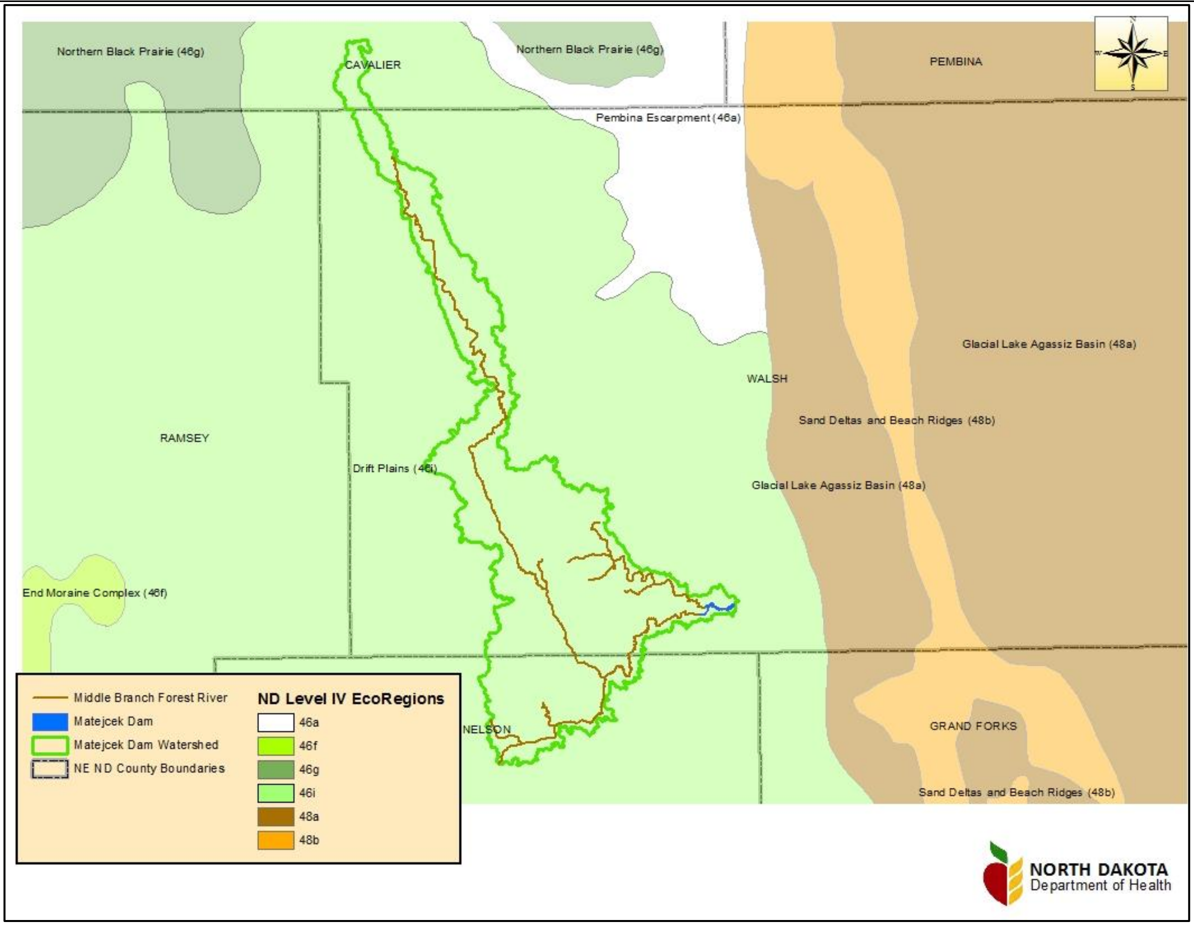

Figure 3. Level IV Ecoregion for the Matejcek Dam Watershed.

Land use data obtained from the National Agricultural Statistics Service (NASS) in 2013 indicates that the Matejcek Dam watershed is primarily agricultural consisting of crop production (29 percent), livestock grazing (26 percent) and fallow land (14 percent). This percentage of agriculture could be even larger as herbaceous wetlands make up 21 percent of the watershed; precipitation for 2013 was heavy at the start of the field season so much of this area did not support cropping, while in dry years would be farmed. (Tables 3 and 4, Figure 4).

Table 3. Major Land Use Categories in the Matejcek Dam Watershed (based on 2013 NASS data).

Major Category	Acres	Percent of Watershed
Cultivated Agriculture	25,605	28.91
Rangeland/Hay	23,059	26.03
Water	21,659	24.45
Barren/Fallow	12,733	14.38
Developed Roads	3,731	4.21
Trees	1,785	2.02

Table 4. Land Use Types in the Matejcek Dam Watershed (based on 2013 NASS data).

Land Use Type	Acres	Percent of Watershed
Herbaceous Wetlands	18,207	20.56
Grassland/Pasture	13,505	15.25
Barren/Fallow/Idle	12,733	14.38
Hay/Alfalfa	9,554	10.78
Wheat /Small Grains(Spring Wheat, Winter Wheat, Oats, Barley)	8,114	9.16
Soybeans	7,918	8.94
Developed/Roads	3,731	4.21
Open Water	3,453	3.90
Canola	3,385	3.82
Corn/Sunflower	3,120	3.52
Beans/Peas	3,067	3.46
Trees	1,785	2.02
TOTAL	88,752	100

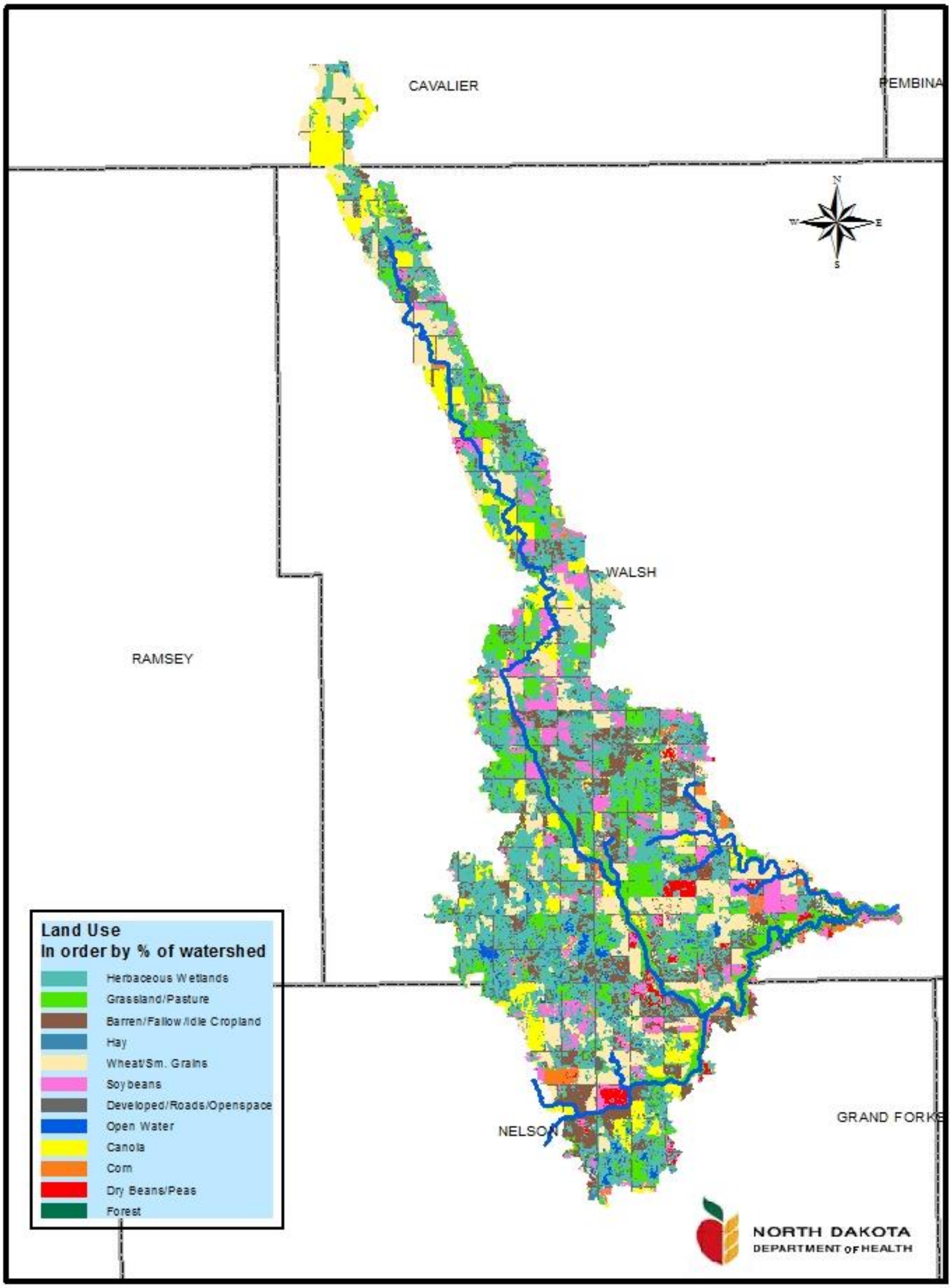

Figure 4. National Agricultural Statistical Survey (2013) Land Use Map for the Matejcek Dam Watershed.

1.4 Climate and Precipitation

Walsh County has a continental climate, with warm summers and cold winters. Temperatures range greatly with an average low temperature in January of -3º F to an average high temperature of 82º F in July. The record low temperature was -40º F in 1912 and the record high temperature was 105º F in 1983. Precipitation occurs primarily during the warm period and is normally heavy in late spring and early summer. Total average annual precipitation for Walsh County is 19.89 inches. About 14.69 inches, or 74 percent, of rain falls between April and September. Average annual snowfall is about 31 inches. Figure 5 shows the total monthly precipitation for the project period (2012-2013) and historic average monthly precipitation (1930-2016) for the area as represented by the North Dakota Agricultural Weather Network (NDAWN) weather station located near Forest River, ND, twenty-one miles to the east of the watershed.

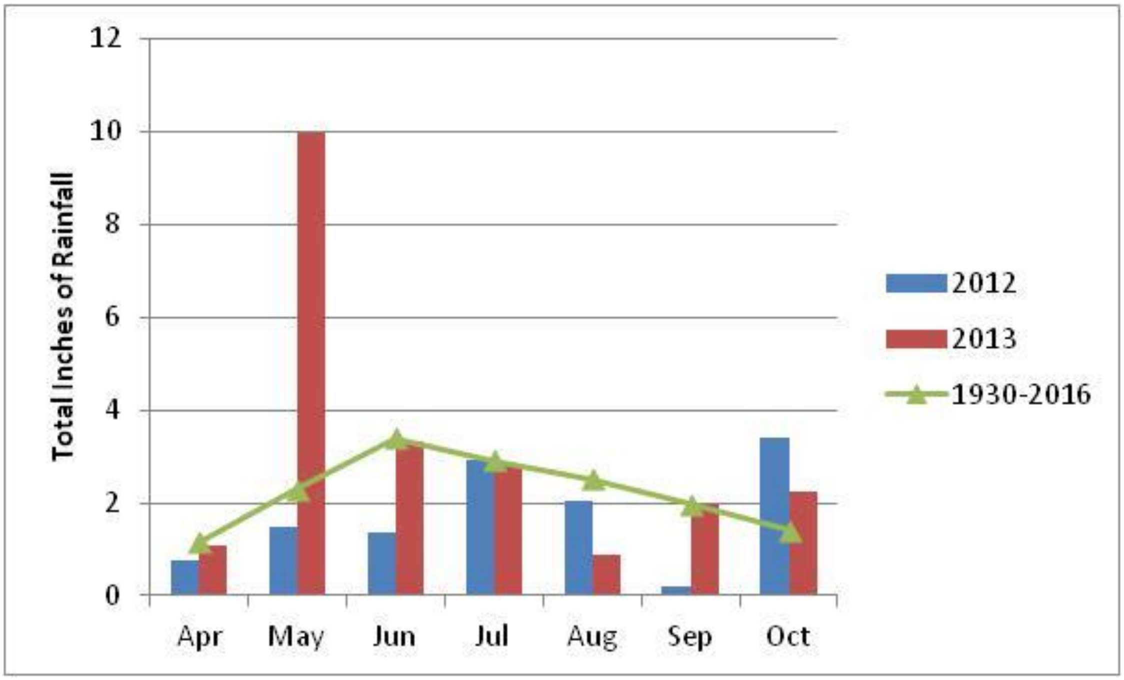

Figure 5. Total Monthly Precipitation (2012-2013) Compared to Historical Average, NDAWN Weather Station, Forest River ND.

1.5 Available Water Quality Data

In 2010, the reservoir was listed on the state's 303(d) list of impaired waters as fully supporting, but threatened for the beneficial uses of recreation and fish and other aquatic biota, due to eutrophication from excessive nutrient loading and low dissolved oxygen.

In 2012, the Walsh County Soil Conservation District (SCD) sponsored a water quality assessment and TMDL development project. Based on the sampling plan and procedures described in the *Matejcek Dam Water Quality and Watershed Assessment Project* Quality Assurance Project Plan (QAPP) (NDDoH, 2012), the SCD collected water quality data at two inlet sites (385576 and 385577), an outlet site (385578), and at one site located in the deepest area of the reservoir (381270) (Figure 6 and Table 5).

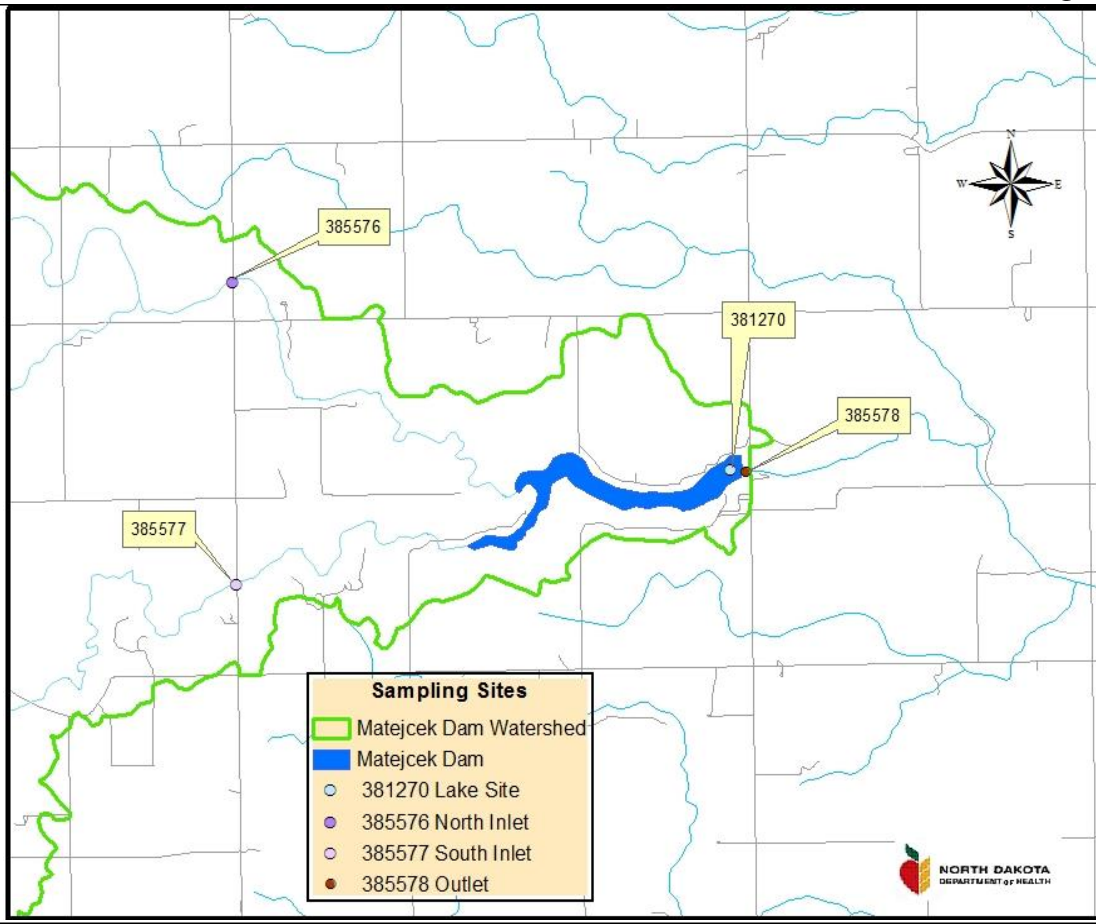

Figure 6. Stream and Lake Sampling Sites for Matejcek Dam.

Table 5. General Information on Water Quality Sampling Sites for Matejcek Dam.

Sample Site	Site ID	Dates Sampled Start	Dates Sampled End	Latitude	Longitude
Stream Sites					
N. Inlet	385576	March 2012	October 2013	48.241389	-97.990000
S. Inlet	385577	March 2012	October 2013	48.216667	-97.990000
Outlet	385578	March 2012	October 2013	48.225278	-97.925556
Lake Site					
Deepest	381270	January 2012	August 2013	48.22549	-97.92745

1.5.1 Stream Water Quality Monitoring

Water quality samples and discharge measurements were taken from the stream sites. Stream parameters analyzed included total nitrogen, total Kjeldahl nitrogen, nitrate-nitrite, ammonia, total and dissolved phosphorus, and total suspended solids (Tables 6 and 7, 8). Sampling frequency for the stream sampling sites was stratified to coincide with the typical hydrograph for the region. This sampling design resulted in more frequent samples collected during spring and early summer, typically when stream discharge is greatest, and less frequent samples collected during the summer and fall. Sampling was discontinued during the winter during ice cover. Stream sampling was also terminated if the stream stopped flowing. If the stream began to flow again, water quality sampling was reinitiated.

Table 6. Summary of Stream Sampling Data, Site 385576 (N. Inlet).

Parameter (mg/L)	N	Average	Minimum	Maximum	Median
Total Nitrogen	59	5.27	1.32	21.5	3.14
Total Kjeldahl Nitrogen	59	4.42	1.19	21.4	2.46
Nitrate/Nitrite	59	0.85	0.03	8.63	0.47
Ammonia	59	1.20	0.03	9.44	0.09
Total Phosphorus	59	0.48	0.03	2.66	0.28
Total Suspended Solids	59	45.20	5	304	23

Table 7. Summary of Stream Sampling Data, Site 385577 (S. Inlet).

Parameter (mg/L)	N	Average	Minimum	Maximum	Median
Total Nitrogen	59	3.16	1.17	36	2.57
Total Kjeldahl Nitrogen	59	2.94	1.03	36	2.33
Nitrate/Nitrite	59	0.22	0.03	1.26	0.08
Ammonia	59	0.43	0.03	17.7	0.06
Total Phosphorus	59	0.40	0.004	1.11	0.38
Total Suspended Solids	59	57.97	5	251	32

Table 8. Summary of Stream Sampling Data, Site 385578 (Outlet).

Parameter (mg/L)	N	Average	Minimum	Maximum	Median
Total Nitrogen	59	2.35	1.57	7.44	2.35
Total Kjeldahl Nitrogen	59	2.11	1.08	7.41	2.15
Nitrate/Nitrite	59	0.25	0.03	1.83	0.09
Ammonia	59	0.22	0.03	3.01	0.13
Total Phosphorus	59	0.37	0.10	0.54	0.37
Total Suspended Solids	59	9.83	5	41	7

1.5.2 Stream Discharge

Mean daily discharge was computed from hourly stream stage recordings and discharge rating curves developed for each stream site by the USGS.

1.5.3 Reservoir Water Quality Monitoring

Reservoir water quality monitoring was conducted by the Walsh County SCD at one site located in the deepest area of Matejcek Dam (381270). Monthly samples were collected between January 2012 and August 2013. The reservoir was sampled twice per month in June, July and August of 2012 as well as June and July of 2013.

The Walsh County SCD followed the methodology for water quality sampling found in the QAPP (NDDoH, 2012).

Nutrient and Chlorophyll-a Data

Based on the data collected in 2012 and 2013, the average total phosphorus concentration for Matejcek Dam was 0.529 mg/L, average total nitrogen concentration was 2.796 mg/L, and average chlorophyll-a concentration was 14.78 µg/L. Since the TMDL target is based on the average growing season chlorophyll-a concentration (20 µg/L), statistics were calculated using data collected between April and November (Table 9). A summary of nutrient and chlorophyll-a data is provided in Table 10. It should be noted that while the season average is below the suggested level, much of July through August of 2012 saw values above this goal (21.4 µg/L to 50.2 µg/L). July through September of 2013 also saw values over the goal of 18 µg/L to 28 µg/L. In both years there were two very low values during the timeframes mentioned, and were probably related to algae die off.

Table 9. Summary of Chlorophyll-a Data, Site 381270 (Deepest Area).

Date	Chlorophyll-a (µg/L)
2012	
4/20/2012	12.90
5/23/2012	0.75*
6/12/2012	0.75*
6/29/2012	5.07
7/5/2012	26.00
7/31/2012	3.10
8/13/2012	6.23
8/28/2012	50.20
9/14/2012	24.10
9/25/2012	21.40
10/16/2012	20.30
2013	
6/16/2013	11.20
7/24/2013	18.00
7/31/2013	28.00
8/14/2013	15.50
8/28/2013	0.75*
9/13/2013	3.29
9/25/2013	18.50

*Concentrations were below lab detection limits

Secchi Disk Transparency Data

Secchi disk transparency data were collected during the open water period between April 2012 and August 2013. The average Secchi disk transparency was 1.55 meters. The maximum Secchi disk transparency measurement recorded was on August 28, 2012 (2.7 meters), while the minimum measurement was recorded on July 31, 2013 (0.5 meters) (Table 10).

Table 10. Summary of Reservoir Sampling Data, Site 381270 (Deepest Area).

Parameter	N	Average	Minimum	Maximum	Median
Total Phosphorus (mg/L)	17	0.529	0.282	0.732	0.537
Total Nitrogen (mg/L)	17	2.796	1.900	3.860	2.647
Total Kjeldahl Nitrogen (mg/L)	17	2.667	1.870	3.670	2.613
Nitrate/Nitrite (mg/L)	17	0.122	0.015	0.527	0.060
Chlorophyll-a (µg/L)*	18	14.78	0.75	50.20	18.25
Secchi Disk (meters)	18	1.55	0.50	2.70	1.35

*Growing Season, April - November

Dissolved Oxygen and Temperature Data

Dissolved oxygen and temperature were monitored at the deepest site on Matejcek Dam from January 2012 through September 2013. Measurements were taken at depths representing the top middle and bottom of the water column during ice cover and open water periods each time a water quality sample was collected. Figures 7 through 10 illustrate the dissolved oxygen and temperature profiles for the assessment period.

The reservoir thermally stratified in late winter and early spring in both 2012 and 2013. The stratification temperature differences were more significant in 2013, with temperatures in the water column ranging from around 2^{o} C at the bottom to 24^{o} C at the top for the entire summer.

Dissolved oxygen levels were below the state water quality standard of 5.0 mg/L in at least a portion of the water column for all samples in both 2012 and 2013 except for the April 20, 2012 sample which was around 12 mg/L. Dissolved oxygen levels in 2013 were significantly worse than 2012, with concentrations dropping to near zero at about five meters of depth for most samples. This coincides with the more significant temperature stratification mentioned above. As mentioned in Section 2.0 below, North Dakota State water quality standards state that the numeric dissolved oxygen standard of 5.0 mg/L as a daily minimum does not apply to the hypolimnion of class 3 lakes and reservoirs, like Matejcek Dam, during periods of thermal stratification. However, in both 2012 and 2013, both the metalimnion and in some cases even the epilimnion had concentrations below 5.0 mg/L.

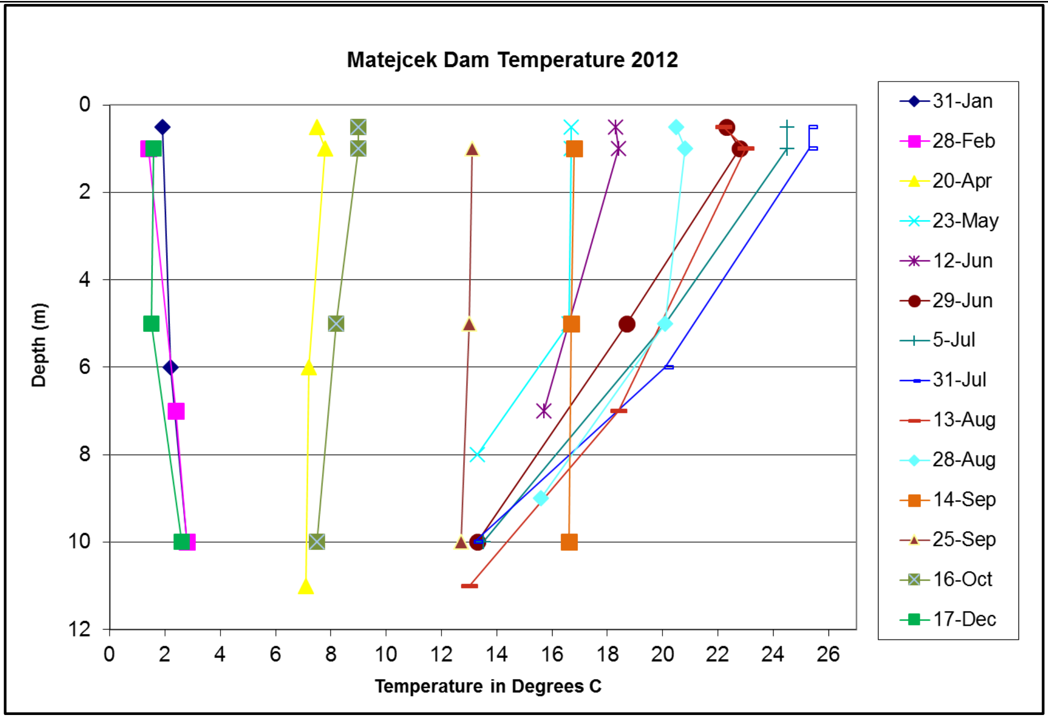

Figure 7. Temperature Profile for Matejcek Dam (2012).

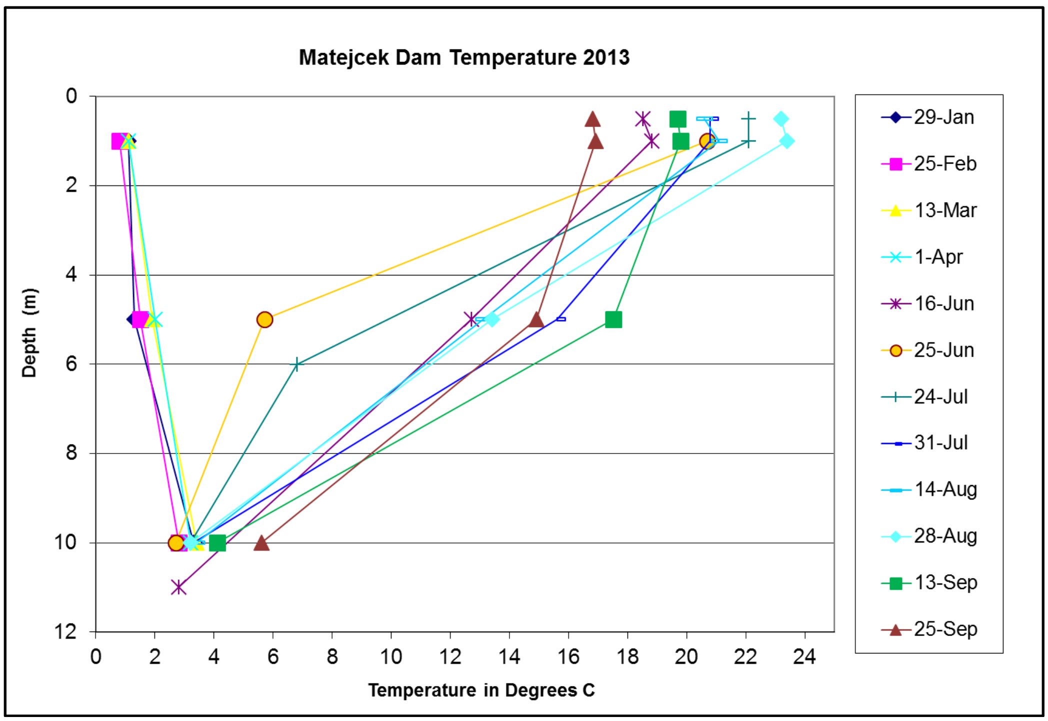

Figure 8. Temperature Profile for Matejcek Dam (2013).

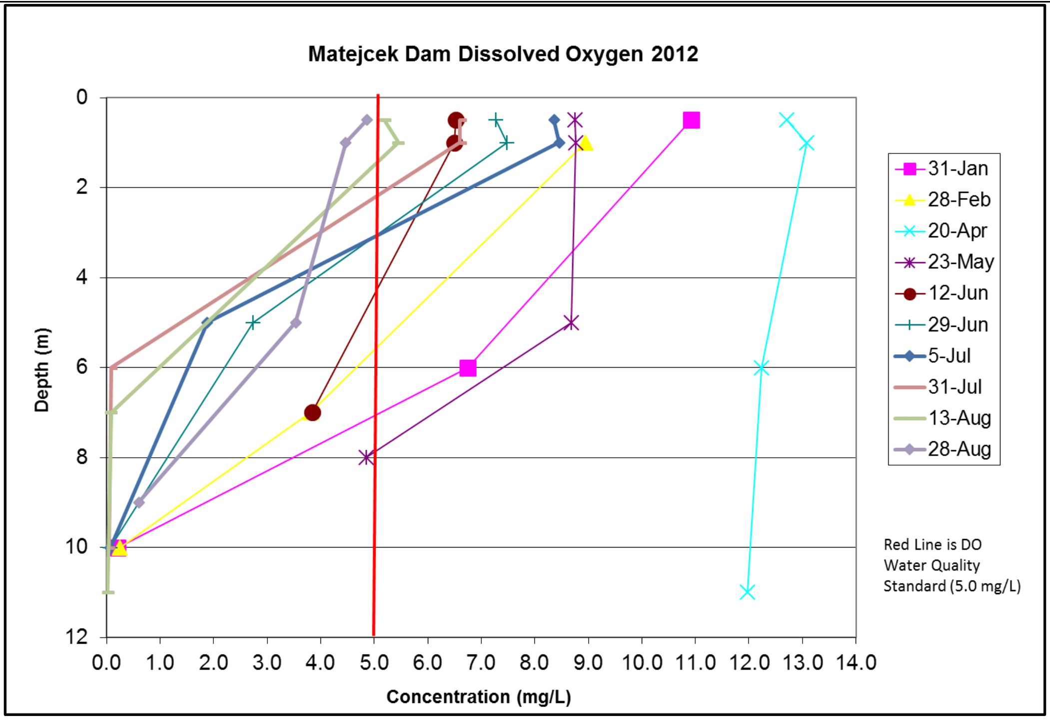

Figure 9. Dissolved Oxygen Profile for Matejcek Dam (2012).

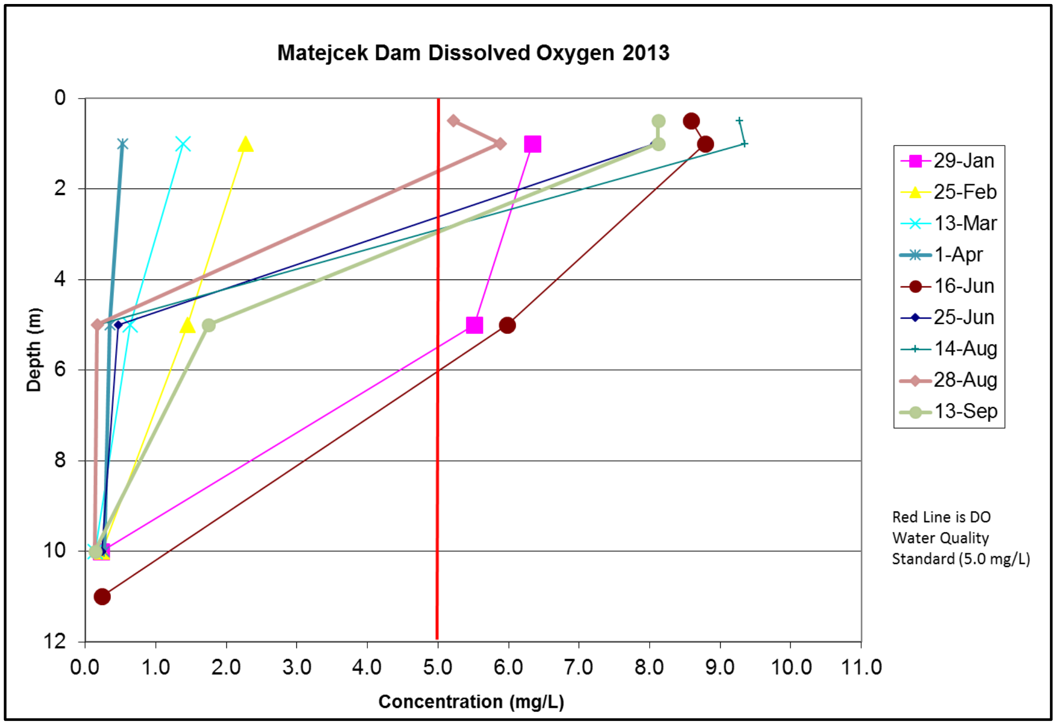

Figure 10. Dissolved Oxygen Profile for Matejcek Dam (2013).

2.0 WATER QUALITY STANDARDS

The Clean Water Act requires that Total Maximum Daily Loads (TMDLs) be developed for waters on a state's Section 303(d) list. A TMDL is defined as “the sum of the individual waste load allocations for point sources and load allocations for nonpoint sources and natural background” such that the capacity of the waterbody to assimilate pollutant loadings is not exceeded. The purpose of a TMDL is to identify the pollutant load reductions or other actions that should be taken so that impaired waters will be able to attain water quality standards. TMDLs are required to be developed with seasonal variations and must include a margin of safety that addresses the uncertainty in the analysis. Separate TMDLs are required to address each pollutant or cause of impairment (i.e., nutrients, sediment).

2.1 Narrative Water Quality Standards

The NDDoH has set narrative water quality standards, which apply to all surface waters in the state. The narrative standards pertaining to nutrient impairments are listed below (NDDoH, 2014b).

- All waters of the state shall be free from substances attributable to municipal, industrial, or other discharges or agricultural practices in concentrations or combinations which are toxic or harmful to humans, animals, plants, or resident aquatic biota.

- No discharge of pollutants, which alone or in combination with other substances shall:
  1) Cause a public health hazard or injury to environmental resources;
  2) Impair existing or reasonable beneficial uses of the receiving waters; or
  3) Directly or indirectly cause concentrations of pollutants to exceed applicable standards of the receiving waters.

In addition to the narrative standards, the NDDoH has set a biological goal for all surface waters in the state. The goal states that “the biological condition of surface waters shall be similar to that of sites or waterbodies determined by the department to be regional reference sites,” (NDDoH, 2014b).

2.2 Numeric Water Quality Standards

Matejcek Dam is classified as a Class 3 warm water fishery. Class 3 fisheries are defined as waterbodies “capable of supporting natural reproduction and growth of warm water fishes (i.e. largemouth bass and bluegill) and associated aquatic biota. Some cool water species may also be present” (NDDoH, 2014b). All classified lakes in North Dakota are assigned aquatic life, recreation, irrigation, livestock watering, and wildlife beneficial uses. The North Dakota State Water Quality Standards (NDDoH, 2014b) state that lakes shall use the same numeric criteria as Class 1 streams, including the state standard for dissolved nitrate as N, of 1.0 mg/L, where up to 10 percent of samples may exceed the 1.0 mg/L. State standards also state that the numeric dissolved oxygen standard of 5.0 mg/L as a daily minimum does not apply to the hypolimnion of class 3 and 4 lakes and reservoirs during periods of thermal stratification. As a guideline for lake and reservoir improvement, a chlorophyll-*a* concentration of 20 µg/L, during the growing season of April – November, is used (Table 11).

Table 11. Numeric Standards Applicable for North Dakota Lakes and Reservoirs (NDDoH , 2014b).

State Water Quality Standard	Parameter	Guidelines	Limit
Numeric Standard for Class I Streams and Classified Lakes	Nitrates (dissolved)	1.0 mg/L	Maximum allowed[1]
Numeric Standard	Dissolved Oxygen	5.0 mg/L	Daily Minimum[2]
Guidelines for Goals in a Lake Improvement or Maintenance Program	Chlorophyll-a	20 µg/L	Goal[3]

[1] "Up to 10% of samples may exceed"
[2] Does not apply to the hypolimnion of Class 3 and 4 lakes and reservoirs during periods of thermal stratification
[3] During the growing season of April through November

3.0 TMDL TARGETS

A TMDL target is the value that is measured to judge the success of the TMDL effort. TMDL targets should be based on state water quality standards, but can also include site-specific values when no numeric criteria are specified in the standard. The following sections summarize water quality targets for Matejcek Dam based on its linkage to maintaining and attaining all of the reservoir's beneficial uses. When the specific target is met, then the reservoir will meet the applicable water quality standards, including its designated beneficial uses.

3.1 TSI Target Based on Chlorophyll-*a*

The state's narrative water quality standards (see Section 2.1) form the basis for aquatic life and recreation use assessment for Section 305(b) reporting and Section 303(d) TMDL listing. In the case of this TMDL, the state's narrative water quality standards also form the basis for setting the TMDL target. State water quality standards contain narrative criteria that require lakes and reservoirs to be "free from" substances "which are toxic or harmful to humans, animals, plants, or resident aquatic biota" or are "in sufficient amounts to be unsightly or deleterious." Narrative standards also prohibit the "discharge of pollutants" (e.g., organic enrichment, nutrients, or sediment), "which alone or in combination with other substances, shall impair existing or reasonable beneficial uses of the receiving waters."

Trophic status is a measure of the productivity of a lake or reservoir and is directly related to the level of nutrients (i.e., phosphorus and nitrogen) entering the lake or reservoir from its watershed and/or from the internal recycling of nutrients. Highly productive lakes, termed "hypereutrophic," contain excessive phosphorus and are characterized by dense growths of weeds, blue-green algal blooms, low transparency, and low dissolved oxygen (DO) concentrations. These lakes experience frequent fish kills and are generally characterized as having excessive rough fish populations (carp, bullhead, and sucker) and poor sport fisheries (Table 12). Due to the frequent algal blooms and excessive weed growth, these lakes are also undesirable for recreational uses such as swimming and boating.

Mesotrophic and eutrophic lakes, on the other hand, generally have lower phosphorus concentrations, low to moderate levels of algae and aquatic plant growth, high transparency, and adequate DO concentrations throughout the year. Mesotrophic lakes may experience periodic algal blooms but at a low frequency, while eutrophic lakes may experience algal blooms of short duration, typically a few days to a week.

Table 12. Water Quality and Beneficial Use Changes That Occur as the Amount of Algae (expressed as Chlorophyll-a concentration) Changes Along the Trophic State Gradient (from Carlson and Simpson, 1996).

TSI Score	Chlorophyll-a (μg/L)	Secchi Disk Transparency (m)	Total Phosphorus (mg/L)	Attributes	Fisheries & Recreation
<30	<0.95	>8	<0.006	**Oligotrophy**: Clear water, oxygen throughout the year in the hypolimnion	Salmonid fisheries dominate
30-40	0.95-2.6	8-4	0.006-0.012	Hypolimnia of shallower lakes may become anoxic	Salmonid fisheries in deep lakes only
40-50	2.6-7.3	4-2	0.012-0.024	**Mesotrophy**: Water moderately clear; increasing probability of hypolimnetic anoxia during summer	Hypolimnetic anoxia results in loss of salmonids. Walleye may predominate
50-60	7.3-20	2-1	0.024-0.048	**Eutrophy**: Anoxic hypolimnia, macrophyte problems possible	Warm-water fisheries only. Bass may dominate.
60-70	20-56	0.5-1	0.048-0.096	Blue-green algae dominate, algal scums and macrophyte problems	Nuisance macrophytes, algal scums, and low transparency may discourage swimming and boating.
70-80	56-155	0.25-0.5	0.096-0.192	**Hypereutrophy**: (light limited productivity). Dense algae and macrophytes	
>80	>155	<0.25	0.192-0.384	Algal scums, few macrophytes	Rough fish dominate; summer fish kills possible

Therefore, for purposes of this TMDL report, it can be concluded that hypereutrophic lakes do not fully support a sustainable sport fishery and are limited in recreational uses, whereas eutrophic and mesotrophic lakes fully support both aquatic life and recreation use.

Carlson's Trophic State Indices (TSIs), based on Secchi disk depth (transparency), chlorophyll-a concentration, and total phosphorus concentration, are indicators used to assess the level of productivity of a lake or reservoir (Carlson, 1977). Due to the relationship between trophic status indicators and the aquatic community (as reflected by the fishery) or between trophic status indicators and the frequency of algal blooms, trophic status is an effective indicator of aquatic life and recreation use support in lakes and reservoirs.

While the three trophic state indicators, chlorophyll-*a*, Secchi disk transparency, and total phosphorus, used in Carlson's TSI each independently estimate algal biomass and should produce the same index value for a given combination of variable values, they often do not. While transparency and phosphorus may co-vary with trophic state, many times the changes observed in a lake's transparency are not caused by changes in algal biomass, but may be due to particulate sediment suspended in the water column. Total phosphorus may or may not be strongly related to algal biomass due to light limitation and/or nitrogen and carbon limitation. Therefore, neither transparency nor phosphorus is an independent estimator of trophic state (Carlson and Simspon, 1996). For these reasons, the NDDoH gives priority to chlorophyll-*a* as the primary trophic state indicator because this variable is the most accurate of the three at predicting algal biomass (Carlson, 1980).

The same conclusion was also reached by a multi-state project team consisting of lake managers and water quality specialists from North Dakota, South Dakota, Montana, Wyoming and EPA Region 8. This group concluded that for lakes and reservoirs in the plains region of EPA Region 8, an average growing season (Apr–Nov) chlorophyll-a concentration of 20 µg/L or less should be the basis for nutrient criteria development for lakes and reservoirs in the plains region (including North Dakota) and that this chlorophyll-a target would be protective of all of a lake or reservoir's beneficial uses, including recreation and aquatic life. The report also concluded that most lakes and reservoirs in the plains region typically have high total phosphorus concentrations, but maintain relatively low productivity, and that due to this condition, chlorophyll-a is a better measure of a lake or reservoirs trophic status than total phosphorus (Houston Engineering, 2011).

Water quality data collected in the reservoir in 2012 and 2013 showed an average growing season chlorophyll-a concentration of 14.78 µg/L (TSI Score of 51.42) and an average Secchi disk transparency of 1.55 meters (TSI Score of 55.55). Based on these data, Matejcek Dam is generally assessed as a eutrophic lake (Table 13).

Based only on the total phosphorus data and corresponding TSI score of 94.12, Matejcek Dam would be considered a highly hypereutrophic reservoir (Table 12, Figure 11). However, Carlson and Simpson (1996) suggest that if the phosphorus TSI value is higher than the chlorophyll-a and Secchi disk transparency TSI value (as is the case with Matejcek Dam), then algae does not dominate light attenuation, and some other factor, such as nitrogen limitation, zooplankton grazing, or toxics may be limiting algal biomass in the lake (Table 14).

Table 13. Carlson's Trophic State Indices for Matejcek Dam.

Parameter	Relationship	Units	TSI Value (Average)	TSI Value (Median)	Trophic Status
Chlorophyll-a	TSI (Chl-a) = 30.6 + 9.81[ln(Chl-a)]	µg/L	51.42	59.09	Eutrophic
Total Phosphorus (TP)	TSI (TP) = 4.15 + 14.42[(ln(TP)]	µg/L	94.12	95.80	Hypereutrophic
Total Nitrogen	TSI (TN) = 54.45+14.43[ln(TN)]	mg/L	69.29	68.50	Hypereutrophic
Secchi Depth (SD)	TSI (SD) = 60 - 14.41[ln(SD)]	Meters	55.55	58.69	Eutrophic

TSI < 30 - Oligotrophic (least productive) TSI 30-50 Mesotrophic
TSI 50-65 Eutrophic TSI > 65 - Hypereutrophic (most productive)

Table 14. Relationships Between TSI Variables and Conditions (from Carlson and Simpson, 1996).

Relationship Between TSI Variables	Conditions
TSI(Chl) = TSI(TP) = TSI(SD)	Algae dominate light attenuation; TN/TP ~ 33:1
TSI(Chl) > TSI(SD)	Large particulates, such as *Aphanizomenon* flakes, dominate
TSI(TP) = TSI(SD) > TSI(CHL)	Non-algal particulates or color dominate light attenuation
TSI(SD) = TSI(CHL) > TSI(TP)	Phosphorus limits algal biomass (TN/TP >33:1)
TSI(TP) >TSI(CHL) = TSI(SD)	Algae dominate light attenuation but some factor such as nitrogen limitation, zooplankton grazing or toxics limit algal biomass.

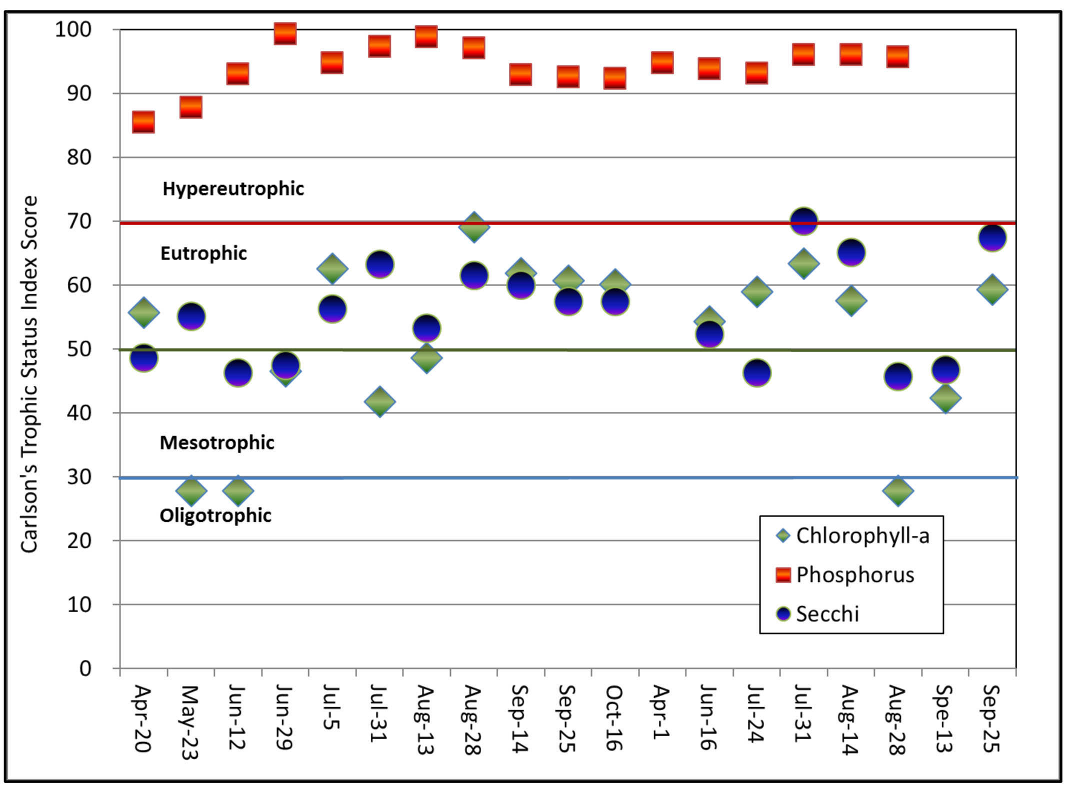

Figure 11. Temporal Distribution of Carlson's TSI Scores for Matejcek Dam.

As stated previously, the NDDoH has established an in-lake growing season average chlorophyll-*a* concentration goal of 20 µg/L for most lake and reservoir nutrient TMDLs, including this TMDL for Matejcek Dam. Based on this target, the critical condition for the TMDL is the growing season, April through November. This chlorophyll-*a* goal corresponds to a chlorophyll-*a* TSI score of 60 which is in the eutrophic range and, as such, will be a trophic state sufficient to maintain both aquatic life and recreation uses of most lakes and reservoirs in the state, including Matejcek Dam.

Through the use of a calibrated water quality model like BATHTUB, the total phosphorus load corresponding to an average chlorophyll-*a* concentration of 20 µg/L can be estimated. Since the observed median chlorophyll-*a* concentration for Matejcek Dam is estimated to be 14.78 µg/L, the TMDL goal and the TMDL equation presented in Section 7.0 was developed assuming no future degradation of water quality within the reservoir (i.e., a lake protection strategy). Based on this assumption the TMDL target is the predicted average growing season chlorophyll-*a* concentration of 13.5 µg/L which corresponds to a 10 percent reduction in the current nutrient load.

3.2 Dissolved Oxygen Target

The North Dakota State Water Quality Standard for dissolved oxygen is 5.0 mg/L as a daily minimum, with up to ten percent of representative samples collected during any three year period occurring below this value provided lethal conditions are avoided. This will be the dissolved oxygen target for Matejcek Dam.

4.0 SIGNIFICANT SOURCES

There are no known point sources upstream of Matejcek Dam. The pollutants of concern originate from nonpoint sources (see Section 1.3). While a portion of the tributary load includes some natural or background sources, the majority of the nitrogen and phosphorus load entering Matejcek Dam is believed to be from nonpoint sources derived from anthropogenic sources in the watershed.

5.0 TECHNICAL ANALYSIS

Establishing a relationship between in-lake water quality targets and pollutant source loading is a critical component of TMDL development. Identifying the cause-and-effect relationship between pollutant loads and the water quality response is necessary to evaluate the loading capacity of the receiving waterbody. The loading capacity is the amount of a pollutant that can be assimilated by the waterbody while still attaining and maintaining water quality standards. This section discusses the technical analysis used to estimate existing loads to Matejcek Dam and the predicted trophic response of the reservoir to reductions in loading capacity.

5.1 Tributary Load Analysis

To facilitate the management and analysis of tributary inflow and outflow water quality and flow data the FLUX program was employed. The FLUX program, developed by the US Corps of Engineers Waterways Experiment Station (Walker, 1996), provides the user with six calculation techniques to estimate the average mass discharge or loading that passes a given river or stream site. FLUX estimates loadings based on grab sample chemical concentrations and the continuous daily flow record. Load is therefore defined as the mass of a pollutant during a given time period (e.g., hour, day, month, season, year). The FLUX program allows the user, through various iterations, to select the most appropriate load calculation technique and data stratification scheme, either by flow or date, which will give a load estimate with the smallest statistical error, as represented by the coefficient of variation. Output from the FLUX program is then provided as an input file to calibrate the BATHTUB eutrophication response model. For a complete description of the FLUX program the reader is referred to Walker (1996).

5.2 BATHTUB Trophic Response Model

The BATHTUB model (Walker, 1996) was used to predict and evaluate the effects of various nutrient load reduction scenarios on Matejcek Dam. BATHTUB performs steady-state water and nutrient balance calculations in a spatially segmented hydraulic network. The model accounts for advective and diffusive transport and nutrient sedimentation. Eutrophication related water quality conditions are predicted using empirical relationships previously developed and tested for reservoir applications.

The BATHTUB model is developed in three phases. The first two phases involve the analysis and reduction of the tributary and in-lake water quality data. The third phase involves model calibration. In the data reduction phase, the in-lake and tributary monitoring data collected as part of the project were summarized in a format which serves as an input to the model.

The tributary data were analyzed and reduced by the FLUX program. FLUX uses tributary inflow and outflow water quality and flow data to estimate average mass discharge or loading that passes a river or stream site using six calculation techniques. Load is therefore defined as the mass of pollutant during a given unit of time. The FLUX model then allows the user to pick the most appropriate load calculation technique with the smallest statistical error. Output for the FLUX program is then used to calibrate the BATHTUB model.

The reservoir data were reduced in Microsoft Excel using three computational functions. These include: 1) the ability to display concentrations as a function of depth, location, and date; 2) summary statistics (e.g., mean, median, etc.); and 3) evaluation of the trophic status. The output data from the Excel program were then used as input to calibrate the BATHTUB model.

When the input data from FLUX and Excel programs are entered in to the BATHTUB model, the user has the ability to compare predicted conditions (model output) to actual conditions using general rates and factors. The BATHTUB model is then calibrated by combining tributary load estimates for the project period with in-lake water quality estimates. The model is termed calibrated when the predicted estimates for the trophic response variables are similar to the observed estimates based on data collected during the 2012-2013 assessment project. BATHTUB then has the ability to predict total phosphorus and nitrogen concentrations, chlorophyll-*a* concentration, and Secchi disk depth and the associated TSI scores as a means of expressing trophic response.

As stated above, BATHTUB can compare predicted vs. actual conditions. After calibration, the model was run based on observed concentrations of phosphorus and nitrogen to derive an estimated annual average total phosphorus and total nitrogen load of 11,237.51 kg and 47,030.10 kg, respectively. The model was then run to evaluate the effectiveness of a number of nutrient reduction alternatives, including: 1) reducing externally derived nutrient loads; 2) reducing internally available nutrients; and 3) reducing both external and internal nutrient loads. (See Appendix B for more detail).

In the case of Matejcek Dam because the average growing season concentration of chlorophyll-*a* was already below the recommended 20 µg/L, BATHTUB was used to model the reservoir's trophic status response based on reductions in just externally derived phosphorus and nitrogen loading. Phosphorus and nitrogen were both used in the simulation model based on their known relationship to eutrophication and also that they are controllable with Best Management Practices (BMPs) implemented in the watershed. Changes in trophic response were evaluated by reducing externally derived nutrient (phosphorus and nitrogen) loading by 10 percent, to be protective of current beneficial uses and prevent degradation. Simulated reductions in chlorophyll-*a*, Secchi disk depth, and total phosphorus-based TSI scores were achieved by reducing phosphorus and nitrogen concentrations in contributing tributaries and other externally delivered sources. Flow was held constant due to uncertainty in estimating changes in hydraulic discharge with the implementation of BMPs.

In order to keep the predicted chlorophyll-*a* concentration from going above the current observed average (no degradation) for Matejcek Dam and to account for the variability in chlorophyll-*a* between the observed and predicted value, using the BATHTUB model 10% reduction in external total phosphorus and nitrogen load would be the best lake protection strategy. This would result in the total phosphorus load being reduced from 11,237.51 kg/yr to 10,102.41 kg/year and total nitrogen load being reduced from 47,030.10 kg/year to 42,420.36 kg/year. The reduction would result in the predicted chlorophyll-*a* average of 13.5 μg/L with most TSI targets in the eutrophic level.

It is generally accepted that a total nitrogen (TN) to total phosphorus (TP) ratio of 14:1 is an optimal balance in freshwater ecosystems and that ratios greater than 14:1 is phosphorus limited and less than 14:1 is nitrogen limiting (Downing and McCauley, 1996). Currently Matejcek Dam has a TN:TP ratio of 4.34:1. A 10 percent reduction in total phosphorus and total nitrogen loading will result in a TN:TP ratio of 5.29:1, which is still very nitrogen limited.

5.3 AnnAGNPS Watershed Model

The Annualized Agricultural NonPoint Source Pollution (AnnAGNPS) model was developed by the USDA Agricultural Research Service and Natural Resource Conservation Service (NRCS). The AnnAGNPS model consists of a system of computer models used to predict nonpoint source pollution (NPS) loadings within agricultural watersheds. The continuous simulation surface runoff model contains programs for: 1) input generation and editing; 2) "annualized" pollutant loading model; and 3) output reformatting and analysis.

The AnnAGNPS model uses batch processing, continual-simulation, and surface runoff pollutant loading to generate amounts of water, sediment, and nutrients moving from land areas (cells) and flowing into the watershed stream network at user specified locations (reaches) on a daily basis. The water, sediment, and chemicals travel throughout the specified watershed outlets. Feedlots, gullies, point sources, and impoundments are special components that can be included in the cells and reaches. Each component adds water, sediment, or nutrients to the reaches.

The AnnAGNPS model is able to partition soluble nutrients between surface runoff and infiltration. Sediment-attached nutrients are also calculated in the stream system. Sediment is divided into five particle size classes (clay, silt, sand, small aggregate, and large aggregate) and are moved separately through the stream reaches.

AnnAGNPS uses various models to develop an annualized load in the watershed. These models account for surface runoff, soil moisture, erosion, nutrients, and reach routing. Each model serves a particular purpose and function in simulating the NPS processes occurring in the watershed.

To generate surface runoff and soil moisture, the soil profile is divided into two layers. The top layer is used as the tillage layer and has properties that change (bulk density, etc.). While the remaining soil profile makes up the second layer with properties that remain static. A daily soil moisture budget is calculated based on rainfall, irrigation, and snow melt runoff, evapotranspiration, and percolation. Runoff is calculated using the NRCS Runoff Curve Number equation. These curve numbers can be modified based on tillage operations, soil moisture, and crop stage.

Overland sediment erosion was determined using a modified watershed-scale version of Revised Universal Soil Loss Equation (RUSLE) (Gerter and Theurer, 1998).

A daily mass balance for nitrogen (N), phosphorus (P), and organic carbon (OC) are calculated for each cell. Major components of N and P considered include plant uptake N and P, fertilization, residue decomposition, and N and P transport. Soluble and sediment absorbed N and P are also calculated. Nitrogen and phosphorus are then separated into organic and mineral phases. Plant uptake N and P are modeled through a crop growth stage index (Bosch et. al. 1998).

The reach routing model moves sediment and nutrients through the watershed. Sediment routing is calculated based upon transport capacity relationships using the Bagnold stream power equation (Bagnold, 1966). Routing of nutrients through the watershed is accomplished by subdividing them into soluble and sediment attached components and are based on reach travel time, water temperature, and decay constant. Infiltration is also used to further reduce soluble nutrients. Both the upstream and downstream points of the reach are calculated for equilibrium concentrations by using a first order equilibrium model.

AnnAGNPS uses 34 different categories of input data and over 400 separate input parameters to execute the model. The input data categories can be split into five major classifications: climatic data, land characterization, field operations, chemical characteristics, and feedlot operations. Climatic data includes precipitation, maximum and minimum air temperature, relative humidity, sky cover, and wind speed. Land characterization consists of soil characterization, curve number, RUSLE parameters, and watershed drainage characterization. Field operations contain tillage, planting, harvest, rotation, chemical operations, and irrigation schedules. Finally, feedlot operations require daily manure rates, times of manure removal, and residue amount from previous operations.

Input parameters are used to verify the model. Some input parameters may be repeated for each cell, soil type, land use, feedlot, and channel reach. Default values are available for some input parameters; others can be simplified because of duplication. Daily climatic input data can be obtained through weather generators, local data, and/or both. Geographical input data including cell boundaries, land slope, slope direction, and land use can be generated by GIS or DEM (Digital Elevation Models).

Output data is expressed through an event based report for stream reaches and a source accounting report for land or reach components. Output parameters are selected by the user for the desired watershed source locations (specific cells, reaches, feedlots, point sources, or gullies) for any simulation period. Source accounting for land or reach components are calculated as a fraction of a pollutant load passing through any reach in the stream network that came from the user identified watershed source locations. Event based output data is defined as event quantities for user selected parameters at desired stream reach locations.

AnnAGNPS was utilized for the Matejcek Dam Water Quality and Watershed Assessment project. The Matejcek Dam watershed delineation began with downloading a 30-meter digital elevation model (DEM) of Walsh County. Delineation is defined as drawing a boundary and dividing the land within the boundary into subwatersheds in such a matter that each subwatershed has uniformed hydrological parameters (land slope, elevation, etc.)

Land use and soil digital images were then used to extract the dominate identification of land use and soil for each subwatershed. This process is achieved by overlaying Landsat and soil images over the subwatershed file. Each dominant soil is then further identified by its physical and chemical soil properties found in a database called National Soils Information System (NASIS) developed by the NRCS. Dominant land use identification input parameters were obtained using Revised Universal Soil Loss Equation (RUSLE).

A three year simulation period was run on the Matejcek Dam watershed at its present condition to provide a best estimation of the current land use practices applied to the soils and slopes of the watershed to obtain nutrient loads from the individual cells as well as the watershed as a whole. Crop rotations were determined from 2012 and 2013 crop data from the National Agricultural Statistical Service (NASS). Over 54 different crop rotations and 29 fertilizer application rates were used to simulate current watershed land use conditions within the Matejcek Dam watershed.

Climate data was derived from the North Dakota Agricultural Weather Network (NDAWN) weather station located in Forest River, ND from January 2012 through December 2013.

The compiled data were used to assess the watershed to identify high priority areas (those with the highest nutrient loads) located in the watershed for potential best management practice (BMP) implementation (Figures 12 and 13). High priority areas were determined to be cells in the watershed providing an estimated annual phosphorus yield of 0.056 lbs/acre/year or greater and/or an estimated annual nitrogen yield of 6.79 lbs/acre/year.

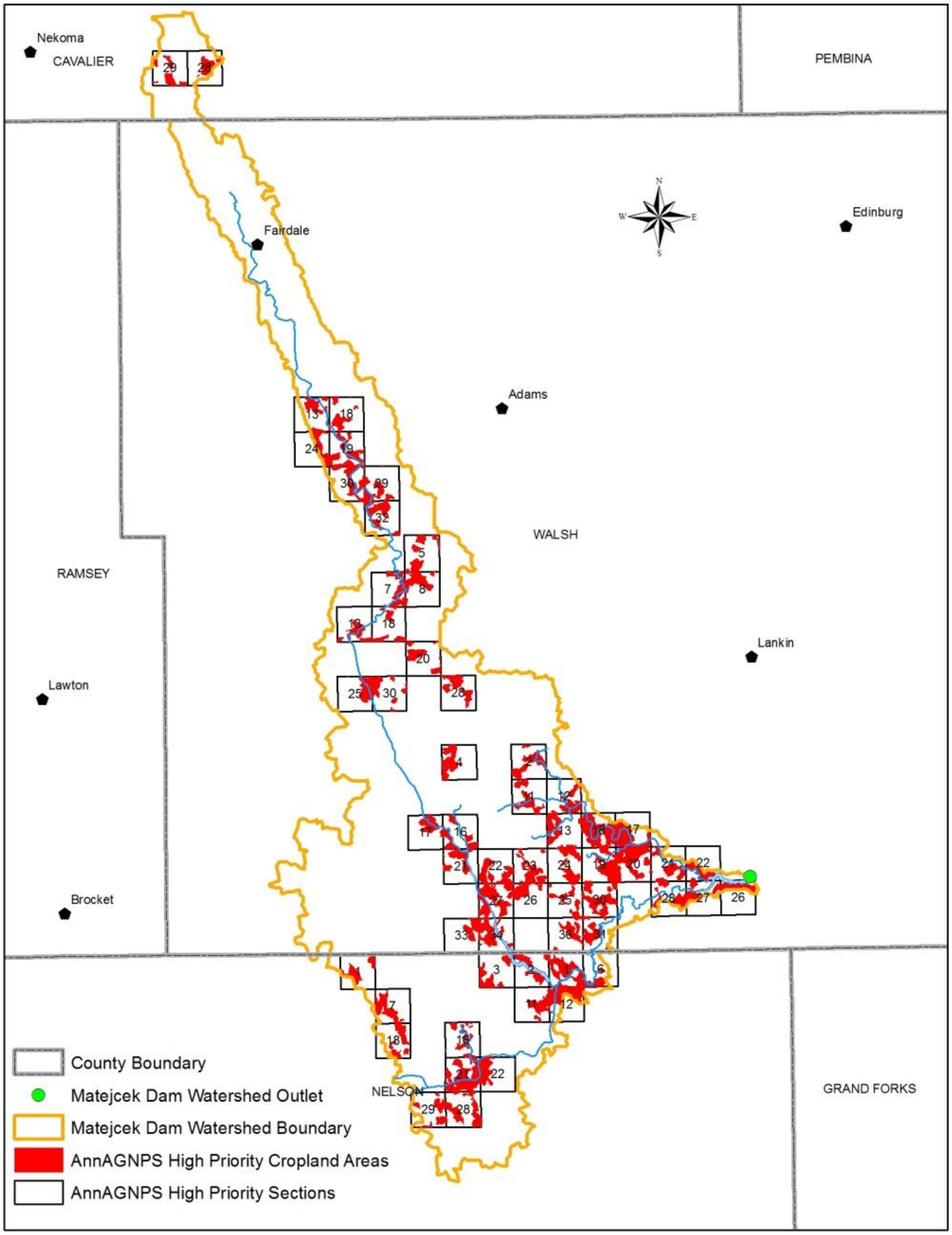

Figure 12. AnnAGNPS Modeled High Priority Cropland in the Matejcek Dam Watershed.

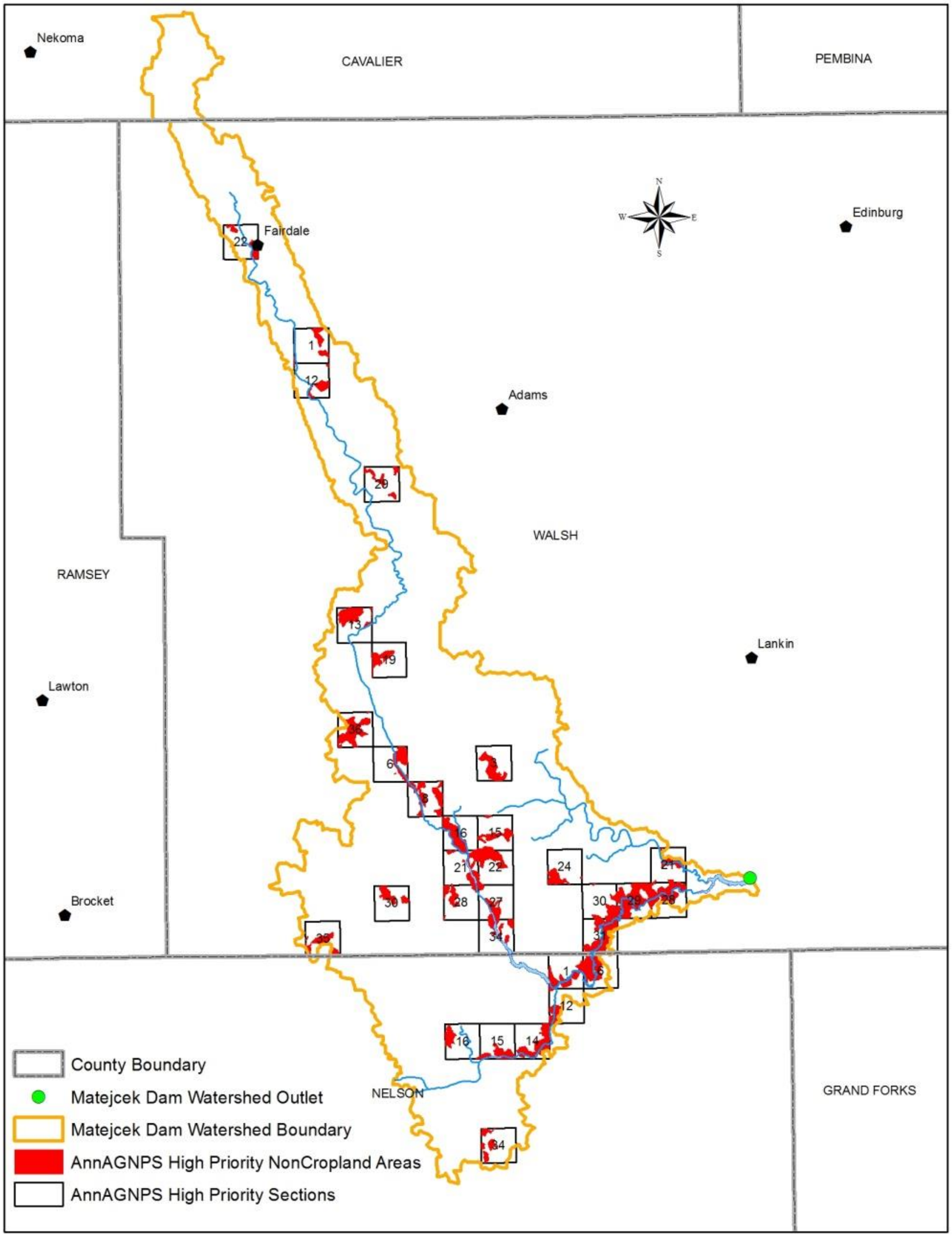

Figure 13. AnnAGNPS Modeled High Priority Non-Cropland in the Matejcek Dam Watershed.

5.4 Dissolved Oxygen

In addition to nutrients, Matejcek Dam is also listed as impaired for aquatic life use due to low dissolved oxygen concentrations (NDDoH, 2014a). Data collected during 2012 and 2013 confirms this assessment (Figure 8, Appendix A) with concentrations below the 5.0 mg/L standard throughout the entire water column.

For Matejcek Dam, and for other eutrophic lakes and reservoirs, low dissolved oxygen levels are directly related to excessive nutrient loading. The cycling of nutrients in aquatic ecosystems is largely determined by oxidation-reduction (redox) potential and the distribution of dissolved oxygen and oxygen-demanding particles (Dodds, 2002). Dissolved oxygen gas has a strong affinity for electrons, and thus influences biogeochemical cycling and the biological availability of nutrients to primary producers such as algae. High levels of nutrients can lead to eutrophication, which is defined as the undesirable growth of algae and other aquatic plants. In turn, eutrophication can lead to increased biological oxygen demand and oxygen depletion due to the respiration of microbes that decompose the dead algae and other organic material. Under ice cover, bacteria can consume more oxygen than photosynthesis can replenish under the limited light and reaeration conditions of thick ice and snow cover.

AGNPS and BATHTUB models indicate that excessive nutrient loading is responsible for the low dissolved oxygen levels in Matejcek Dam. Wetzel (1983) summarized, “The loading of organic matter to the hypolimnion and sediments of productive eutrophic lakes increases the consumption of dissolved oxygen. As a result, the oxygen content of the hypolimnion is reduced progressively during the period of summer stratification.”

Carpenter et al. (1998), has shown that nonpoint sources of phosphorous has lead to eutrophic conditions for many lake/reservoirs across the U.S. One consequence of eutrophication is oxygen depletions caused by decomposition of algae and aquatic plants. They also document that a reduction in nutrients will eventually lead to the reversal of eutrophication and attainment of designated beneficial uses. However, the rates of recovery are variable among lakes/reservoirs. This supports the NDDoH’s viewpoint that decreased nutrient loads at the watershed level will result in improved oxygen levels, the concern is that this process takes a significant amount of time (5-15 years).

In Lake Erie, heavy loadings of phosphorous have impacted the lake severely. Monitoring and research from the 1960’s has shown that depressed hypolimnetic dissolved oxygen levels were responsible for large fish kills and large mats of decaying algae. Bi-national programs to reduce nutrients into the lake have resulted in a downward trend of the oxygen depletion rate since monitoring began in the 1970’s. The trend of oxygen depletion has lagged behind that of phosphorous reduction, but this was expected
(See: http://www.epa.gov/glnpo/lakeerie/dostory.html).

Nürnberg (1995a, 1995b, 1997, 1998), developed a model that quantified duration (days) and extent of lake oxygen depletion, referred to as an anoxic factor (AF). This model showed that AF is positively correlated with average annual total phosphorous concentrations. The AF may also be used to quantify response to watershed restoration measures which makes it very useful for TMDL development. Nürnberg (1995a) developed several regression models that show nutrients control all trophic state indicators related to oxygen and phytoplankton in lakes and reservoirs. These models were developed from water quality characteristics using a suite of North American lakes. NDDoH has calculated the morphometric parameters such as surface area (A_o = 129.1 acres; 0.52 km^2), mean depth (z = 19.2 feet; 5.85 meters), and the ratio of mean depth to the surface area ($z/A_o^{0.5} = 3.35$) for Matejcek Dam which show that these parameters are within the range of lakes used by Nürnberg. Based on this information, NDDoH is confident that Nürnberg’s empirical nutrient-oxygen relationship holds true for North Dakota lakes and reservoirs. The NDDoH is also confident that prescribed BMPs will reduce external loading of nutrients to Matejcek Dam which will reduce algae blooms, thereby reducing hypolimnetic oxygen depletions rates resulting in increase oxygen levels over time.

As levels of phosphorus are reduced by the implementation of best management practices, dissolved oxygen levels will improve. This is supported by the research of Thornton, et al (1990). They state that, "…as organic deposits were exhausted, oxygen conditions improved."

6.0 MARGIN OF SAFETY AND SEASONALITY

6.1 Margin of Safety

Section 303(d) of the Clean Water Act and EPA's regulations require that "TMDLs shall be established at levels necessary to attain and maintain the applicable narrative and numerical water quality standards with seasonal variations and a margin of safety that takes into account any lack of knowledge concerning the relationship between effluent limitations and water quality." The margin of safety (MOS) can either be incorporated into conservative assumptions used to develop the TMDL (implicit) or added as a separate component of the TMDL (explicit). For the purposes of this nutrient TMDL, a MOS of 10 percent of the loading capacity will be used as an explicit MOS.

Assuming the existing phosphorus and nitrogen load to Matejcek Dam from tributary sources and internal cycling is 11,237.51 kg/yr and 47,030.10 kg/yr, respectively, and the TMDL target is the predicted average growing season chlorophyll-a concentration of 13.50 µg/L, then a "protection strategy" reduction of 10 percent in total phosphorus and nitrogen loading would result in TMDL target loading capacities of 10,102.41 kg/year for total phosphorus and 42,420.36 kg/year for total nitrogen. Based on a 10 percent explicit margin of safety (MOS), the total phosphorus MOS for the Matejcek Dam TMDL would be 1,010.24 kg and the total nitrogen MOS would be 4,242.04 kg.

Monitoring and adaptive management during the implementation phase, along with post-implementation monitoring related to the effectiveness of the TMDL controls, will be used to ensure the attainment of the targets.

6.2 Seasonality

Section 303(d)(1)(C) of the Clean Water Act and the EPA's regulations require that a TMDL be established with seasonal variations. The Matejcek Dam TMDL addresses seasonality because the BATHTUB and AnnAGNPS models incorporate seasonal differences in their prediction of annual total phosphorus and nitrogen loadings, therefore the TMDL will be protective for all seasons.

7.0 TMDL

Table 15 summarizes the nutrient TMDL for Matejcek Dam in terms of loading capacity, wasteload allocations, load allocations, and a margin of safety. The TMDL can be generically described by the following equation.

TMDL = LC = WLA + LA + MOS

where

LC loading capacity, or the greatest loading a waterbody can receive without violating water quality standards;

WLA wasteload allocation, or the portion of the TMDL allocated to existing or future point sources;

LA load allocation, or the portion of the TMDL allocated to existing or future non-point sources;

MOS margin of safety, or an accounting of the uncertainty about the relationship between pollutant loads and receiving water quality. The margin of safety can be provided implicitly through analytical assumptions or explicitly by reserving a portion of the loading capacity.

7.1 Nutrient TMDL

Based on data collected in 2012 and 2013, the existing total phosphorus and total nitrogen loads to Matejcek Dam are estimated to be 11,237.51 kg/year and 47,030.10 kg/year, respectively. Assuming a 10 percent reduction in total phosphorus and total nitrogen load will result in a predicted average growing season chlorophyll-a concentration of 13.50 µg/L and this chlorophyll-a concentration will protect and maintain Matejcek Dam's beneficial uses, the total phosphorus and total nitrogen TMDLs or loading capacities are 10,102.41 kg/year and 42,420.36 kg/year, respectively. Assuming 10 percent of the loading capacities are explicitly assigned to the MOSs and there are no point sources in the watershed, all of the remaining loading capacities are assigned to the nonpoint source load allocation (Table 15).

In November 2006 EPA issued a memorandum "Establishing TMDL "Daily" Loads in Light of the Decision by the U.S. Court of Appeals for the D.C. Circuit in Friends of the Earth, Inc. v. EPA et. al., No. 05-5015 (April 25, 2006) and Implications for NPDES Permits," which recommends that all TMDLs and associated load allocations and wasteload allocations include a daily time increment in conjunction with other appropriate temporal expressions that may be necessary to implement the relevant water quality standard. While the NDDoH believes that the appropriate temporal expression for nutrient loading to lakes and reservoirs is as an annual load, the phosphorus and nitrogen TMDLs have also been expressed as daily loads. In order to express the phosphorus and nitrogen TMDLs as daily loads, the annual total phosphorus loading capacity 10,102.41 kg/year was divided by 365 days. Based on this analysis, the phosphorus TMDL, expressed as an average daily load, is 27.68 kg/day with the load allocation equal to 24.91 kg/day and the MOS equal to 2.77 kg/day. Similarly, the total nitrogen TMDL, expressed as a daily load, is 116.22 kg/day with the load allocation equal to 104.60 kg/day and the MOS equal to 11.62 kg/day.

Table 15. Summary of the Total Phosphorus and Total Nitrogen TMDLs for Matejcek Dam.

Category	Total Phosphorus (kg/year)	Total Nitrogen (kg/year)	Explanation
Existing Load	11,237.51	47,030.10	From observed data
Loading Capacity	10,102.41	42,420.36	Total load estimated from the BATHTUB model analysis predicted to maintain an average growing season chlorophyll-a concentration of 13.50 µg/L
Wasteload Allocation	0	0	No point sources in the contributing watershed
Load Allocation	9,092.17	38,178.32	Entire loading capacity minus MOS is allocated to nonpoint sources
MOS	1,010.24	4,242.04	10% of the loading capacity (kg/year) is reserved as an explicit margin of safety

7.2 Dissolved Oxygen TMDL

As a result of the direct influence of eutrophication on increased biological oxygen demand and microbial respiration, it is expected that by attaining the phosphorus and nitrogen load reductions necessary to meet the chlorophyll-a concentration target for Matejcek Dam, the dissolved oxygen standard will be met. A 10 percent reduction in total phosphorus and total nitrogen loading to Matejcek Dam is expected to maintain or slightly lower the current algal biomass levels in the water column, thereby reducing the hypolimnetic oxygen demand exerted by the decomposition of these primary producers (see Section 5.4 for additional justification). The predicted reduction in biological oxygen demand is therefore assumed to result in compliance with the dissolved oxygen standard.

8.0 ALLOCATION

A 10 percent nutrient load reduction target was established for the Matejcek Dam watershed. This reduction was set based on the BATHTUB model, which predicted that under similar hydraulic conditions, an external nutrient load reduction of 10 percent would lower Carlson's chlorophyll-a TSI from 51.42 (equivalent to an average growing season chlorophyll-a concentration of 14.78 µg/L) to 50.72 (equivalent to an average growing season chlorophyll-a concentration of 13.50 µg/L).

Using the AnnAGNPS model, it was determined that cells with a phosphorus yield of 0.056 lbs/acre/year or greater and/or cells with a nitrogen yield of 6.79 lbs/acre/year are high priority areas in the watershed (Figure 13). These are the critical cells which should be targeted and further examined by a watershed implementation project to determine the necessity and types of BMP's to be implemented.

The TMDL in this report is a plan to improve water quality by implementing BMPs through a volunteer, incentive-based approach. This TMDL plan is put forth as a recommendation for what needs to be accomplished for Matejcek Dam and its watershed to meet and protect its beneficial uses. Water quality monitoring should continue to assess the effects of the recommendations made in this TMDL. Through adaptive management monitoring may indicate that loading capacity recommendations provided in this report may need to be adjusted to protect Matejcek Dam.

9.0 PUBLIC PARTICIPATION

To satisfy the public participation requirement of this TMDL, a hard copy of the TMDL for Matejcek Dam and a request for comment were mailed to participating agencies, partners, and to those who request a copy.

Those included in the mailing were the following:

- Walsh County Soil Conservation District;
- Walsh County Water Resource Board;
- North Dakota Game and Fish Department;
- Natural Resource Conservation Service (State Office); and
- U.S. Environmental Protection Agency, Region VIII.

In addition to notifying specific agencies of this draft TMDL report's availability, the TMDL was be posted on the North Dakota Department of Health, Division of Water Quality web site at http://www.ndhealth.gov/WQ/SW/Z2_TMDL/TMDLs_Under_PublicComment/B_Under_Public_Comment.htm. A 30 day public notice soliciting comment and participation was also published in the Walsh County Record and the Grand Forks Herald.

10.0 MONITORING

To insure that the BMPs implemented as a part of any watershed restoration plan will reduce nutrient levels, water quality monitoring will be conducted in accordance with an approved QAPP.

Specifically, monitoring will be conducted for all variables that are currently causing impairments to the beneficial uses of the waterbody. Once a watershed restoration plan (e.g., 319 PIP) is implemented, monitoring will be conducted in the lake/reservoir beginning two years after implementation and extending five years after the implementation project is complete.

11.0 TMDL IMPLEMENTATION STRATEGY

Implementation of TMDLs is dependent upon the availability of Section 319 NPS funds or other watershed restoration programs (e.g., USDA EQIP), as well as securing a local project sponsor and the required matching funds. Provided these three requirements are in place, a project implementation plan (PIP) is developed in accordance with the TMDL and submitted to the North Dakota Nonpoint Source Pollution Task Force and US EPA for approval. The implementation of the best management practices contained in the NPS PIP is voluntary. Therefore, success of any TMDL implementation project is ultimately dependent on the ability of the local project sponsor to find cooperating producers.

Monitoring is an important and required component of any PIP. As a part of the PIP, data are collected to monitor and track the effects of BMP implementation as well as to judge overall project success. QAPPs detail the strategy of how, when and where monitoring will be conducted to gather the data needed to document the TMDL implementation goal(s). As data are gathered and analyzed, watershed restoration tasks are adapted to place BMPs where they will have the greatest benefit to water quality.

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Appendix A
Matejcek Dam Deepest Site (381270) Dissolved Oxygen and Temperature Data

Matejcek Dam Deepest Lake Site 381270 – Dissolved Oxygen

DATE_COLL	TIME_COLL	Parameter	Res_Value	Units
31-Jan-12	14:00	Dissolved oxygen (DO)	10.92	mg/l
31-Jul-12	14:10	Dissolved oxygen (DO)	6.75	mg/l
31-Jan-12	14:20	Dissolved oxygen (DO)	0.21	mg/l
28-Feb-12	14:15	Dissolved oxygen (DO)	8.94	mg/l
28-Feb-12	14:20	Dissolved oxygen (DO)	3.81	mg/l
28-Feb-12	14:25	Dissolved oxygen (DO)	0.24	mg/l
20-Apr-12	15:20	Dissolved oxygen (DO)	13.08	mg/l
20-Apr-12	15:30	Dissolved oxygen (DO)	12.23	mg/l
20-Apr-12	15:35	Dissolved oxygen (DO)	11.97	mg/l
20-Apr-12	15:40	Dissolved oxygen (DO)	12.7	mg/l
23-May-12	11:30	Dissolved oxygen (DO)	8.75	mg/l
23-May-12	13:00	Dissolved oxygen (DO)	8.77	mg/l
23-May-12	13:15	Dissolved oxygen (DO)	8.68	mg/l
23-May-12	13:25	Dissolved oxygen (DO)	4.85	mg/l
12-Jun-12	11:15	Dissolved oxygen (DO)	6.52	mg/l
12-Jun-12	13:30	Dissolved oxygen (DO)	6.5	mg/l
12-Jun-12	13:30	Dissolved oxygen (DO)	3.84	mg/l
12-Jun-12	13:30	Dissolved oxygen (DO)	3.84	mg/l
29-Jun-12	13:15	Dissolved oxygen (DO)	7.27	mg/l
29-Jun-12	13:20	Dissolved oxygen (DO)	7.48	mg/l
29-Jun-12	13:30	Dissolved oxygen (DO)	2.73	mg/l
29-Jun-12	13:40	Dissolved oxygen (DO)	0.07	mg/l
05-Jul-12	10:15	Dissolved oxygen (DO)	8.46	mg/l
05-Jul-12	10:30	Dissolved oxygen (DO)	1.88	mg/l
05-Jul-12	11:00	Dissolved oxygen (DO)	0.07	mg/l
05-Jul-12	10:35	Dissolved oxygen (DO)	8.36	mg/l
31-Jul-12	09:30	Dissolved oxygen (DO)	6.6	mg/l
31-Jul-12	10:15	Dissolved oxygen (DO)	6.6	mg/l
31-Jul-12	10:30	Dissolved oxygen (DO)	0.08	mg/l
31-Jul-12	10:45	Dissolved oxygen (DO)	0.04	mg/l
13-Aug-12	13:45	Dissolved oxygen (DO)	5.19	mg/l
13-Aug-12	14:00	Dissolved oxygen (DO)	5.45	mg/l
13-Aug-12	14:15	Dissolved oxygen (DO)	0.08	mg/l
13-Aug-12	14:30	Dissolved oxygen (DO)	0.02	mg/l
28-Aug-12	09:12	Dissolved oxygen (DO)	4.86	mg/l
28-Aug-12	09:50	Dissolved oxygen (DO)	4.47	mg/l
28-Aug-12	10:10	Dissolved oxygen (DO)	3.53	mg/l
28-Aug-12	10:20	Dissolved oxygen (DO)	0.06	mg/l
14-Sep-12	10:15	Dissolved oxygen (DO)	3.56	mg/l
14-Sep-12	10:30	Dissolved oxygen (DO)	3.33	mg/l
14-Sep-12	10:45	Dissolved oxygen (DO)	3.02	mg/l
25-Sep-12	09:45	Dissolved oxygen (DO)	7.32	mg/l
25-Sep-12	10:00	Dissolved oxygen (DO)	7.34	mg/l
25-Sep-12	10:15	Dissolved oxygen (DO)	6.84	mg/l
16-Oct-12	13:00	Dissolved oxygen (DO)	9.48	mg/l
16-Oct-12	14:00	Dissolved oxygen (DO)	9.48	mg/l

DATE_COLL	TIME_COLL	Parameter	Res_Value	Units
16-Oct-12	14:15	Dissolved oxygen (DO)	7.87	mg/l
16-Oct-12	14:30	Dissolved oxygen (DO)	5.19	mg/l
17-Dec-12	10:30	Dissolved oxygen (DO)	8.45	mg/l
17-Dec-12	11:00	Dissolved oxygen (DO)	8.07	mg/l
17-Dec-12	11:15	Dissolved oxygen (DO)	2.23	mg/l
29-Jan-13	11:30	Dissolved oxygen (DO)	6.34	mg/l
29-Jan-13	11:45	Dissolved oxygen (DO)	5.51	mg/l
29-Jan-13	12:00	Dissolved oxygen (DO)	0.22	mg/l
25-Feb-13	11:00	Dissolved oxygen (DO)	2.27	mg/l
25-Feb-13	11:15	Dissolved oxygen (DO)	1.45	mg/l
25-Feb-13	11:30	Dissolved oxygen (DO)	0.23	mg/l
13-Mar-13	11:00	Dissolved oxygen (DO)	1.39	mg/l
13-Mar-13	11:15	Dissolved oxygen (DO)	0.64	mg/l
13-Mar-13	11:45	Dissolved oxygen (DO)	0.14	mg/l
01-Apr-13	11:30	Dissolved oxygen (DO)	0.53	mg/l
01-Apr-13	11:45	Dissolved oxygen (DO)	0.35	mg/l
01-Apr-13	12:00	Dissolved oxygen (DO)	0.27	mg/l
16-Jun-13	14:45	Dissolved oxygen (DO)	8.59	mg/l
16-Jun-13	12:30	Dissolved oxygen (DO)	8.79	mg/l
16-Jun-13	14:00	Dissolved oxygen (DO)	5.98	mg/l
16-Jun-13	14:30	Dissolved oxygen (DO)	0.24	mg/l
25-Jun-13	13:00	Dissolved oxygen (DO)	8.07	mg/l
25-Jun-13	13:15	Dissolved oxygen (DO)	0.47	mg/l
22-Jun-13	13:30	Dissolved oxygen (DO)	0.23	mg/l
14-Aug-13	13:00	Dissolved oxygen (DO)	9.27	mg/l
14-Aug-13	13:30	Dissolved oxygen (DO)	9.35	mg/l
14-Aug-13	14:00	Dissolved oxygen (DO)	0.17	mg/l
14-Aug-13	14:30	Dissolved oxygen (DO)	0.14	mg/l
28-Aug-13	09:00	Dissolved oxygen (DO)	5.22	mg/l
28-Aug-13	10:00	Dissolved oxygen (DO)	5.88	mg/l
28-Aug-13	10:30	Dissolved oxygen (DO)	0.17	mg/l
28-Aug-13	11:00	Dissolved oxygen (DO)	0.14	mg/l
13-Sep-13	09:30	Dissolved oxygen (DO)	8.12	mg/l
13-Sep-13	10:30	Dissolved oxygen (DO)	8.21	mg/l
13-Sep-13	11:00	Dissolved oxygen (DO)	1.75	mg/l
13-Sep-13	11:30	Dissolved oxygen (DO)	0.14	mg/l
25-Sep-13	09:30	Dissolved oxygen (DO)	11.06	mg/l
25-Sep-13	10:00	Dissolved oxygen (DO)	11.28	mg/l
25-Sep-13	10:30	Dissolved oxygen (DO)	4.05	mg/l
25-Sep-13	11:00	Dissolved oxygen (DO)	0.18	mg/l

Matejcek Dam Deepest Lake Site 381270 – Temperature

DATE_COLL	TIME_COLL	DEPTH	Parameter	Res_Value	Units
31-Jan-12	14:00	1	Temperature, water	1.9	deg C
31-Jul-12	14:10	6	Temperature, water	2.2	deg C
31-Jan-12	14:20	10	Temperature, water	2.8	deg C
28-Feb-12	14:15	1	Temperature, water	1.4	deg C
28-Feb-12	14:20	7	Temperature, water	2.4	deg C
28-Feb-12	14:25	10	Temperature, water	2.8	deg C
20-Apr-12	15:20	1	Temperature, water	7.8	deg C
20-Apr-12	15:30	6	Temperature, water	7.2	deg C
20-Apr-12	15:35	11	Temperature, water	7.1	deg C
20-Apr-12	15:40	0.923	Temperature, water	7.5	deg C
23-May-12	11:30	0.923	Temperature, water	16.7	deg C
23-May-12	13:00	1	Temperature, water	16.7	deg C
23-May-12	13:15	5	Temperature, water	16.6	deg C
23-May-12	13:25	8	Temperature, water	13.3	deg C
12-Jun-12	11:15	0.923	Temperature, water	18.3	deg C
12-Jun-12	13:30	1	Temperature, water	18.4	deg C
12-Jun-12	13:30	7	Temperature, water	15.7	deg C
12-Jun-12	13:30	7	Temperature, water	15.7	deg C
29-Jun-12	13:15	0.923	Temperature, water	22.3	deg C
29-Jun-12	13:20	1	Temperature, water	22.8	deg C
29-Jun-12	13:30	5	Temperature, water	18.7	deg C
29-Jun-12	13:40	10	Temperature, water	13.3	deg C
05-Jul-12	10:15	1	Temperature, water	24.5	deg C
05-Jul-12	10:30	5	Temperature, water	20.1	deg C
05-Jul-12	11:00	10	Temperature, water	13.5	deg C
05-Jul-12	10:35	0.923	Temperature, water	24.5	deg C
31-Jul-12	09:30	0.923	Temperature, water	25.3	deg C
31-Jul-12	10:15	1	Temperature, water	25.3	deg C
31-Jul-12	10:30	6	Temperature, water	20.1	deg C
31-Jul-12	10:45	10	Temperature, water	13.2	deg C
13-Aug-12	13:45	0.923	Temperature, water	22.2	deg C
13-Aug-12	14:00	1	Temperature, water	23	deg C
13-Aug-12	14:15	7	Temperature, water	18.4	deg C
13-Aug-12	14:30	11	Temperature, water	13	deg C
28-Aug-12	09:12	0.923	Temperature, water	20.5	deg C
28-Aug-12	09:50	1	Temperature, water	20.8	deg C
28-Aug-12	10:10	5	Temperature, water	20.1	deg C
28-Aug-12	10:20	9	Temperature, water	15.6	deg C
14-Sep-12	10:15	1	Temperature, water	16.8	deg C
14-Sep-12	10:30	5	Temperature, water	16.7	deg C
14-Sep-12	10:45	10	Temperature, water	16.6	deg C
25-Sep-12	09:45	1	Temperature, water	13.1	deg C
25-Sep-12	10:00	5	Temperature, water	13	deg C
25-Sep-12	10:15	10	Temperature, water	12.7	deg C
16-Oct-12	13:00	2	Temperature, water	9	deg C
16-Oct-12	14:00	1	Temperature, water	9	deg C

DATE_COLL	TIME_COLL	DEPTH	Parameter	Res_Value	Units
16-Oct-12	14:15	5	Temperature, water	8.2	deg C
16-Oct-12	14:30	10	Temperature, water	7.5	deg C
17-Dec-12	10:30	1	Temperature, water	1.6	deg C
17-Dec-12	11:00	5	Temperature, water	1.5	deg C
17-Dec-12	11:15	10	Temperature, water	2.6	deg C
29-Jan-13	11:30	1	Temperature, water	1.1	deg C
29-Jan-13	11:45	5	Temperature, water	1.3	deg C
29-Jan-13	12:00	10	Temperature, water	3.3	deg C
25-Feb-13	11:00	1	Temperature, water	0.8	deg C
25-Feb-13	11:15	5	Temperature, water	1.5	deg C
25-Feb-13	11:30	10	Temperature, water	2.8	deg C
13-Mar-13	11:00	1	Temperature, water	1.1	deg C
13-Mar-13	11:15	5	Temperature, water	1.9	deg C
13-Mar-13	11:45	10	Temperature, water	3.4	deg C
01-Apr-13	11:30	1	Temperature, water	1.1	deg C
01-Apr-13	11:45	5	Temperature, water	2	deg C
01-Apr-13	12:00	10	Temperature, water	3.2	deg C
16-Jun-13	14:45	0.923	Temperature, water	18.5	deg C
16-Jun-13	12:30		Temperature, water	18.8	deg C
16-Jun-13	14:00		Temperature, water	12.7	deg C
16-Jun-13	14:30	13	Temperature, water	2.8	deg C
25-Jun-13	13:00	1	Temperature, water	20.7	deg C
25-Jun-13	13:15	5	Temperature, water	5.7	deg C
22-Jun-13	13:30	10	Temperature, water	2.7	deg C
24-Jul-13	13:30	1	Temperature, water	22.1	deg C
24-Jul-13	13:45	6	Temperature, water	6.8	deg C
24-Jul-13	14:00	10	Temperature, water	3.2	deg C
24-Jul-13	13:15	2	Temperature, water	22.1	deg C
31-Jul-13	12:00	0.923	Temperature, water	20.8	deg C
31-Jul-13	12:30	1	Temperature, water	20.8	deg C
31-Jul-13	13:00	5	Temperature, water	15.6	deg C
31-Jul-13	13:30	10	Temperature, water	3.3	deg C
14-Aug-13	13:00	0.923	Temperature, water	20.6	deg C
14-Aug-13	13:30	1	Temperature, water	21.1	deg C
14-Aug-13	14:00	5	Temperature, water	13.1	deg C
14-Aug-13	14:30	10	Temperature, water	3.4	deg C
28-Aug-13	09:00	0.923	Temperature, water	23.2	deg C
28-Aug-13	10:00	1	Temperature, water	23.4	deg C
28-Aug-13	10:30	5	Temperature, water	13.4	deg C
28-Aug-13	11:00	10	Temperature, water	3.2	deg C
13-Sep-13	09:30	0.923	Temperature, water	19.7	deg C
13-Sep-13	10:30	1	Temperature, water	19.8	deg C
13-Sep-13	11:00	5	Temperature, water	17.5	deg C
13-Sep-13	11:30	10	Temperature, water	4.1	deg C
25-Sep-13	09:30	0.923	Temperature, water	16.8	deg C
25-Sep-13	10:00	1	Temperature, water	16.9	deg C
25-Sep-13	10:30	5	Temperature, water	14.9	deg C
25-Sep-13	11:00	10	Temperature, water	5.6	deg C

Appendix B
Matejcek Dam Deepest Site (381270) Nutrient, Chlorophyll-*a*, and Secchi Data

Matejcek Dam Deepest Site Data

STORET_NUM	DATE_COLL	Phosphorus	T Nitrogen	TKN	NO3/NO4	Chlorophyll-*a*	Secchi
381270	20-Apr-12	0.282	1.900	1.870	0.015	12.90	2.2
381270	23-May-12	0.332	2.460	2.423	0.032	0.75	1.4
381270	12-Jun-12	0.476	2.707	2.647	0.055	0.75	2.6
381270	29-Jun-12	0.732	3.860	3.670	0.185	5.07	2.4
381270	05-Jul-12	0.537	2.703	2.623	0.070	26.00	1.3
381270	31-Jul-12	0.639	3.233	3.165	0.060	3.10	0.8
381270	13-Aug-12	0.709	3.540	3.390	0.145	6.23	1.6
381270	28-Aug-12	0.629	3.120	3.073	0.037	50.20	0.9
381270	14-Sep-12	0.473	2.597	2.567	0.015	24.10	1
381270	25-Sep-12	0.461	2.647	2.617	0.015	21.40	1.2
381270	16-Oct-12	0.452	2.673	2.613	0.060	20.30	1.2
381270	01-Apr-13	0.537	3.670	3.143	0.527		
381270	16-Jun-13	0.504	2.463	2.150	0.308	11.20	1.7
381270	24-Jul-13	0.479	2.367	2.033	0.328	18.00	2.6
381270	31-Jul-13	0.584	2.610	2.467	0.143	28.00	0.5
381270	14-Aug-13	0.587	2.510	2.465	0.038	15.50	0.7
381270	28-Aug-13	0.573	2.480	2.430	0.040	0.75	2.7
381270	13-Sep-13					3.29	2.5
381270	25-Sep-13					18.50	0.6

Appendix C
BATHTUB Analysis for Matejcek Dam

Matejcek Dam

Overall Water Balance						Averaging Period =	2.00	years
				Area	Flow	Variance	CV	Runoff
Trb	Type	Seg	Name	km^2	hm^3/yr	$(hm3/yr)^2$	-	m/yr
1	1	1	Inlet	93.3	6.4	0.00E+00	0.00	0.07
3	4	1	Outlet	111.6	7.6	0.00E+00	0.00	0.07
4	1	1	Ungauged Inflow	18.3	1.3	0.00E+00	0.00	0.07
PRECIPITATION				0.5	0.1	0.00E+00	0.00	0.20
TRIBUTARY INFLOW				111.6	7.6	0.00E+00	0.00	0.07
***TOTAL INFLOW				112.1	7.7	0.00E+00	0.00	0.07
GAUGED OUTFLOW				111.6	7.6	0.00E+00	0.00	0.07
ADVECTIVE OUTFLOW				0.5	0.1	0.00E+00	0.00	0.19
***TOTAL OUTFLOW				112.1	7.7	0.00E+00	0.00	0.07
***EVAPORATION					0.0	0.00E+00	0.00	

Overall Mass Balance Based Upon				Observed		Outflow & Reservoir Concentrations				
Component:				TOTAL P						
				Load		Load Variance			Conc	Export
Trb	Type	Seg	Name	kg/yr	%Total	$(kg/yr)^2$	%Total	CV	mg/m^3	$kg/km^2/yr$
1	1	1	Inlet	573.3	78.1%	0.00E+00		0.00	90.0	6.1
2	4	1	Outlet	861.1		1.50E+05		0.45	113.0	7.7
3	1	1	Ungauged Inflow	144.4	19.7%	0.00E+00		0.00	115.5	7.9
PRECIPITATION				16.1	2.2%	6.49E+01	100.0%	0.50	152.4	30.0
TRIBUTARY INFLOW				717.7	97.8%	0.00E+00		0.00	94.2	6.4
***TOTAL INFLOW				733.8	100.0%	6.49E+01	100.0%	0.01	95.0	6.5
GAUGED OUTFLOW				861.1	117.3%	0.00E+00		0.00	113.0	7.7
ADVECTIVE OUTFLOW				11.8	1.6%	0.00E+00		0.00	113.0	22.0
***TOTAL OUTFLOW				872.9	119.0%	0.00E+00		0.00	113.0	7.8
***RETENTION				-139.1		6.49E+01		0.06		

Overflow Rate (m/yr)	14.4	Nutrient Resid. Time (yrs)	0.1133
Hydraulic Resid. Time (yrs)	0.0952	Turnover Ratio	17.7
Reservoir Conc (mg/m3)	113	Retention Coef.	-0.190

Overall Mass Balance Based Upon				Observed		Outflow & Reservoir Concentrations				
Component:				TOTAL N						
				Load		Load Variance			Conc	Export
Trb	Type	Seg	Name	kg/yr	%Total	$(kg/yr)^2$	%Total	CV	mg/m^3	$kg/km^2/yr$
1	1	1	Inlet	10427.7	80.1%	0.00E+00		0.00	1637.0	111.8
2	4	1	Outlet	14013.2		5.95E+07		0.55	1839.0	125.6
3	1	1	Ungauged Inflow	2047.5	15.7%	0.00E+00		0.00	1638.0	111.9
PRECIPITATION				537.0	4.1%	7.21E+04	100.0%	0.50	5080.0	1000.0
TRIBUTARY INFLOW				12475.2	95.9%	0.00E+00		0.00	1637.2	111.8
***TOTAL INFLOW				13012.2	100.0%	7.21E+04	100.0%	0.02	1684.3	116.0
GAUGED OUTFLOW				14013.2	107.7%	0.00E+00		0.00	1839.0	125.6
ADVECTIVE OUTFLOW				192.3	1.5%	0.00E+00		0.00	1839.0	358.0
***TOTAL OUTFLOW				14205.4	109.2%	0.00E+00		0.00	1839.0	126.7
***RETENTION				-1193.3		7.21E+04		0.23		

Overflow Rate (m/yr)	14.4	Nutrient Resid. Time (yrs)	0.1040
Hydraulic Resid. Time (yrs)	0.0952	Turnover Ratio	19.2
Reservoir Conc (mg/m3)	1839	Retention Coef.	-0.092

Matejcek Dam

Predicted & Observed Values Ranked Against CE Model Development Dataset

Segment:	**1**	**Main Lake**				
	Predicted Values--->			**Observed Values--->**		
Variable	**Mean**	**CV**	**Rank**	**Mean**	**CV**	**Rank**
TOTAL P MG/M3	112.8	0.45	82.9%	113.0		83.0%
TOTAL N MG/M3	1839.0	0.55	82.9%	1839.0		82.9%
C.NUTRIENT MG/M3	88.0	0.35	87.0%	88.1		87.1%
CHL-A MG/M3	15.0	0.52	72.9%	14.8		71.7%
SECCHI M	0.8	0.45	33.9%	0.8		34.6%
ORGANIC N MG/M3	1624.6	0.34	99.2%	1624.0		99.2%
TP-ORTHO-P MG/M3	25.1	0.35	42.6%	25.0		42.4%
ANTILOG PC-1	970.9	0.77	85.3%	949.6		84.9%
ANTILOG PC-2	7.3	0.22	59.2%	7.2		58.6%
(N - 150) / P	15.0	0.74	42.6%	14.9		42.5%
INORGANIC N / P	2.4	5.53	0.6%	2.4		0.6%
TURBIDITY 1/M	0.9		66.7%	0.9		66.7%
ZMIX * TURBIDITY	1.2		10.9%	1.2		10.9%
ZMIX / SECCHI	1.7	0.46	4.0%	1.7		3.8%
CHL-A * SECCHI	11.8	0.28	58.2%	11.7		57.6%
CHL-A / TOTAL P	0.1	0.26	27.1%	0.1		25.6%
FREQ(CHL-a>10) %	63.5	0.49	72.9%	61.8		71.7%
FREQ(CHL-a>20) %	22.0	1.13	72.9%	20.7		71.7%
FREQ(CHL-a>30) %	7.7	1.60	72.9%	7.1		71.7%
FREQ(CHL-a>40) %	2.9	1.97	72.9%	2.6		71.7%
FREQ(CHL-a>50) %	1.2	2.26	72.9%	1.1		71.7%
FREQ(CHL-a>60) %	0.5	2.51	72.9%	0.5		71.7%
CARLSON TSI-P	72.3	0.09	82.9%	72.3		83.0%
CARLSON TSI-CHLA	57.2	0.09	72.9%	56.9		71.7%
CARLSON TSI-SEC	63.4	0.10	66.1%	63.2		65.4%

Matejcek Dam - Minus 10%

Overall Water Balance — **Averaging Period = 2.00 years**

Trb	Type	Seg	Name	Area km^2	Flow hm^3/yr	Variance (hm3/yr)^2	CV -	Runoff m/yr
1	1	1	Inlet	93.3	6.4	0.00E+00	0.00	0.07
2	4	1	Outlet	111.6	7.6	0.00E+00	0.00	0.07
3	1	1	Ungauged Inflow	18.3	1.3	0.00E+00	0.00	0.07
PRECIPITATION				0.5	0.1	0.00E+00	0.00	0.20
TRIBUTARY INFLOW				111.6	7.6	0.00E+00	0.00	0.07
***TOTAL INFLOW				112.1	7.7	0.00E+00	0.00	0.07
GAUGED OUTFLOW				111.6	7.6	0.00E+00	0.00	0.07
ADVECTIVE OUTFLOW				0.5	0.1	0.00E+00	0.00	0.19
***TOTAL OUTFLOW				112.1	7.7	0.00E+00	0.00	0.07
***EVAPORATION					0.0	0.00E+00	0.00	

Overall Mass Balance Based Upon — **Observed** — **Outflow & Reservoir Concentrations**
Component: — **TOTAL P**

Trb	Type	Seg	Name	Load kg/yr	% Total	Load Variance (kg/yr)^2	% Total	CV	Conc mg/m^3	Export kg/km^2/yr
1	1	1	Inlet	516.0	77.9%	0.00E+00		0.00	81.0	5.5
2	4	1	Outlet	861.1		1.22E+05		0.41	113.0	7.7
3	1	1	Ungauged Inflow	129.9	19.6%	0.00E+00		0.00	103.9	7.1
PRECIPITATION				16.1	2.4%	6.49E+01	100.0%	0.50	152.4	30.0
TRIBUTARY INFLOW				645.9	97.6%	0.00E+00		0.00	84.8	5.8
***TOTAL INFLOW				662.0	100.0%	6.49E+01	100.0%	0.01	85.7	5.9
GAUGED OUTFLOW				861.1	130.1%	0.00E+00		0.00	113.0	7.7
ADVECTIVE OUTFLOW				11.8	1.8%	0.00E+00		0.00	113.0	22.0
***TOTAL OUTFLOW				872.9	131.9%	0.00E+00		0.00	113.0	7.8
***RETENTION				-210.9		6.49E+01		0.04		

Overflow Rate (m/yr)	14.4	Nutrient Resid. Time (yrs)	0.1256
Hydraulic Resid. Time (yrs)	0.0952	Turnover Ratio	15.9
Reservoir Conc (mg/m3)	113	Retention Coef.	-0.319

Overall Mass Balance Based Upon — **Observed** — **Outflow & Reservoir Concentrations**
Component: — **TOTAL N**

Trb	Type	Seg	Name	Load kg/yr	% Total	Load Variance (kg/yr)^2	% Total	CV	Conc mg/m^3	Export kg/km^2/yr
1	1	1	Inlet	9384.9	79.8%	0.00E+00		0.00	1473.3	100.6
2	4	1	Outlet	14013.2		4.86E+07		0.50	1839.0	125.6
3	1	1	Ungauged Inflow	1842.8	15.7%	0.00E+00		0.00	1474.2	100.7
PRECIPITATION				537.0	4.6%	7.21E+04	100.0%	0.50	5080.0	1000.0
TRIBUTARY INFLOW				11227.7	95.4%	0.00E+00		0.00	1473.4	100.6
***TOTAL INFLOW				11764.7	100.0%	7.21E+04	100.0%	0.02	1522.8	104.9
GAUGED OUTFLOW				14013.2	119.1%	0.00E+00		0.00	1839.0	125.6
ADVECTIVE OUTFLOW				192.3	1.6%	0.00E+00		0.00	1839.0	358.0
***TOTAL OUTFLOW				14205.4	120.7%	0.00E+00		0.00	1839.0	126.7
***RETENTION				-2440.8		7.21E+04		0.11		

Overflow Rate (m/yr)	14.4	Nutrient Resid. Time (yrs)	0.1150
Hydraulic Resid. Time (yrs)	0.0952	Turnover Ratio	17.4
Reservoir Conc (mg/m3)	1839	Retention Coef.	-0.207

Matejcek Dam - Minus 10%

Predicted & Observed Values Ranked Against CE Model Development Dataset

Segment:	**1**	**Main Lake**				
	Predicted Values--->			**Observed Values--->**		
Variable	**Mean**	**CV**	**Rank**	**Mean**	**CV**	**Rank**
TOTAL P MG/M3	101.8	0.45	79.9%	113.0		83.0%
TOTAL N MG/M3	1662.7	0.55	78.6%	1839.0		82.9%
C.NUTRIENT MG/M3	79.2	0.35	84.0%	88.1		87.1%
CHL-A MG/M3	13.5	0.52	68.3%	14.8		71.7%
SECCHI M	0.9	0.45	39.0%	0.8		34.6%
ORGANIC N MG/M3	1528.6	0.32	98.9%	1624.0		99.2%
TP-ORTHO-P MG/M3	23.6	0.34	40.1%	25.0		42.4%
ANTILOG PC-1	803.5	0.76	81.8%	949.6		84.9%
ANTILOG PC-2	7.3	0.22	60.0%	7.2		58.6%
(N - 150) / P	14.9	0.75	42.2%	14.9		42.5%
INORGANIC N / P	1.7	7.91	0.2%	2.4		0.6%
TURBIDITY 1/M	0.9		66.7%	0.9		66.7%
ZMIX * TURBIDITY	1.2		10.9%	1.2		10.9%
ZMIX / SECCHI	1.6	0.46	2.7%	1.7		3.8%
CHL-A * SECCHI	11.8	0.28	58.2%	11.7		57.6%
CHL-A / TOTAL P	0.1	0.26	27.1%	0.1		25.6%
FREQ(CHL-a>10) %	57.1	0.57	68.3%	61.8		71.7%
FREQ(CHL-a>20) %	17.4	1.25	68.3%	20.7		71.7%
FREQ(CHL-a>30) %	5.5	1.73	68.3%	7.1		71.7%
FREQ(CHL-a>40) %	2.0	2.10	68.3%	2.6		71.7%
FREQ(CHL-a>50) %	0.8	2.40	68.3%	1.1		71.7%
FREQ(CHL-a>60) %	0.3	2.66	68.3%	0.5		71.7%
CARLSON TSI-P	70.8	0.09	79.9%	72.3		83.0%
CARLSON TSI-CHLA	56.2	0.09	68.3%	56.9		71.7%
CARLSON TSI-SEC	62.0	0.11	61.0%	63.2		65.4%

Appendix D
US EPA Region 8 TMDL Review and Comments

Draft Matejcek Dam Nutrient and Dissolved Oxygen TMDL
Date: June 5, 2017
Reviewer: Al Basile, EPA R8

EPA TMDL Review Elements

1. *Identification of Waterbody, Pollutant of Concern, Pollutant Sources, Priority Ranking, and Natural Background.*

Identification of Waterbody
The waterbody is identified on page 1 of the tmdl report. A more detailed description of the waterbody is also included on page 2. Impairments listed on the 303d list include dissolved oxygen, and nutrients/eutrophication/biological indicators (page 3).

Pollutant of Concern
The pollutant of concern is not clearly identified upfront in the report. However, later in the report in the modeling section it becomes clear that both N and P are the pollutants of concern. Would be helpful to identify this earlier in the report if possible. Could be a short section entitled "pollutants of concern" with just a couple sentences.

Pollutant Sources
Very little information is provided (see section 4.0), only two sentences. Some discussion of the types of nonpoint sources in the watershed should be included. Is it mostly agriculture – row crop? livestock? Rangeland? This will help the reader better understand the types of issues that need to be addressed in the watershed. It does not need to be an exhaustive write-up, but would be helpful to have more than a couple sentences.

Priority Ranking
Priority ranking is not provided in the tmdl report.

Natural Background
Discussion of natural background is not provided. Where it is possible to separate natural background from nonpoint sources, the tmdl should include a description of natural background.

2. *Description of Applicable Water Quality Standards and Numeric Water Quality Target*

State Water Quality Standard
Narrative and numeric water quality standards are provided on page 14. Numerics only cover nitrate and dissolved oxygen. A guideline for chl-a, not a standard, is proposed at 20 ug/L. Discussion is warranted at some point regarding the 20 ug/L threshold. Good rule of thumb is instantaneous chl-a of 15 ug/L is leading edge of bloom. If average chl-a is 20 ug/L, lake is under bloom conditions more than 50% of the time. Instantaneous chl-a >20 ug/L has often been characterized in the literature as a nuisance and instantaneous chl-a >30 ug/L as a severe nuisance. Maximum values would likely exceed 40 ug/L assuming an average of 20 ug/L.

Designated Uses
Designated uses are discussed on page 3 and also on page 14. Page 14 provides a bit more detail – aquatic life (class 3 fishery), recreation, irrigation, livestock watering, and wildlife. Assuming those are all the designated uses?

Numeric Water Quality Target

The numeric water quality target was set at the existing condition for chl-a. Median from ambient monitoring data is 14.78 ug/L. Target was set a bit lower at the predicted chl-a of 13.5 ug/L, assuming a 10% reduction in existing loading. Modeling was done using BATHTUB (walker, 1996).

For dissolved oxygen, there is a theoretical discussion in Section 5.4 with respect to how reductions in nutrient loading (mostly P) should improve dissolved oxygen, but no real link to ensure that average chl-a of 13.5 ug/L will get you there. Would be helpful to have better justification, as algal biomass will only decrease about 1 ug/L from existing conditions. This is a tough one and in many cases will be based upon best professional judgment. Rationale in this case is weak as 1 ug/L reduction in chl-a is not much.

Also, when discussing the water quality target, it is mentioned in text on page 15 that "mesotrophic lakes do not experience algal blooms, while eutrophic lakes may occasionally experience algal blooms." This language is not quite accurate as mesotrophic lakes do periodically experience algal blooms but at much lower frequencies than eutrophic lakes. And of course magnitudes are much less in mesotrophic lakes as well.

Antidegradation Policy

Not provided in TMDL report. When we are conducting our review and approval of any tmdl, we are looking to see if a short summary of the states antidegradation policy is provided. This can be as short as a few sentences, but it is one of the items on our checklist for approving a tmdl.

3. Loading Capacity – Linking Water Quality and Pollutant Sources

Loading Capacity

Loading capacity is presented on page 21: TP=10,102 kg/yr and TN=42,420 kg/yr. The loading capacity was converted to a daily load on page 28: TP=27.68 kg/day and TN=116.22 kg/day. Also see Table 15.

Linking Pollutant Load to Numeric Target

The loading capacity was set at 27 kg/day TP and 116 kg/day TN to meet the numeric water quality target of 13.5 ug/L chl-a. The BATHTUB water quality model was used to link pollutant loading to the numeric water quality target.

Supporting Documentation for the TMDL Analysis

Appendices are provided with supporting documentation including water quality data and modeling results.

Critical Conditions

Not clearly identified in the TMDL report. However, critical conditions occur during summertime when the frequency and magnitude of nuisance algal blooms are greatest. Loading capacity was set to achieve standards during this critical time period. Again, uncertain if dissolved oxygen criteria will be attained.

4. Load Allocations (LA)

The LA is presented in Table 15. Entire loading capacity minus MOS is allocated to nonpoint sources.

5. Wasteload Allocation (WLA)

The WLA is presented in Table 15. The WLA was set at 0 as no point sources in the watershed.

6. Margin of Safety (MOS)

The MOS is presented in Table 15. Ten percent of the loading capacity is reserved as an explicit MOS.

7. Seasonal Variation

Seasonal variation is discussed in section 6.2. Not sure the language provided addresses the intent of seasonal variation. Primary intent is to ensure that the TMDL is adequate to ensure that water quality standards will be met during all seasons. So, a simple statement clarifying that seasonal variation has been addressed and that the TMDL will be protective during all seasons.

8. Reasonable Assurance

There are no point sources in this watershed, so reasonable assurance is not needed.

9. Monitoring Plan to Track TMDL Effectiveness

A simple statement acknowledging that monitoring will be conducted beginning two years after implementation is presented in Section 10.

10. Implementation

A short discussion on implementation is provided in section 11.

11. Public Participation

Presently out for public comment.

12. Submittal Letter

Expected with final submittal.

<u>Summary of Outstanding Issues</u>

1. Would be helpful if the pollutants of concern were identified upfront in the report. Had to get to the modeling section to identify that N and P were the pollutants of concern. Could be a short section entitled “pollutants of concern.”
2. Very little information is provided on pollutant sources, only two sentences (see section 4.0). Some discussion of the types of nonpoint sources in the watershed should be included. Is it mostly agriculture – row crop? livestock? Rangeland? This will help the reader better understand the types of issues that need to be addressed in the watershed. It does not need to be an exhaustive write-up, but would be helpful to have more than a couple sentences.
3. Priority Ranking is not provided in the TMDL report.

4. Discussion of natural background is not provided. Where it is possible to separate natural background from nonpoint sources, the TMDL should include a description of natural background. If not possible, just a simple statement with rationale.
5. Discussion is warranted at some point regarding the 20 ug/L chl-a threshold. Good rule of thumb is instantaneous chl-a of 15 ug/L is leading edge of bloom. If average chl-a is 20 ug/L, lake is under bloom conditions more than 50% of the time. Instantaneous chl-a >20 ug/L has often been characterized in the literature as a nuisance and instantaneous chl-a >30 ug/L as a severe nuisance. Maximum values would likely exceed 40 ug/L assuming an average of 20 ug/L.
6. Please verify that all designated uses are provided on page 14.
7. For dissolved oxygen, there is a theoretical discussion in Section 5.4 with respect to how reductions in nutrient loading (mostly P) should improve dissolved oxygen, but no real link to ensure that average chl-a of 13.5 ug/L will get you there. Would be helpful to have better justification, as algal biomass will only decrease about 1 ug/L from existing conditions. This is a tough one and in many cases will be based upon best professional judgment. However, rationale in this case is weak as 1 ug/L reduction in chl-a is not much.
8. When discussing the water quality target, it is mentioned in text on page 15 that "mesotrophic lakes do not experience algal blooms, while eutrophic lakes may occasionally experience algal blooms." This language is not quite accurate as mesotrophic lakes do periodically experience algal blooms but at much lower frequencies than eutrophic lakes. And of course magnitudes are much less in mesotrophic lakes as well.
9. The states Antidegradation Policy is not provided in the TMDL report. When we are conducting our review and approval of any tmdl, we are looking to see if a short summary of the states antidegradation policy is provided. This can be as short as a few sentences.
10. Critical Conditions are not clearly identified in the TMDL report. Again, just a couple sentences acknowledging that critical conditions occur during the summer season when the frequency and magnitude of nuisance algal blooms are greatest.
11. Although Seasonal Variation is provided in the TMDL report in section 6.2, not sure the language provided addresses the intent of seasonal variation. Primary intent is to ensure that the TMDL is adequate to ensure that water quality standards will be met during all seasons. So, just need a simple statement clarifying that seasonal variation has been addressed and that the TMDL will be protective during all seasons.

Appendix E
NDDoH Response to Comments

1) Language added to Section 1.1.

2) Language referring to Landuse added to Section 1.3.

3) Added the word "TMDL" to Table 2.

4) No specific data or information is available on the nutrient contribution from "Natural Background" in the Matejcek Dam watershed. Additional wording was added to Section 4.0.

5) The 20 ug/L criteria stated in our State water quality standards as a guideline for use as a goal in any lake or reservoir improvement or maintenance program. Justification is found in the document *Development of Nutrient Criteria for Lakes and Reservoirs for North Dakota in Region 8.*

6) Designated uses were clarified in Section 2.2.

7) The justification describing the DO and nutrient reduction relationship provided in Section 5.4 was discussed previously with EPA Region 8 and agreed to by the State and the Region.

8) Language in Section 3.1 was modified to clarify the differences between mesotrophic and eutrophic lakes.

9) Antidegradation language is still being developed by the TMDL program, therefore there is state antidegradation policy is not referenced in the TMDL.

10) The critical condition is the in-lake growing season average (April-November). A sentence was added to Section 3.1 that clarifies critical condition.

11) Language was added to Section 6.2 to reflect the use models in the development of this TMDL to account for seasonal variation.