Nutrient, Sediment, and Dissolved Oxygen TMDLs for Indian Creek Dam in Hettinger County, North Dakota

Final: November 2006

Prepared for:
USEPA Region 8
999 18th Street
Suite 300
Denver, CO 80202

Prepared by:
Paul L. Keeney and Michael J. Hargiss
Environmental Scientists
North Dakota Department of Health
Division of Water Quality
Gold Seal Center, 4th Floor
918 East Divide Avenue
Bismarck, ND 58501-1947

North Dakota Department of Health
Division of Water Quality

Nutrient, Sediment, and Dissolved Oxygen TMDLs for Indian Creek Dam in Hettinger County, North Dakota

John Hoeven, Governor
Terry Dwelle, M.D., State Health Officer

North Dakota Department of Health
Division of Water Quality
Gold Seal Center, 4th Floor
918 East Divide Avenue
Bismarck, ND 58501-1947

701.328.5210

Table of Contents

1.0 INTRODUCTION AND DESCRIPTION OF THE WATERSHED 1
1.1 Clean Water Act Section 303 (d) Listing Information 3
1.2 Topography 3
1.3 Land Use/Land Cover 4
1.4 Climate and Precipitation 5
1.5 Available Water Quality Data 7
1.5.1 1991-1992 Lake Water Quality Assessment Project 7
1.5.2 2001-2002 Indian Creek TMDL Project 7

2.0 WATER QUALITY STANDARDS 12
2.1 Narrative Water Quality Standards 13
2.2 Numeric Water Quality Standards 13

3.0 TMDL TARGETS 14
3.1 Nutrient Target 14
3.2 Dissolved Oxygen Target 15

4.0 SIGNIFICANT SOURCES 15

5.0 TECHNICAL ANALYSIS 16
5.1 Tributary Load Analysis 16
5.2 BATHTUB Trophic Response Model 16
5.3 AnnAGNPS Watershed Model 19
5.4 Dissolved Oxygen 22
5.5 Sediment 23

6.0 MARGIN OF SAFETY AND SEASONALITY 25
6.1 Margin of Safety 25
6.2 Seasonality 25

7.0 TMDL 25
7.1 Nutrient TMDL 26
7.2 Sediment TMDL 26
7.3 Dissolved Oxygen TMDL 26

8.0 ALLOCATION 26

9.0 PUBLIC PARTICIPATION 27

10.0 MONITORING 28

11.0 TMDL IMPLEMENTATION STRATEGY 28

12.0 ENDANGERED SPECIES ACT COMPLIANCE 29

13.0 REFERENCES 31

List of Figures

1. North Dakota Game and Fish Contour Map of Indian Creek Dam 2

2. Aerial Depiction of Indian Creek Dam and Watershed 4

3. Land Use Data Coverage for Indian Creek Dam 5

4. Average Maximum Monthly Temperature From 1983-2004 at the North Dakota Agriculture Weather Network (NDAWN), Mott, ND Weather Station 6

5. Average Monthly Precipitation From 1983-2004 at the North Dakota Agriculture Weather Network (NDAWN), Mott, ND Weather Station 6

6. Indian Creek Dam Inlet and Outlet Sampling Locations 8

7. Summary of Temperature Data for Indian Creek Dam's Deepest Area Site (380765) 10

8. Summary of Dissolved Oxygen Concentrations for Indian Creek Dam's Deepest Area Site (380765) 10

9. Summary of Temperature Data for Indian Creek Dam's Deepest Area Site (380765) 11

10. Summary of Dissolved Oxygen Profiles for Indian Creek Dam's Deepest Area Site (380765) 11

11. Predicted Trophic Response to Phosphorus Loads of Indian Creek Dam showing observed score and a 25, 50, and 75 Percent Load Reduction 18

12. AnnAGNPS Identification of Critical Areas for BMP Implementation 27

13. Office Transmittal Received from US Fish & Wildlife Service 29

14. Threatened and Endangered Species List and Designated Critical Habitat 30

List of Tables

1. General Characteristics of Indian Creek Dam and its Watershed 1

2. Indian Creek Dam Section 303(d) Listing Information 3

3. Indian Creek Dam Sampling and Analysis Variables 7

4. Data Summary for Indian Creek Dam TMDL Project 2001-2004 9

5. Nutrient Concentration Comparisons at Indian Creek Dam 9

6. Average Monthly Secchi Depths in Indian Creek Dam 2001-2004 12

7. Average Total Suspended Solid Concentrations for the Indian Creek Dam Inlet and Outlet Sites (2002-2004) 12

8. Numeric Standards Applicable for North Dakota Lakes and Reservoirs 14

9. Carlson's Trophic State Indices for Indian Creek Dam 15

10. Observed and Predicted Values for Selected Trophic Response Variables Assuming 25, 50, and 75 Percent Reductions in External Phosphorus and Nitrogen Loading 18

11. Water Volume and Nutrient Concentrations at Outlet from 2001-2003 21

12. AnnAGNPS Estimated Sediment Intake for Indian Creek Dam (2001-2003) 23

13. Summary of the Phosphorus TMDL for Indian Creek Dam 26

Appendices

A. A Calibrated Trophic Response Model (BATHTUB) for Indian Creek Dam as a Tool to Calibrate Various Nutrient Reduction Alternatives

B. Annualized Agricultural Nonpoint Source Model Data (AnnAGNPS)

C. Dissolved Oxygen and Temperature Data

D. EPA Formal Comments

E. United States Fish and Wildlife Service Formal Comments

F. Department Response to all Comments

1.0 INTRODUCTION AND DESCRIPTION OF THE WATERSHED

Indian Creek Dam is a small reservoir on Indian Creek, a tributary to the Cannonball River, and is located in Hettinger County, North Dakota (Figure 1). Completed in 1978, Indian Creek Dam was constructed for the purpose of anticipated high nutrient and sediment runoff from the contributing watershed. To help alleviate the negative water quality impacts, an automatic hypolimnion drawdown was installed, and repairs were made to two small dams on the southwest and western drainages to act as sediment retention ponds.

The Indian Creek watershed is a 10,733-acre watershed located in the Cannonball Drainage of south central Hettinger County (Figure 1). The watershed of Indian Creek Dam lies completely within the Northwestern Great Plains ecoregion (43a); which is characterized by a semiarid rolling plain of shale, siltstone, and sandstone with occasional buttes and badlands. The topography of this ecoregion was largely unaffected by glaciation and retains its original soils and complex stream drainage pattern. Native grasslands persist in areas of steep or broken topography but have been largely replaced by spring wheat and alfalfa over most of the ecoregion. However, agriculture is often hindered by erratic precipitation patterns and limited opportunities for irrigation. Table 1 summarizes some of the geographical, hydrological, and physical characteristics of Indian Creek Dam and its watershed.

Table 1. General Characteristics of Indian Creek Dam and its Watershed.

Legal Name	Indian Creek Dam
Major Drainage Basin	Lower Missouri River Basin
Nearest Municipality	Regent, North Dakota
Assessment Unit ID	ND-10130204-006-L_00
County Location	Hettinger County, North Dakota
Physiographic Region	Missouri Plateau
Latitude	46.33362
Longitude	-102.63505
Surface Area	196.3- acres
Watershed Area	10,733- acres
Average Depth	12.3- feet
Maximum Depth	32- feet
Volume	2,432.2 acre-feet
Tributaries	Indian Creek, unnamed tributaries
Type of Waterbody	Constructed Reservoir
Dam Type	Constructed Earthen Dam
Fishery Type	Trout, Walleye, Northern Pike, Bluegill, and Smallmouth Bass

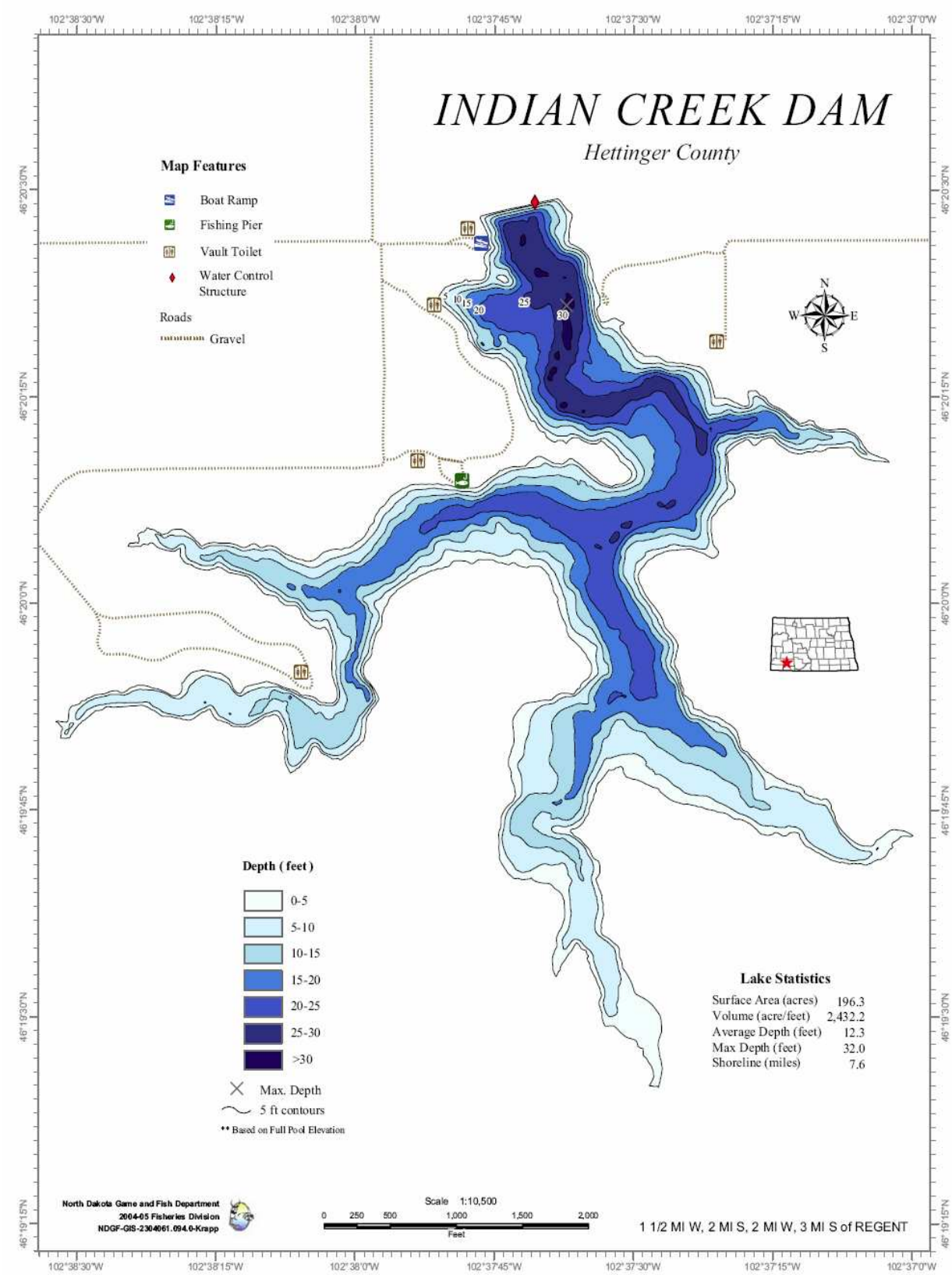


Figure 1. North Dakota Game and Fish Contour Map of Indian Creek Dam.

1.1 Clean Water Act Section 303(d) Listing Information

As part of the Clean Water Act Section 303(d) TMDL listing process for 2004, the North Dakota Department of Health has identified Indian Creek Dam as an impaired waterbody (Table 2). Based on a Trophic State Index (TSI) score, aquatic life and recreational uses of Indian Creek Dam were assessed as "fully supporting, but threatened. Aquatic life is listed as impaired due to nutrients, sedimentation, and low dissolved oxygen. Recreational use is impaired due to nutrients. North Dakota's Section 303(d) list does not provide any potential sources of these impairments. Indian Creek Dam has been classified as a Class 3 warm-water fishery. Class 3 lakes and reservoirs are "capable of supporting growth and propagation of nonsalmonid fishes and associated aquatic biota" (NDDoH, 1991).

Table 2. Indian Creek Dam Section 303(d) Listing Information (NDDoH, 2004).

Assessment Unit ID	ND-10130204-006-L_00
Waterbody Name	Indian Creek Dam
Water Quality Standard Class	3 -Warm-water fishery
Impaired Uses	Fish and Other Aquatic Biota (fully supporting but threatened), Recreation (fully supporting but threatened)
Pollutants of Concern	Nutrients, Dissolved Oxygen, Sedimentation
Priority	High
First Appeared on 303(d) list	1998

1.2 Topography

Indian Creek Dam is located in the Missouri Plateau portion of the Northwestern Great Plains ecoregion. The landscape is dominated by a mosaic of spring wheat, alfalfa, and grazing land that covers the short-grass prairie. Native grasslands still persist in steep and broken terrain. The topography of the area is composed of gently rolling to hilly uplands except near prominent buttes and badlands areas. This region also contains well defined drainages in the form of intermittent and perennial streams. Soils present in the watershed are moderately deep to shallow, a product of weathered loamy glacial till or soft bedrock. Additionally, soils are moderately fertile to fertile, well drained and susceptible to wind and water erosion. Slopes are mainly gentle with relief ranging from 300-500 feet (NDDoH, 1993). Some areas are either non-glaciated, or were glaciated so long ago as to have no glacial evidence remaining. The elevation in Hettinger County ranges from 2,590 feet MSL in the northwest to approximately 2,720 feet MSL in the southeast. Figure 2 shows an aerial photo of the Indian Creek Dam watershed and the gentle relief present in this portion of Hettinger County.

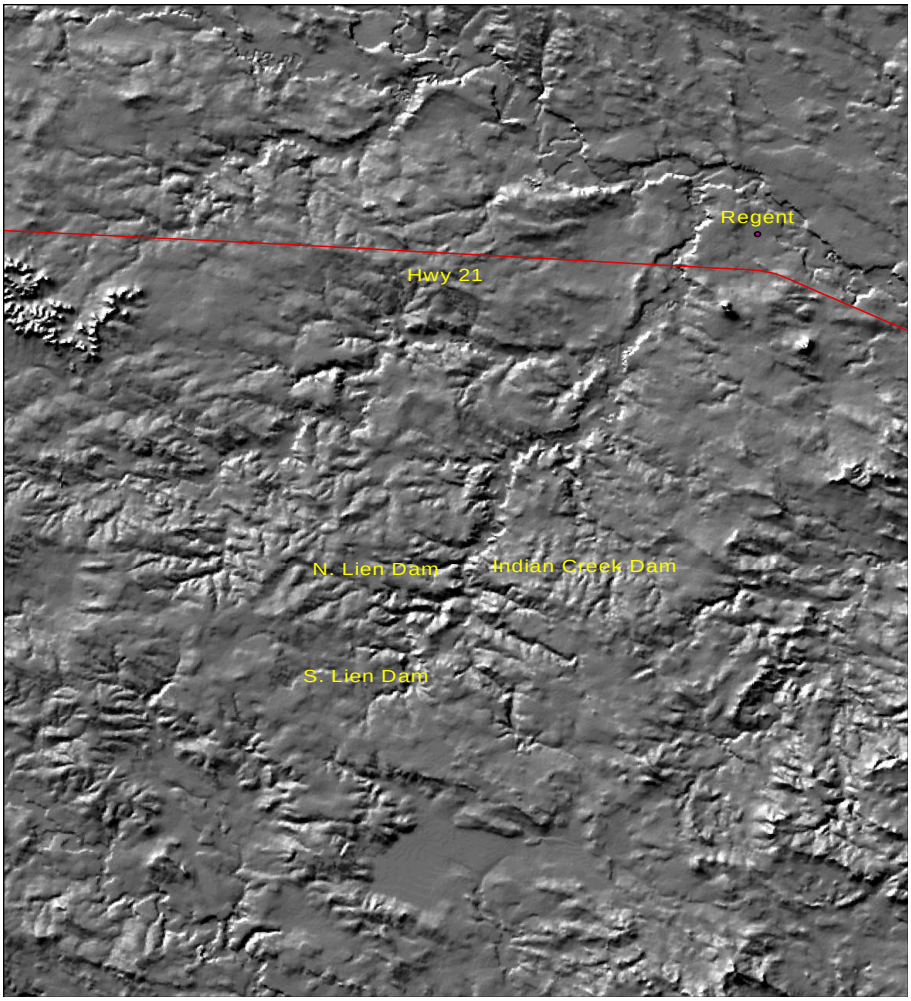


Figure 2. Aerial Depiction of Indian Creek Dam and Watershed.

1.3 Land Use/Land Cover

Land use in the Indian Creek watershed is primarily agricultural (87%). Approximately 77% of land within the watershed is used for cropland, 7% pasture land, 1% hay land, and 2% CRP respectively (Figure 3). The remainder of the land is in farmstead and feedlot areas ("other" in Figure 3), or wildlife management area habitat. There are no large urban areas, however, several farmsteads are present throughout the area. Potential natural vegetation in this watershed includes: prairie sandreed, little bluestem, blue grama, and needlegrass.

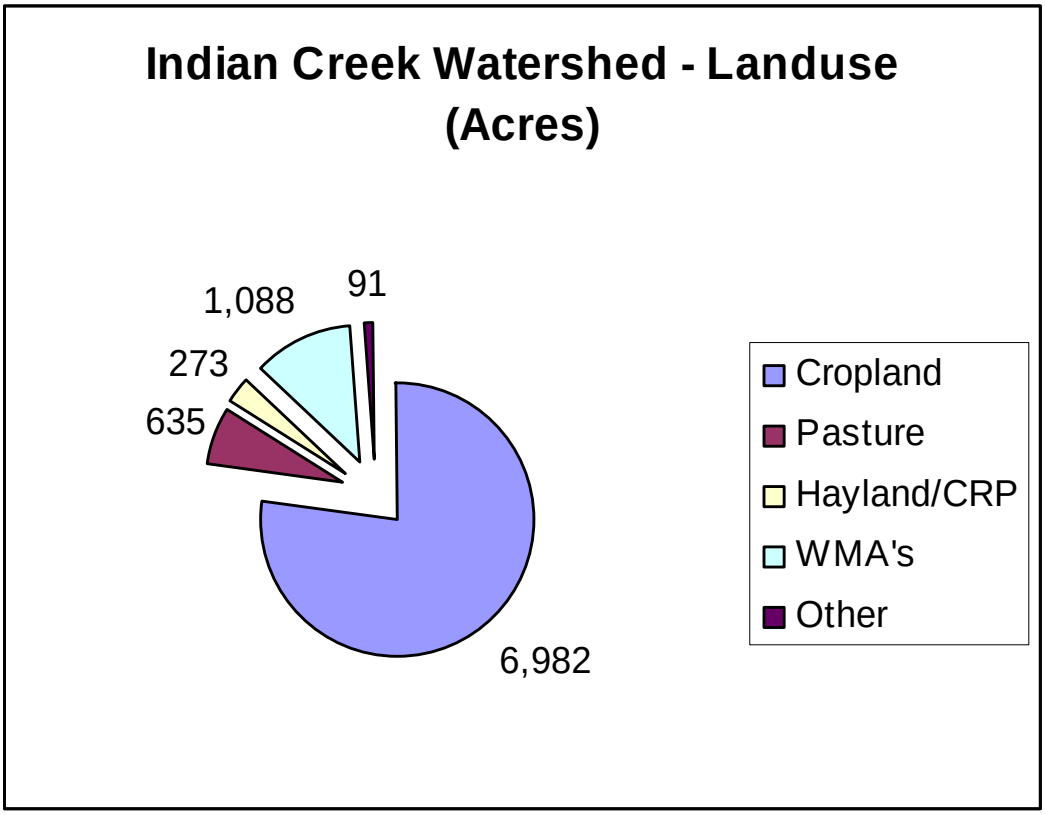


Figure 3. Estimated Land Use Data Coverage for Indian Creek Dam.

1.4 Climate and Precipitation

Indian Creek Dam and its watershed lie within the southwestern climate division of North Dakota. Southwestern North Dakota has a typical continental climate characterized by large annual, daily, and day-to-day temperature changes, light to moderate precipitation, and nearly continuous air movement. The normal air temperature in January is 16°F, while the normal air temperature in July is 69°F (NDAWN, 2006). Over the last twenty years the average annual temperature and precipitation recorded in nearby Mott, North Dakota, is 56° F and 15.76 inches, respectively. Extreme seasonal variations in temperature and precipitation are typical of the climate in this region. Average maximum monthly temperature in Mott between 1983 and 2004 is shown in Figure 4, while average monthly precipitation totals are shown in Figure 5 (NDAWN, 2006). June is the wettest month of the year with average precipitation of 2.88 inches. Precipitation events tend to be brief and intense and occur mainly during the months of May through August, with little precipitation from November through March.

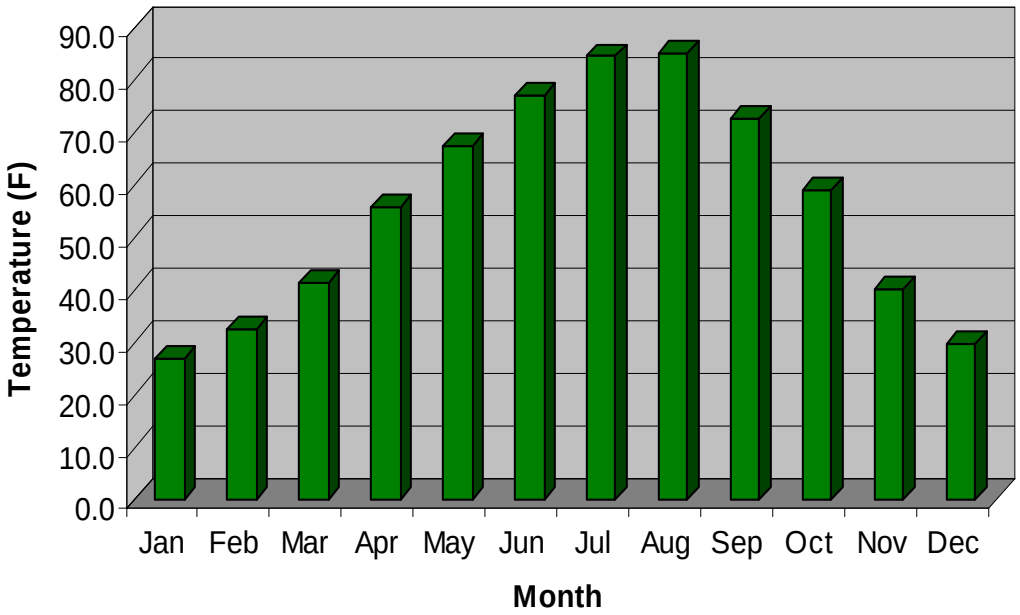


Figure 4. Average Maximum Monthly Temperature From 1983-2004 at the North Dakota Agriculture Weather Network (NDAWN), Mott, ND Weather Station.

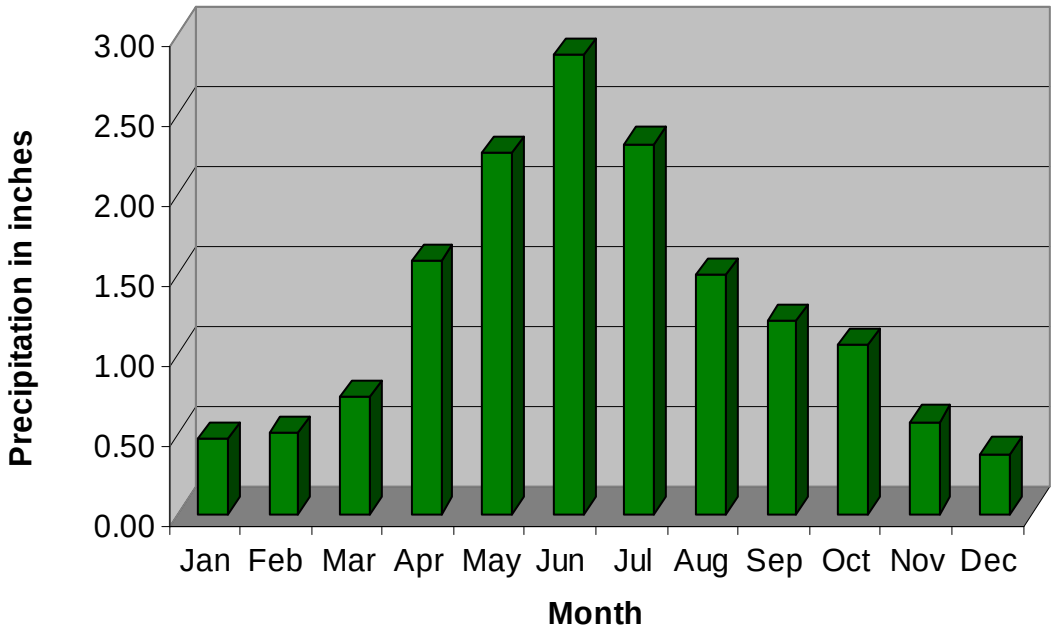


Figure 5. Average Monthly Precipitation From 1983-2004 at the North Dakota Agriculture Weather Network (NDAWN), Mott, ND Weather Station.

1.5 Available Water Quality Data

1.5.1 1991-1992 Lake Water Quality Assessment Project

A Lake Water Quality Assessment (LWQA) was conducted on Indian Creek Dam in 1991-1992. Samples were taken twice during the summer of 1991 and once during the winter of 1991-1992. The samples were collected at one site located in the deepest area of the lake (380765). Water column samples consisted of three separate depths (1, 3, and 6 meters in the summer) and (1, 3, and 5 meters during the winter). During the summer water quality sampling periods, Indian Creek Dam was not thermally stratified. Dissolved oxygen concentrations were near saturation to a depth of 3 to 5 meters and were adequate to maintain aquatic life. Winter samples also showed no thermal stratification, with dissolved oxygen concentrations in January at approximately 3 mg L^{-1} or less throughout the water column.

The 1991-1992 LWQA Project characterized Indian Creek Dam as a lake having extremely hard water, rich in both minerals and nutrients. The volume weighted mean for total phosphate as P was 0.195 mg L^{-1}. The volume weighted means are calculated by weighing the parameter analyzed by the percentage of water volume represented at each depth interval. Although this is a relatively low concentration compared to many lakes in North Dakota, it does exceed the state's target concentration of 0.02 mg L^{-1}. Trophic status was assessed using the water quality data collected during the summer of 1991, indicating that Indian Creek Dam is hypereutrophic. Secchi disk transparency readings of 1 meter or less were recorded during summer sampling. Total phosphate as P concentrations at the surface were between 0.170 and 0.274 mg L^{-1} and chlorophyll-a concentrations were between 0.019 and 0.039 mg L^{-1}. Additional evidence supporting this trophic status assessment included: a large macrophyte biomass covering 20-25 percent of the lake surface area, a phytoplankton community dominated by one or two species of blue-green algae, frequent nuisance algal blooms, and low dissolved oxygen concentrations in the lower portion of the water column during summer and throughout the majority of the water column during ice cover conditions.

1.5.2 2001-2005 Indian Creek Dam TMDL Project

The Hettinger County Soil Conservation District (SCD) conducted a water quality assessment of Indian Creek Dam and its watershed from 2001-2005. The SCD followed the methodology for water quality sampling found in the Quality Assurance Project Plan (QAPP) for the Indian Creek Dam TMDL Project (NDDoH, 2001). Sampling and analysis variables are shown in Table 3.

Table 3. Indian Creek Dam Sampling and Analysis Variables.

Field Measurements	General Chemical Variables	Nutrient Variables	Biological Variables
Secchi Disk Transparency	pH	Total Phosphorus	Chlorophyll-a
Temperature	Specific Conductance	Dissolved Phosphorus	Phytoplankton
Dissolved Oxygen	Major Anions & Cations	Total Nitrogen	Fecal Coliform
	Total Suspended Solids	Total Kjeldahl Nitrogen	
		Nitrate plus Nitrite Nitrogen	
		Ammonia Nitrogen	

Stream Monitoring

Sampling frequency for the stream sampling sites was stratified to coincide with the typical hydrograph for the region. This sampling design results in more frequent samples during spring and early summer when stream discharge is typically at its peak; and less frequent samples during the summer and fall. Sampling is discontinued during winter ice cover conditions, and terminated if the stream stopped flowing. If the stream should begin flowing again, water quality sampling is reinitiated at the same sampling locations (Figure 6).

Lake Monitoring

In order to accurately account for temporal variation in lake water quality, the lake was sampled twice per month during the open water season and monthly during ice cover conditions.

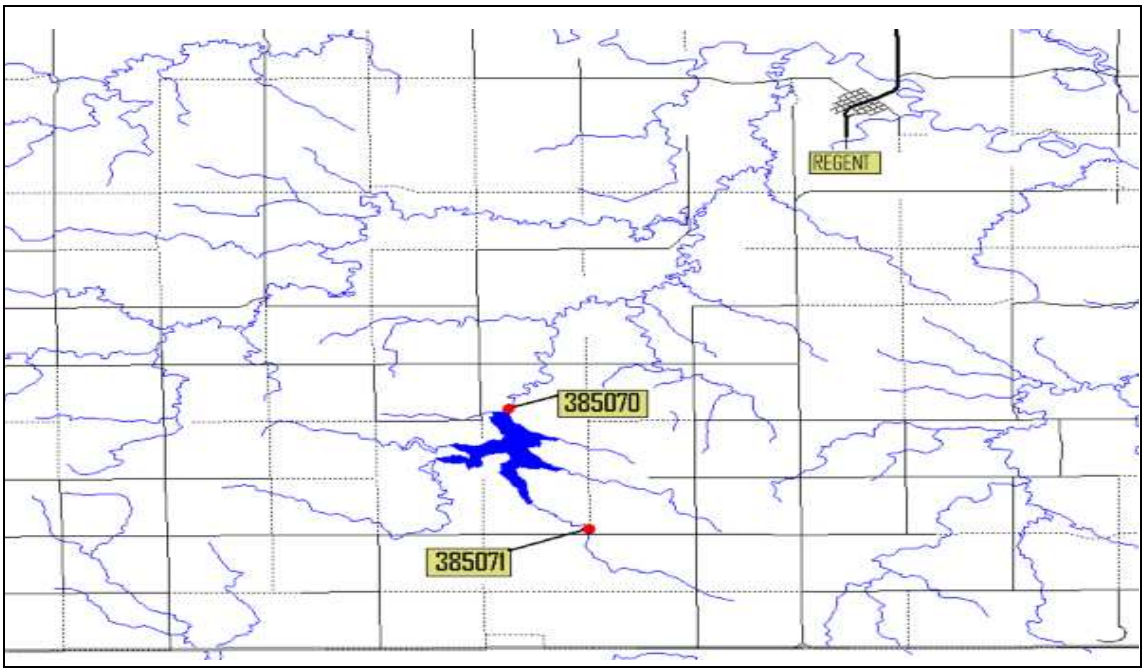


Figure 6. Indian Creek Dam Inlet and Outlet Sampling Locations.

Nutrient Data

Between October 2001 and February 20005 surface water quality parameters were monitored in Indian Creek Dam at one location in the deepest area of the reservoir (380765), at one tributary location (inlet, 385071) and at one location below the dam (outlet, 385070). Sample parameters and average volume weighted mean concentrations for the reservoir and inlet sites are provided in Table 4. Average concentrations of total and dissolved phosphorus were higher at the inlet, while total nitrogen and total Kjeldahl nitrogen were greater at the deepest site of the reservoir. Indian Creek Dam contained an average total nitrogen to total phosphorus ratio of nearly 37:1 at site 380765 (Table 4). Ratios above 7.2 generally indicate that phosphorus is the limiting nutrient (Chapra, 1997).

Table 4. Data Summary for Indian Creek Dam TMDL Project 2001-2005.

Parameter	Inlet Stream Site #385071					Deepest Site #380765					Volume-weighted Mean
	N	Max	Median	Avg	Min	N	Max	Median	Avg	Min	
Total Phosphorus (mg L^{-1})	42	0.523	0.125	0.140	0.004	62	0.098	0.049	0.046	0.008	0.046
Dissolved Phosphorus (mg L^{-1})	35	0.354	0.010	0.033	0.004	56	0.102	0.006	0.019	0.004	0.018
Total Nitrogen (mg L^{-1})	42	3.260	1.460	1.636	1.140	62	2.920	1.640	1.676	1.260	1.692
Total Kjeldahl Nitrogen (mg L^{-1})	42	2.570	1.410	1.505	0.700	62	2.900	1.620	1.645	1.240	1.662
Nitrate/Nitrite (mg L^{-1})	42	2.120	0.020	0.131	0.020	62	0.090	0.020	0.031	0.020	0.03
chlorophyll-a (µg/L)	N/A	N/A	N/A	N/A	N/A	16	76.40	11.00	16.90	3.00	N/A
Secchi Disk (meters)	N/A	N/A	N/A	N/A	N/A	15	2.50	1.50	1.34	0.50	N/A

Nutrient concentrations for Indian Creek Dam in 2001-2005 were compared to data collected from Indian Creek Dam in 1991-1992. Average nutrient concentrations reported for the 1991-1992 LWQA were higher when compared to the 2001-2005 Indian Creek Dam Assessment. The 2001-2005 Indian Creek Dam Assessment showed reductions in nutrient concentrations such as nitrate-nitrite, total Kjeldahl nitrogen, and total phosphorus when compared to the 1991-1992 LWQA data (Table 5).

Table 5. Nutrient Concentration Comparisons at Indian Creek Dam.

Parameter	Indian Creek Dam 1991-1992	Indian Creek Dam 2001-2005
Nitrate/Nitrite (mg L^{-1})	0.035	0.031
Total Kjeldahl Nitrogen (mg L^{-1})	2.820	1.662
Total Phosphorus (mg L^{-1})	0.195	0.046

Dissolved Oxygen and Temperature Data

Dissolved oxygen and temperature were monitored at the deepest area site of Indian Creek Dam from October 2001-February 2005. Raw data is provided in Appendix C, while Figures 7-10 illustrate the results of the temperature and dissolved oxygen data for the deepest monitoring site, respectively. Samples were collected at 1-meter intervals during ice cover and open water periods. During the summer sampling of 2002, Indian Creek Dam was thermally stratified on July 24, 2002 between four and five meters of depth. At that time dissolved oxygen concentrations ranged from 10.8 mg L^{-1} at the surface, and declined in concentration from 5.06 mg L^{-1} to 4.19 mg L^{-1} at 4-5 meters of depth. Based on the 2001-2003 data there appears to be a period during the summer season (July) when dissolved oxygen consistently falls below the 5 mg L^{-1} state standard in the hypolimnion. When comparing the dissolved oxygen concentrations in the deepest area site of Indian Creek Dam during 2001-2003 and 2004-2005, the concentrations of dissolved oxygen during the summer of 2004 were below the 5 mg/L^{-1} state standard during July, August, and September. The data indicates that the summer months of July-September are critical for dissolved oxygen concentrations in Indian Creek Dam, especially during dry years. All other months show results above the 5 mg/L^{-1} state

standard. The cause-and-effect relationship between nutrients, water temperature, plant growth and decomposition, and the resulting low dissolved oxygen levels in a waterbody is well established in the scientific literature.

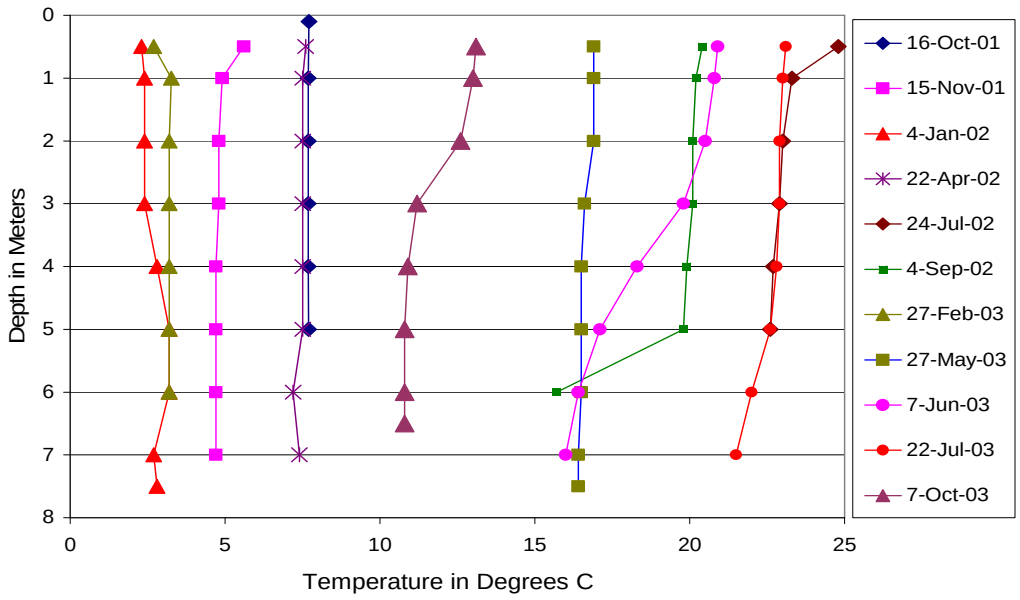


Figure 7. Summary of Temperature Data for Indian Creek Dam's Deepest Area Site (380765), 2001-2003.

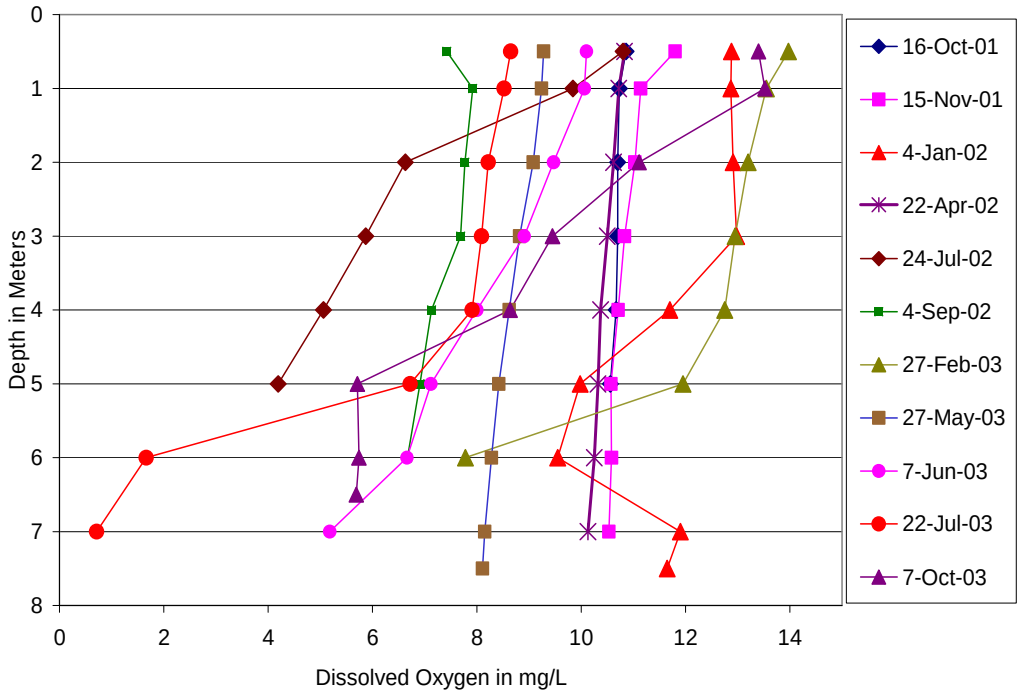


Figure 8. Summary of Dissolved Oxygen Concentrations for Indian Creek Dam's Deepest Area Site (380765), 2001-2003.

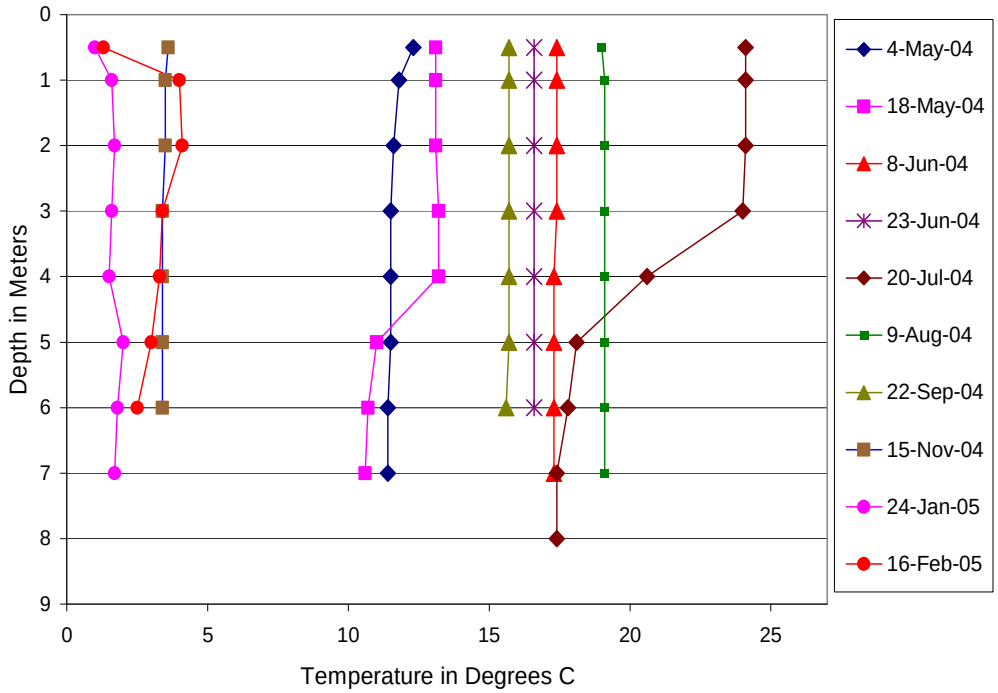


Figure 9. Summary of Temperature Data for Indian Creek Dam's Deepest Area Site (380765), 2004-2005.

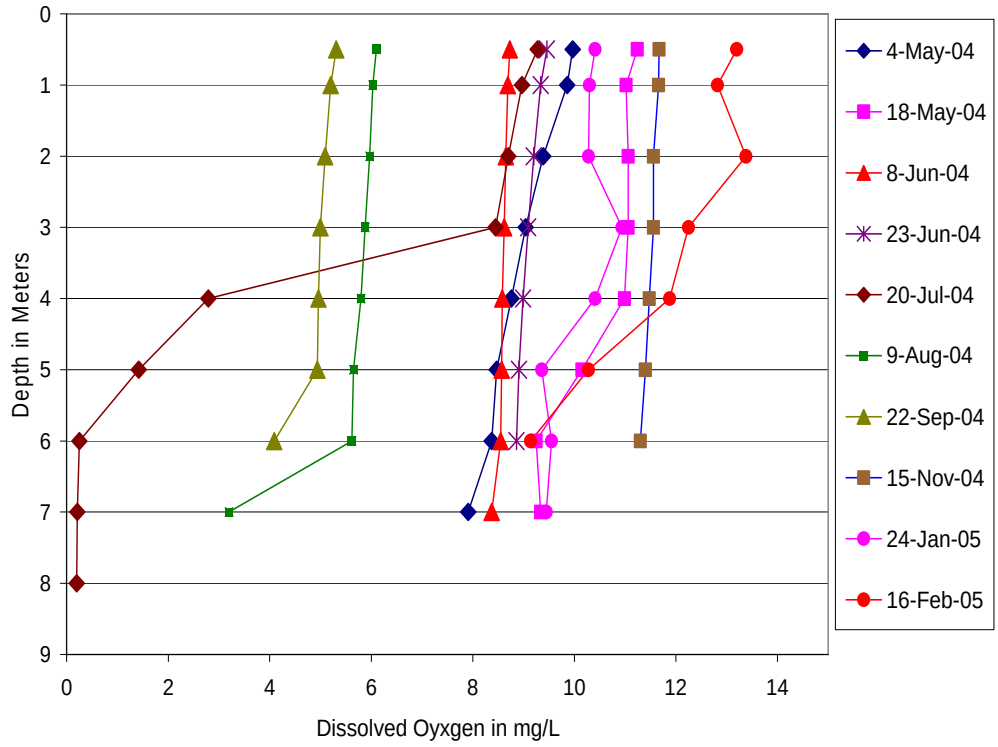


Figure 10. Summary of Dissolved Oxygen Profiles for Indian Creek Dam's Deepest Area Site (380765), 2004-2005.

Secchi Disk Transparency and In-Lake Total Suspended Solids

Secchi disk transparency data were collected by SCD staff between October 2001 and September 2004 (Table 6). As shown in Table 6, the average Secchi disk transparency for the deepest sampling site was 1.34 meters for Indian Creek Dam. Based on Secchi disk transparency, the TSI score for this reservoir is 57.7 (well within the eutrophic range).

While Secchi disk depths were taken for only 4 months of the year on average from 2001-2004, the data shows that visibility throughout the water column was lowest during September and October. The greatest Secchi disk depths on Indian Creek Dam were measured during the optimal growing season months of June and July (Table 6). Water clarity in a reservoir can be affected by many factors. Algal biomass, total suspended solids, and other debris all affect Secchi depth measurements.

Table 6. Average Monthly Secchi Depths in Indian Creek Dam 2001-2004.

Month	Average Secchi Depth (M)	Month	Average Secchi Depth (M)
January	NA	July	1.45
February	NA	August	1.5
March	NA	September	1.13
April	0.75	October	0.75
May	1.17	November	NA
June	2.08	December	NA

Tributary Total Suspended Solids

One hundred eleven total suspended solid (TSS) samples were collected by the Slope-Hettinger SCD staff between April 2002 and September 2004. TSS samples were collected from the inlet site (385071) and outlet site (385070) of Indian Creek Dam. Average TSS concentrations at the inlet and outlet sites were 19.3 and 7.2 mg L^{-1} respectively (Table7). As evidenced by Table 7 suspended solids are being retained within the reservoir. This data shows that samples taken from the outlet contained less than half of the TSS concentration taken from samples at the inlet.

Table 7. Average Total Suspended Solid Concentrations for the Indian Creek Dam Inlet and Outlet Sites (2002-2004).

Site ID	Site Description	Average TSS (mg/L)
385071	Inlet	19.3
385070	Outlet	7.2

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 (e.g., nutrients, sediment).

2.1 Narrative Water Quality Standards

The North Dakota Department of Health 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, 2001).

- 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, 2001).

2.2 Numeric Water Quality Standards

Indian Creek Dam is classified as a Class 3 warm water fishery. Class 3 fisheries are defined as waterbodies "capable of supporting growth and propagation of nonsalmonid fishes and associated aquatic biota" (NDDoH, 1991). 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 state that lakes shall use the same numeric criteria as Class 1 streams. This includes the state standard for dissolved oxygen set at no less than 5 mg L^{-1}. State standards for lakes and reservoirs also specify guidelines for nitrogen (1.0 mg L^{-1} as nitrate) and phosphorus (0.1 mg L^{-1} as total phosphorus) (Table 8).

Table 8. Numeric Standards Applicable for North Dakota Lakes and Reservoirs (NDDoH, 2001).

Parameter		Guidelines	Limit
Guidelines or Standards for Classified Lakes			
	Nitrates (dissolved)	1.0 mg L^{-1}	Maximum allowed[1]
	Phosphorus (total)	0.1 mg L^{-1}	Maximum allowed[1]
	Dissolved Oxygen	5 mg L^{-1}	Not less than
Guidelines for goals in a lake improvement or maintenance program			
	NO_3 as N	0.25 mg L^{-1}	Goal
	PO_4 as P	0.02 mg L^{-1}	Goal

[1] **"Interim guideline limits"**

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 Indian Creek Dam based on its impaired beneficial uses. If the specific target is met, it is assumed the reservoir will meet the applicable water quality standards, including its designated beneficial uses.

3.1 Nutrient Target

A Carlson's Trophic State Index (TSI) target of 53.75 based on total phosphorus was chosen for the Indian Creek Dam endpoint. North Dakota's 2004 Integrated Section 305(b) and Section 303(d) Water Quality Assessment Report indicates that Carlson's (TSI) is the primary indicator used to assess beneficial uses of the state's lakes and reservoirs (NDDoH, 2004). Trophic status is the measure of productivity of a lake or reservoir and is directly related to the level of nutrients (phosphorus and nitrogen) entering the lake or reservoir from its watershed. Lakes tend to become eutrophic (more productive) with higher nitrogen and phosphorus inputs. Eutrophic lakes often have nuisance algal blooms, limited water clarity, and low dissolved oxygen concentrations that can result in impaired aquatic life and recreational uses. Carlson's TSI attempts to measure the trophic state of a lake using nitrogen, phosphorus, chlorophyll-a, and Secchi disk depth measurements (Carlson, 1977).

Trophic State Index (TSI) values were calculated for total phosphorus, chlorophyll-*a*, and Secchi disk transparency at Indian Creek Dam. The highest TSI value was for total phosphorus at 60, while chlorophyll-*a* and Secchi depth values were 59 and 56, respectively (Table 9). Based on Carlson's TSI and water quality data collected between October 2001 and September 2004, Indian Creek Dam was generally assessed as a eutrophic lake (Table 9). Eutrophic lakes are characterized by large growths of weeds, blue-green algal blooms, and low dissolved oxygen concentrations. These lakes may experience periodic fish kills and are generally characterized as having excessive rough

fish populations (carp, bullhead, and sucker) that can reflect poorly on the sport fishery. Because of frequent algal blooms and excessive weed growth, eutrophic lakes often become undesirable for recreational uses such as swimming and boating.

Table 9. Carlson's Trophic State Indices for Indian Creek Dam.

Parameter	Relationship	Units	TSI Value	Trophic Status
Chlorophyll-*a*	TSI (Chl-a) = 30.6 + 9.81[ln(Chl-a)]	µg/L	59	eutrophic
Total Phosphorus (TP)	TSI (TP) = 4.15 + 14.42[ln(TP)]	µg/L	60	eutrophic
Secchi Depth (SD)	TSI (SD) = 60 - 14.41[ln(SD)]	meters	56	eutrophic

TSI < 40 - Oligotrophic (least productive)
TSI 40-50 Mesotrophic
TSI 50-60 Eutrophic
TSI > 60 - Hypereutrophic (most productive)

The reasons for the different TSI values estimated for Indian Creek Dam are varied. According to the phosphorus TSI value, Indian Creek Dam is a productive lake (eutrophic) (Table 9). Carlson and Simpson (1996) suggest that if the phosphorus and secchi depth TSI values are relatively similar and higher than the chlorophyll-*a* TSI value, then dissolved color or nonalgal particulates dominate light attenuation. It follows that, as is the case with Indian Creek Dam, if the secchi depth and chlorophyll-*a* TSI values are similar, then chlorophyll-*a* is dominating light attenuation. Carlson and Simpson (1996) also state that a nitrogen index value might be a more universally applicable nutrient index than a phosphorus index, but it also means that a correspondence of the nitrogen index with the chlorophyll-a index cannot be used to indicate nitrogen limitation.

While the TSI target of 53.75 based on total phosphorus will not bring concentrations of total phosphorus to the NDDoH State Water Quality Standard guideline for lakes (0.02 mg/L), it should result in a change of trophic status for the lake from eutrophic to borderline mesotrophic during all times of the year. Given the size of the lake, the probable amount of phosphorus in bottom sediments, nearly constant wind in North Dakota causing a mixing effect, and few cost effective ways to reduce in-lake nutrient cycling, this was determined to be the best possible outcome for the reservoir. If the specified TMDL TSI target of 53.75 based on total P is met, the reservoir can be expected to meet the applicable water quality standards for aquatic life and recreational beneficial uses.

3.2 Dissolved Oxygen Target

The North Dakota State Water Quality Standard for dissolved oxygen is "no less than 5.0 mg/L^{-1}" and will be the dissolved oxygen target for Indian Creek Dam.

4.0 SIGNIFICANT SOURCES

There are no known point sources upstream of Indian Creek Dam. It is assumed that the pollutants of concern originate from non-point sources. Most of the land upstream from Indian Creek Dam is farmed. The remainder is used for pasture or kept as permanent herbaceous cover. There are no urban areas within the watershed. There are also no lake homes around the reservoir. However, there are small farmsteads spread throughout the watershed. The vast majority of nutrient loads are transported with overland runoff from agricultural areas.

Precipitation directly to the lake's surface is another possible source of nutrients. During the assessment period of Indian Creek Dam, less than average precipitation was received in the watershed.

In addition, existing land use and AnnAGNPS modeling (see section 5.3 AnnAGNPS Watershed Model) within the Indian Creek Dam watershed indicates that the majority of NPS loading is likely coming from cropland (77 percent of land within the watershed is cropped). A small percentage (7%) of land in the watershed is used for pasture. It is possible that a small amount of nutrient loading also originates from land used for pasture. Best management practices should also be implemented on land used for pasture in order to address loading from these lands.

5.0 TECHNICAL ANALYSIS

Establishing a relationship between in-stream 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 and trophic response of the receiving waterbodies. 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 utilized to estimate existing loads to Indian Creek Dam and the predicted trophic response of the reservoir to reductions in loading capacity.

5.1 Tributary Load Analysis

Watershed hydraulic and pollutant loads were estimated using actual water quality data and the annualized agricultural nonpoint source (AnnAGNPS) model. The AnnAGNPS model was developed by the US Department of Agriculture's Agricultural Research Services to model relative quantity and quality of outflow from a watershed in order to assess the pollution potential.

The AnnAGNPS model delineated sub-watersheds into inlets and an outlet in order to run the model on the Indian Creek Dam watershed. Model outputs include hydraulic and soluble sediment attached nutrient loads from each sub-watershed, as well as the lake outlet (see appendix B). Since the bathtub model also requires the load of total nitrogen and total phosphorus, these were calculated as a ratio of the soluble load. The ratios were calculated from 42 inlet samples and 74 outlet samples collected between October 16, 2001 and February 16, 2005. These data were then provided as input data to calibrate the BATHTUB eutrophication response model.

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 Indian Creek 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 can serve as inputs to the model.

The tributary data were analyzed and estimated by the AnnAGNPS watershed model. AnnAGNPS uses actual tributary inflow, outflow, water quality, flow data, and land use practices to estimate average mass discharge or loading that passes a river or stream site. Load is therefore defined as the mass of pollutant during a given unit of time. Output from the AnnAGNPS model may then be used to effectively calibrate the BATHTUB watershed model for further estimates of current watershed characteristics.

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

When the input data from the AnnAGNPS model and Excel programs are entered into 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 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 observed estimates from the project monitoring data. BATHTUB then has the ability to predict total phosphorus concentration, chlorophyll-a concentration, and secchi disk transparency 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 load of 2,461.2 kg and an annual average total nitrogen load of 50,160.5 kg. 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.

In the case of Indian Creek Dam, BATHTUB modeled two nutrient reduction alternatives. The first alternative reduced externally derived phosphorus. Phosphorus was used in the initial set of simulation models based on its known relationship to eutrophication and that it is controllable with the implementation of watershed Best Management Practices (BMPs) or lake restoration methods. Changes in trophic response were evaluated by reducing externally derived phosphorus loading by 25, 50, and 75 percent. Simulated reductions were achieved by reducing phosphorus concentrations in contributing tributaries and other externally delivered sources. Flow was held constant due to the uncertainty of estimating changes in hydraulic discharge with the implementation of BMPs.

Table 10. Observed and Predicted Values for Selected Trophic Response Variables Assuming 25, 50, and 75 Percent Reductions in External Phosphorus and Nitrogen Loading.

Variable	Observed Value	Predicted Value		
		25%	50%	75%
Total Phosphorus (mg/L)	0.05	0.041	0.031	0.019
Total Dissolved Phosphorus (mg/L)	0.020	0.017	0.014	0.010
Total Nitrogen (mg/L)	1.690	1.274	0.858	0.442
Organic Nitrogen (mg/L)	1.630	1.351	1.068	0.754
Chlorophyll-a (µg/L)	18.24	14.03	9.47	4.39
Secchi Disk Transparency (meters)	1.34	1.54	1.87	2.46
Carlson's TSI for Phosphorus	60.54	57.78	53.75	46.47
Carlson's TSI for Chlorophyll-a	58.94	56.51	52.66	45.11
Carlson's TSI for Secchi Disk	55.78	53.74	50.96	47.05

To acquire a noticeable change in the tropic status of Indian Creek Dam the BATHTUB model predicted that a 50 percent reduction in total phosphorus load would achieve the target total phosphorus concentration of 0.031 mg L^{-1} and a total nitrogen concentration of 0.858 mg L^{-1} (Table 10). This reduction in phosphorus and nitrogen is predicted to result in a reservoir that is nearly mesotrophic (Figure 11).

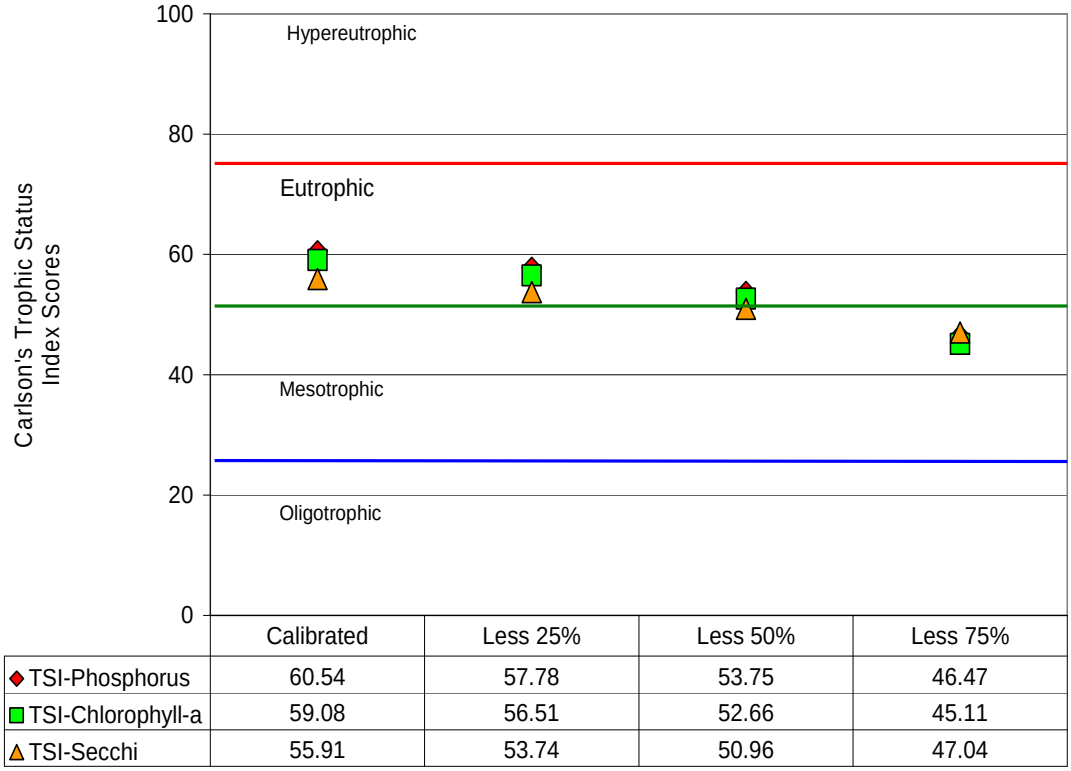


Figure 11. Predicted Trophic Response to Phosphorus Loads of Indian Creek Dam showing the observed score and a 25, 50, and 75 Percent Load Reduction.

5.3 AnnAGNPS Watershed Model

The Annualized Agricultural Non-Point Source Pollution (AnnAGNPS) model was developed by the USDA Agricultural Research Service and Natural Resource Conservation Service (NRCS) to expand the earlier AGNPS single event model. 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 chemicals (nutrients and pesticides) 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 watershed reaches to the 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 chemicals to the reaches.

The AnnAGNPS model is able to partition soluble nutrients and pesticides between surface runoff and infiltration. Sediment attached nutrients and pesticides 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, pesticides, 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 split into two layers. The top layer is used as the tillage layer and has properties that change (e.g., bulk density), while the remaining soil profile makes up the second layer with properties that remain static. A daily soil moisture budget is calculated based on runoff (i.e., rainfall, irrigation, and snow melt), evapotranspiration and percolation. Runoff is calculated using the SCS 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 RUSLE (Geter and Theurer, 1998).

A daily mass balance for nitrogen (N), phosphorus (P), and organic carbon (OC) are calculated for each cell. Major components considered include plant uptake of 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 divided into organic and mineral phases. Plant uptake of N and P are modeled through a crop growth stage index (Theurer et. al. 1998).

Each pesticide is expressed in a daily mass balance. The AnnAGNPS model allows for numerous pesticides, each exhibiting their own chemical properties. Major components of the pesticide model include foliage wash-off, vertical transport in the soil profile, and

degradation. Soluble and sediment absorbed fractions are calculated for each cell on a daily basis.

The reach routing model moves sediment, nutrients, and pesticides through the watershed. Sediment routing is calculated based upon transport capacity relationships using the Bagnold stream power equation (Bagnold, 1966). Routing of nutrients and pesticides through the watershed is accomplished by subdividing them into soluble and sediment attached components and are based on reach travel time, water temperature, and a 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. Additionally, 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, landuse, 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 landuse 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 Indian Creek Dam TMDL project. The Indian Creek watershed delineation began with downloading a 30 meter digital elevation model (DEM) of Hettinger County from the United States Geological Survey (USGS) website. Delineation is defined as drawing a boundary and dividing the land within the boundary into subwatersheds in such a matter that each subwatershed has uniform hydrological parameters (land slope, elevation, etc.).

Landuse and soil digital images were then used to extract the dominant identification of landuse 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 landuse identification input parameters were obtained using the Revised Universal Soil Loss Equation (RUSLE).

Major landuses in the Indian Creek watershed were identified as wheat, grassland, and alfalfa. Harrowing and no tillage were used in the cropland field operations. Crop rotation consisted of wheat, durum, and canola. Planting was done in early April and harvest took place in late August. Fertilizer application consisted of 11-52-0 (Mono Ammonium Phosphate) fertilizer applied in the spring for canola and anhydrous ammonia applied in the fall for wheat and durum.

Climate data was obtained from the North Dakota Agricultural Weather Network (NDAWN) website. Actual climatic data was retrieved from the NDAWN station located in Mott, North Dakota for the years of 2001-2003. Unfortunately the data in 2001 was only available starting in mid-August. The (Generation of weather Elements for Multiple applications) GEM climatic model provided by the AnnAGNPS model was then utilized to provide synthetic data to supplement the missing NDAWN data prior to August 2001.

As stated above, the AnnAGNPS model allows the user to specify which output parameters are desired for watershed source locations. In the case of the Indian Creek watershed the output data was used to calibrate the BATHTUB model. During the assessment of Indian Creek Dam, the watershed experienced an extended period of no flow events and a flow regime could not be established. The source accounting output data was used to determine the annual accumulation of nutrients and water volume moving through the Indian Creek Dam watershed. The AnnAGNPS model simulation was run for three separate years from 2001-2003. Desired watershed source locations consisted of the inlets (Cell 19, 29, 32, 55, 116, 117 and 174) and outlet (Cell 18) of Indian Creek Dam. When calibrating the BATHTUB model only the inlet (Cell 55) and the outlet (Cell 18) were used because these two cells contained the sampling sites identified in the Quality Assurance Project Plan (QAPP) for the Indian Creek Dam TMDL project. Results of all other output data can be found in Appendix B.

Table 11. Water Volume and Nutrient Concentrations at Outlet from 2001-2003.

Outlet (Cell 18)	Units	2001	2002	2003	Total	Average
Water volume	acre feet	191.98	364.32	62.73	619.03	206.34
Attached Nitrogen Accumulation	tons/year	2.81	1.03	0.15	3.99	1.33
Soluble Nitrogen Accumulation	tons/year	7.36	7.22	2.5	17.08	5.69
Attached Phosphorus Accumulation	tons/year	0.16	0.09	0.04	0.29	0.096
Soluble Phosphorus Accumulation	tons/year	0.76	0.47	0.24	1.47	0.49

5.4 Dissolved Oxygen

Indian Creek Dam is listed as not supporting, fish and aquatic biota uses because of dissolved oxygen levels observed below the North Dakota water quality standard. The North Dakota water quality standard for dissolved oxygen is "not less than 5.0 mg L^{-1}". For Indian Creek Dam, low dissolved oxygen levels appear to be 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.

AnnAGNPS and BATHTUB models indicate that excessive nutrient loading is responsible for the low dissolved oxygen levels in Indian Creek 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 phosphorus 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 Department of Health'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 phosphorus 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. Binational 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 phosphorus reduction, but this was expected (See: http://www.epa.gov/glnpo/lakeerie/dostory.html).

Nürnberg (1995, 1995a, 1996, 1997), 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 phosphorus (TP) concentrations. The AF may also be used to quantify responses to watershed restoration measures which make it very useful for TMDL development. Nürnberg (1996) developed several regression models that show nutrients control all trophic state

indicators related to oxygen and phytoplankton in lakes/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 = 196.3 acres; 0.794 km^2), mean depth (z = 12.3 feet; 3.74 meters), and the ratio of mean depth to surface area ($z/A_o^{0.5}$ = 0.88) for Indian Creek 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. NDDoH is also confident that prescribed BMPs will reduce external loading of nutrients to Indian Creek Dam which will reduce algae blooms and therefore increase oxygen levels over time.

Best professional judgment concludes that 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." To insure that the implementation of BMPs will reduce phosphorus levels and result in a corresponding increase in dissolved oxygen, water quality monitoring will be conducted in accordance with an approved Quality Assurance Project Plan.

5.5 Sediment

The AnnAGNPS model estimated sediment inflows for Indian Creek Dam (Table 12). The time period over which this amount of storage occurred was 1.00 years, assuming complete retention. Therefore, sediment accumulated within the reservoir at an average annual rate of 35,684.11 kg/yr during the years of data collection (2001-2003). This value represents the entire sediment load measured at the inlet (sub-watershed 55), thus assuming 100% retention and a very conservative assumption to further justify delisting of sediment impairments in Indian Creek Dam.

Mulholland and Elwood (1982), state that the acceptable average accumulation rate of sediment within reservoirs is 2 cm/year. Based on a conversion from mass of sediment storage to depth of sediment storage, it can be assumed that Indian Creek Dam is accumulating sediment at a current rate that is considered acceptable for reservoirs.

Table 12. AnnAGNPS Estimated Sediment Intake for Indian Creek Dam (2001-2003).

Total Suspended Solids	Inflow (kg)
2001	78,935.96
2002	20,750.94
2003	7,365.43
Average	35,684.11

Based on the Mulholland and Elwood (1982) average accumulation rate of 2 cm/yr within reservoirs, a conversion from mass of sediment storage to depth of sediment storage is needed for comparison.

In order to perform the conversion from mass to depth of sediment, the particle density of soil is needed. For most mineral soils the average density of particles is in the range of 2.6 to 2.7 g/cm^3. This narrow range reflects the predominance of quartz and clay

minerals in the soil matrix. Since soils in the Indian Creek Dam watershed are mineral soils, the particle density of silicate minerals can be used to calculate a depth of sediment accumulation within the reservoir. For the sake of providing an implicit margin of safety, the low end of the range (2.6 g/cm^3) will be used to calculate the equivalent depth of 35,684.11 kg of sediment in Indian Creek Dam.

Based on a sediment loading of 35,684.11 kg/yr times a sediment density of 2.60 g/cm^3, the sediment volume deposited in Indian Creek Dam is 92,778,686 cm^3 each year.

$$35{,}684{,}110 \text{ g/yr} * (2.60 \text{ g/cm}^3)^{-1} = 13{,}724{,}657.69 \text{ cm}^3\text{/yr}$$

Based on a surface area of 196.3 acres (7,943,979,156.39 cm^2), the annual sedimentation rate is 0.00173 cm per year [(13,724,657.69 cm^3/yr)/ (7,943,979,156.39 cm^2)]. This estimated annual sediment accumulation rate is well below the acceptable average sedimentation rate of typical reservoirs.

Further support for the removal of sediment as a pollutant of concern can also be found in literature. As Waters (1995) states, suspended sediment concentrations less than 25 mg L^{-1} is not harmful to fisheries; between 25 and 80 mg L^{-1} reduces fish yield; between 80 and 400 mg L^{-1} is unlikely to display a good fishery; and suspended sediment concentration greater than 400 mg L^{-1} will exhibit a poor fishery. Therefore, research by Waters (1995) supports the view that the mean TSS concentration in Indian Creek Dam of 13.2 mg L^{-1} is not considered harmful to fisheries. While seven samples out of one hundred sixteen exceeded the 25 mg L^{-1} concentration stated by Waters (1995) as reducing fish yield, only two samples exceeded the 80 mg L^{-1} deemed unlikely to display a good fishery. Therefore, it is the recommendation of this TMDL that, in the next North Dakota 303(d) list cycle, Indian Creek Dam should be de-listed for sediment impairments.

Justification for delisting is also based on the Natural Resources Conservation Service (NRCS) Sedimentation Rate Standard for reservoirs. This standard is set at 1/8 inch of sediment eroded from the watershed drainage areas delivered and detained in the sediment pool over the 50-year expected life of the project. Therefore:

Assuming Watershed Area = 10,733 acres = 16.77 mi^2 = 4.6752948 x 10^8 ft^2
and the NRCS Sedimentation Rate Standard equals 1/8 inch over 50 yrs, then
Sediment Volume = (4.67529480 x 10^8 ft^2 * 1/8 inch)/12 inches = 4,870,100.31 ft^3;

Therefore the predicted amount of sediment in Indian Creek Dam at 1/8 inch over 50 years = (4,870,100.31 ft^3 * 28,316.8467117 cm^3) = 1.379058839 x 10^{11} cm^3.

If you compare this to the calculated annual sedimentation rate from observed data entering Indian Creek Dam which equals 35,684,110 g/yr * (2.60 g/cm^3)$^{-1}$ = 13,724,657.69 cm^3/yr, then the calculated sediment accumulation rate from observed data entering Indian Creek Dam over 50 years equals (13,724,657.69 cm^3/yr * 50 yrs) = 686,232,884.6 cm^3.

Using a sedimentation rate standard of 1/8 inch over 50 years, Indian Creek Dam's predicted sediment accumulation rate could be 1.379058839 x 10^{11} cm^3. When compared with the current sedimentation accumulation rate into the reservoir over 50 years of

686,232,884.6 cm^3, Indian Creek Dam appears to be well under the predicted sedimentation rate standard.

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 should 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).

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. Indian Creek Dam's TMDL addresses seasonality because the BATHTUB model incorporates seasonal differences in its prediction of annual total phosphorus and nitrogen loadings.

7.0 TMDL

The table and sections below summarize the nutrient, sediment, and dissolved oxygen TMDLs for Indian Creek Dam in terms of loading capacity, waste load 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 = waste load 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

Table 13. Summary of the Phosphorus TMDL for Indian Creek Dam.

Category	Total Phosphorus (kg/yr)	Explanation
Existing Load	2,461.2	From observed data
Loading Capacity	1,230.6	50 percent total reduction based on BATHTUB modeling
Waste load Allocation	0.0	No point sources
Load Allocation	1,107.5	Entire loading capacity minus MOS is allocated to non-point sources
MOS	123.1	10% of the loading capacity (1,230.6 kg/yr) is reserved as an explicit margin of safety

Based on data collected from 2001 through 2004, the existing load to Indian Creek Dam is estimated at 2,461.2 kg. Assuming a 50% reduction based on BATHTUB and AnnAGNPS modeling results in Indian Creek Dam reaching a TMDL target total phosphorus concentration of 0.031 mg L^{-1}, then the TMDL or Loading Capacity is 1,230.6 kg. Assuming 10% of the loading capacity (1,230.6 kg/yr) is assigned to the MOS and there are no point sources in the watershed, all of the remaining loading capacity (1,107.5 kg/yr) is assigned to the load allocation.

7.2 Sediment TMDL

No reduction necessary. It is the recommended that Indian Creek Dam be de-listed for sediment.

7.3 Dissolved Oxygen TMDL

As a result of the direct influence of eutrophication on increased biological oxygen demand and microbial respiration, it is anticipated that meeting the phosphorus load reduction target in Indian Creek Dam will address the dissolved oxygen impairment. A reduction in total phosphorus load to Indian Creek Dam would be expected to lower algal biomass levels in the water column thereby reducing the biological oxygen demand exerted by the decomposition of these primary producers. The reduction in biological oxygen demand is therefore assumed to result in attainment of the dissolved oxygen standard.

8.0 ALLOCATION

This TMDL will be implemented by several parties on a volunteer basis. Phosphorus loads into the reservoir will be reduced by 50 % through treatment of the AnnAGNPS identified critical areas (Figure 12). There are 99 cells within the Indian Creek Dam watershed ranging in size from 1 to 120 acres that were identified as “critical” by AnnAGNPS modeling. Critical areas in the watershed appear green, and were valued at 0.10- 0.77% phosphorus as a percentage of total phosphorus. Highly critical areas are distinguished by red cells valued at 0.78 - 3.1%

phosphorus as a percentage of total phosphorus. These cells represent a total area of 2,024.89 (cropland) and 124.94 (pasture/rangeland) acres, or 20% of the entire watershed. If the watershed critical areas can be treated with BMPs like CRP, no-till, nutrient management systems, grazing systems, etc., then the specified reduction is possible. Also, by effectively utilizing hypolimnetic withdrawal techniques according to recommendations from the NDDoH and the North Dakota Game and Fish Department, there will be an additional phosphorus load reduction and possible added improvement in dissolved oxygen levels during the winter.

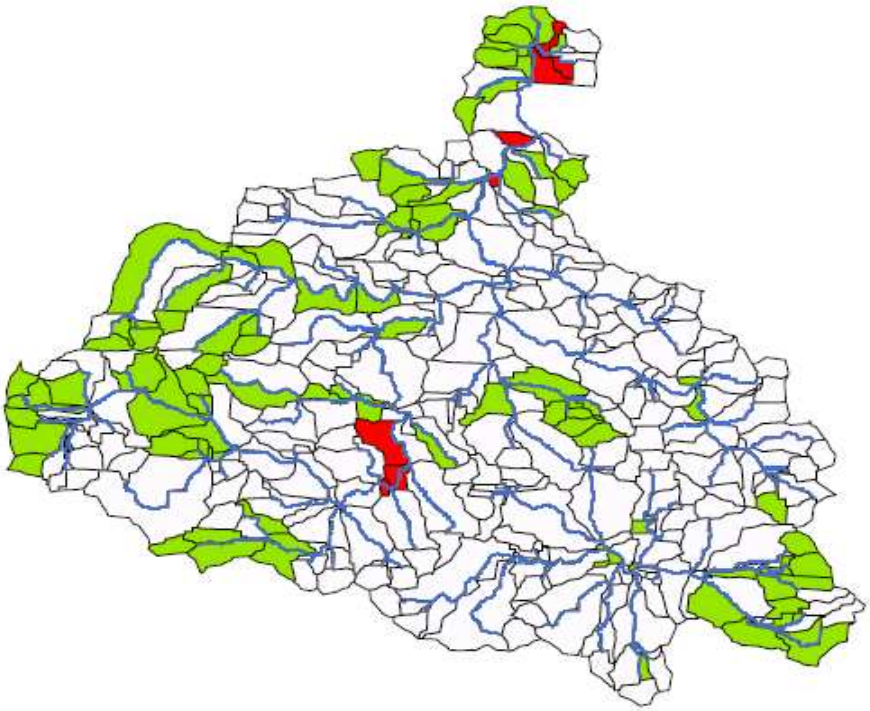


Figure 12. AnnAGNPS Identification of Critical Areas for BMP Implementation.

9.0 PUBLIC PARTICIPATION

To satisfy the public participation requirement of this TMDL, a hard copy of the TMDL for Indian Creek Dam and a request for comment was mailed to participating agencies, partners, and to those who requested a copy. Those included in the mailing of a hard copy are as follows:

- Hettinger County Soil Conservation District
- Hettinger County Water Resource Board
- Natural Resource Conservation Service (Hettinger County Field Office)
- U.S. Environmental Protection Agency, Region 8
- U.S. Fish & Wildlife Service

In addition to mailing copies of the draft Indian Creek Dam TMDL report to interested parties, the TMDL was posted on the North Dakota Department of Health web site at http://www.health.state.nd.us/wq/ and a 30-day public notice soliciting comment and participation was published in the following newspapers:

- The Herald (New England), published September 1, 2006
- Dickinson Press, published September 1, 2006
- The Bismarck Tribune, published September 1, 2006

The public comment period concluded November 3, 2006. Comments were received from the U.S Environmental Protection Agency (EPA) and the U.S. Fish and Wildlife Service (USFWS). Formal written comments submitted to the NDDoH can be found in Appendices D and E. The Department's response to all comments received is provided in Appendix F.

10.0 MONITORING

To insure that the implementation of BMPs will reduce phosphorus levels and result in a corresponding increase in dissolved oxygen, water quality monitoring will be conducted in accordance with an approved Quality Assurance Project Plan (QAPP).

Specifically, monitoring will be conducted for all variables that are currently causing impairments to the beneficial uses of the waterbody. These include, but are not limited to nutrients (i.e., nitrogen and phosphorus) and dissolved oxygen. Once a watershed restoration plan (e.g. Clean Water Act Section 319 Project Implementation Plan) is implemented, monitoring will be conducted in the lake/reservoir beginning two years after implementation and extending 5 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 ND Nonpoint Source Pollution Task Force and EPA for approval. The implementation of the best management practices contained in the NPS pollution management project 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. Quality Assurance Project Plans (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.

12.0 ENDANGERED SPECIES ACT COMPLIANCE

States are encouraged to participate with the USFWS and EPA in documenting threatened and endangered species on the Endangered Species List. In an effort to assist in Endangered Species Act compliance, a request for a list of endangered and/or threatened species was made to the USFWS (Figures 13 and 14). A hard copy of the draft TMDL report was also sent to the USFWS Bismarck, North Dakota office for review.

The following is a list of threatened or endangered species specific to Hettinger County. While potentially present in Hettinger County, these species may or may not use habitats directly associated with Indian Creek Dam and its watershed.

- Whooping crane (Grus Americana), Endangered
- Black-footed ferret (Mustela nigripes), Endangered
- Bald eagle (Haliaeetus leucocephalus), Threatened

On October 25, 2006 the NDDoH received comments from the USFWS which included an assessment stating that the proposed TMDL will have “no effect” on federally listed threatened or endangered species and “no adverse modification” to proposed or designated critical habitat. The department concurs with this "no effect" determination regarding this proposed TMDL.

U.S. Fish & Wildlife Service
3425 Miriam Avenue
Bismarck, North Dakota 58501

OFFICE TRANSMITTAL

To: Paul Keeney
Regional TMDL/Watershed Liaison
Division of Water Quality
ND Department of Health
Bismarck, ND

☐ Action
☒ Information

From: Kevin Johnson Division: Ecological Services Date: 5-5-06

As requested in your letter of April 24, 2006, enclosed find a list of the threatened and endangered species and designated critical habitat for the counties of Grant, Hettinger and Williams. These lists are to help in your development of Total Maximum Daily Loads for several watersheds in western and southwestern North Dakota.

If you need anything else, please feel free to give us a call.

RECEIVED
MAY 08 2006
DIV. OF WATER QUALITY

Figure 13. Office Transmittal Received from U.S. Fish & Wildlife Service.

FEDERAL THREATENED AND ENDANGERED SPECIES
FOUND IN HETTINGER COUNTY
NORTH DAKOTA
May 2006

ENDANGERED SPECIES

Birds

Whooping crane (Grus Americana): Migrates through west and central counties during spring and fall. Prefers to roost on wetlands and stockdams with good visibility. Young adult summered in North Dakota in 1989, 1990, and 1993. Total population 140-150 birds.

Mammals

Black-footed ferret (Mustela nigripes): Exclusively associated with prairie dog towns. No records of occurrence in recent years, although there is potential for reintroduction in the future.

THREATENED SPECIES

Birds

Bald eagle (Haliaeetus leucocephalus): Migrates spring and fall statewide but primarily along the major river courses. It concentrates along the Missouri River during winter and is known to nest in the floodplain forest.

Figure 14. Threatened and Endangered Species List.

13.0 REFERENCES

Carlson, R.C. 1977. *A Trophic State Index for Lakes*. Limnology and Oceanography. 22:361-369.

Carlson, R.C. and J. Simpson. 1996. *A Coordinators Guide to Volunteer Lake Monitoring Methods*. North American Lake Management Society.

Chapra, S. 1997. *Surface Water-Quality Monitoring*. The McGraw Hill Companies, Inc.

Dodds, W. K. 2002. Freshwater Ecology: Concepts and Environmental Applications. Academic Press, San Diego, California.

Forester, Deborah L., 2000 *Water Quality in the Credit River: 1964 to 1998*. M.A. Department of Geography/Institute for Environmental Studies, University of Toronto.

Hutchinson, G.E. 1973. *Eutrophication. The Scientific Background of a Contemporary Practical Problem.* American Science. 61:269-279.

MacDonald, L.H., A. Smart, and R.C. Wissmar. 1991. *Monitoring guidelines to evaluate effects of forestry activities on streams in the Pacific Northwest and Alaska*. EPA Publication EPA/910/9-91-001. U.S. Environmental Protection Agency Region 10, Seattle, WA.

Middlebrooks, E.J. Falkenborg, D.H. Maloney, T.E. 1997. *Modeling the Eutrophication Process*. Ann Arbor Science Publishers Inc. Ann Arbor, MI.

Mulholland, P.J. and Elwood, J.W. 1982. *The role of lake and reservoir sediments as sinks in the perturbed global carbon cycle*. Tellus, v. 34, pp. 490-499.

NCDC. 2004. *US Monthly Precipitation for Cooperative and National Weather Service Sites* [Online]. National Climatic Data Center. Available at http://lwf.ncdc.noaa.gov/oa/climate/online/coop-precip.html.

NDAWN. 2006. *US Monthly Average Air Temperature and Precipitation Tables* [Online]. North Dakota Agricultural Weather Network. Available at http://ndawn.ndsu.nodak.edu/

NDDoH. 1993. *North Dakota Lake Assessment Atlas*. North Dakota Department of Health, Division of Water Quality. Bismarck, North Dakota.

NDDoH. 2001. *Standards of Quality for Waters of the State.* Chapter 33-16-02 of the North Dakota Century Code. North Dakota Department of Health, Division of Water Quality. Bismarck, North Dakota.

NDDoH. 2004. *North Dakota 2004 Integrated Section 305(b) Water Quality Assessment Report and Section 303(d) List of Waters Needing Total Maximum Daily Loads.* North Dakota Department of Health, Division of Water Quality. Bismarck, North Dakota.

NDDoH. 1991. *Standards of Water Quality for the State of North Dakota*. Bismarck, North Dakota. 29 pp.

Nürnberg, Gertrud K., 1995. Quantifying Anoxia in Lakes. *Limnology and Oceanography* 40: 1100-1111.

Nürnberg, Gertrud, K., 1995. The Anoxic Factor, a Quantitative Measure of Anoxia and Fish Species Richness in Central Ontario Lakes. *Transactions of the American Fisheries Society* 124: 677-686.

Nürnberg, Gertrud, K., 1997. Coping with Water Quality Problems due to Hypolimnetic Anoxia in Central Ontario Lakes. *Water Qual. Res. J. Canada* 32: 391-405.

Nürnberg, Gertrud, K., 1998. Trophic State of Clear and Colored, Soft and Hardwater Lakes with Special Consideration of Nutrients, Anoxia, Phytoplankton and Fish. *Journal of Lake and Reservoir Management* 12: 432-447

Thorton, Kent W, Kimmel, Bruce , Payne, Forrest E 1990, *Resevoir Limnology: Ecological Perspectives*. Wiley-Interscience Publication. New York.

Tunney, H. Carton O.T. 1997. *Phosphorus Loss from Soil to Water*. Cab International. New York, NY.

Vollenweider, R.A. 1968. *Scientific Fundamentals of the Eutrophication of Lakes and lowing Waters, with Particular Reference to Nitrogen and Phosphorus as Factors in Eutrophication.* Technical Report DAS/CSI/68.27, Organization for Economic Cooperation and Development, Paris.

Walker, W.W. 1996. *Simplified Procedures for Eutrophication Assessment and Prediction: User Manual*. Instruction Report W-96-2. U.S. Army Corps of Engineer Waterways Experiment Station, Vicksburg, MS.

Waters, T.F. 1995. *Sediment in streams--Sources, biological effects, and control*. American Fisheries Society, Monograph 7. Bethesda, Maryland.

Wetzel, R.G. 1983, *Limnology*. 2nd ed. Saunders College Publishing. Fort Worth, TX.

Appendix A

A Calibrated Trophic Response Model (Bathtub) for Indian Creek Dam
As a Tool to Evaluate Various Nutrient Reduction Alternatives
Based on Anne-AGNPS Modeling and Data Collected by the Hettinger County Soil Conservation District from
October 16, 2001 through February 16, 2005
Prepared by
Peter Wax
July 11, 2006

Introduction

In order to meet the project goals, as set forth by the project sponsors of identifying possible options to improve the trophic condition of Indian Creek Dam to levels capable of maintaining the reservoirs beneficial uses (e.g., fishing, recreation, and drinking water supply), and the objectives of this project, which are to: (1) develop a nutrient and sediment budget for the reservoir; (2) identify the primary sources and causes of nutrients and sediments to the reservoir; and (3) examine and make recommendations for reservoir restoration measures which will reduce documented nutrient and sediment loadings to the reservoir, a calibrated trophic response model was developed for Indian Creek Dam. The model enables investigations into various nutrient reduction alternatives relative to the project goal of improving Indian Creek Dam's trophic status. The model will allow resource managers and the public to relate changes in nutrient loadings to the trophic condition of the reservoir and to set realistic lake restoration goals that are scientifically defensible, achievable and socially acceptable.

Methods

For purposes of this project, the BATHTUB program was use to predict changes in trophic status based on changes in nutrient loading. The BATHTUB program, developed by the US Army Corps of Engineers Waterways Experiment Station (Walker 1996), applies an empirically derived eutrophication model to reservoirs. The 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 are summarized, or reduced, in a format which can serve as inputs to the model. The following is a brief explanation of the computer software, methods, and procedures used to complete each of these phases.

Tributary Data

Watershed hydraulic and pollutant loads were estimated using actual water quality data and the annualized agricultural nonpoint source (AnnAGNPS) model. The AnnAGNPS model was developed by the US Department of Agriculture's Agriculrural Research Services to model relative quantity and quality of outflow from a watershed in order to assess there pollution potential.

The AnnAGNPS model identified six subwatersheds entering Indian Creek dam ranging in size from 0.11 to 13.06 square kilometers for a total watershed size 37.57 square kilometers including the lake surface. Model outputs include hydraulic, and soluble and sediment attached nutrient loads from each subwatershed as well as the lake outlet. Since the bathtub model also requires the load of total nitrogen and total phosphorus these were calculated as a ratio the soluble load. The ratios were calculated from 42 inlet samples and 74 outlet samples collected between October 16, 2001 and February 16, 2005. These data were then provided as an input data to calibrate the BATHTUB eutrophication response model.

Lake Data

Indian Creek Dam's in-lake water quality data was reduced using Microsoft Excel. The data was reduced in excel to provide three computational functions, including: (1) the ability to display constitute concentrations as a function of depth, location, and/or date; (2) calculate summary statistics (e.g., mean, median and standard error in the mixed layer of the lake or reservoir); and (3) track the temporal trophic status. The Excel program output data is used as input to calibrate the BATHTUB model.

Bathtub Model Calibration

As stated previously, the BATHTUB eutrophication model was selected for this project as a means of evaluating the effects of various nutrient reduction alternatives on the predicted trophic status of Indian Creek Dam. BATHTUB performs water and nutrient balance calculations in a steady-state. The BATHTUB model also allows the user to spatially segment the reservoir. Eutrophication related water quality variables (e.g., total phosphorus, total nitrogen, chlorophyll-*a*, secchi depth, organic nitrogen, orthophosphorous, and hypolimnetic oxygen depletion rate) are predicted using empirical relationships previously developed and tested for reservoir systems (Walker 1985).

Within the BATHTUB program the user can select from six schemes based on reservoir morphometry and the needs of the resource manager. Using BATHTUB the user can view the reservoir as a single spatially averaged reservoir or as single segmented reservoir. The user can also model parts of the reservoir, such as an embayment, or model a collection of reservoirs. For purposes of this project, Indian Creek Dam was modeled as a single, spatially averaged, reservoir.

Once input is provided to the model from FLUX and Excel the user can compare predicted conditions (i.e., model output) to actual conditions. Since BATHTUB uses a set of generalized rates and factors, predicted vs. actual conditions may differ by a factor of 2 or more using the initial, un-calibrated, model. These differences reflect a combination of measurement errors in the inflow and outflow data, as well as unique features of the reservoir being modeled.

In order to closely match an actual in-lake condition with the predicted condition, BATHTUB allows the user to modify a set of calibration factors (Table 1). For a complete description of the BATHTUB model the reader is referred to Walker (1996).

Table 1. Selected model parameters, number and name of model, and where appropriate the calibration factor used for Indian Creek Dam Bathtub Model.

Model Option	Model Selection	Calibration Factor
Conservative Substance	0 Not Computed	1.00
Phosphorus Balance	2 2nd Order, Decay	0.98
Phosphorus – Ortho P	2	0.85
Nitrogen Balance	5 Buchman Flushing	1.01
Organic Nitrogen	5	2.70
Chlorophyll-a	1 P, N, Low Turbidity	0.75
Secchi Depth	1 Vs. Chla & Turbidity	1.00
Phosphorus Calibration	2 Concentrations	NA
Nitrogen Calibration	2 Concentrations	NA
Availability Factors	0 ignore	NA
Mass-Balance Tables	0 Use Observed Concentrations	NA

Results

The trophic response model, BATHTUB, has been calibrated to match Indian Creek Dam's trophic response for the project period between October 16th, 2001 to Fenruary 16 2005. This is accomplished by combining AnnAGNPS annualized loading estimates for the hydrologic years 2001, 2002 and 2003 with in-lake water quality collected between October 16th, 2001 to Fenruary 16 2005.

Hydraulic and pollutant load for the project period is estimated by the USDA, ARS AnnAGNPS model and the corresponding in-lake water quality data are reduced utilizing Excel. The output from these two programs is then provided as input to the BATHTUB model. The model is calibrated through several iterations, first by selecting appropriate empirical relationships for model coefficients (e.g., nitrogen and phosphorus sedimentation, nitrogen and phosphorus decay, oxygen depletion, and algal/chlorophyll growth), and second by adjusting model calibration factors for those coefficients (Table 1). The model is termed calibrated when the predicted estimates for the trophic response variables are similar to observed estimates made from project monitoring data.

The two primary nutrients controlling trophic response in Indian Creek Dam are nitrogen and phosphorus. After calibration the observed average annual concentration of total nitrogen and total phosphorus compare well with those of the BATHTUB model. The model predicts that the reservoir has a three-year volume-weighted mean total phosphorus concentration of 0.0499 mg L^{-1} and a three-year volume-weighted total nitrogen concentration of 1.690 mg L^{-1} compared to observed values for total phosphorus and total nitrogen of 0.050 mg L^{-1} and 1.690 mg L^{-1}, respectively (Table 2).

Other measures of trophic response predicted by the model are average annual chlorophyll-a concentration and average secchi disk transparency. The calibrated model did just as good a job of predicting average chlorophyll-a concentration and secchi disk transparency within the reservoir as total phosphorus and total nitrogen (Table 2).

Once predictions of total phosphorus, chlorophyll-a, and secchi disk transparency are made, the model calculates Carlson's Trophic Status Index (TSI) (Carlson 1977) as a means of expressing predicted trophic response (Table 2). Carlson's TSI is an index that can be used to measure the relative trophic state of a lake or reservoir. Simply stated, trophic state is how much production (i.e., algal and weed growth) occurs in the waterbody. The lower the nutrient concentrations are within the waterbody the lower the production and the lower the trophic state or level. In contrast, increased nutrient concentrations in a lake or reservoir increase the production of algae and weeds which make the lake or reservoir more eutrophic or of a higher trophic state. Oligotrophic is the term which describes the least productive lakes and hypereutrophic is the term used to describe lakes and reservoirs with excessive nutrients and primary production.

Table 2. Observed and Predicted Values for Selected Trophic Response Variables for the Calibrated "BATHTUB" Model.

	Value	
Variable	Observed	Predicted
Total Phosphorus as P (mg/L)	0.050	0.0499
Total Dissolved Phosphorus (mg/L)	0.020	0.0199
Total Nitrogen as N (mg/L)	1.690	1.690
Organic Nitrogen as N (mg/L)	1.630	1.607
Chlorophyll-a (μg/L)	17.97	18.24
Secchi Disk Transparency (meters)	1.34	1.33
Carlson's TSI for Phosphorus	60.56	60.54
Carlson's TSI for Chlorophyll-a	58.94	59.08
Carlson's TSI for Secchi Disk	55.78	55.91

Figure 1 provides a graphic summary of the TSI range for each trophic level compared to values for each of the trophic response variables. The calibrated model provided predictions of trophic status which are similar to the observed TSI values for the project period (Table 2). Over all the predicted and observed TSI values for phosphorus, chlorophyll and secchi disk suggest Indian Creek Dam is eutrophic. Figure 2 is a graphic that shows the annual temporal distribution of Indian Creek Dam's trophic state based on the three parameters total phosphorus as phosphate, and chlorophyll-a concentrations and secchi disk depth transparency.

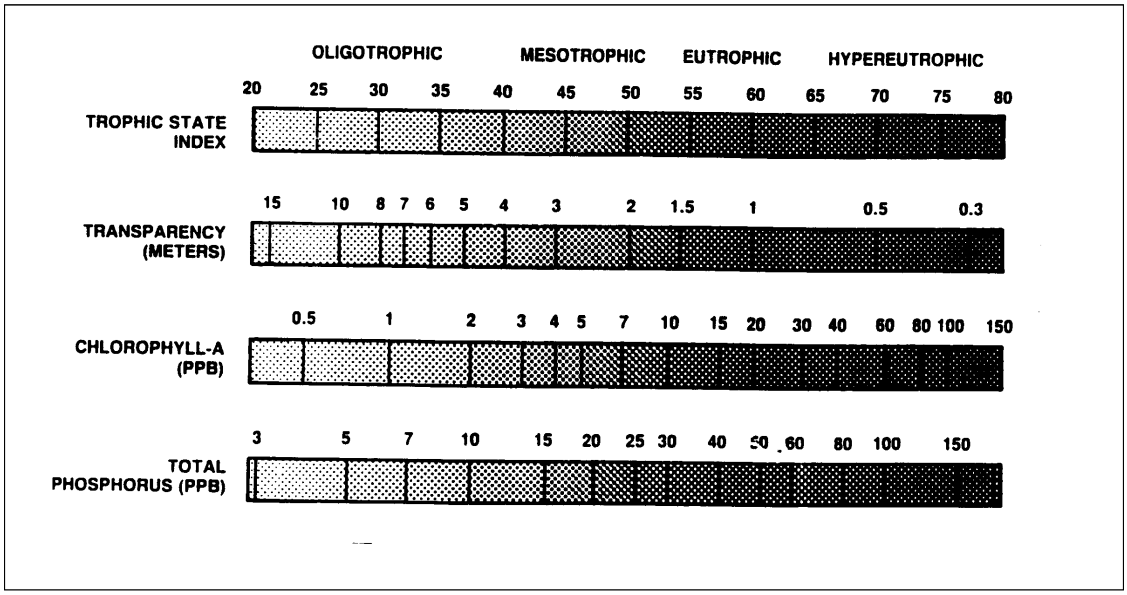


Figure 1. Graphic depiction of Carlson's Trophic Status Index

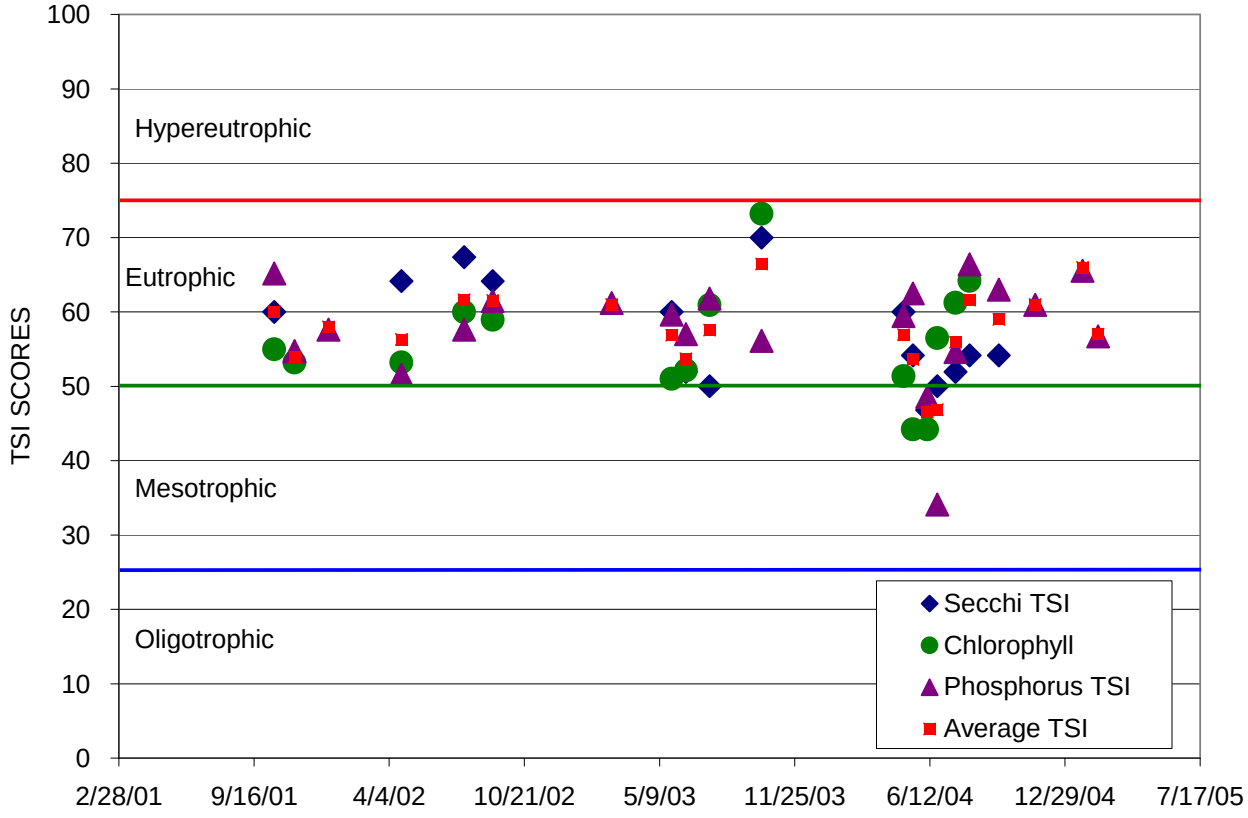


Figure 2. Temporal distribution of Carlosn's Trophic Status Index scores for Indian Creek Dam (10/16/2001 – 2/16/2005)

Model Predictions

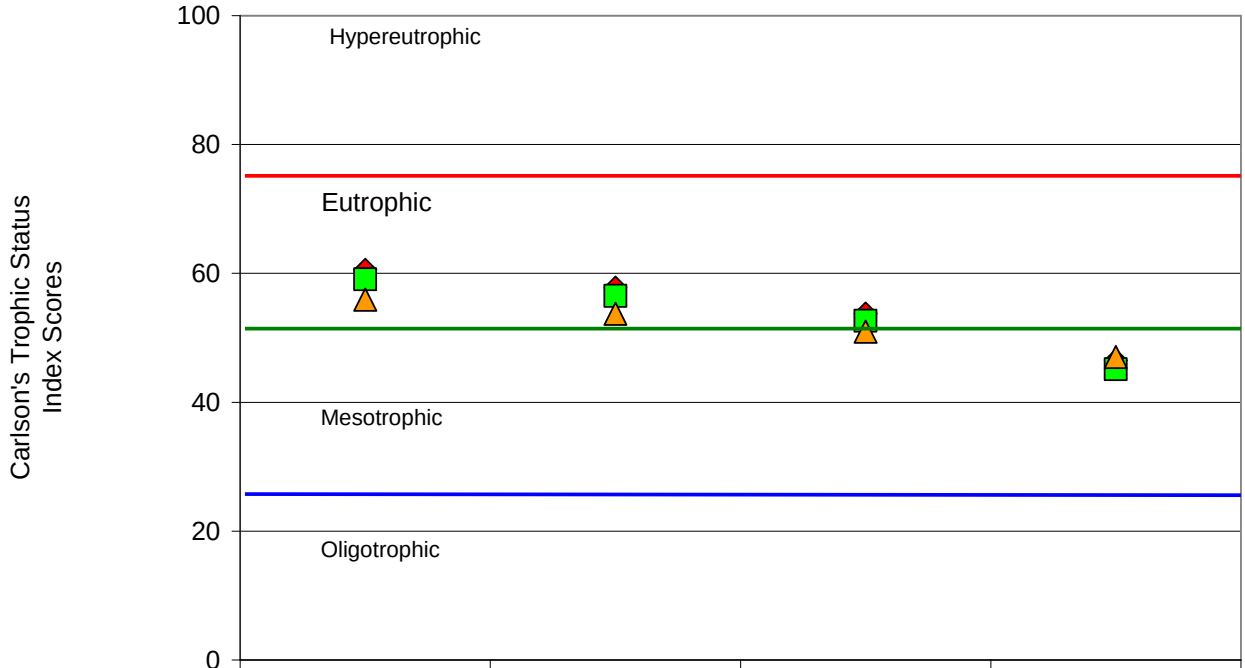
Once the model is calibrated to existing conditions, the model can be used to evaluate the effectiveness of any number of nutrient reduction or lake restoration alternatives. This evaluation is accomplished comparing predicted trophic state, as reflected by Carlson's TSI, with currently observed TSI values. Modeled nutrient reduction alternatives are presented in three basic categories: (1) reducing externally derived nutrient loads; (2) reducing internally available nutrients; and (3) reducing both external and internal nutrient loads. For Indian Creek Dam only external nutrient loads were addressed. External nutrient loads were addressed because they are known to cause eutrophication and because they are controllable through the implementation of watershed Best Management Practices (BMPs).

Predicted changes in trophic response to Indian Creek Dam were evaluated by reducing externally derived phosphorus loads by 25, 50, and 75 percent. These reductions were simulated in the model by reducing the phosphorus and nitrogen concentrations in the contributing tributary and other external delivery sources by 25, 50, and 75 percent. Since there is no reliable means of estimating how much hydraulic discharge would be reduced through the implementation of BMPs, flow was held constant.

The model results indicate that if it were possible to reduce external phosphorus loading to Indian Creek Dam by 50 percent the average annual total phosphorus concentrations in the lake would decrease significantly (Table 3, Figure 3). With a 50 percent reduction in external phosphorus and nitrogen load, the model predicts a reduction in Carlson's TSI score from 60.54 to 53.75 for total phosphorus, 58.94 to 52.66 for chlorophyll-a, and from 55.78 to 50..96 for secchi disk transparency, corresponding to a trophic response from state of eutrophic to borderline mesotrophic.

Table 3. Calibrated model, and Predicted Values for Selected Trophic Response Variables Assuming a 25, 50, and 75 Percent Reduction in External Phosphorus and Nitrogen Loading.

		Predicted		
Variable	Calibrated	25 %	50 %	75 %
Total Phosphorus as P (mg/L)	0.050	0.041	0.031	0.019
Total Dissolved Phosphorus (mg/L)	0.020	0.017	0.014	0.010
Total Nitrogen as N (mg/L)	1.690	1.274	0.858	0.442
Chlorophyll-a (μg/L)	18.24	14.03	9.47	4.39
Secchi Disk Transparency (meters)	1.34	1.54	1.87	2.46
Carlson's TSI for Phosphorus	60.54	57.78	53.75	46.47
Carlson's TSI for Chlorophyll-a	58.94	56.51	52.66	45.11
Carlson's TSI for Secchi Disk	55.78	53.74	50.96	47.05



	Calibrated	Less 25%	Less 50%	Less 75%
TSI-Phosphorus	60.54	57.78	53.75	46.47
TSI-Chlorophyll-a	59.08	56.51	52.66	45.11
TSI-Secchi	55.91	53.74	50.96	47.04

Figure 3. Predicted trophic response to phosphorus load reductions to Indian Creek Dam of 25, 50, and 75 Percent.

Appendix B

AnnAGNPS Model Data

2001

```
Totals at Outlet:
          Simulation Days            365
          Drainage Area        10733.931

Outlet                Y Y Y Y Y N         Y          10733.93  10733.93
          Water                                      228.2935
          Bed & Bank       0.0       0.0       0.0       0.0       0.0
          Gully            0.0       0.0       0.0       0.0       0.0
          Sheet&Rill    79.976    57.470     1.170       0.0       0.0
          Size Total    79.976    57.470     1.170       0.0       0.0
          Source Tot       0.0       0.0   138.616   138.616
          Nutrients       2.81      7.36      1.39       0.0      0.23      1.14

18        Upstream   Y Y Y Y Y N         Y           9231.22   9231.22
          Water                                      191.9862
          Bed & Bank       0.0       0.0       0.0       0.0       0.0
          Gully            0.0       0.0       0.0       0.0       0.0
          Sheet&Rill    66.130    80.926     1.419       0.0       0.0
          Size Total    66.130    80.926     1.419       0.0       0.0
          Source Tot       0.0       0.0   148.475   148.475
          Nutrients       2.14      5.96      1.05       0.0      0.16      0.76

19        Upstream   Y Y Y Y Y N         Y            431.24    472.75
          Water                                       3.5461
          Bed & Bank       0.0       0.0       0.0       0.0       0.0
          Gully            0.0       0.0       0.0       0.0       0.0
          Sheet&Rill     3.613     5.901     1.276       0.0       0.0
          Size Total     3.613     5.901     1.276       0.0       0.0
          Source Tot       0.0       0.0    10.790    10.790
          Nutrients       0.09      0.09      0.04       0.0  0.20E-02  0.63E-02

29        Upstream   Y Y Y Y Y N         Y             23.25     26.06
          Water                                       1.5021
          Bed & Bank       0.0       0.0       0.0       0.0       0.0
          Gully            0.0       0.0       0.0       0.0       0.0
          Sheet&Rill     0.259     0.118     0.047       0.0       0.0
          Size Total     0.259     0.118     0.047       0.0       0.0
          Source Tot       0.0       0.0     0.424     0.424
          Nutrients   0.30E-02      0.02  0.13E-02       0.0  0.34E-04  0.19E-02

32        Upstream   Y Y Y Y Y N         Y            949.15   1095.66
          Water                                      10.8739
          Bed & Bank       0.0       0.0       0.0       0.0       0.0
          Gully            0.0       0.0       0.0       0.0       0.0
          Sheet&Rill     6.553     9.456     0.526       0.0       0.0
          Size Total     6.553     9.456     0.526       0.0       0.0
          Source Tot       0.0       0.0    16.535    16.535
          Nutrients       0.14      0.22      0.07       0.0  0.56E-02      0.02

55        Upstream   Y Y Y Y Y N         Y           3040.76   3129.89
          Water                                      54.1464
          Bed & Bank       0.0       0.0       0.0       0.0       0.0
          Gully            0.0       0.0       0.0       0.0       0.0
          Sheet&Rill    28.223    51.603     7.186       0.0       0.0
          Size Total    28.223    51.603     7.186       0.0       0.0
```

```
          Source Tot       0.0       0.0    87.012    87.012
          Nutrients       0.73      1.70      0.34       0.0      0.04      0.20

116       Upstream   Y Y Y Y Y N         Y             22.41     33.01
          Water                                      0.0016
          Bed & Bank       0.0       0.0       0.0       0.0       0.0
          Gully            0.0       0.0       0.0       0.0       0.0
          Sheet&Rill     0.212     0.518     0.065       0.0       0.0
          Size Total     0.212     0.518     0.065       0.0       0.0
          Source Tot       0.0       0.0     0.794     0.794
          Nutrients   0.18E-02  0.25E-03  0.78E-03       0.0  0.20E-04  0.57E-04

117       Upstream   Y Y Y Y Y N         Y           3207.70   3207.70
          Water                                     70.8736
          Bed & Bank       0.0       0.0       0.0       0.0       0.0
          Gully            0.0       0.0       0.0       0.0       0.0
          Sheet&Rill    20.290    29.634     0.272       0.0       0.0
          Size Total    20.290    29.634     0.272       0.0       0.0
          Source Tot       0.0       0.0    50.196    50.196
          Nutrients       0.83      2.60      0.42       0.0      0.07      0.40

174       Upstream   Y Y Y Y Y N         Y            958.62    989.44
          Water                                     32.1073
          Bed & Bank       0.0       0.0       0.0       0.0       0.0
          Gully            0.0       0.0       0.0       0.0       0.0
          Sheet&Rill    11.696    19.784     3.918       0.0       0.0
          Size Total    11.696    19.784     3.918       0.0       0.0
          Source Tot       0.0       0.0    35.398    35.398
          Nutrients       0.51      1.09      0.25       0.0      0.03      0.15
```

2002

```
Totals at Outlet:
          Simulation Days            365
          Drainage Area        10733.931

Outlet               Y Y Y Y Y N         Y          10733.93  10733.93
          Water                                     427.2376
          Bed & Bank       0.0       0.0       0.0       0.0       0.0
          Gully            0.0       0.0       0.0       0.0       0.0
          Sheet&Rill    29.748    26.794     0.241       0.0       0.0
          Size Total    29.748    26.794     0.241       0.0       0.0
          Source Tot       0.0       0.0    56.784    56.784
          Nutrients       1.41      9.41      0.74       0.0      0.14      0.69

18        Upstream   Y Y Y Y Y N         Y           9231.22   9231.22
          Water                                     364.3287
          Bed & Bank       0.0       0.0       0.0       0.0       0.0
          Gully            0.0       0.0       0.0       0.0       0.0
          Sheet&Rill    24.062    29.355     0.233       0.0       0.0
          Size Total    24.062    29.355     0.233       0.0       0.0
          Source Tot       0.0       0.0    53.650    53.650
          Nutrients       1.03      7.22      0.55       0.0      0.09      0.47

19        Upstream   Y Y Y Y Y N         Y            431.24    472.75
          Water                                     12.8179
          Bed & Bank       0.0       0.0       0.0       0.0       0.0
```

	Gully		0.0	0.0	0.0	0.0	0.0	
	Sheet&Rill		1.052	1.771	0.028	0.0	0.0	
	Size Total		1.052	1.771	0.028	0.0	0.0	
	Source Tot		0.0	0.0	2.850	2.850		
	Nutrients		0.02	0.13	0.01	0.0	0.75E-03	0.31E-02
29	Upstream	Y Y Y Y Y N			Y	23.25	26.06	
	Water					2.4379		
	Bed & Bank		0.0	0.0	0.0	0.0	0.0	
	Gully		0.0	0.0	0.0	0.0	0.0	
	Sheet&Rill		0.159	0.074	0.031	0.0	0.0	
	Size Total		0.159	0.074	0.031	0.0	0.0	
	Source Tot		0.0	0.0	0.264	0.264		
	Nutrients		0.18E-02	0.02	0.81E-03	0.0	0.21E-04	0.14E-02
32	Upstream	Y Y Y Y Y N			Y	949.15	1095.66	
	Water					30.3254		
	Bed & Bank		0.0	0.0	0.0	0.0	0.0	
	Gully		0.0	0.0	0.0	0.0	0.0	
	Sheet&Rill		1.780	2.797	0.317	0.0	0.0	
	Size Total		1.780	2.797	0.317	0.0	0.0	
	Source Tot		0.0	0.0	4.894	4.894		
	Nutrients		0.11	0.54	0.06	0.0	0.48E-02	0.02
55	Upstream	Y Y Y Y Y N			Y	3040.76	3129.89	
	Water					108.9848		
	Bed & Bank		0.0	0.0	0.0	0.0	0.0	
	Gully		0.0	0.0	0.0	0.0	0.0	
	Sheet&Rill		8.246	13.651	0.977	0.0	0.0	
	Size Total		8.246	13.651	0.977	0.0	0.0	
	Source Tot		0.0	0.0	22.874	22.874		
	Nutrients		0.33	2.08	0.17	0.0	0.02	0.12
116	Upstream	Y Y Y Y Y N			Y	22.41	33.01	
	Water					0.2996		
	Bed & Bank		0.0	0.0	0.0	0.0	0.0	
	Gully		0.0	0.0	0.0	0.0	0.0	
	Sheet&Rill		0.099	0.243	0.0	0.0	0.0	
	Size Total		0.099	0.243	0.0	0.0	0.0	
	Source Tot		0.0	0.0	0.343	0.343		
	Nutrients		0.83E-03	0.27E-02	0.37E-03	0.0	0.93E-05	0.61E-04
117	Upstream	Y Y Y Y Y N			Y	3207.70	3207.70	
	Water					134.9697		
	Bed & Bank		0.0	0.0	0.0	0.0	0.0	
	Gully		0.0	0.0	0.0	0.0	0.0	
	Sheet&Rill		7.578	9.884	0.434	0.0	0.0	
	Size Total		7.578	9.884	0.434	0.0	0.0	
	Source Tot		0.0	0.0	17.896	17.896		
	Nutrients		0.38	3.08	0.21	0.0	0.05	0.25
174	Upstream	Y Y Y Y Y N			Y	958.62	989.44	
	Water					43.4783		
	Bed & Bank		0.0	0.0	0.0	0.0	0.0	
	Gully		0.0	0.0	0.0	0.0	0.0	
	Sheet&Rill		3.865	5.724	0.049	0.0	0.0	
	Size Total		3.865	5.724	0.049	0.0	0.0	
	Source Tot		0.0	0.0	9.639	9.639		
	Nutrients		0.18	1.17	0.09	0.0	0.02	0.09

2003

Totals at Outlet:

	Simulation Days		365				
	Drainage Area		10733.931				
Outlet		Y Y Y Y Y N		Y	10733.93	10733.93	
	Water				76.5432		
	Bed & Bank	0.0	0.0	0.0	0.0	0.0	
	Gully	0.0	0.0	0.0	0.0	0.0	
	Sheet&Rill	8.374	2.189	0.051	0.0	0.0	
	Size Total	8.374	2.189	0.051	0.0	0.0	
	Source Tot	0.0	0.0	10.614	10.614		
	Nutrients	0.19	3.11	0.09	0.0	0.07	0.38
18	Upstream	Y Y Y Y Y N		Y	9231.22	9231.22	
	Water				62.7361		
	Bed & Bank	0.0	0.0	0.0	0.0	0.0	
	Gully	0.0	0.0	0.0	0.0	0.0	
	Sheet&Rill	6.968	5.604	0.058	0.0	0.0	
	Size Total	6.968	5.604	0.058	0.0	0.0	
	Source Tot	0.0	0.0	12.630	12.630		
	Nutrients	0.15	2.50	0.07	0.0	0.04	0.24
19	Upstream	Y Y Y Y Y N		Y	431.24	472.75	
	Water				1.0313		
	Bed & Bank	0.0	0.0	0.0	0.0	0.0	
	Gully	0.0	0.0	0.0	0.0	0.0	
	Sheet&Rill	0.336	0.370	0.035	0.0	0.0	
	Size Total	0.336	0.370	0.035	0.0	0.0	
	Source Tot	0.0	0.0	0.741	0.741		
	Nutrients	0.71E-02	0.07	0.31E-02	0.0	0.68E-03	0.36E-02
29	Upstream	Y Y Y Y Y N		Y	23.25	26.06	
	Water				0.6992		
	Bed & Bank	0.0	0.0	0.0	0.0	0.0	
	Gully	0.0	0.0	0.0	0.0	0.0	
	Sheet&Rill	0.045	0.019	0.005	0.0	0.0	
	Size Total	0.045	0.019	0.005	0.0	0.0	
	Source Tot	0.0	0.0	0.070	0.070		
	Nutrients	0.52E-03	0.01	0.23E-03	0.0	0.59E-05	0.60E-03
32	Upstream	Y Y Y Y Y N		Y	949.15	1095.66	
	Water				3.2357		
	Bed & Bank	0.0	0.0	0.0	0.0	0.0	
	Gully	0.0	0.0	0.0	0.0	0.0	
	Sheet&Rill	0.725	0.599	0.064	0.0	0.0	
	Size Total	0.725	0.599	0.064	0.0	0.0	
	Source Tot	0.0	0.0	1.387	1.387		
	Nutrients	0.01	0.16	0.48E-02	0.0	0.19E-02	0.01
55	Upstream	Y Y Y Y Y N		Y	3040.76	3129.89	
	Water				16.4401		
	Bed & Bank	0.0	0.0	0.0	0.0	0.0	
	Gully	0.0	0.0	0.0	0.0	0.0	
	Sheet&Rill	2.649	4.821	0.649	0.0	0.0	
	Size Total	2.649	4.821	0.649	0.0	0.0	
	Source Tot	0.0	0.0	8.119	8.119		
	Nutrients	0.06	0.76	0.03	0.0	0.01	0.06

116	Upstream	Y Y Y Y Y N		Y		22.41	33.01	
	Water					0.0		
	Bed & Bank		0.0	0.0	0.0	0.0	0.0	
	Gully		0.0	0.0	0.0	0.0	0.0	
	Sheet&Rill		0.0	0.0	0.0	0.0	0.0	
	Size Total		0.0	0.0	0.0	0.0	0.0	
	Source Tot		0.0	0.0	0.0	0.0		
	Nutrients		0.0	0.0	0.0	0.0	0.0	0.0
117	Upstream	Y Y Y Y Y N		Y		3207.70	3207.70	
	Water					22.4872		
	Bed & Bank		0.0	0.0	0.0	0.0	0.0	
	Gully		0.0	0.0	0.0	0.0	0.0	
	Sheet&Rill		1.899	2.439	0.010	0.0	0.0	
	Size Total		1.899	2.439	0.010	0.0	0.0	
	Source Tot		0.0	0.0	4.348	4.348		
	Nutrients		0.05	1.08	0.02	0.0	0.02	0.12
174	Upstream	Y Y Y Y Y N		Y		958.62	989.44	
	Water					10.0687		
	Bed & Bank		0.0	0.0	0.0	0.0	0.0	
	Gully		0.0	0.0	0.0	0.0	0.0	
	Sheet&Rill		0.881	1.731	0.174	0.0	0.0	
	Size Total		0.881	1.731	0.174	0.0	0.0	
	Source Tot		0.0	0.0	2.785	2.785		
	Nutrients		0.02	0.32	0.78E-02	0.0	0.73E-02	0.04

Appendix C
Dissolved Oxygen and Temperature Raw Data

Dissolved Oxygen and Temperature Raw Data Table

Site #	Date	Depth (m)	Temp	DO
380765	10/16/2001	0.5	7.71	10.86
380765	10/16/2001	1	7.69	10.73
380765	10/16/2001	2	7.69	10.70
380765	10/16/2001	3	7.69	10.70
380765	10/16/2001	4	7.68	10.67
380765	10/16/2001	5	7.70	10.56
380765	11/15/2001	0.5	5.6	11.8
380765	11/15/2001	1	4.9	11.14
380765	11/15/2001	2	4.8	11.03
380765	11/15/2001	3	4.8	10.83
380765	11/15/2001	4	4.7	10.71
380765	11/15/2001	5	4.7	10.57
380765	11/15/2001	6	4.7	10.58
380765	11/15/2001	7	4.7	10.53
380765	01/04/2002	0.5	2.3	12.88
380765	01/04/2002	1	2.4	12.87
380765	01/04/2002	2	2.4	12.91
380765	01/04/2002	3	2.4	12.98
380765	01/04/2002	4	2.8	11.70
380765	01/04/2002	5	3.2	9.98
380765	01/04/2002	6	3.2	9.55
380765	01/04/2002	7	2.7	11.90
380765	01/04/2002	7.5	2.8	11.65
380765	04/22/2002	0.5	7.6	10.83
380765	04/22/2002	1	7.5	10.72
380765	04/22/2002	2	7.5	10.62
380765	04/22/2002	3	7.5	10.50
380765	04/22/2002	4	7.5	10.37
380765	04/22/2002	5	7.5	10.32
380765	04/22/2002	6	7.2	10.25
380765	04/22/2002	7	7.4	10.13
380765	07/24/2002	0.5	24.8	10.8
380765	07/24/2002	1	23.3	9.84
380765	07/24/2002	2	23.0	6.63
380765	07/24/2002	3	22.9	5.87
380765	07/24/2002	4	22.7	5.06
380765	07/24/2002	5	22.6	4.19
380765	09/04/2002	0.5	20.4	7.42
380765	09/04/2002	1	20.2	7.92
380765	09/04/2002	2	20.1	7.77

380765	09/04/2002	3	20.1	7.69
380765	09/04/2002	4	19.9	7.13
380765	09/04/2002	5	19.8	6.91
380765	09/04/2002	6	15.7	6.67
380765	02/27/2003	0.5	2.7	13.97
380765	02/27/2003	1	3.3	13.55
380765	02/27/2003	2	3.2	13.20
380765	02/27/2003	3	3.2	12.95
380765	02/27/2003	4	3.2	12.75
380765	02/27/2003	5	3.2	11.95
380765	02/27/2003	6	3.2	7.78
380765	05/27/2003	0.5	16.9	9.28
380765	05/27/2003	1	16.9	9.24
380765	05/27/2003	2	16.9	9.08
380765	05/27/2003	3	16.6	8.82
380765	05/27/2003	4	16.5	8.62
380765	05/27/2003	5	16.5	8.42
380765	05/27/2003	6	16.5	8.28
380765	05/27/2003	7	16.4	8.15
380765	05/27/2003	7.5	16.4	8.11
380765	06/07/2003	0.5	20.9	10.10
380765	06/07/2003	1	20.8	10.06
380765	06/07/2003	2	20.5	9.47
380765	06/07/2003	3	19.8	8.91
380765	06/07/2003	4	18.3	8.00
380765	06/07/2003	5	17.1	7.12
380765	06/07/2003	6	16.4	6.66
380765	06/07/2003	7	16.0	5.18
380765	07/22/2003	0.5	23.1	8.65
380765	07/22/2003	1	23.0	8.52
380765	07/22/2003	2	22.9	8.22
380765	07/22/2003	3	22.9	8.09
380765	07/22/2003	4	22.8	7.91
380765	07/22/2003	5	22.6	6.72
380765	07/22/2003	6	22.0	1.66
380765	07/22/2003	7	21.5	0.71
380765	10/07/2003	0.5	13.1	13.4
380765	10/07/2003	1	13.0	13.52
380765	10/07/2003	2	12.6	11.11
380765	10/07/2003	3	11.2	9.45
380765	10/07/2003	4	10.9	8.64
380765	10/07/2003	5	10.8	5.71
380765	10/07/2003	6	10.8	5.74
380765	10/07/2003	6.5	10.8	5.69
380765	05/04/2004	0.5	12.3	9.97
380765	05/04/2004	1	11.8	9.86
380765	05/04/2004	2	11.6	9.39
380765	05/04/2004	3	11.5	9.04

380765	05/04/2004	4	11.5	8.76
380765	05/04/2004	5	11.5	8.47
380765	05/04/2004	6	11.4	8.37
380765	05/04/2004	7	11.4	7.91
380765	05/18/2004	0.5	13.1	11.24
380765	05/18/2004	1	13.1	11.02
380765	05/18/2004	2	13.1	11.06
380765	05/18/2004	3	13.2	11.06
380765	05/18/2004	4	13.2	10.99
380765	05/18/2004	5	11.0	10.15
380765	05/18/2004	6	10.7	9.25
380765	05/18/2004	7	10.6	9.34
380765	06/08/2004	0.5	17.4	8.73
380765	06/08/2004	1	17.4	8.69
380765	06/08/2004	2	17.4	8.65
380765	06/08/2004	3	17.4	8.62
380765	06/08/2004	4	17.3	8.58
380765	06/08/2004	5	17.3	8.57
380765	06/08/2004	6	17.3	8.55
380765	06/08/2004	7	17.3	8.37
380765	06/23/2004	0.5	16.6	9.46
380765	06/23/2004	1	16.6	9.34
380765	06/23/2004	2	16.6	9.20
380765	06/23/2004	3	16.6	9.09
380765	06/23/2004	4	16.6	8.99
380765	06/23/2004	5	16.6	8.91
380765	06/23/2004	6	16.6	8.86
380765	07/20/2004	0.5	24.1	9.28
380765	07/20/2004	1	24.1	8.97
380765	07/20/2004	2	24.1	8.70
380765	07/20/2004	3	24.0	8.45
380765	07/20/2004	4	20.6	2.79
380765	07/20/2004	5	18.1	1.42
380765	07/20/2004	6	17.8	0.25
380765	07/20/2004	7	17.4	0.21
380765	07/20/2004	8	17.4	0.20
380765	08/09/2004	0.5	19.0	6.10
380765	08/09/2004	1	19.1	6.03
380765	08/09/2004	2	19.1	5.97
380765	08/09/2004	3	19.1	5.88
380765	08/09/2004	4	19.1	5.80
380765	08/09/2004	5	19.1	5.65
380765	08/09/2004	6	19.1	5.62
380765	08/09/2004	7	19.1	5.20
380765	09/22/2004	0.5	15.7	5.31
380765	09/22/2004	1	15.7	5.20
380765	09/22/2004	2	15.7	5.09
380765	09/22/2004	3	15.7	5.00

380765	09/22/2004	4	15.7	4.96
380765	09/22/2004	5	15.7	4.94
380765	09/22/2004	6	15.6	4.09
380765	11/15/2004	0.5	3.6	11.67
380765	11/15/2004	1	3.5	11.66
380765	11/15/2004	2	3.5	11.56
380765	11/15/2004	3	3.4	11.56
380765	11/15/2004	4	3.4	11.48
380765	11/15/2004	5	3.4	11.40
380765	11/15/2004	6	3.4	11.30
380765	01/24/2005	0.5	1.0	10.41
380765	01/24/2005	1	1.6	10.30
380765	01/24/2005	2	1.7	10.28
380765	01/24/2005	3	1.6	10.94
380765	01/24/2005	4	1.5	10.41
380765	01/24/2005	5	2.0	9.36
380765	01/24/2005	6	1.8	9.55
380765	01/24/2005	7	1.7	9.45
380765	02/16/2005	0.5	1.3	13.20
380765	02/16/2005	1	4.0	12.82
380765	02/16/2005	2	4.1	13.38
380765	02/16/2005	3	3.4	12.25
380765	02/16/2005	4	3.3	11.88
380765	02/16/2005	5	3.0	10.28
380765	02/16/2005	6	2.5	9.14

APPENDIX D
EPA Formal Comments

EPA REGION VIII TMDL REVIEW FORM

Document Name:	**Indian Creek Dam Nutrient and Dissolved Oxygen TMDLs**
Submitted by:	**Mike Ell, NDDoH**
Date Received:	**October 4, 2006**
Review Date:	**October 26, 2006**
Reviewer:	**Vern Berry, EPA**
Formal or Informal Review?	**Informal - Public Notice**

This document provides a standard format for EPA Region 8 to provide comments to the North Dakota Department of Health (NDDoH) on TMDL documents provided to the EPA for either official formal or informal review. All TMDL documents are measured against the following 12 review criteria:

1. Water Quality Impairment Status
2. Water Quality Standards
3. Water Quality Targets
4. Significant Sources
5. Technical Analysis
6. Margin of Safety and Seasonality
7. Total Maximum Daily Load
8. Allocation
9. Public Participation
10. Monitoring Strategy
11. Restoration Strategy
12. Endangered Species Act Compliance

Each of the 12 review criteria are described below to provide the rational for the review, followed by EPA's comments. This review is intended to ensure compliance with the Clean Water Act and also to ensure that the reviewed documents are technically sound and the conclusions are technically defensible.

1. Water Quality Impairment Status

Criterion Description – Water Quality Impairment Status

TMDL documents must include a description of the listed water quality impairments. While the 303(d) list identifies probable causes and sources of water quality impairments, the information contained in the 303(d) list is generally not sufficiently detailed to provide the reader with an adequate understanding of the impairments. TMDL documents should include a thorough description/summary of all available water quality data such that the water quality impairments are clearly defined and linked to the impaired beneficial uses and/or appropriate water quality standards.

- ☒ Satisfies Criterion
- ☐ Satisfies Criterion. Questions or comments provided below should be considered.
- ☐ Partially satisfies criterion. Questions or comments provided below need to be addressed.
- ☐ Criterion not satisfied. Questions or comments provided below need to be addressed.
- ☐ Not a required element in this case. Comments or questions provided for informational purposes.

SUMMARY – Indian Creek Dam (reservoir) is located near the town of Regent in Hettinger County, North Dakota. It is a 196.3 acre man-made impoundment on Indian Creek in the Lower Missouri River basin of North Dakota. Indian Creek and a few small, unnamed tributaries drain into the reservoir. Indian Creek Dam is listed on the State's 2004 303(d) list as impaired for aquatic life and recreational uses by nutrients/eutrophication, and for aquatic life for low dissolved oxygen and sedimentation/siltation. Approximately 10,733 acres of land drain to the reservoir from the watershed. Indian Creek Dam is classified as a Class 3 warm water fishery, and is listed as a high priority (i.e., 1A) for TMDL development. The majority of the land use in this watershed is agricultural (approximately 87 percent). Cropland acreage is approximately 77%, pastureland is approximately 7% and alfalfa/hay is approximately 1%.

2. Water Quality Standards

Criterion Description – Water Quality Standards

The TMDL document must include a description of all applicable water quality standards for all affected jurisdictions. TMDLs result in maintaining and attaining water quality standards. Water quality standards are the basis from which TMDLs are established and the TMDL targets are derived, including the numeric, narrative, use classification, and antidegradation components of the standards.

- ☒ Satisfies Criterion
- ☐ Satisfies Criterion. Questions or comments provided below should be considered.
- ☐ Partially satisfies criterion. Questions or comments provided below need to be addressed.
- ☐ Criterion not satisfied. Questions or comments provided below need to be addressed.
- ☐ Not a required element in this case. Comments or questions provided for informational purposes.

SUMMARY – Indian Creek Dam is impaired for dissolved oxygen and nutrients/eutrophication and sedimentation/siltation. The North Dakota Department of Health has set narrative water quality standards that apply to all surface waters of the state. The NDDoH narrative standards that apply to nutrients and sedimentation include:

"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." (See NDAC 33-16-02-08.1.a.(4))

"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." (See NDAC 33-16-02-08.1.e.)

In addition to the narrative standards, the NDDH has set a biological goal for all surface waters of the state:

"The biological condition of surface waters shall be similar to that of sites or waterbodies determined by the department to be regional reference sites." (See NDAC 33-16-02-08.2.a.)

Currently, North Dakota does not have a numeric standard for nutrients, however nutrient guidelines for lakes have been established. The nutrient guidelines for lakes are: NO3 as N = 0.25 mg/L; PO4 as P = 0.02 mg/L; and total phosphorous = 0.1 mg/L.

The numeric standard for dissolved oxygen is $\geq$ 5.0 mg/L (single sample minimum).

Other applicable water quality standards are included on pages 12 - 14 of the TMDL report.

3. Water Quality Targets

Criterion Description – Water Quality Targets

Quantified targets or endpoints must be provided to address each listed pollutant/water body combination. Target values must represent achievement of applicable water quality standards and support of associated beneficial uses. For pollutants with numeric water quality standards, the numeric criteria are generally used as the TMDL target. For pollutants with narrative standards, the narrative standard must be translated into a measurable value. At a minimum, one target is required for each pollutant/water body combination. It is generally desirable, however, to include several targets that represent achievement of the standard and support of beneficial uses (e.g., for a sediment impairment issue it may be appropriate to include targets representing water column sediment such as TSS, embeddeness, stream morphology, up-slope conditions and a measure of biota).

☐ Satisfies Criterion
☐ Satisfies Criterion. Questions or comments provided below should be considered.
☒ Partially satisfies criterion. Questions or comments provided below need to be addressed.
☐ Criterion not satisfied. Questions or comments provided below need to be addressed.
☐ Not a required element in this case. Comments or questions provided for informational purposes.

SUMMARY – The main water quality target for this TMDL is based on interpretation of narrative provisions found in State water quality standards. In North Dakota, algal blooms can limit contact and immersion recreation beneficial uses. Also algal blooms can deplete oxygen levels which can affect aquatic life uses. Several algal species are considered to be nuisance aquatic species. TSI measurements can be used to estimate how much algal production may occur in lakes. Therefore, TSI is used as a measure of the narrative standard in order to determine whether beneficial uses are being met.

Nutrient reduction response modeling was conducted with BATHTUB, an Army Corps of Engineers eutrophication response model. The results of the modeling show that a 50% reduction in external phosphorous loading to the reservoir will achieve a total phosphorous TSI of 53.75, which corresponds to a phosphorous concentration of 0.031 mg/L. This target is based on best professional judgement and will fully support its beneficial uses.

The TMDL does not contain a target for sediment because the assessment concludes that the reservoir is not impaired for sediment. The report recommends removing Indian Creek Dam sediment as a cause of impairment from the next Section 303(d) list.

The water quality targets used in this TMDL are: **maintain a mean annual total phosphorous TSI at or below 53.75; maintain a dissolved oxygen level of not less than 5 mg/L.**

COMMENTS – We recommend that the nutrient target be clearly stated in the first or second paragraph of Section 3.1 rather than the last paragraph. Further, we recommend that Section 3.1 be renamed "Nutrient Target" to correspond to the TMDL (i.e., "3.1 Nutrient Target" - matches the "Nutrient TMDL" in Section 7.1).

Section 3.0, TMDL Targets, do not mention a target for dissolved oxygen. Typically, when a pollutant has a numeric water quality standard, the TMDL target is equal to the numeric standard (e.g., DO $\geq$ 5.0 mg/L. We recommend that a brief section (e.g., "Section 3.2 – Dissolved Oxygen Target") be added to include a target for dissolved oxygen.

4. Significant Sources

Criterion Description – Significant Sources

TMDLs must consider all significant sources of the stressor of concern. All sources or causes of the stressor must be identified or accounted for in some manner. The detail provided in the source assessment step drives the rigor of the allocation step. In other words, it is only possible to specifically allocate quantifiable loads or load reductions to each significant source when the relative load contribution from each source has been estimated. Ideally, therefore, the pollutant load from each significant source should be quantified. This can be accomplished using site-specific monitoring data, modeling, or application of other assessment techniques. If insufficient time or resources are available to accomplish this step, a phased/adaptive management approach can be employed so long as the approach is clearly defined in the document.

- ☒ Satisfies Criterion
- ☐ Satisfies Criterion. Questions or comments provided below should be considered.
- ☐ Partially satisfies criterion. Questions or comments provided below need to be addressed.
- ☐ Criterion not satisfied. Questions or comments provided below need to be addressed.
- ☐ Not a required element in this case. Comments or questions provided for informational purposes.

SUMMARY – The TMDL identifies the major sources of phosphorous as coming from nonpoint source agricultural landuses within the watershed. In particular, a loading analysis was done for nutrients and sediment considering various agricultural land use and land management factors. Cropland and pastureland are the primary sources identified. Approximately 77% of the landuse is cropland and 7% is pastureland in the watershed.

5. Technical Analysis

Criterion Description – Technical Analysis

*TMDLs must be supported by an appropriate level of technical analysis. It applies to **all** of the components of a TMDL document. It is vitally important that the technical basis for **all** conclusions be articulated in a manner that is easily understandable and readily apparent to the reader. Of particular importance, the cause and effect relationship between the pollutant and impairment and between the selected targets, sources, TMDLs, and allocations needs to be supported by an appropriate level of technical analysis.*

☐ Satisfies Criterion
☐ Satisfies Criterion. Questions or comments provided below should be considered.
☒ Partially satisfies criterion. Questions or comments provided below need to be addressed.
☐ Criterion not satisfied. Questions or comments provided below need to be addressed.
☐ Not a required element in this case. Comments or questions provided for informational purposes.

SUMMARY – The technical analysis addresses the needed phosphorous reduction to achieve the desired water quality. The TMDL recommends a 50% reduction in external average annual total phosphorous loads to Indian Creek Dam. Based on the loads measured during the period of the assessment the total phosphorous load should be 1,230.6 kg/yr to achieve the proposed TP TSI target. This reduction is based in large part on the BATHTUB mathematical modeling of the reservoir and its predicted response to nutrient load reductions. The FLUX model was used to facilitate the analysis and reduction of tributary inflow and outflow nutrient and sediment loadings for Indian Creek Dam. Output from the FLUX program is then provided as an input file to calibrate the BATHTUB eutrophication response model.

The Annualized Agricultural Non-Point Source Model (AnnAGNPS) model was used to simulate alterations in land use practices and the resulting nutrient reduction response. The nutrient loading source analysis, that was used to identify necessary controls in the watershed, was based on the identification of critical cells and highly critical cells (i.e., those with higher phosphorous loading rates). The initial load reductions specified by this TMDL will be achieved through controls on the critical cells within the watershed to improve: pasture conditions, tillage practices or fertilizer management.

The technical analysis also addresses the Indian Creek Dam sediment listing. The analysis concludes that the reservoir is not impaired by sediment, and that it should be delisted from the state's Section 303(d) list. Justification for this action is based on: 1) the conclusion that the average total suspended solids (TSS) concentration in Indian Creek Dam (i.e., 13.2 mg/L) is below the values found in research studies to be harmful to aquatic life; and 2) the conclusion that the sediment accumulation rate in the Dam is well below the average sedimentation rate of typical reservoirs - based on calculations of sediment balance and accumulation rates in the reservoir compared to NRCS and literature values.

Improvements in the dissolved oxygen concentration of the reservoir can be achieved through reduction of organic loading to the reservoir as a result of proposed BMP implementation. The TMDL contains a linkage analysis between phosphorous loading and low dissolved oxygen in lakes and reservoirs. It is anticipated that meeting the phosphorous load reduction target in Indian Creek Dam will address the dissolved oxygen impairment.

COMMENTS – The dissolved oxygen linkage analysis should be moved from Section 7.3 and added to the DO technical analysis Section 5.4. We suggest that the third paragraph of Section 5.4 be moved, and modified as necessary, to Section 7.3.

6. Margin of Safety and Seasonality

Criterion Description – Margin of Safety and Seasonality

A margin of safety (MOS) is a required component of the TMDL that accounts for the uncertainty about the relationship between the pollutant loads and the quality of the receiving water body (303(d)(1)(c)). The MOS can be implicitly expressed by incorporating a margin of safety into conservative assumptions used to develop the TMDL. In other cases, the MOS can be built in as a separate component of the TMDL (in this case, quantitatively, a TMDL = WLA + LA + MOS). In all cases, specific documentation describing the rational for the MOS is required.

Seasonal considerations, such as critical flow periods (high flow, low flow), also need to be considered when establishing TMDLs , targets, and allocations.

☒ Satisfies Criterion
☐ Satisfies Criterion. Questions or comments provided below should be considered.
☐ Partially satisfies criterion. Questions or comments provided below need to be addressed.
☐ Criterion not satisfied. Questions or comments provided below need to be addressed.
☐ Not a required element in this case. Comments or questions provided for informational purposes.

SUMMARY – A 10% explicit margin of safety is specified in the nutrient TMDL of 123.1 kg/yr of phosphorous. Seasonality was adequately considered by evaluating the cumulative impacts of the various seasons on water quality and by proposing BMPs that can be tailored to seasonal needs.

7. TMDL

Criterion Description – Total Maximum Daily Load

TMDLs include a quantified pollutant reduction target. According to EPA regulations (see 40 CFR 130.2(i)). TMDLs can be expressed as mass per unit of time, toxicity, % load reduction, or other measure. TMDLs must address, either singly or in combination, each listed pollutant/water body combination.

☒ Satisfies Criterion
☐ Satisfies Criterion. Questions or comments provided below should be considered.
☐ Partially satisfies criterion. Questions or comments provided below need to be addressed.
☐ Criterion not satisfied. Questions or comments provided below need to be addressed.
☐ Not a required element in this case. Comments or questions provided for informational purposes.

SUMMARY – The TMDL established for Indian Creek Dam is a 1,230.6 kg/yr total phosphorus load to the reservoir (50% reduction in external annual total phosphorus load). This is the "measured load" which derived from the BATHTUB model using the flow and concentration data collected during the period of the assessment. The annual loading will vary from year-to-year; therefore, this TMDL is considered a long term average percent reduction in phosphorous loading. The TMDL contains a linkage

analysis between phosphorous loading and low dissolved oxygen in lakes and reservoirs. It is anticipated that meeting the phosphorous load reduction target in Indian Creek Dam will address the dissolved oxygen impairment.

8. Allocation

Criterion Description – Allocation

TMDLs apportion responsibility for taking actions or allocate the available assimilative capacity among the various point, nonpoint, and natural pollutant sources. Allocations may be expressed in a variety of ways such as by individual discharger, by tributary watershed, by source or land use category, by land parcel, or other appropriate scale or dividing of responsibility. A performance based allocation approach, where a detailed strategy is articulated for the application of BMPs, may also be appropriate for nonpoint sources. Every effort should be made to be as detailed as possible and also, to base all conclusions on the best available scientific principles.

In cases where there is substantial uncertainty regarding the linkage between the proposed allocations and achievement of water quality standards, it may be necessary to employ a phased or adaptive management approach (e.g., establish a monitoring plan to determine if the proposed allocations are, in fact, leading to the desired water quality improvements).

- ☒ Satisfies Criterion
- ☐ Satisfies Criterion. Questions or comments provided below should be considered.
- ☐ Partially satisfies criterion. Questions or comments provided below need to be addressed.
- ☐ Criterion not satisfied. Questions or comments provided below need to be addressed.
- ☐ Not a required element in this case. Comments or questions provided for informational purposes.

SUMMARY – This TMDL addresses the need to achieve further reductions in nutrients to attain water quality goals in Indian Creek Dam. The allocations in the TMDL include a "load allocation" attributed agricultural to nonpoint sources, and an explicit margin of safety. There are no known point source contributions in this watershed. The source allocations for phosphorous are assigned to the critical loading cells in the watershed that were identified by the AnnAGNPS model. The subwatershed areas with critical phosphorous loading are shown in Figure 12 of the TMDL. There is a desire to move forward with controls in the areas of the basin where there is confidence that phosphorous reductions can be achieved through modifications to critical cells within the watershed.

9. Public Participation

Criterion Description – Public Participation

The fundamental requirement for public participation is that all stakeholders have an opportunity to be part of the process. Notifications or solicitations for comments regarding the TMDL should clearly identify the product as a TMDL and the fact that it will be submitted to EPA for review. When the final TMDL is submitted to EPA for review, a copy of the comments received by the state should be also submitted to EPA.

- ☒ Satisfies Criterion
- ☐ Satisfies Criterion. Questions or comments provided below should be considered.
- ☐ Partially satisfies criterion. Questions or comments provided below need to be addressed.
- ☐ Criterion not satisfied. Questions or comments provided below need to be addressed.
- ☐ Not a required element in this case. Comments or questions provided for informational purposes.

SUMMARY – The TMDL includes a summary of the public participation process that has occurred. It describes the opportunities the public had to be involved in the TMDL development process. Copies of the draft TMDL were mailed to stakeholders in the watershed during public comment. Also, the draft

TMDL was be posted on NDoDH's Water Quality Division website, and a public notice for comment was published in three newspapers.

10. Monitoring Strategy

Criterion Description – Monitoring Strategy

TMDLs may have significant uncertainty associated with selection of appropriate numeric targets and estimates of source loadings and assimilative capacity. In these cases, a phased TMDL approach may be necessary. For Phased TMDLs, it is EPA's expectation that a monitoring plan will be included as a component of the TMDL documents to articulate the means by which the TMDL will be evaluated in the field, and to provide supplemental data in the future to address any uncertainties that may exist when the document is prepared.

☐ Satisfies Criterion
☒ Satisfies Criterion. Questions or comments provided below should be considered.
☐ Partially satisfies criterion. Questions or comments provided below need to be addressed.
☐ Criterion not satisfied. Questions or comments provided below need to be addressed.
☐ Not a required element in this case. Comments or questions provided for informational purposes.

SUMMARY – Future monitoring is recommended in Section 10.0 of the TMDL to address margin of safety and seasonality needs, as well as provide additional data to ensure that the goals of the TMDL are met.

COMMENTS – Monitoring is necessary to address margin of safety and seasonality needs, as well as provide additional data to ensure that the goals of the TMDL are met. Monitoring should continue until it can be demonstrated that water quality goals are achieved. We recommend that the monitoring period continue for at least 10 years after the BMPs are implemented (perhaps conducting monitoring every 3-5 years until the TMDL target is met).

11. Restoration Strategy

Criterion Description – Restoration Strategy

At a minimum, sufficient information should be provided in the TMDL document to demonstrate that if the TMDL were implemented, water quality standards would be attained or maintained. Adding additional detail regarding the proposed approach for the restoration of water quality is not currently a regulatory requirement, but is considered a value added component of a TMDL document.

☐ Satisfies Criterion
☐ Satisfies Criterion. Questions or comments provided below should be considered.
☐ Partially satisfies criterion. Questions or comments provided below need to be addressed.
☐ Criterion not satisfied. Questions or comments provided below need to be addressed.
☒ Not a required element in this case. Comments or questions provided for informational purposes.

SUMMARY – The North Dakota Department of Health will work with the local soil conservation district, local volunteer groups and landowners to initiate restoration projects in the watershed.

12. Endangered Species Act Compliance

Criterion Description – Endangered Species Act Compliance

EPA's approval of a TMDL may constitute an action subject to the provisions of Section 7 of the Endangered Species Act (ESA). EPA will consult, as appropriate, with the US Fish and Wildlife Service (USFWS) to determine if there is an effect on listed endangered and threatened species pertaining to EPA's approval of the TMDL. The responsibility to consult with the USFWS lies with EPA and is not a requirement under the Clean Water Act for approving TMDLs. States are encouraged, however, to participate with USFWS and EPA in the consultation process and, most importantly, to document in its TMDLs the potential effects (adverse or beneficial) the TMDL may have on listed as well as candidate and proposed species under the ESA.

☐ Satisfies Criterion
☐ Satisfies Criterion. Questions or comments provided below should be considered.
☐ Partially satisfies criterion. Questions or comments provided below need to be addressed.
☐ Criterion not satisfied. Questions or comments provided below need to be addressed.
☒ Not a required element in this case. Comments or questions provided for informational purposes.

SUMMARY – EPA will request ESA Section 7 concurrence from the USFWS for this TMDL.

APPENDIX E
USFWS Formal Comments

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Ecological Services
3425 Miriam Avenue
Bismarck, North Dakota 58501

OCT 23 2006

Mr. Mike Ell
Environmental Administrator
Division of Water Quality
North Dakota Department of Health
918 East Divide Avenue
Bismarck, North Dakota 58501-1947

Dear Mr. Ell:

The U.S. Fish and Wildlife Service (Service) has reviewed draft Total Maximum Daily Loads for Indian Creek Dam in Hettinger County, and for Armourdale Dam in Towner County, and offers the following comments.

The North Dakota Department of Health (Department) has identified both Indian Creek and Armourdale Dams as being water quality limited and needing Total Maximum Daily Loads (TMDL). Both reservoirs are on the Department's Section 303(d) List of Impaired Waters. Aquatic life in the reservoirs is listed as impaired due to nutrients, sedimentation, and low dissolved oxygen. Recreational uses are impaired due to nutrients. The draft TMDL indicates there are no waste allocations from point sources in either watershed. Pollutant loads are attributed to nonpoint sources.

The draft documents provide a good discussion on identifying the pollutant reductions needed and actions that should be taken to achieve water quality standards for the two reservoirs. The Service supports the Department's efforts to restore the aquatic life and recreational uses of these two waterbodies.

Section 12.0 "Endangered Species Act compliance" within both drafts lists threatened and endangered species "*specific to*" the water body and respective county. The list of species in both documents is correct for the respective county; however, the species listed are not, as the documents say, "*specific to*" the waterbodies. Although listed species could use habitats associated with the waterbodies, we do not have any records of listed species occurring specifically at Indian Creek Dam or Armourdale Dam.

Section 12.0 could benefit from a discussion on how the proposed TMDL would affect threatened or endangered species. If a Federal agency authorizes, funds, or carries out a proposed action, the responsible Federal agency, or its designated agent, is required to evaluate whether the action "may affect" listed species or may adversely modify proposed or designated critical habitat. If the Federal agency determines the action "may affect"

listed species or may adversely modify proposed or designated critical habitat, then the responsible Federal agency shall request formal section 7 consultation with this office. If the evaluation shows a "no effect" determination for listed species and no adverse modification of proposed or designated critical habitat, further consultation is not necessary. If a private entity or state or local agency receives Federal funding for a project or action, or if any Federal permit is required, the responsible Federal agency may designate the fund recipient or permittee as its agent for purposes of section 7 consultation.

The U.S. Environmental Protection Agency (EPA) is the Federal agency that must approve or disapprove the Department's proposed TMDL's for Indian Creek and Armourdale Dam. Expanding Section 12.0 to include a discussion on affects to federally listed species and any adverse modification of proposed or designated critical habitat would assist EPA in their determination of "may affect" or "no affect." A yet more efficient approach would be to have the Department designated as EPA's agent for purposes of ESA determinations. If the determination is "No Effect", there is no further need for coordination with or concurrence by the Service. Additionally, an expanded discussion on the proposed TMDL's affect, if any, on listed species would provide the Service with an opportunity during the draft comment period to review the Department's endangered species assessment. The Department could then submit to EPA the final TMDL along with the Service's comments and the Department's determination relative to affects to federally-listed species. This would expedite EPA's review and approval/disapproval of the final TMDL and eliminate the administrative step of EPA's requesting Service concurrence on EPA's affects determination.

In light of the absence of discussions on affects to threatened or endangered species within the current draft TMDL documents, the Service is providing the Department with our assessment that the TMDL's for Indian Creek Dam and Armourdale Dam will have "no effect" on federally listed threatened or endangered species and "no adverse modification" to proposed or designated critical habitat. If you concur with this determination, no further concurrence is needed from the Service.

Thank you for the opportunity to comment on the draft documents. If you have any questions or need further assistance please do not hesitate to contact Kevin Johnson of my staff, or contact me directly, at 701-250-4481, or at the letterhead address.

Sincerely,

Jeffrey K. Towner

Jeffrey K. Towner
Field Supervisor
North Dakota Field Office

cc: Director, ND Game & Fish Department, Bismarck
(Attn: S. Ellstad)

Appendix F
Department response to all comments

A 30 day public notice soliciting comment and participation for the Indian Creek Dam Nutrient, Sediment, and Dissolved Oxygen TMDLs was held from October 3 to November 3, 2006. The North Dakota Department of Health received a formal letter from Vern Berry of the Environmental Protection Agency (EPA) dated October 26, 2006, and Jeffrey K.Towner Field Supervisor of the United States Fish and Wildlife Service dated October 23, 2006. Below are the comments made, the section(s) they address, and the department's response.

Environmental Protection Agency (EPA) Comments

Section 3.0 TMDL Targets

Comment from EPA: "We recommend that the nutrient target be clearly stated in the first or second paragraph of Section 3.1 rather than the last paragraph. Further, we recommend that Section 3.1 be renamed "Nutrient Target" to correspond to the TMDL (i.e., "3.1 Nutrient Target" - matches the "Nutrient TMDL" in Section 7.1)."

Section 3.0, TMDL Targets, do not mention a target for dissolved oxygen. Typically, when a pollutant has a numeric water quality standard, the TMDL target is equal to the numeric standard (e.g., DO $\geq$ 5.0 mg/L. We recommend that a brief section (e.g., "Section 3.2 – Dissolved Oxygen Target") be added to include a target for dissolved oxygen.

NDDOH Response: Corrections were made to the TMDL document pertaining to the naming of Section 3.1, the nutrient target was addressed, and language was added to Section 3.2 concerning the dissolved oxygen target per EPA request.

Section 5.4 Dissolved Oxygen and Section 7.3 Dissolved Oxygen TMDL

Comments from EPA: "The dissolved oxygen linkage analysis should be moved from Section 7.3 and added to the DO technical analysis Section 5.4. We suggest that the third paragraph of Section 5.4 be moved, and modified as necessary, to Section 7.3."

NDDOH Response: Changes have been made to the TMDL document concerning the dissolved oxygen linkage analysis in Section 7.3 and dissolved oxygen technical analysis Section 5.4 per EPA request.

United States Fish and Wildlife Service Comments

Section 12.0 Endangered Species Act Compliance

Comment from USFWS: "Section 12.0 "Endangered Species Act Compliance" within both drafts lists threatened and endangered species "specific to" the water body and respective county. The list of species in both documents is correct for the respective county; however, the species listed are not, as the documents say, "specific to" the waterbodies. Although listed species could use habitats associated with the waterbodies, we do not have any records of listed species occurring specifically at Indian Creek Dam or Armourdale Dam."

NDDOH Response: Section 12.0 has been changed to reflect the USFWS comments regarding endangered or threatened species and their presence in the waterbody or associated habitats.

Comments from USFWS: "…In light of the absence of discussions on affects to threatened or endangered species within the current draft TMDL documents, the Service is providing the Department with our assessment that the TMDL's for Indian Creek Dam and Armourdale Dam will have "no effect" on federally listed threatened or endangered species and "no adverse modification" to proposed or designated critical habitat. If you concur with this determination, no further concurrence is needed from the Service."

NDDOH Response: The North Dakota Department of Health concurs with the United States Fish and Wildlife Service's determination of a "no effect" on federally listed threatened or endangered species and "no adverse modification" to proposed or designated critical habitat relating to the Indian Creek Dam TMDL. Language has been added to Section 12.0 of the TMDL document concurring with the USFWS's determination.