Nutrient and Dissolved Oxygen TMDLs for Powers Lake in Burke and Mountrail Counties, North Dakota

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1.0 INTRODUCTION AND DESCRIPTION OF THE WATERSHED

Powers Lake is located on the southern edge of the community of Powers Lake in northwestern North Dakota (Figures 1 and 2). The lake discharges into a tributary of the White Earth River. It is a natural freshwater lake found in the Coteau region of North Dakota. It has a surface area of 1,616 acres with a watershed size of 44,458 acres. Based on lake statistics provided by the North Dakota Game and Fish Department (Figure 3), Powers Lake has an average depth of 7.2 feet with a maximum depth of 11.1 feet. Table 1 summarizes some of the geographical, hydrological, and physical characteristics of Powers Lake. This lake has received extensive community support and there is a strong desire to maintain the fishery as well as keep the lake aesthetically pleasing for the people that use it. Currently, a watershed coordinator is employed through the State's Section 319 grant to implement conservation practices aimed at reducing the documented nonpoint source pollution described in a 2001 assessment.

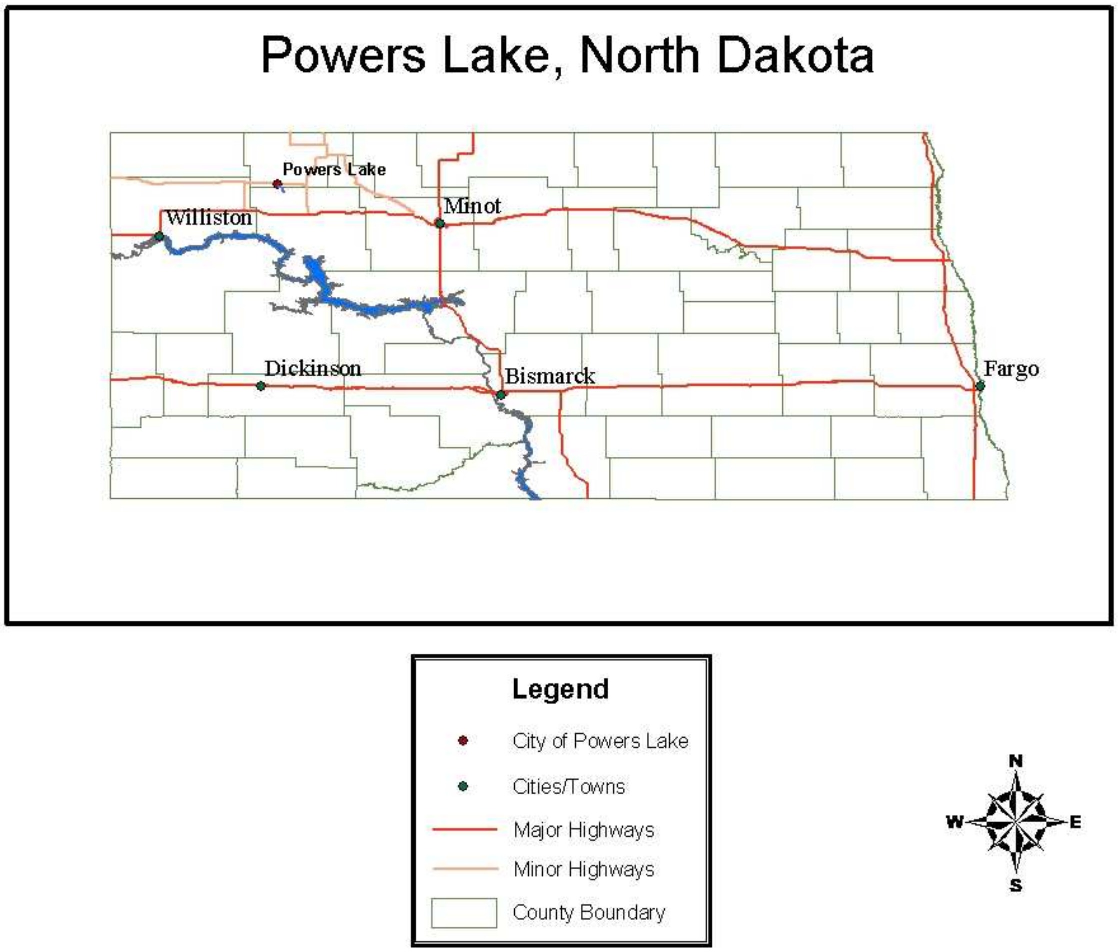

Figure 1. Location of Powers Lake in North Dakota.

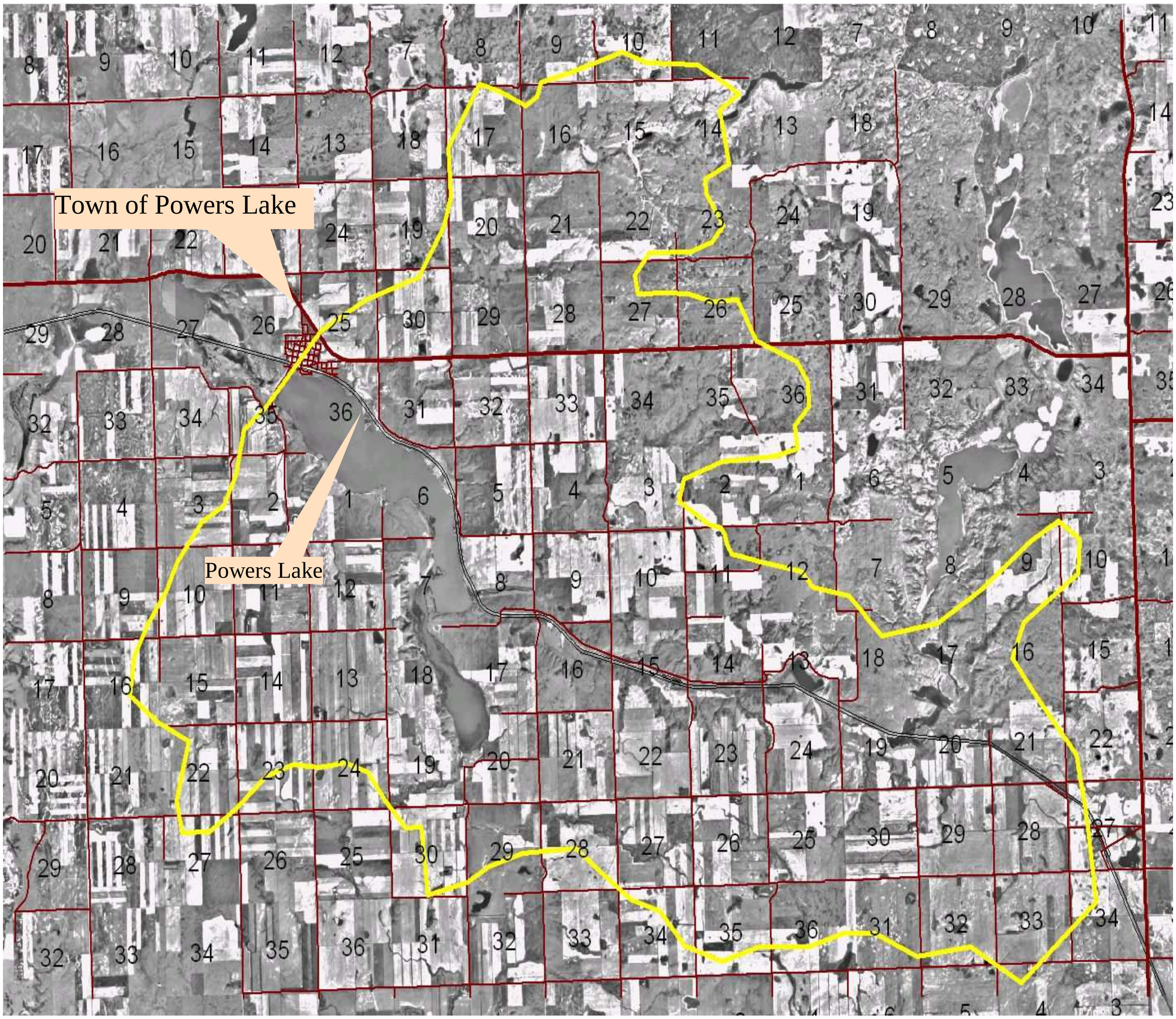

Figure 2. Location of the Powers Lake Watershed.

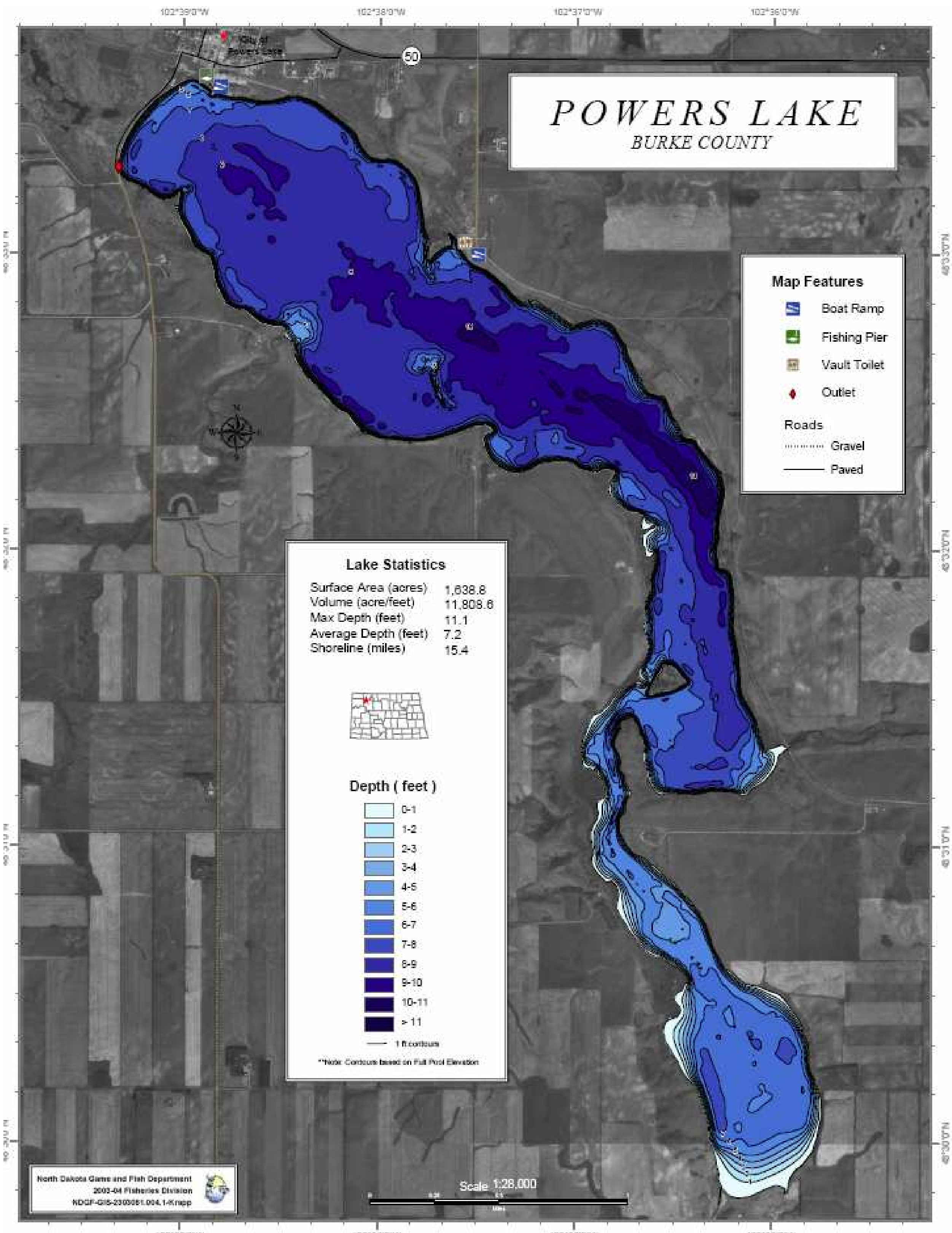

Figure 3. North Dakota Game and Fish Contour Map of Powers Lake

Table 1. General Characteristics of Powers Lake and the Powers Lake Watershed

Legal Name	Powers Lake
Major Drainage Basin	Missouri River – Lake Sakakawea
8-Digit HUC	10110101
Nearest Municipality	Powers Lake, ND
County	Burke and Mountrail Counties, ND
Eco-region	Northern Missouri Coteau
Latitude	48.92429
Longitude	-102.26945
Surface Area	1,638.8 acres
Watershed Area	44,458 acres
Average Depth	7.2 Feet
Maximum Depth	11.1 Feet
Volume	11,808.6 acre-feet
Tributaries	Un-named tributaries
Outlets	Tributary to White Earth River
Type of Waterbody	Natural Lake
Fishery Type	Warm water – yellow perch, northern pike
Classified Beneficial Uses	Municipal and domestic water supply, recreation, aquatic life, agricultural uses, and industrial water supply

1.1 Clean Water Act Section 303(d) Listing Information

Table 2 details the TMDL listing information for Powers Lake. Based on the 2006 Section 303(d) List of Impaired Waters Needing TMDLs (NDDoH, 2006), the North Dakota Department of Health (NDDoH) has identified Powers Lake as fully supporting, but threatened for aquatic life uses due to nutrients, low dissolved oxygen levels, and sediment and fully supporting, but threatened for recreational uses due to nutrients. As reflected in its title, this TMDL report only addresses the nutrient impairments for aquatic life and recreation use and the low dissolved oxygen impairment for aquatic life use. Sediment remains as a Section 303(d) TMDL listed pollutant threatening aquatic life use. Currently, there are not adequate data available to address the sediment TMDL listing. It is expected that once the monitoring data that are currently being collected as part of the Section 319 Watershed Implementation and Lake Restoration Project are made available a TMDL will be prepared to address this pollutant.

Table 2. 2006 Section 303(d) TMDL Listing Information for Powers Lake.

Assessment Unit ID	ND-10110101-001-L_00
Description	Powers Lake
Size	1,638.8 acres
Impaired Designated Uses	Fish and Other Aquatic Biota; Recreation
Use Support	Fully Supporting but Threatened
Impairment	Nutrients, Sediment, and Dissolved Oxygen
Priority	1 (High)

1.2 Topography

Powers Lake is located in the eco-region known as the Northern Missouri Coteau portion of the Northwestern Glaciated Plains. It lies in a transition zone between a more boreal climate to the north and a more arid climate to the west. Willow and aspen may occur at wetland margins, Rough fescue appears in grassland associations. Stream drainage is absent or uncommon and there are numerous pothole (temporary and seasonal) wetlands (Figure 4). Wetlands tend to dry out earlier in the summer than on the Missouri Coteau to the south and east. The physiography is hummocky, rolling terrain. The surface material is Wisconsinan glacial till over Tertiary sandstone and shale. Mollisols are the dominant soil order, with Zahl, Williams, and Parnell being the most common soil series. Western wheatgrass, green needlegrass, and little bluestem are some of the potential native vegetation. These soils are very deep, well drained or moderately well drained, and formed in glacial till. Permeability is moderate to slow (USEPA, et al. 1998). Elevation at Powers Lake is 2,206 feet mean-sea-level, and local relief is typically less than 25 feet.

Figure 4. Aerial View of Wetlands in the Northern Missouri Coteau.

1.3 Landuse/Land Cover in the Watershed

Primary land use in the Powers Lake watershed is farm and ranch land, with approximately 65.63 percent cultivated and 29.69 percent in some form of permanent grass or herbaceous cover (NDDoH, 2001). The remainder of the land is in roads or farmsteads. When analyzed by subwatershed, the percentage of cropland ranged from a high of nearly 100 percent in the south subbasin to a low of 50 percent in the lands immediately surrounding Powers Lake (Table 3).

Table 3. Percent Landuse in the Powers Lake Watershed.

Subwatershed	Cultivated (%)	Pasture (%)	Hay (%)	CRP (%)	Other (%)	N[1]
Northeast	83.33	16.67	NI[2]	NI	NI	5
Lunds Valley	60.61	27.27	3.03	6.06	3.03	20
South	100.00	NI	NI	NI	NI	4
West	85.71	NI	14.29	NI	NI	6
Immediate	50.00	7.17	14.29	14.29	14.29	7
Total	65.63	17.19	6.25	6.25	4.69	42

[1](N) Number of sample points per watershed
[2](NI) None identified

1.4 Climate and Precipitation

North Dakota's climate is characterized by large temperature variation across all time scales, light to moderate irregular precipitation, plentiful sunshine, low humidity, and nearly continuous wind. Its location at the geographic center of North America results in a strong continental climate, which is exacerbated by the mountains to the west. There are no barriers to the north or south so a combination of cold, dry air masses originating in the far north and warm humid air masses originating in the tropical regions regularly overflow the state. Movement of these air masses and their associated fronts causes near continuous wind and often results in large day to day temperature fluctuations in all seasons. The average last freeze in spring occurs in late May. In the fall, the first 32 degree or lower temperature occurs between September 10th and 25th. However, freezing temperatures have occurred as late as mid-June and as early as mid-August. About 75 percent of the annual precipitation falls during the period of April to September, with 50 to 60 percent occurring between April and July. Most of the summer rainfall is produced during thunderstorms, which occur on an average of 25 to 35 days per year. On the average, rains occur once every three or four days during the summer. Winter snowpack, although persistent from December through March, only averages around 15 inches (Enz, 2003).

Average yearly air temperature at the Bowbells, North Dakota weather station, 26 miles northeast Powers Lake, is 38 degrees and average wind speed is 10.7 mph. Average annual precipitation ranges from 7 to 14 inches. November through February averaged only about 0.50 inches per month, mostly as snow. Measurable precipitation (0.01 inch or more) occurs on an average of 65 to 100 days during the year, but over 50 percent of these events produce less than 0.10 inch (NDAWN. 2004).

1.5 Available Water Quality Data

In 1999, the City of Powers Lake approached the North Dakota Department of Health (NDDoH) for help in addressing the declining water quality of Powers Lake. The result was a sediment survey conducted during the ice-cover period in 1999-2000 and an assessment of water quality and quantity data conducted during February through October of 2001. The Burke County Soil Conservation District (SCD) was the local sponsor for the project. This assessment monitored the water quality and quantity in for contributing streams, the lake, and the lake outlet. Sediment volumes present within the lake were also determined. Water quality samples were collected using the methodology described in the *Quality Assurance Project Plan (QAPP) for the Powers Lake Assessment Project* (NDDoH, 2001). These sites are identified in Table 4 and Figure 4. The data were analyzed and summarized by Mr. Peter Wax, Environmental Scientist, NDDoH, and provided in this report.

Table 4. General Information for Water Quality Sampling Sites for Powers Lake.

Sampling Site	Site ID	Number of Samples Taken	Latitude (approx.)	Longitude (approx.)
Northeast Tributary	385035	33	48^o N 33’ 18”	-102^o W 37’ 30”
Lunds Valley Tributary	385036	30	48^o N 31’ 18”	-102^o W 34’ 53”
West Tributary	385037	7	48^o N 32’ 7”	-102^o W 39’ 7”
South Tributary	385038	21	48^o N 29’ 19”	-102^o W 36’ 8”
Lake Outlet	385039	31	48^o N 33’ 25”	-102^o W 39’ 16”
In Lake	380870	48	48^o N 32’ 17”	-102^o W 36’ 36”

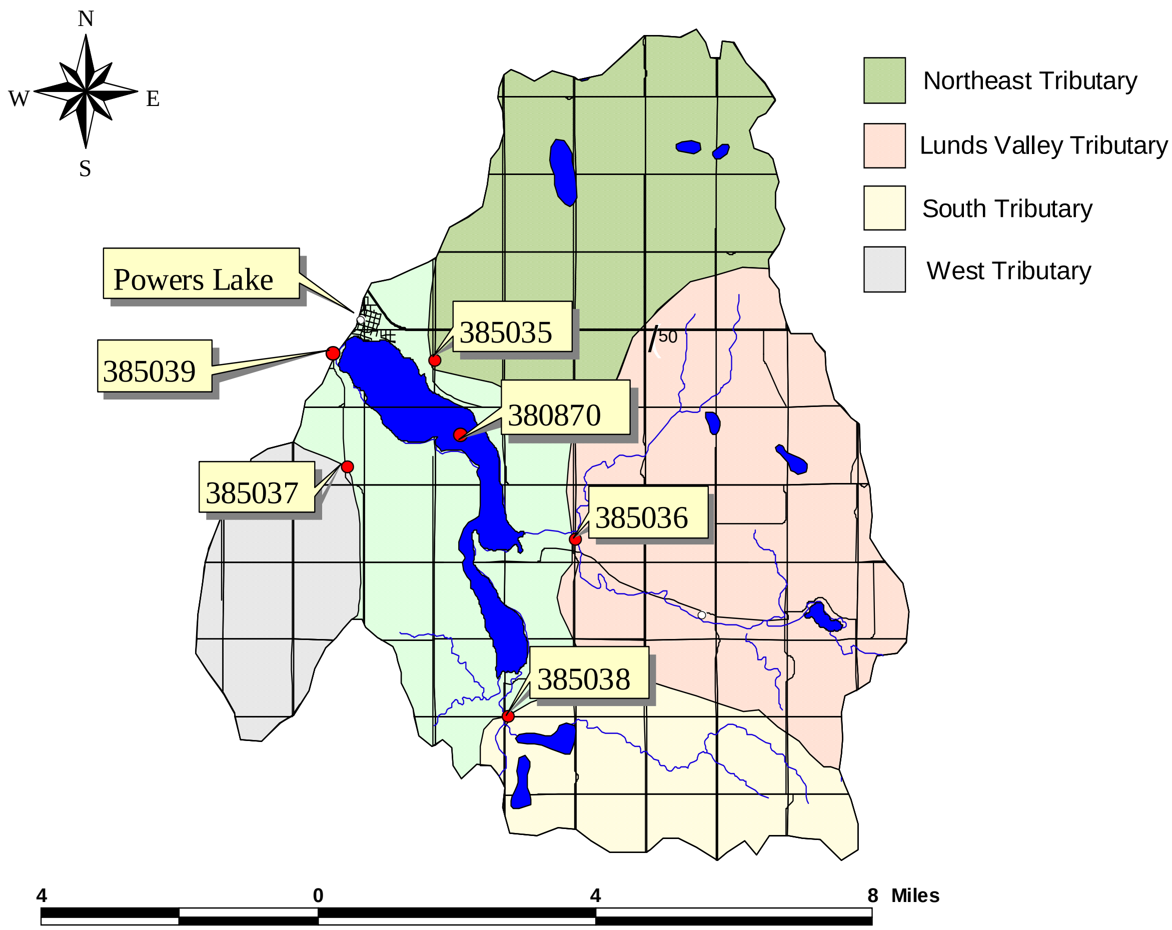

Figure 5. Powers Lake Sampling Locations.

<u>1.5.1 Stream Data</u>

Four stream sites were located at the pour point of each of the above listed subwatersheds. The fifth stream site was located at the outlet of Powers Lake. Manual stream gauging stations were installed at the stream monitoring sites and used to collect stage/discharge data. Stream parameters analyzed included total nitrogen, total Kjeldahl nitrogen, nitrate-nitrite, ammonia, total phosphorus, total suspended solids, (Tables 5 through 9). Most of the stream monitoring activities occurred between March and September, 2001. Using stream flow and water quality data, sediment and nutrient loads were calculated for each location using the computer model FLUX. These data were then used to calibrate the BATHTUB computer model.

Table 5. Summary of Stream Sampling Data, STORET # 385035 (Northeast Tributary).

Description	Total Nitrogen (mg/L)	TKN (mg/L)	Nitrate-Nitrite (mg/L)	Ammonia (mg/L)	Total Phosphorus (mg/L)	TSS (mg/L)
Minimum[1]	0.52	0.50	0.01	0.005	0.116	2.5
Maximum	4.90	3.49	1.89	0.911	2.54	83
Median	1.535	1.47	0.035	0.0125	0.4965	2.5
Mean	1.740559	1.528794	0.207941	0.074735	0.59885	9.441176

[1] If the sample result came back non-detect, half of the detection limit was used for calculations.

Table 6. Summary of Stream Sampling Data, STORET # 385036 (Lunds Valley Tributary).

Description	Total Nitrogen (mg/L)	TKN (mg/L)	Nitrate-Nitrite (mg/L)	Ammonia (mg/L)	Total Phosphorus (mg/L)	TSS (mg/L)
Minimum[1]	1.25	1.11	0.01	0.005	0.115	2.5
Maximum	3.17	2.78	1.78	0.083	1.71	276
Median	1.99	1.85	0.01	0.005	0.502	2.5
Mean	2.07871	1.901613	0.170645	0.018774	0.588	12.75806

[1] If the sample result came back non-detect, half of the detection limit was used for calculations.

Table 7. Summary of Stream Sampling Data, STORET # 385037 (West Tributary).

Description	Total Nitrogen (mg/L)	TKN (mg/L)	Nitrate-Nitrite (mg/L)	Ammonia (mg/L)	Total Phosphorus (mg/L)	TSS (mg/L)
Minimum[1]	1.62	0.83	0.40	0.005	0.487	2.5
Maximum	2.74	1.51	1.62	0.164	0.811	209
Median	2.175	1.22	0.925	0.0195	0.7075	25
Mean	2.16875	1.1825	0.98625	0.058	0.67725	65.6875

[1] If the sample result came back non-detect, half of the detection limit was used for calculations.

Table 8. Summary of Stream Sampling Data, STORET # 385038 (South Tributary).

Description	Total Nitrogen (mg/L)	TKN (mg/L)	Nitrate-Nitrite (mg/L)	Ammonia (mg/L)	Total Phosphorus (mg/L)	TSS (mg/L)
Minimum[1]	1.25	1.02	0.01	0.005	0.98	2.5
Maximum	3.00	2.27	1.11	0.818	1.18	163
Median	1.65	1.47	0.18	0.005	0.5	12
Mean	1.837826	1.495652	0.341304	0.057174	0.556174	26

[1] If the sample result came back non-detect, half of the detection limit was used for calculations.

Table 9. Summary of Stream Sampling Data, STORET # 385039 (Lake Outlet).

Description	Total Nitrogen (mg/L)	TKN (mg/L)	Nitrate-Nitrite (mg/L)	Ammonia (mg/L)	Total Phosphorus (mg/L)	TSS (mg/L)
Minimum[1]	1.0	0.98	0.01	0.005	0.102	2.5
Maximum	3.35	3.29	0.09	0.301	0.488	112
Median	1.65	1.63	0.02	0.005	0.294	26
Mean	1.813226	1.783548	0.025161	0.030548	0.307387	27.67742

[1] If the sample result came back non-detect, half of the detection limit was used for calculations.

Hydraulic discharge was estimated for all five water quality monitoring stations (Figure 6). The seasonal hydraulic discharge for the five stations balanced well, indicating that the discharge errors are acceptable for assessment purposes (Table 10).

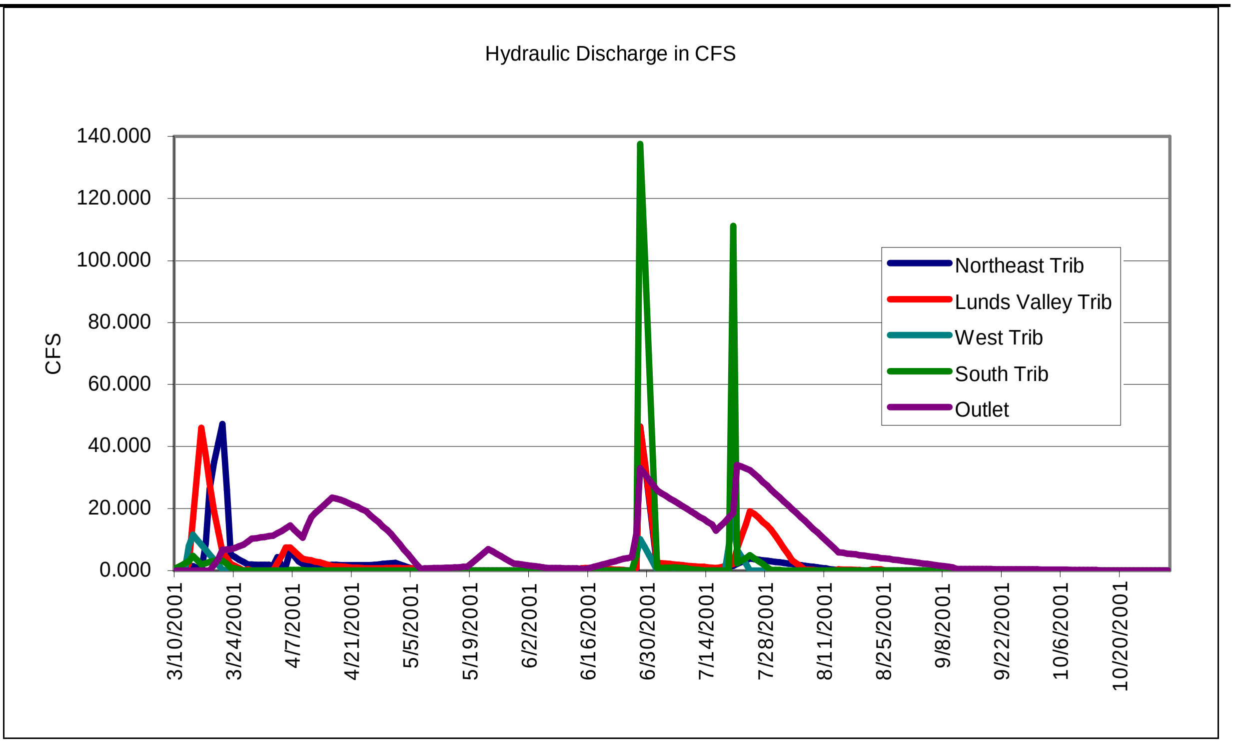

Figure 6. Hydraulic Discharge for the Powers Lake Watershed 3/10/01 through 10/31/01.

Table 10. Hydraulic Balance for Powers Lake Watershed (3/10/01 through 10/31/01).

Station	Hectare Meters Cubed	Millions of Gallons
Precipitation	1.96	517.60
NE Trib. (385035)	1.15	303.83
Lunds Valley (385036)	1.50	396.30
West Trib. (385037)	0.477	126.02
South Trib. (385038)	1.30	343.46
Total Gauged Flow	4.427	1169.61
Evaporation	2.62	690.09
Outlet (385039)	4.580	1210.04
Ungauged Outflow	-0.806	212.94

1.5.2 Lake Data

The in-lake site is located in the deepest part of the reservoir at the north end near the dam. Lake monitoring occurred briefly in February of 2000 and one sample in June of 2000, but due to drought conditions it was suspended. It later continued from February of 2001 through October of 2001, as outlined in the QAPP (NDDoH, 2000). Lake parameters included phytoplankton, chlorophyll a, total nitrogen, total Kjeldahl nitrogen, nitrate-nitrite, ammonia, phosphorus (total and dissolved), Secchi disk transparency, and temperature and dissolved oxygen profiles. Fecal coliform data was also collected within the watershed and will be discussed later in a separate TMDL specifically addressing that parameter. The data collected characterized Powers Lake as a hypereutrophic, nitrogen-limited lake that does not thermally stratify. Monthly mean concentrations of selected parameters are shown in Table 11. Minimum, maximum, median and mean concentrations of measured parameters of interest are shown in Table 12. If results for a selected parameter were below detection limits, one half of the detection limit was used to figure medians and means. Figures 6 and 7 are of the temperature and dissolved oxygen profiles.

Table 11. Powers Lake's Mean Monthly Concentrations of Select Water Quality Parameters (ugL^{-1}).

Month	Total Ammonia	Nitrate + Nitrite	Total Nitrogen	Total Diss. Phosphorus	Total Phosphorus	Chlorophyll-a
Jan	248	120	2898	355	403	---
Feb	283	50	1605	---	232	---
May	16	20	1548	96	232	60.5
Jun	33	20	1475	120	219	22.0
Jul	10	20	2483	157	364	31.5
Aug	11	20	3108	41	330	81.0
Sep	10	20	3438	23	291	111.0
Oct	10	20	2563	27	193	117.0

Table 12. Minimum, Maximum, Median, and Mean Values for Selected Water Quality Parameters for Powers Lake (STORET #380870).

Parameter	Minimum	Maximum	Median	Mean
Chlorophyll-a (ug/L)	18	121	71.5	70.583333
Total Nitrogen (mg/L)	1.23	3.8	2.43	2.467813
Total Kjeldahl Nitrogen (mg/L)	1.03	3.78	2.36	2.422813
Nitrate-Nitrite (mg/L)	<0.02**	0.23	0.01	0.038125
Ammonia (mg/L)	<0.01**	0.288	0.005	0.062594
Total Phosphorus (mg/L)	0.103	0.591	0.2995	0.297
Total Dissolved Phosphorus (mg/L)	0.017	0.492	0.0925	0.137967
Secchi Disk Depth (m)	0.15	0.36	0.205	0.2275

* Calculated as a geometric mean.
** Results below detection limit

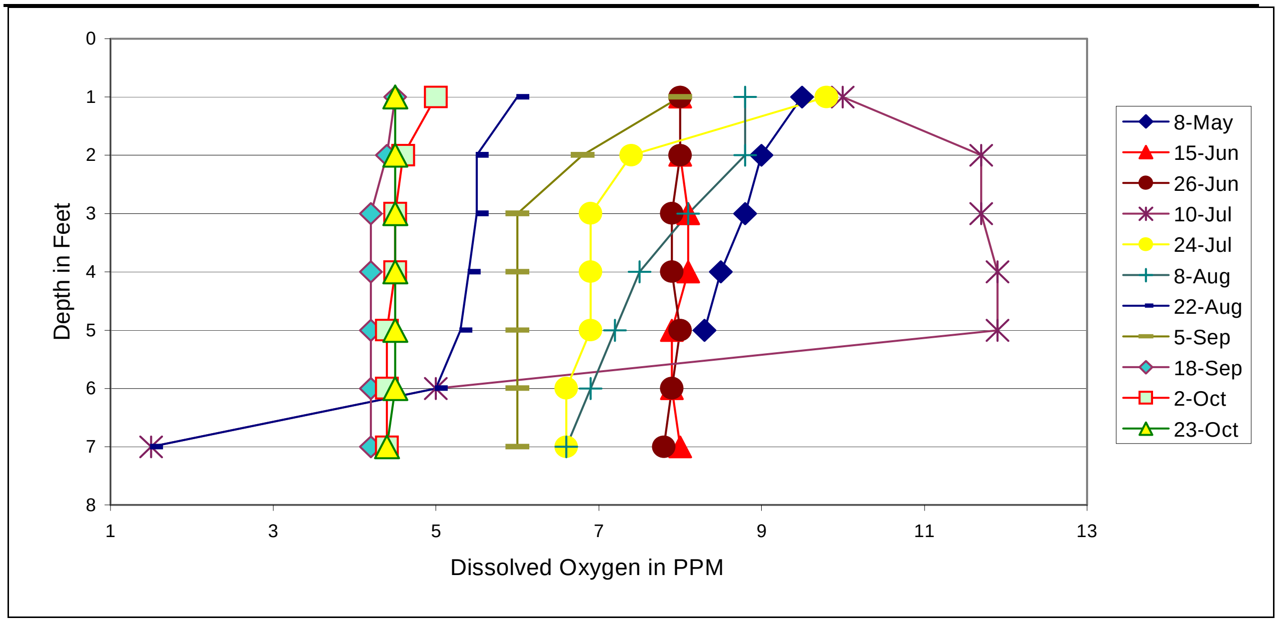

Figure 7. In-Lake Dissolved Oxygen Profile for 2001.

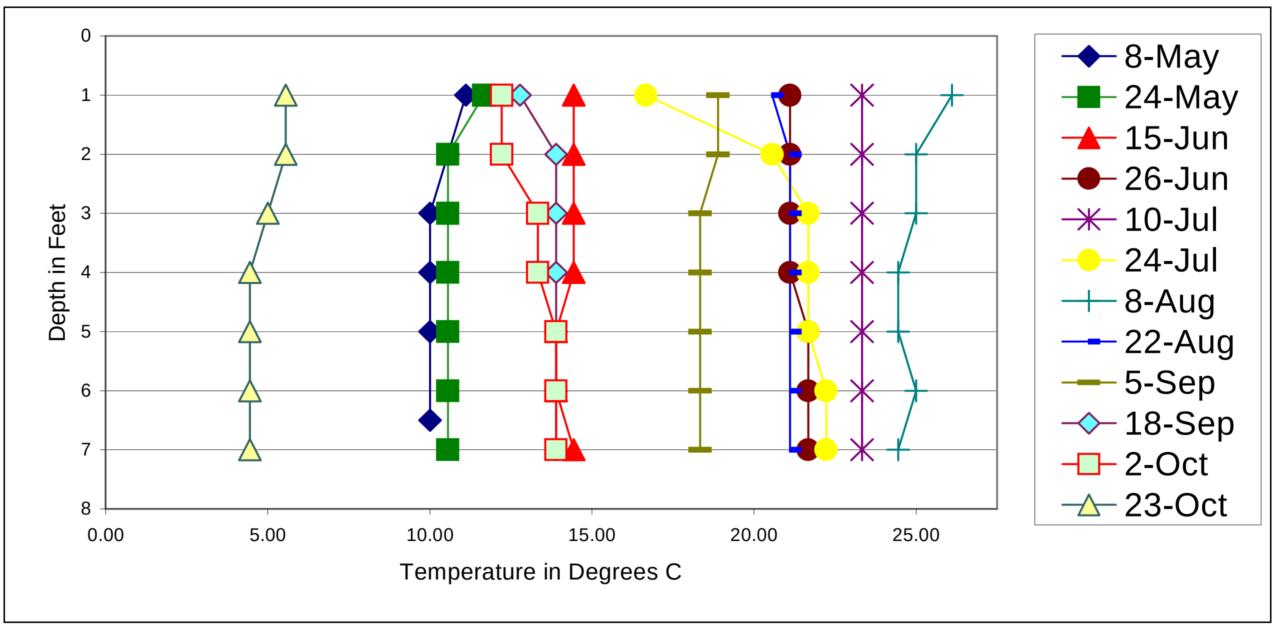

Figure 8. In-Lake Temperature Profile for 2001.

Powers Lake data was also compared to data from a study of similar lakes in northwestern North Dakota (RLRSD, 2000). In general, when compared to other lakes in this region of the northwestern North Dakota glaciated plains, Powers Lake had lower than average TKN and ammonia concentrations, similar nitrate/nitrite concentrations, and higher than average total phosphorus concentrations (Table 13).

Table 13. Regional Lake Water Quality Compared to Powers Lake's Water Quality[1].

	Total Phosphorus	Nitrate/ Nitrite	TKN	Ammonia	Chlorophyll-*a*	Secchi Disk Depth
Units	mg/L	mg/L	mg/L	mg/L	μg/L	meters
Powers Lake	0.297	0.038	2.42	0.062	70.58	0.23
Other North Dakota Lakes						
Max	0.707	0.123	5.06	0.677	237.5	2.29
Min	0.031	0.006	1.09	0.025	3.5	0.15
Average	0.147	0.044	2.87	0.234	56.4	1.13
Median	0.056	0.029	2.57	0.191	11.0	1.01

[1]Eleven regional lakes were sampled for this study (RLRSD, 2000). Data from Powers Lake Assessment (NDDoH, 2000.) was compared to data from this study. Powers Lake values are depth averaged except for nitrate/nitrite and chlorophyll-*a*.

2.0 WATER QUALITY STANDARDS

The Powers Lake is a Class 3 lake with the following definition:

- *Warm water fishery. Waters capable of supporting growth and propagation of nonsalmonid fishes and associated aquatic biota.*

It is also defined in the State Water Quality Standards that:

- *The beneficial uses and parameter limitations designated for Class I streams shall apply to all classified lakes.*

The tributaries flowing in to and out of Powers Lake are Class III streams.

- *The quality of the waters in this class shall be suitable for agricultural and industrial uses such as stock watering, irrigation, washing, and cooling. These streams have low average flows and generally prolonged periods of no flow. The quality of these waters must be maintained to protect recreation, fish, and aquatic biota*. (NDDoH, 2001).

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 NDDH 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

Standards of Quality for Waters of the State (NDDoH, 2006) establishes numeric standards for dissolved oxygen, total phosphorus, and nitrates (dissolved) (Table 14). The numeric standards for Class I Streams include all classified lakes. In addition, nutrient guidelines that have been established for use as goals in lake improvement and maintenance programs are also listed in Table 14. Lake use attainment determinations are often made using Carlson's Trophic State Index (TSI), which is further discussed in Section 3.1 (Carlson, 1977). No numeric criteria have been developed for sediment.

Table 14. Numeric Standards from *Standards of Quality for Waters of the State* (NDDoH, 2006).

Parameter	Parameter Limitation	Condition
Standards for Class I Streams and Classified Lakes:		
Nitrates (dissolved)	1.0 mg/l	Maximum allowed[1]
Phosphorus (total)	0.1 mg/l	Maximum allowed[1]
Dissolved Oxygen	5.0 mg/l	Not less than
Guidelines for Goals in a Lake Improvement or Maintenance Program:		
NO_3 as N	0.25 mg/l	Goal
PO_4 as P	0.02 mg/l	Goal

[1] The standards for nitrates(N) and phosphorus(P) are intended as interim guideline limits. Since each stream or lake has unique characteristics which determine the levels of these constituents that will cause excessive plant growth (eutrophication), the department reserves the right to review these standards after additional study and to set specific limitations on any waters of the state. However, in no case shall the standards for nitrates(N) exceed 10 mg/L for waters used as municipal or domestic drinking water supply.

3.0 TMDL TARGETS

TMDL targets are the values that are measured to judge the success of the TMDL effort. TMDL targets must 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 Powers lake based on its beneficial uses. If the specific target is met, it is assumed the lake will meet applicable water quality standards, including its designated beneficial uses.

3.1 Nutrient Target

The assessment methodology for lakes and reservoirs described in North Dakota's 2004 Integrated Section 305(b) and Section 303(d) Water Quality Assessment Report indicates that Carlson's Trophic State Index(TSI) is the primary indicator used to assess beneficial uses of the State's lakes and reservoirs (NDDH, 2004). Trophic state 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, and/or from internal cycling. Lakes tend to become eutrophic (more productive) with higher nitrogen and phosphorus inputs. Eutrophic lakes often have nuisance algal blooms, limited 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).

Based on Carlson's TSI and water quality data collected between March 2001 and October 2001, Powers Lake was determined to be a nitrogen-limited hypereutrophic lake. Hypereutrophic lakes are characterized by large growths of weeds, blue-green algal blooms, and low dissolved oxygen concentrations. These lakes experience frequent fish kills and are generally characterized as having excessive rough fish populations (carp, bullhead, sucker) and poor sport fisheries. Because of the frequent algal blooms and excessive weed growth, these lakes are also undesirable for recreational uses such as swimming and boating. The various TSI values were calculated for Powers Lake (Table 15) using the data obtained from the assessment study.

Table 15. Carlson's Trophic State Indices for Powers Lake.

Parameter	Relationship	Units	TSI Value[1]	Trophic Status
Chlorophyll-*a*	TSI (Chl-a) = 30.6 + 9.81[ln(Chl-a)]	µg/L	72.37	Hypereutrophic
Total Phosphorus (TP)	TSI (TP) = 4.15 + 14.42[ln(TP)]	µg/L	86.82	Hypereutrophic
Secchi Depth (SD)	TSI (SD) = 60 - 14.41[ln(SD)]	meters	81.74	Hypereutrophic

[1]TSI values were calculated using average surface values from the Powers Lake in-lake monitoring station (see Table 13).
TSI < 40 = Oligotrophic (least productive) TSI 50-60 = Eutrophic
TSI 40-50 = Mesotrophic TSI > 60 = Hypereutrophic (most productive)

The temporal distribution for Carlson's TSI scores did not show a significant pattern, indicating that this condition is relatively constant throughout the entire growing season (Figures 9, 10, and 11).

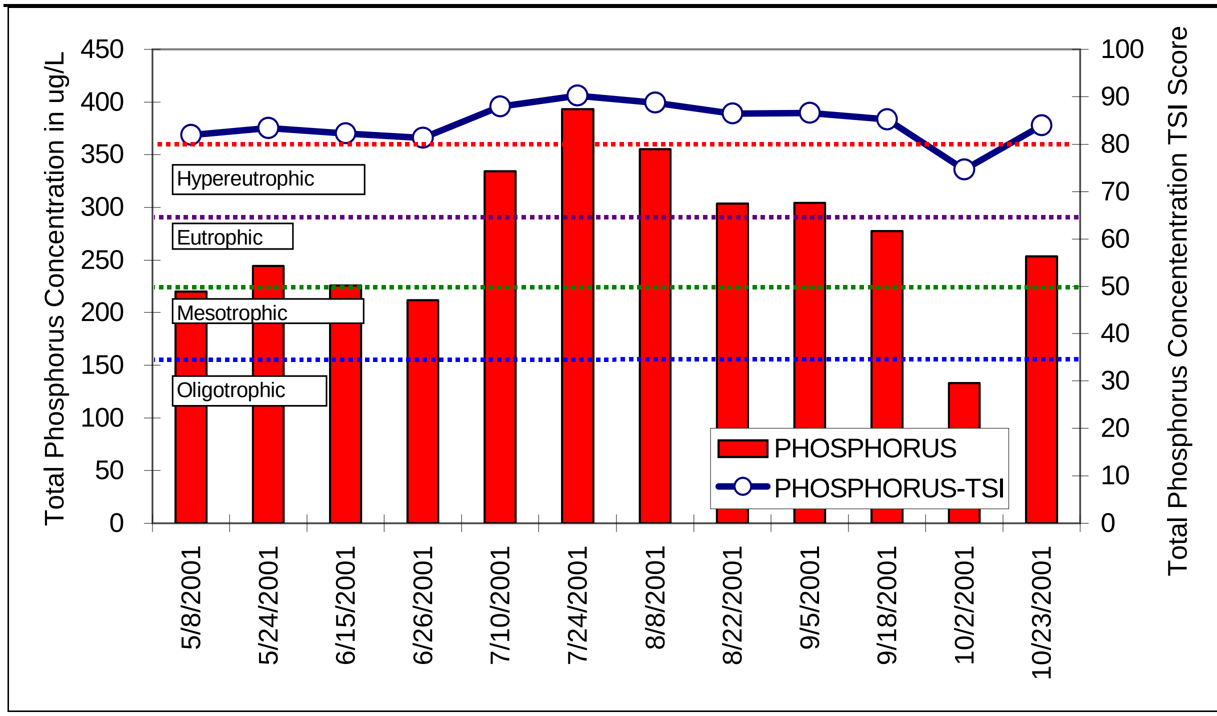

Figure 9. Temporal Distribution of Total Phosphorus Concentrations and Corresponding TSI Scores.

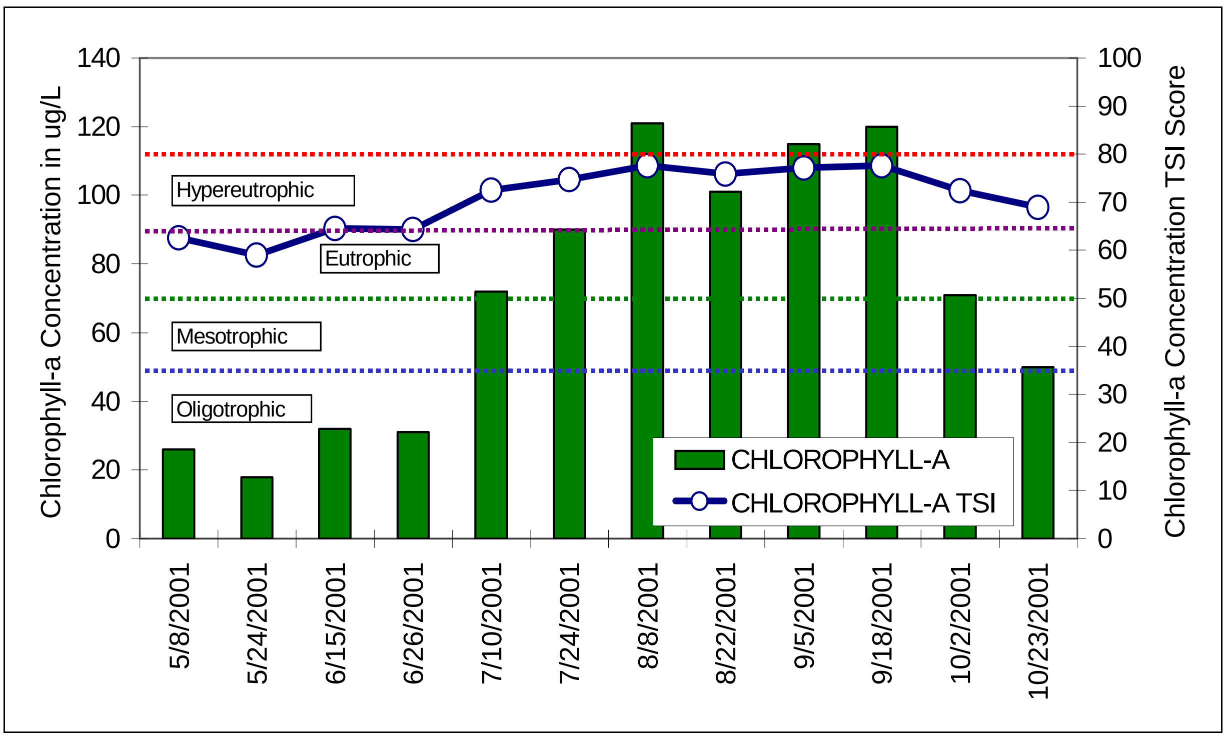

Figure 10. Temporal Distribution of Chlorophyll-a Concentrations and Corresponding TSI Scores.

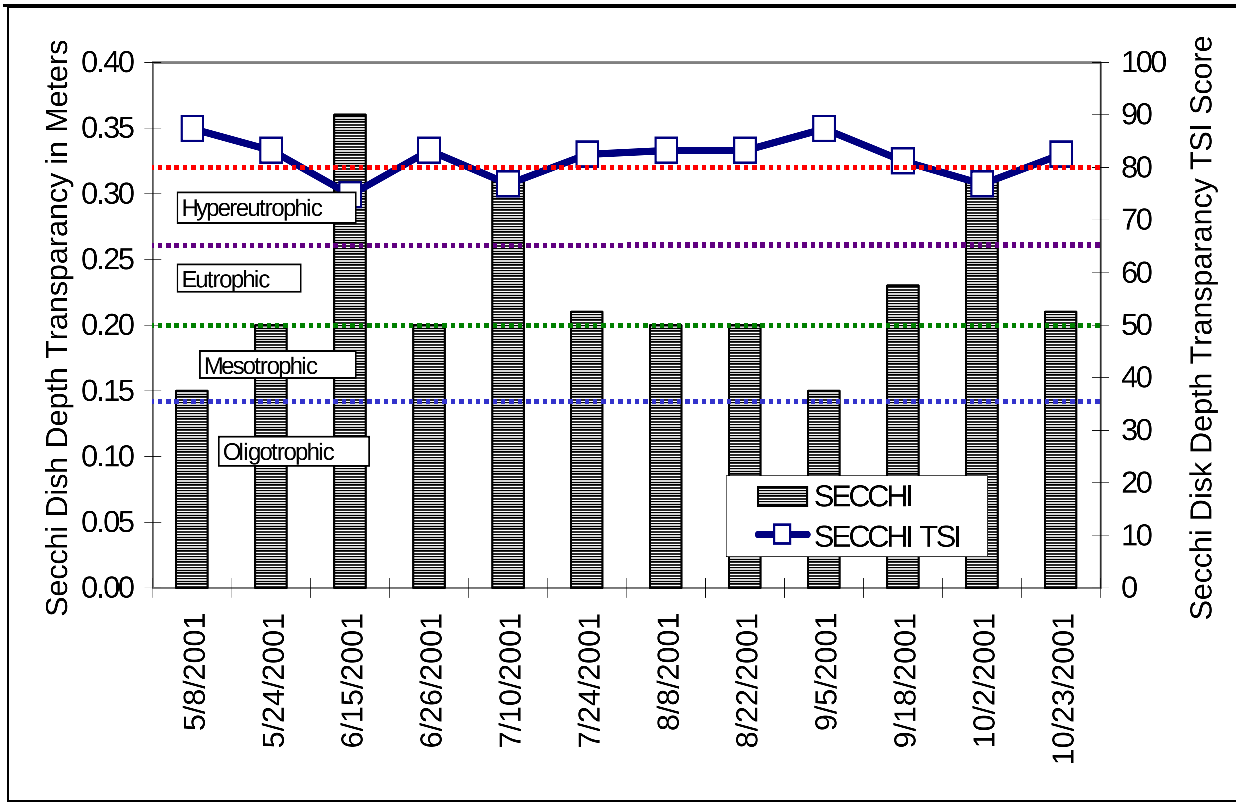

Figure 11. Temporal Distribution of Secchi Disk Transparency Depth and Corresponding TSI Scores.

The three variables, chlorophyll pigments, Secchi depth, and total phosphorus, in Carlson's TSI independently estimate algal biomass (production as a result of excess nutrients). The three index variables are interrelated by linear regression models, and should produce the same index value for a given combination of variable values. Any of the three variables can therefore theoretically be used to classify a waterbody. For the purpose of classification, priority is given to chlorophyll, because this variable is the most accurate of the three at predicting algal biomass (Carlson 1980). Although transparency and phosphorus may co-vary with trophic state, the changes in transparency are caused by changes in algal biomass and total phosphorus may or may not be strongly related to algal biomass. Neither transparency nor phosphorus is an independent estimator of trophic state. (Carlson 1996).

A major strength of TSI is that the interrelationships between variables can be used to identify certain conditions in the lake or reservoir that are related to the factors that limit algal biomass or affect the measured variables. When more than one of the three variables is measured, it is possible that different index values will be obtained. Because the relationships between the variables were originally derived from regression relationships and the correlations were not perfect, some variability between the index values is to be expected. (Carlson 1996). These deviations of the total phosphorus or the Secchi depth index from the chlorophyll index can be used to identify conditions and causes relating to the lake or reservoir's trophic state. Some possible interpretations of deviations of the index values are given in Table 16 below (updated from Carlson 1983).

Table 16. Relationship Between TSI Variables and Conditions.

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

By interpreting the data in Table 15 through the use of Table 16, Powers Lake's transparency seems to be dominated by non-algal factors such as color or turbidity, or where very small particles predominate. In such situations as this where phosphorus and transparency are correlated, but chlorophyll is not, turbid situations exist where phosphorus is bound to clay particles. This coincides with the soil survey mentioned in earlier sections.

Through analysis of assessment data, Powers Lake was determined to be nitrogen limited. In order to decrease the trophic state from hypereutrophic down to eutrophic, a reduction in phosphorus loading will have to occur. A Carlson's chlorophyll-a TSI target of 55.02 was chosen for the Powers Lake endpoint through the use of BATHTUB modeling. Through this model it was determined that a 50 percent internal load reduction along with a 75 percent external load reduction in phosphorus is required to bringing the lake into the target trophic state of eutrophic; this corresponds to a chlorophyll-a TSI of 55.02 (See also Table 26 for the model results used to determine this).

The TMDL target based upon the chlorophyll-a TSI was chosen for several reasons. First, there is a great deal of interest in the watershed to improve lake quality. A Section 319 Nonpoint Source Management grant has already been awarded and the implementation phase is moving forward. In order to keep monitoring costs down so as to better use the majority of grant money towards conservation practices on the ground, and to insure continued public support of the project, the TSI score of the most publicly identifiable component was chosen. Second, as mentioned above, chlorophyll-a is the variable most accurate at predicting algal biomass, which is driven by nutrient loading. It is believed that the turbidity issues will be addressed through the sediment TMDL load reduction. Also, the degree of improvement in Secchi disk depth, for an equal amount of phosphorus diverted, will become greater as a mesotrophic state is approached. (Cooke, et.al., 1986).

While the target TSI score resulting from the 50 percent internal/ 75 percent external phosphorus load reduction will not bring the concentration of total phosphorus to the NDDoH State Water Quality Standard guideline for lakes (0.02 mg/L) (Table 14), it should be recognized that these are just guidelines. Lakes vary a great deal in North Dakota. Shallow lakes are especially hard to improve without addressing the internal phosphorus cycling, which comes at a higher cost. This reduction in phosphorus load should result in a change of trophic status for the lake from hypereutrophic down to eutrophic. Given the size of the lake (1,638.8 acres), the position of the lake along the landscape (from NW to SE), and the nearly constant wind in northwestern North Dakota causing a mixing effect, this was determined to be the best possible outcome for Powers Lake. If the specified TMDL chlorophyll-a target of 55.02 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 "5.0 mg/L as a daily minimum (up to 10% of representative samples collected during any three year period may be less than this value provided that lethal conditions are avoided)" and will be the dissolved oxygen target for Powers Lake.

4.0 SIGNIFICANT SOURCES

4.1 Point Sources

The city of Powers Lake's wastewater lagoons discharge into a different watershed and are not of concern for this report. There are no permitted Confined Animal Feeding Operations (CAFOs) in the Powers Lake watershed and only one permitted AFO. As a condition of this AFO's permit all runoff from the feeding area must be contained, therefore there is no runoff to surface waters.

4.2 Nonpoint Sources

4.2.1 Stormwater Runoff

The City of Powers Lake lies adjacent to the lake itself, so provides a source of runoff pollution. Monitoring specific to stormwater runoff was not conducted in 2001, but a general visual stormwater survey was conducted as a part of the ongoing Section 319 grant in the watershed. Potential sources of pollution have been noted and are being addressed as a part of this grant.

4.2.2 Agricultural Sources

The majority of nutrient loads are transported with overland runoff from agricultural areas. According to the 2001 landuse assessment, approximately 65.63 percent of the land upstream of the reservoir is cultivated, 29.69 percent is in some form of permanent grass or herbaceous cover, and the remainder is in roads or farmsteads (Table 3). This landuse survey divided the watershed into four subwatersheds roughly corresponding to the upstream tributary monitoring sites in the basin and the fifth subwatershed being the area surrounding the lake.

The average crop reside after fall tillage average 60.24 percent, but following spring tillage and spring planting, the residue average dropped by more than half to 27.62 percent. Data on cropping pattern, soil type and percent slope were combined in the Universal Soil Loss equation to provide estimates of average soil loss within each subwatershed and for the entire Powers Lake watershed (Table 17).

Table 17. Percent Crop Residue After Tillage and Average USLE Estimates.

Subwatershed	Percent Crop Residue After Tillage		Average Universal Soil Loss (tons/ac.)
	Fall	Spring	
Northeast	58.0	26.0	3.02
Lunds Valley	60.0	28.5	1.06
South	67.5	32.5	0.56
West	55.0	25.0	1.04
Immediate	62.9	16.0	0.55
Entire Watershed	60.2	27.6	1.16

The landuse assessment also provided estimates of range and pasture condition for the project period (Table 18).

Table 18. Summary of Range and Pasture Condition[1].

	Condition		
Subwatershed	Good	Fair	Poor
Northeast	00.00	100.00	00.00
Lunds Valley	66.67	33.33	00.00
South	NE[2]	NE	00.00
West	NE	NE	00.00
Immediate	100.00	00.00	00.00
Entire Watershed	63.64	36.36	00.00

[1] Expressed as a percentage of all sampling units with range and pasture land in the subwatershed or watershed.
[2] No estimate provided due to small sample size within watershed

Kilograms per square kilometer delivery of total nitrogen, total phosphorus as phosphate, total suspended solids and water were calculated for the contributing subwatersheds (Table 19). It was determined that the hydraulic load for station 385036 (Lunds Valley) was underestimated, so delivery estimates are not to be viewed as absolute, but useful for comparisons of delivery rates between subwatersheds. In general, the subwatersheds Northeast, Lunds Valley, and West have similar delivery characteristics, while the South is much larger. This is graphically displayed in pounds per acre in Figures 12, 13, and 14. The increase in delivery per acre from the South subwatershed is primarily due to two large rainfall events that did not affect the more northern subwatersheds.

Table 19. Total Nitrogen, Total Phosphorus and Total Suspended Solids Delivery Estimates (kg/km^2) for Four Subwatersheds of Powers Lake.

Subwatershed	Total Nitrogen	Total Phosphorus	Total Suspended Solids
Northeast	48.17	14.62	638.02
Lunds Valley	52.24	17.34	2159.88
West	60.64	20.58	584.39
South	101.99	30.65	5512.11

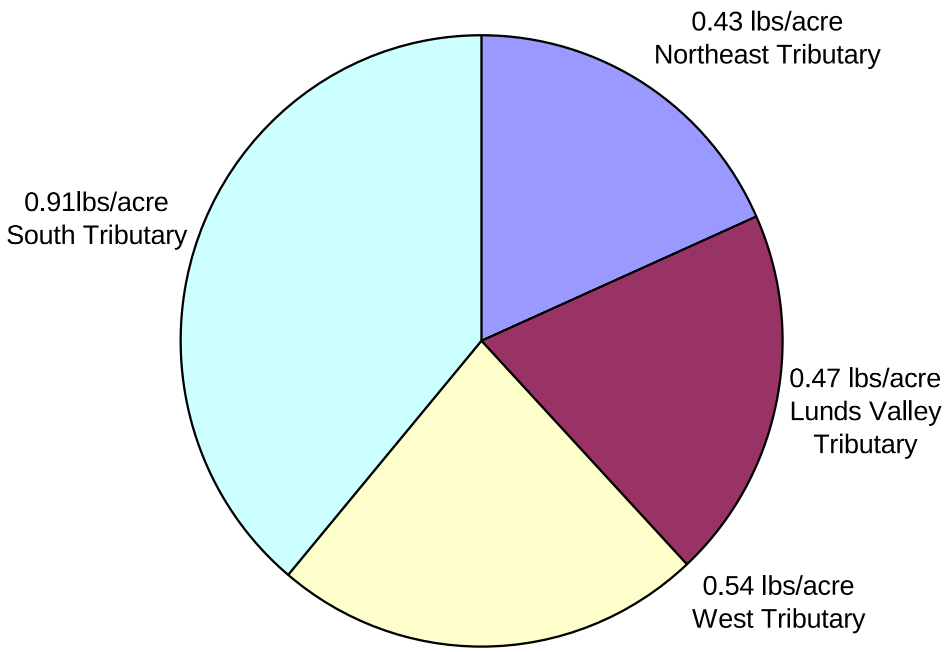

Figure 12. Total Nitrogen Yield (lbs./acre) by Subwatershed.

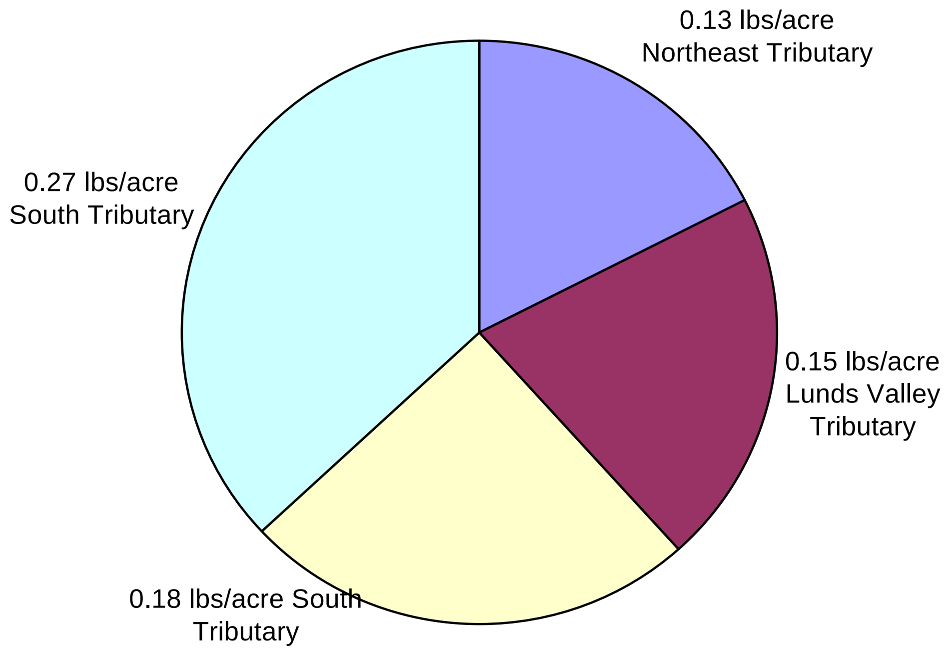

Figure 13. Total Phosphorus Yield (lbs./acre) by Subwatershed.

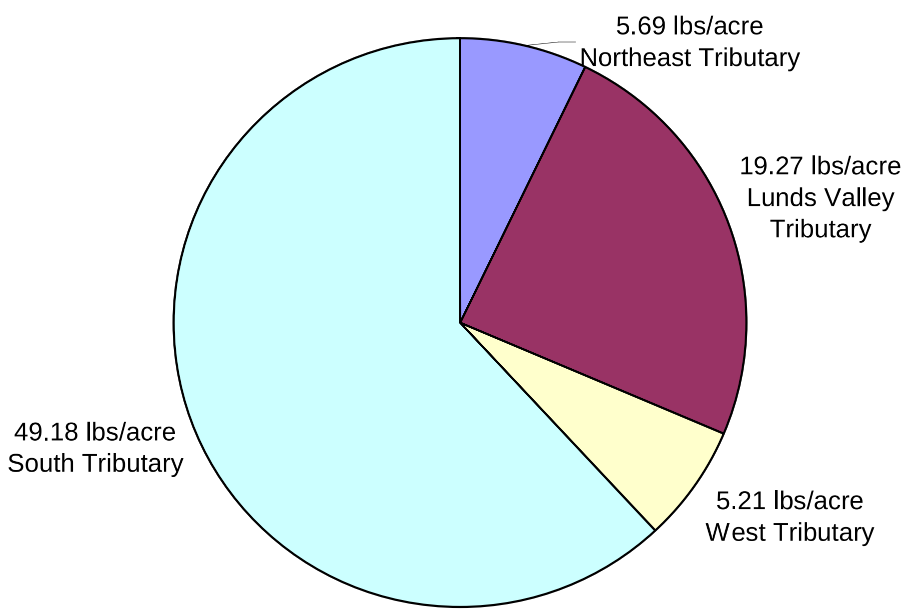

Figure 14. Total Suspended Solids Yield (lbs/acre) by Subwatershed.

5.0 TECHNICAL ANALYSIS

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

5.1 Tributary Load Analysis

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

5.2 BATHTUB Trophic Response Model

The BATHTUB model (Walker, 1996) was used to predict and evaluate the effects of various nutrient load reduction scenarios on Powers Lake. 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 reduced by the FLUX program. FLUX uses tributary inflow and outflow water quality and flow data to estimate average mass discharge or loading that passes a river or stream site using six calculation techniques. Load is therefore defined as the mass of a pollutant during a given unit of time. In the case of Powers Lake, the FLUX program came up with an annual phosphorus load of 5,245.4 kg/yr, including both internal and external loads. Phosphorus loads for the individual subwatersheds were also calculated (Table 20). The FLUX model then allows the user to pick the most appropriate load calculation technique with the smallest statistical error. Output for the FLUX program is then used to calibrate the BATHTUB model.

Table 20. Powers Lake Total Phosphorus Budget for 2001.

Source	Phosphorus Load (kg)
Precipitation	195.9
Northeast Trib. (385035)	629.8
Lunds Valley Trib. (385036)	976.6
West Trib. (385037)	349.4
South Trib. (385038)	723.7
Outflow (380539)	1,167.0
Net Retention	1,708.3
In-Lake cycling	2,370.0
Total Annual Load (External Load + In-Lake Cycling)	5,245.4
Trapping Efficiency	59%
Hydraulic Residence Time	2.96 years (1080.4 days)

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) an 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 FLUX 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 then calibrated by combining tributary load estimates for the project period with in-lake water quality estimates. The model is termed calibrated when the predicted estimates for the trophic response variables are similar to observed estimates from the project monitoring data. BATHTUB then has the ability to predict total phosphorus concentration, chlorophyll-a concentration, and Secchi disk transparency along with the associated TSI scores as a means of expressing trophic response.

As stated above, BATHTUB can compare predicted vs. actual conditions (Table 23). After calibration, the model was run based on observed concentrations of phosphorus and nitrogen, to derive an estimated an annual average total phosphorus external load of 2875.4 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.

Table 21. Observed and Predicted Values for Selected Trophic Response Variables for the Calibrated BATHTUB Model.

Variable	Observed	Predicted
Total Phosphorus as P (mg/L)	0.309[1]	0.309
Total Nitrogen as N (mg/L)	2.545[1]	2.545
Chlorophyll-a (*u*g/L)	70.68[2]	70.70
Secchi Disk Transparency (m)	0.23[2]	0.23
Carlson's TSI for Phosphorus	86.82	86.83
Carlson's TSI for Chlorophyll-a	66.86	66.96
Carlson's TSI for Secchi Disk	81.74	81.18

1-Annual volume weighted averages
2-Average

In the case of Powers Lake, 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 external derived phosphorus loading by 50, 75, and 90 percent (Tables 22, 23, and 24). Simulated reductions were achieved by reducing phosphorus concentrations in contributing tributaries and other externally delivery sources. Flow was held constant due to uncertainty in of estimating changes in hydraulic discharge with the implementation of BMPs. These reductions alone did not bring the lake to the desired trophic state (Figure 15).

Table 22. Powers Lake's Observed and Calibrated Model with a 50 Percent Reduction in External Loads of Total Phosphorus and Total Nitrogen.

Variable	Observed	Modeled 50% External Reduction
Total phosphorus (mg/L)	0.309	0.206
Total nitrogen (mg/L)	2.545	1.984
Conservative nutrient (Nitrogen, mg/L)	0.168	0.123
Chlorophyll-a (µg/L)	40.30	33.19
Secchi disk depth (m)	0.22	0.27
Carlson's TSI phosphorus	86.82	80.98
Carlson's TSI chlorophyll-a	66.86	64.96
Carlson's TSI Secchi disk	81.74	78.77

Table 23. Powers Lake's Observed and Calibrated Model with a 75 Percent Reduction in External Loads of Total Phosphorus and Total Nitrogen.

Variable	Observed	Modeled 75% External Reduction
Total phosphorus (mg/L)	0.309	0.139
Total nitrogen (mg/L)	2.545	1.674
Conservative nutrient (Nitrogen, mg/L)	0.168	0.094
Chlorophyll-a (µg/L)	40.30	26.87
Secchi disk depth (m)	0.22	0.32
Carlson's TSI phosphorus	86.82	75.26
Carlson's TSI chlorophyll-a	66.86	62.88
Carlson's TSI Secchi disk	81.74	76.36

Table 24. Powers Lake's Observed and Calibrated Model with a 90 Percent Reduction in External Loads of Total Phosphorus and Total Nitrogen.

Variable	Observed	Modeled 90% External Reduction
Total phosphorus (mg/L)	0.309	0.087
Total nitrogen (mg/L)	2.545	1.475
Conservative nutrient (Nitrogen, mg/L)	0.168	0.068
Chlorophyll-a (µg/L)	40.30	20.24
Secchi disk depth (m)	0.22	0.40
Carlson's TSI phosphorus	86.82	68.56
Carlson's TSI chlorophyll-a	66.86	60.11
Carlson's TSI Secchi disk	81.74	73.33

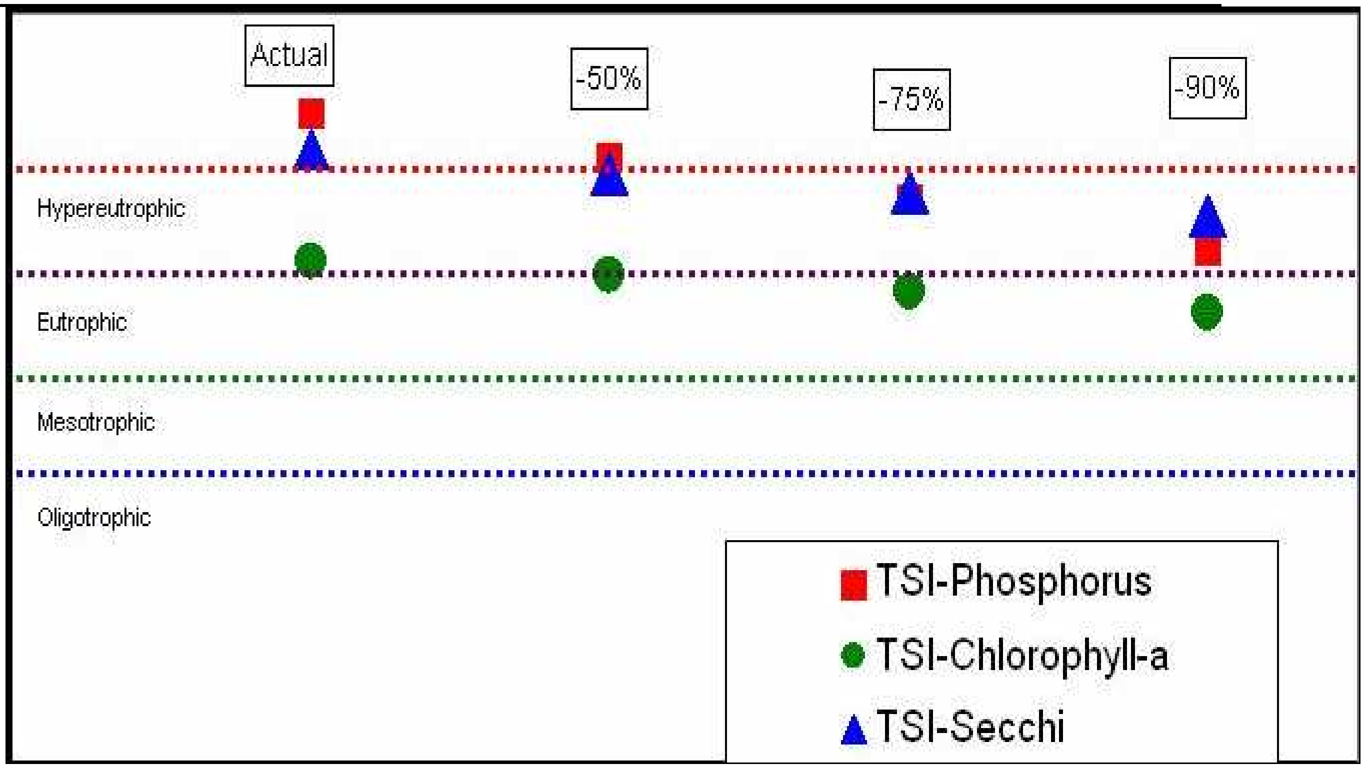

Figure 15. Model-Predicted Lake Trophic Response from Decreases in External Loads.

The model was then run again to assess different levels of reduction in external pollution loads with a 50 percent reduction in internal nutrient load. This data is presented in Tables 25, 26 and 27, and Figure 16.

Table 25. Powers Lake's Observed and Calibrated Model with a 50 Percent Reduction in Internally Available Nutrients and 50 Percent Reduction in External Loads of Total Nitrogen and Total Phosphorus.

Variable	Observed	Modeled 50% Internal and 50% External Reduction
Total phosphorus (mg/L)	0.309	0.049
Total nitrogen (mg/L)	2.545	0.689
Conservative nutrient (Nitrogen, mg/L)	0.168	0.033
Chlorophyll-a (µg/L)	40.30	14.01
Secchi disk depth (m)	0.22	1.16
Carlson's TSI phosphorus	86.82	60.43
Carlson's TSI chlorophyll-a	66.86	56.50
Carlson's TSI Secchi disk	81.74	57.83

Table 26. Powers Lake's Observed and Calibrated Model with a 50 Percent Reduction in Internally Available Nutrients and 75 Percent Reduction in External Loads of Total Nitrogen and Total Phosphorus.

Variable	Observed	Modeled 50% Internal and 75% External Reduction
Total phosphorus (mg/L)	0.309	0.041
Total nitrogen (mg/L)	2.545	0.689
Conservative nutrient (Nitrogen, mg/L)	0.168	0.033
Chlorophyll-a (µg/L)	40.30	14.01
Secchi disk depth (m)	0.22	1.64
Carlson's TSI phosphorus	86.82	57.68
Carlson's TSI chlorophyll-a	66.86	55.02
Carlson's TSI Secchi disk	81.74	52.91

Table 27. Powers Lake's Observed and Calibrated Model with a 50 Percent Reduction in Internally Available Nutrients and 90 Percent Reduction in External Loads of Total Nitrogen and Total Phosphorus.

Variable	Observed	Modeled 50% Internal and 90% External Reduction
Total phosphorus (mg/L)	0.309	0.038
Total nitrogen (mg/L)	2.545	0.532
Conservative nutrient (Nitrogen, mg/L)	0.168	0.024
Chlorophyll-a (µg/L)	40.30	11.29
Secchi disk depth (m)	0.22	1.93
Carlson's TSI phosphorus	86.82	56.43
Carlson's TSI chlorophyll-a	66.86	54.38
Carlson's TSI Secchi disk	81.74	50.54

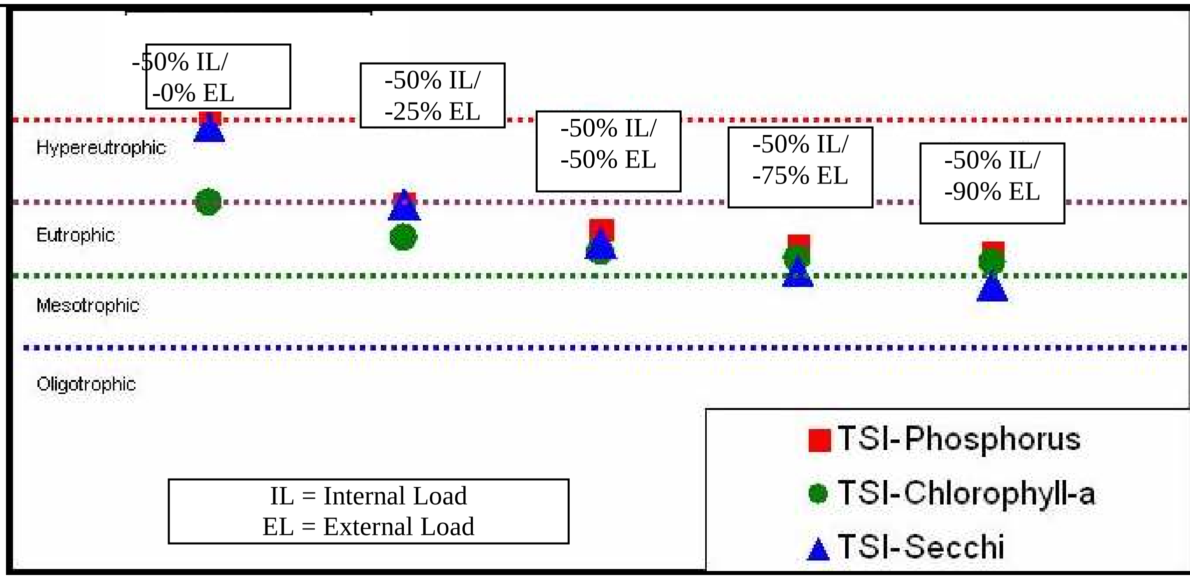

Figure 16. Model-Predicted Lake Trophic Response with Decreases in External Loads of Total Nitrogen and Total Phosphorus and 50 Percent Reduction in Internally Available Total Nitrogen and Total Phosphorus.

The model results indicate that if it were possible to reduce internal nutrient loading in Powers Lake by 50 percent and external phosphorus loading 75 percent, the average annual total phosphorus and chlorophyll-a concentrations in the lake would decrease and Secchi disk transparency depth would increase. Table 28 shows the observed and predicted 50 percent internal load reduction and 75 percent external load reduction values used for constructing the TMDL (Section 7.0).

Table 28. Observed Load and Predicted Load Reduction Values from BATHTUB Model.

TMDL	Observed TP Load, External + Internal (kg/yr)	Predicted 50% Internal Reduction (kg/yr)	Predicted 75% External Load Reduction (kg/yr)	Predicted Load after 50 % Internal & 75 % External Reductions (kg/yr)
Nutrients (expressed and P) and Dissolved Oxygen	5,245.4	-1,185.00	-2,156.55	1,903.85

Using the AGNPS model, it was determined that if 87 percent of the moderate to high sediment and nutrient loading cells were addressed through BMPs, then the sediment load would decrease by 57 percent, and phosphorus load would decrease by 76 percent. This exceeds the reduction determined necessary to reach the desired trophic state and will allow the lake to reach the chlorophyll-a TSI target value of 55.02 determined in Section 3.1.

5.3 AGNPS Watershed Model

In 2004, the Powers Lake Watershed received a Section 319 grant from the NDDoH to start implementing conservation practices based on a report that was written after the assessment. As a part of this five year project, Agricultural Nonpoint Source Model (AGNPS), was used to determine the changes in landuse since the 2001 assessment. AGNPS, developed by the United States Department of Agriculture, Agricultural Research Service, was then used to analyze and predict the effect single storm events can be expected to have on water quality in a watershed.

The primary objectives for using the AGNPS 3.65 model were to: 1) evaluate NPS contributions within the watersheds; 2) identify critical pollutant source areas within the watershed; and 3) evaluate potential pollutant (nitrogen, phosphorus, and sediment) reduction estimates that can be achieved through the implementation of various BMP implementation scenarios.

The AGNPS 3.65 model is a single event model that has twenty input parameters. Sixteen parameters were used to calculate nutrient/sediment output, surface runoff and erosion. The parameters used where receiving cell, aspect, SCS curve, percent slope, slope shape, slope length, Manning's roughness coefficient, K-factor, C-factor, P-factor, surface conditions constant, soil texture, fertilizer inputs, point source indicators, COD factor and channel indicator.

The AGNPS 3.65 model was used in conjunction with an intensive land use survey to determine critical areas within the Powers Lake Watershed. AGNPS also allows division into subwatersheds (Figure 17). Criteria used during the landuse assessment were percent cover on cropland and pasture/range conditions. These criteria were used to determine the C factor for each cell. The initial model was run using current conditions determined during the land use assessment. A 25yr/24hr storm event (4.10-inches.) in Burke County was applied to the model to evaluate relative pollutant yields from each 40-acre cell. Each quarter, quarter of land was given a cell number. Each cell represents 40-acres of land. The results for each subwatershed were analyzed statistically. Critical cells were identified using the 25th percentile method. Phosphorus readily attaches to soil particles for transport. Figure 16 shows those areas with moderate soil loss (3-4.99 tons/ac) and cells with high soil loss (>5.00 tons/ac).Cells with sediment phosphorous levels above 2.5 tons/ac were identified as critical (Figure 19).

The model was run a second time depicting a best case scenario, in which all critical cropland and pasture/rangeland cells were treated with BMPs. The BMPs used during the second run were no till, nutrient management, prescribed grazing and pasture/hayland plantings. The BMPs were reflected within the model by making changes in the input parameters.

Once nutrient loadings are decreased, algal biomass will decline, dissolved oxygen will increase, and the overall trophic status of the reservoir will improve.

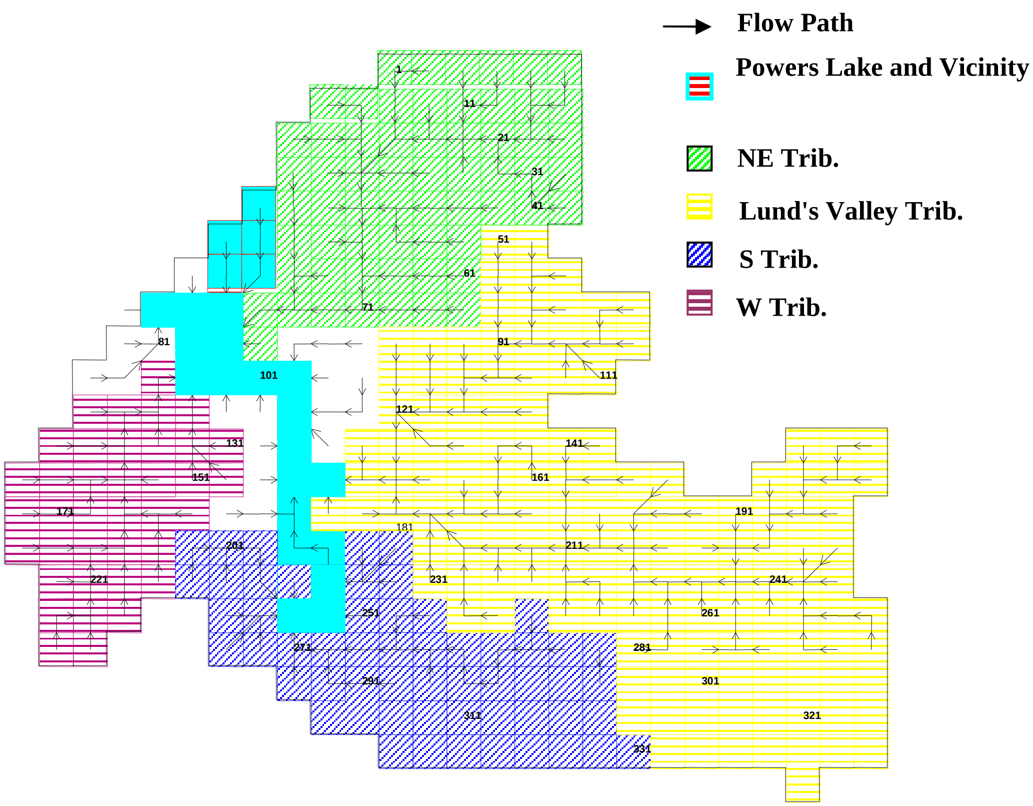

Figure 17. AGNPS Model Derived Flow Paths

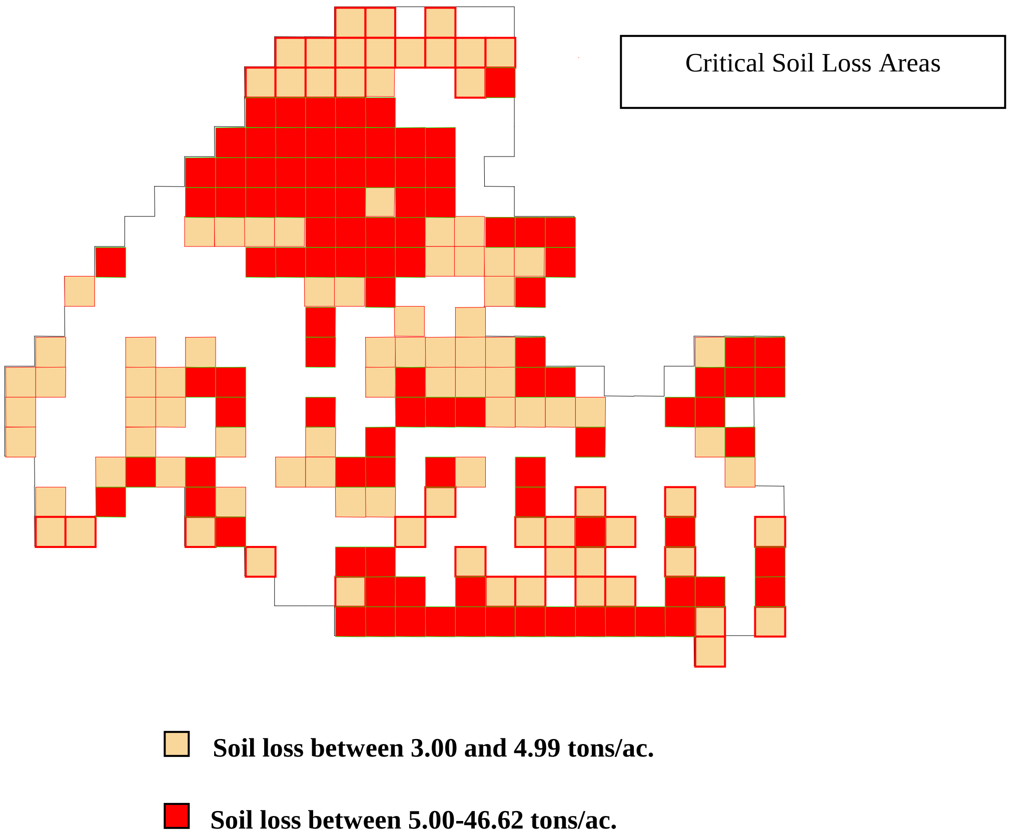

Figure 18. AGNPS Identified Moderate and High Soil Loss Areas.

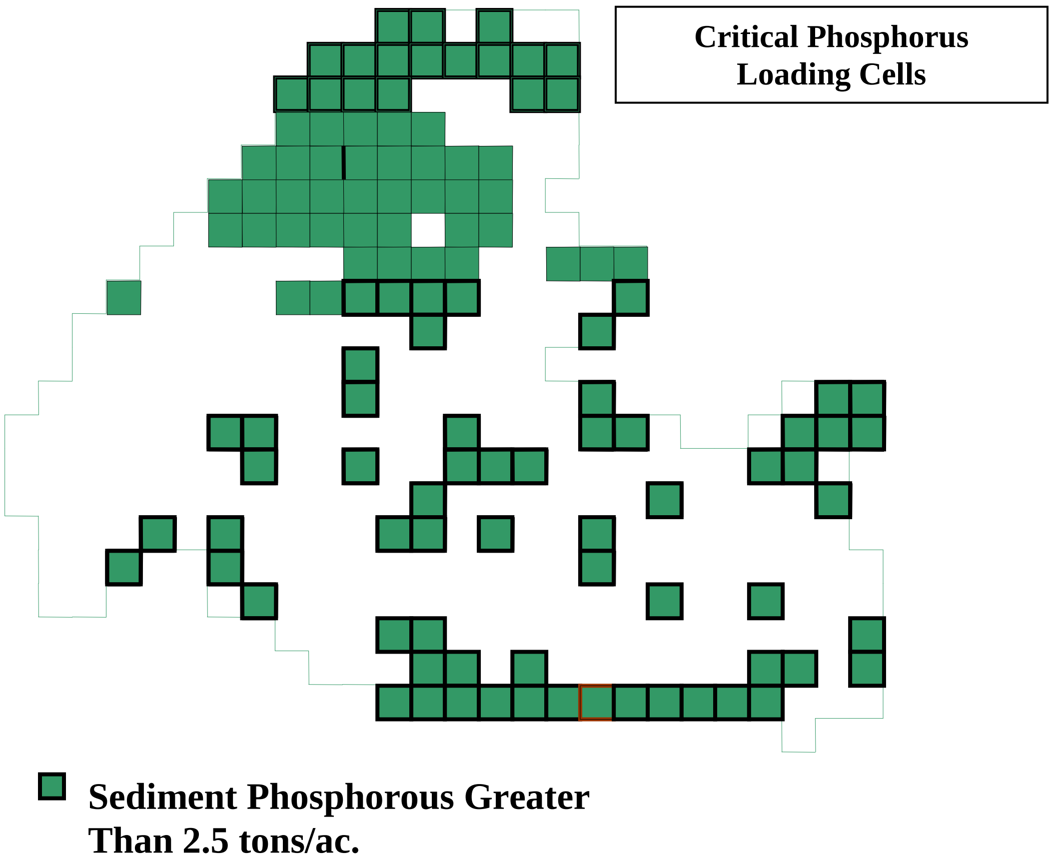

Figure 19. AGNPS Identified Critical Phosphorus Loading Cells.

5.4 Dissolved Oxygen

Powers Lake is listed as fully supporting but threatened for fish and aquatic biota designated uses because dissolved oxygen levels are below the State's water quality standard. (see Figure 7). AGNPS and BATHTUB models indicate that excessive nutrient loading is responsible for the low dissolved oxygen levels in Powers Lake.

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 increased productivity of the system resulting in 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.

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

Carpenter et al. (1998), has shown that nonpoint sources of phosphorous 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 North Dakota 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 phosphorous have impacted the lake severely. Monitoring and research from the 1960’s has shown that depressed hypolimnetic dissolved oxygen levels were responsible for large fish kills and large mats of decaying algae. 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 phosphorous 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 phosphorous (TP) concentrations. The AF may also be used to quantify response to watershed restoration measures which makes 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 = 1,616 acres; 6.54 km^2), mean depth (z = 5.7 feet; 1.74 meters), and the ratio of the metric mean depth to the surface area ($z/A_o^{0.5}$ = 0.73) for Powers Lake which show that these parameters are within the range of lakes used by Nürnberg (Table 20). 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 Powers Lake which will reduce algae blooms and therefore increase oxygen levels over time.

Table 29. Range of Parameters within Nürnberg's Model.

Variable	Nürnberg Range
z (meters)	1.6 – 200
A_o (km^2)	5 – 8.2 x 10^6
$z/A_o^{0.5}$	0.14 – 48.1

As a result of this direct influence, it is anticipated that meeting the phosphorus load reduction target in Powers Lake will address the dissolved oxygen impairment. A reduction in total phosphorus load to Powers Lake 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 water quality 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 shall be established at levels necessary to attain and maintain the applicable narrative and numerical water quality standards with seasonal variations and a margin of safety which 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).

Assuming the current annual total phosphorus load is 5,245.4 kg/yr, a 75 percent external and 50 percent internal reduction is equivalent to 3,341.55 kg/yr and will be achieved through the implementation of best management practices affecting agricultural land in the watershed. An additional 5 percent load reduction, or 95.19 kg/yr, is being used to provide an additional margin of safety to account for additional or non-responsive NPS sources. Additionally, conservative assumptions were used within the calculations and models, as well as determining the target TSI scores, thus adding implicitly to the margin of safety. Finally, the area immediate to the lake, including the town of Powers Lake, was not included with the rest of the subwatersheds in the allocation portion of this document (Section 8.0), due to the fact it is difficult to calculate loading from this small area. The Section 319 project already under implementation addresses nonpoint source pollution from Powers Lake in terms of a Stormwater Pollution Plan and most of the rest of the area around the lake is undeveloped and in some sort of herbaceous cover at this time. Any reduction in NPS pollution that occurs in this area will add to the margin of safety for this TMDL.

Also, since the impairments are nonpoint source in nature, and mostly derived from agricultural sources, all TMDLs are linked to each other (see descriptions of each in Section 3.0). Phosphorus, because of its tendency to sorb to soil particles and organic matter, is primarily transported in surface runoff with eroded sediments (USEPA, 1999a). Dissolved oxygen can decline if nutrient and sediment loads are high. A reduction focused on phosphorus will improve the water quality in regards to sediment and dissolved oxygen as well.

As an additional margin of safety during the implementation phase, a project implementation plan will be developed to include concurrent and post-implementation monitoring to investigate the effectiveness of the TMDL controls and to determine the attainment of the targets. The project implementation plan is not a static document, but an adaptive management tool that will be used and modified as the situation necessitates throughout the implementation phase.

6.2 Seasonality

Section 303(d)(1)(C) of the Clean Water Act and the U.S. Environmental Protection Agency (EPA's) regulations require that a TMDL be established with seasonal variations. The Powers Lake TMDLs address seasonality because the BATHTUB model incorporates seasonal differences in its prediction of annual average total phosphorus concentrations.

7.0 TMDL

The tables below summarizes the nutrient, sediment, and dissolved oxygen TMDLs for Powers Lake in terms of loading capacity, wasteload allocations, load allocations, and a margin of safety. The TMDL can be generically described by the following equation:

TMDL = LC = WLA + LA + MOS where:

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

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

LA load allocation, or the portion of the TMDL allocated to existing or future nonpoint sources;

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

7.1 Nutrient TMDL

A Carlson's chlorophyll-a TSI target of 55.02 was chosen for the Powers Lake nutrient TMDL target. Through the use of the BATHTUB model it was determined that a 50 percent internal load reduction along with a 75 percent external load reduction in phosphorus is required to restore the lake to the target trophic state of eutrophic; this corresponds to a chlorophyll-a TSI of 55.02 (Table 30).

Table 30. Observed and Predicted TSI Scores Assuming a 75 Percent Reduction in External and 50 Percent Reduction in Internal Phosphorus Loading.

Variable	TSI Score Observed	TSI Score Modeled 75% External, 50% Internal Reduction in P Loading
Carlson's TSI for Phosphorus	86.82	57.68
Carlson's TSI for Chlorophyll-a	66.86	55.02
Carlson's TSI for Secchi Disk	81.74	52.91

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

Based on data collected in 2001, the existing annual total phosphorus load to Powers Lake is estimated at 5245.4 kg/yr. Assuming a 75% reduction in external phosphorus loading combined with a 50% reduction in internal phosphorus loading will result in Powers Lake reaching a TMDL target total phosphorus concentration of 0.041 mg L^{-1} and an accompanying chlorophyll-a TSI target of 55.02, the TMDL or Loading Capacity is 1903.85 kg/yr. Assuming 5% of the loading capacity (95.19 kg/yr) is explicitly assigned to the MOS and there are no point sources in the watershed, all of the remaining loading capacity (1808.66 kg/yr) is assigned to the load allocation (Table 31).

In November 2006 EPA issued a memorandum "Establishing TMDL "Daily" Loads in Light of the Decision by the U.S. Court of Appeals for the D.C. Circuit in Friends of the Earth, Inc. v. EPA et. al., No. 05-5015 (April 25, 2006) and Implications for NPDES Permits," which recommends that all TMDLs and associated load allocations and wasteload allocations include a daily time increment in conjunction with other appropriate temporal expressions that may be necessary to implement the relevant water quality standard. While the Department believes that the appropriate temporal expression for phosphorus loading to lakes and reservoirs is as an annual load, the phosphorus TMDL has also been expressed as a daily load. In order to express this phosphorus TMDL as a daily load the annual loading capacity of 1903.85 kg/yr was divided by 365 days. Based on this analysis, the phosphorus TMDL, expressed as an average daily load, is 5.216 kg/day with the load allocation equal to 4.955 kg/day and the MOS equal to 0.261 kg/day.

Table 31. Summary of the Nutrient TMDL for Powers Lake.

Category	Total Phosphorus (kg/yr)	Explanation
Existing Load (Total)	5,245.40	From observed data
External	2,875.40	
Internal	2,370.00	
Loading Capacity (Total)	1,903.85	
External	718.85	75% reduction based on model
Internal	1,185.00	50% reduction based on model
Wasteload Allocation	0	No point sources
Load Allocation	1,808.66	Entire loading capacity minus MOS is allocated to nonpoint sources
MOS	95.19	Explicit five percent (5%) of total loading capacity MOS

7.2 Dissolved Oxygen TMDL

It is expected that by attaining the nutrient load reduction target established for Powers Lake, the dissolved oxygen impairment will be addressed. A reduction in nutrient load to Powers Lake 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 the biological oxygen demand is therefore assumed to result in attainment of the of the State's dissolved oxygen Water Quality Standard.

8.0 ALLOCATION

Powers Lake's watershed supports extensive agriculture where cropland constitutes a majority of the landuse. In order to determine more accurately where pollution loading was originating, and to most effectively implement conservation practices, Powers Lake was divided into five smaller subwatersheds. These were labeled Northeast, Lunds Valley, West, South, and Immediate (for area immediately surrounding the lake, including the town of Powers Lake). For purposes of loading, the first four subwatersheds were considered. Using the AGNPS model, it was determined that if 87 percent of the moderate to high soil erosion and nutrient loading cells were addressed through best management practices (BMPs), the sediment load would decrease by 57 percent, and phosphorus load would decrease by 76 percent. Both of these values are within the reduction required by the above TMDL. Through data analysis it was determined that all subwatersheds do not contribute equally (Table 19 and Figures 12, 13, and 14). In order to allocate loads based on contributions, Table 32 was created. It should be noted that while precipitation contributes 6.8% of the load, there are no BMPs to address this issue. To account for this portion of the load, each of the subwatersheds was given an equal portion of the precipitation load (1.7%), in addition to their own.

Table 32. Observed Total Phosphorus Load and Load Allocation Divided by Subwatershed.

Tributary	Total Phosphorus Mass Load (kg) Observed	Percent of Total External Load (%)	Portion of TMDL External Load Allocation[1] TP (kg)
Northeast (385035)	629.8	21.9	161.17[1]
Lunds Valley (385036)	976.6	34.0	243.80[1]
West (385037)	349.4	12.1	94.24[1]
South (385038)	723.7	25.2	183.70[1]
Precipitation	195.9	6.8	-
Total	2,875.4	100.00	682.91[1]

[1] Based on individual subwatershed's percent of load + 1.7% of total to account for precipitation load.

Table 33. Summary of Total Phosphorus Load, Reduction, and Allocation Amounts.

Load Allocation Amounts	Total Phosphorus Load (kg)
Total Load (kg)	**5,245.40**
Observed Internal Load	2,370.00
50 Percent Internal TMDL Reduction + MOS	1,244.25
Internal Allocation	1,125.75
Observed External Load	2,875.40
75 Percent External TMDL Reduction +MOS	2,192.49
External Allocation	682.91
Total Allocation (Internal + External)-5% MOS	**1,808.66**

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

9.0 PUBLIC PARTICIPATION

To satisfy the public participation requirement of this TMDL, a hard copy of the TMDL for Powers Lake 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 were:

- Powers Lake Watershed Committee
- Mountrail and Burk County Soil Conservation Districts
- Mountrail and Burke County Water Resource Boards
- North Dakota Game and Fish Department
- Natural Resource Conservation Service (State, Mountrail and Burke County Field Offices)
- U.S. Environmental Protection Agency, Region VIII
- U.S. Fish & Wildlife Service

In addition, the TMDL report was been posted on the North Dakota Department of Health, Division of Water Quality web site at http://www.health.state.nd.us/wq/ . A 30 day public notice soliciting comment and participation was also been published in the following newspapers:

- The Bismarck Tribune.
- Minot Daily News
- Burke County Tribune
- Mountrail County Promoter

In response to the Department's public notice, comments were received from the US Fish and Wildlife Service's North Dakota Field Office, the US EPA Region 8 and from Scott Elstad with the North Dakota Game and Fish Department in the form of hand written notes in the margins of the draft report. A copy of the US EPA's and US Fish and Wildlife Service's.comments are provided in Appendices E and F, respectively. The Department's response to comments are provided in Appendix G.

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. Since a watershed restoration plan (e.g. 319 PIP) has already been implemented, monitoring will be conducted in the lake/reservoir according to the approved QAPP, beginning two years after implementation and extending five years after the implementation project is complete.

11.0 TMDL IMPLEMENTATION STRATEGY

Implementation of TMDLs is dependent upon the availability of Section 319 NPS funds or other watershed restoration programs (e.g. USDA EQIP), as well as securing a local project sponsor and the required matching funds. Provided these three requirements are in place, a project implementation plan (PIP) is developed in accordance with the TMDL and submitted to the ND Nonpoint Source Pollution Task Force and US 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.

Since Powers Lake has already moved into implementation of conservations practices to reduce nutrients in the watershed and improve the trophic status of the lake, a monitoring plan is currently in place. (Appendix C)

12.0 ENDANGERED SPECIES ACT COMPLIANCE

The North Dakota Department of Health has reviewed the list of Threatened and Endangered Species in Burke and Mountrail Counties as provided by the US Fish and Wildlife Service (Appendix C). Although there are listed species present in the county they do not utilize the waterbody that is targeted by this TMDL. It is, therefore, the Department's best professional judgment that the Powers Lake TMDL poses "No Adverse Effect" to those Threatened and Endangered species listed for Burke and Mountrail Counties. In a letter dated September 4, 2008 (Appendix F) which was sent in response to the Department's request for public comments on the Powers Lake TMDL report, the US Fish and Wildlife Service concurred with the Department's conclusion.

13.0 REFERENCES

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Appendix A

A Calibrated Trophic Response Model (BATHTUB) for Powers Lake

Model Calibration:

OUTPUT FORMAT: 2 OPTION: 1
CASE: Calibrated Model
HYDRAULIC AND DISPERSION PARAMETERS:

SEG	OUT	NET INFLOW HM3/YR	RESIDENCE TIME YRS	OVERFLOW RATE M/YR	MEAN VELOCITY KM/YR	----DISPERSION----- ESTIMATED KM2/YR	NUMERIC KM2/YR	EXCHANGE RATE HM3/YR
1	0	3.77	2.95874	.6	3.0	1000.	14.	0.

OUTPUT FORMAT: 3 OPTION: 2
CASE: Calibrated Model
GROSS WATER BALANCE:

ID	T	LOCATION	DRAINAGE AREA KM2	---- FLOW (HM3/YR) ---- MEAN	VARIANCE	CV	RUNOFF M/YR
1	1	385035	19.430	1.150	.000E+00	.000	.059
2	1	385036	88.100	1.500	.000E+00	.000	.017
3	1	385037	14.300	.477	.000E+00	.000	.033
4	1	385038	8.420	1.300	.000E+00	.000	.154
5	4	385039	134.090	4.580	.000E+00	.000	.034
		PRECIPITATION	6.530	1.959	.154E+00	.200	.300
		EXTERNAL INFLOW	130.250	4.427	.000E+00	.000	.034
		***TOTAL INFLOW	136.780	6.386	.154E+00	.061	.047
		GAUGED OUTFLOW	134.090	4.580	.000E+00	.000	.034
		UNGAUGED OUTFLOW	2.690	-.806	.768E+00	1.087	-.300
		***TOTAL OUTFLOW	136.780	3.774	.768E+00	.232	.028
		***EVAPORATION	.000	2.612	.614E+00	.300	.000
		***STORAGE INCREASE	.000	.000	.000E+00	.000	.000

GROSS MASS BALANCE BASED UPON ESTIMATED CONCENTRATIONS
COMPONENT: TOTAL P

ID	T	LOCATION	----- LOADING ---- KG/YR	%(I)	--- VARIANCE --- KG/YR**2	%(I)	CV	CONC MG/M3	EXPORT KG/KM2
1	1	385035	629.6	21.9	.000E+00	.0	.000	547.5	32.4
2	1	385036	976.6	34.0	.000E+00	.0	.000	651.1	11.1
3	1	385037	349.4	12.2	.000E+00	.0	.000	732.4	24.4
4	1	385038	723.7	25.2	.000E+00	.0	.000	556.7	86.0
5	4	385039	1416.2	49.3	.624E+05	650.1	.176	309.2	10.6
		PRECIPITATION	195.9	6.8	.959E+04	100.0	.500	100.0	30.0
		EXTERNAL INFLOW	2679.3	93.2	.000E+00	.0	.000	605.2	20.6
		***TOTAL INFLOW	2875.2	100.0	.959E+04	100.0	.034	450.2	21.0
		GAUGED OUTFLOW	1416.2	49.3	.624E+05	650.1	.176	309.2	10.6
		UNGAUGED OUTFLOW	-249.2	-8.7	.839E+05	873.9	1.162	309.2	-92.6
		***TOTAL OUTFLOW	1167.0	40.6	.787E+05	819.9	.240	309.2	8.5
		***STORAGE INCREASE	.0	.0	.000E+00	.0	.000	.0	.0
		***NET RETENTION	1708.3	59.4	.834E+05	869.0	.169	.0	.0

HYDRAULIC		-------------- TOTAL P --------------			
OVERFLOW RATE M/YR	RESIDENCE TIME YRS	POOL CONC MG/M3	RESIDENCE TIME YRS	TURNOVER RATIO -	RETENTION COEF -
.58	2.9587	309.2	1.2009	.8327	.5941

GROSS MASS BALANCE BASED UPON ESTIMATED CONCENTRATIONS
COMPONENT: TOTAL N

ID	T	LOCATION	LOADING KG/YR	LOADING %(I)	VARIANCE KG/YR**2	VARIANCE %(I)	CV	CONC MG/M3	EXPORT KG/KM2
1	1	385035	2074.6	13.8	.000E+00	.0	.000	1804.0	106.8
2	1	385036	2941.5	19.6	.000E+00	.0	.000	1961.0	33.4
3	1	385037	1029.5	6.9	.000E+00	.0	.000	2158.2	72.0
4	1	385038	2407.6	16.1	.000E+00	.0	.000	1852.0	285.9
5	4	385039	11657.1	77.8	.791E+07	74.2	.241	2545.2	86.9
PRECIPITATION			6530.0	43.6	.107E+08	100.0	.500	3333.3	1000.0
EXTERNAL INFLOW			8453.2	56.4	.000E+00	.0	.000	1909.5	64.9
***TOTAL INFLOW			14983.2	100.0	.107E+08	100.0	.218	2346.3	109.5
GAUGED OUTFLOW			11657.1	77.8	.791E+07	74.2	.241	2545.2	86.9
UNGAUGED OUTFLOW			-2051.4	-13.7	.629E+07	59.0	1.223	2545.2	-762.6
***TOTAL OUTFLOW			9605.6	64.1	.566E+07	53.1	.248	2545.2	70.2
***STORAGE INCREASE			.0	.0	.000E+00	.0	.000	.0	.0
***NET RETENTION			5377.5	35.9	.629E+07	59.0	.466	.0	.0

HYDRAULIC		-------------- TOTAL N --------------			
OVERFLOW RATE M/YR	RESIDENCE TIME YRS	POOL CONC MG/M3	RESIDENCE TIME YRS	TURNOVER RATIO -	RETENTION COEF -
.58	2.9587	2545.2	1.8968	.5272	.3589

OUTPUT FORMAT: 6 OPTION: 1
CASE: Calibrated Model

T STATISTICS COMPARE OBSERVED AND PREDICTED MEANS
USING THE FOLLOWING ERROR TERMS:
1 = OBSERVED WATER QUALITY ERROR ONLY
2 = ERROR TYPICAL OF MODEL DEVELOPMENT DATA SET
3 = OBSERVED AND PREDICTED ERROR

SEGMENT: 1 deepest

VARIABLE		OBSERVED MEAN	OBSERVED CV	ESTIMATED MEAN	ESTIMATED CV	RATIO	T STAT 1	T STAT 2	T STAT 3
TOTAL P	MG/M3	309.0	.00	309.2	.18	1.00	.00	.00	.00
TOTAL N	MG/M3	2545.0	.00	2545.2	.24	1.00	.00	.00	.00
C.NUTRIENT	MG/M3	167.7	.00	167.7	.20	1.00	.00	.00	.00
CHL-A	MG/M3	40.3	.00	40.7	.28	.99	.00	-.03	-.03
SECCHI	M	.2	.00	.2	.25	.96	.00	-.16	-.18
ORGANIC N	MG/M3	181.0	.00	181.5	.27	1.00	.00	-.01	-.01
TP-ORTHO-P	MG/M3	143.0	.00	143.2	.32	1.00	.00	.00	-.01

OUTPUT FORMAT: 7 OPTION: 1
CASE: Calibrated Model

OBSERVED AND PREDICTED DIAGNOSTIC VARIABLES
RANKED AGAINST CE MODEL DEVELOPMENT DATA SET

SEGMENT: 1 deepest

VARIABLE		----- VALUES ----- OBSERVED	ESTIMATED	--- RANKS (%) ---- OBSERVED	ESTIMATED
TOTAL P	MG/M3	309.00	309.22	98.1	98.1
TOTAL N	MG/M3	2545.00	2545.22	92.7	92.7
C.NUTRIENT	MG/M3	167.65	167.70	97.3	97.3
CHL-A	MG/M3	40.30	40.70	97.1	97.2
SECCHI	M	.22	.23	1.8	2.1
ORGANIC N	MG/M3	181.00	181.49	3.0	3.0
TP-ORTHO-P	MG/M3	143.00	143.23	95.0	95.0
ANTILOG PC-1		2034.08	2004.76	94.7	94.6
ANTILOG PC-2		3.73	3.87	15.0	16.7
(N - 150) / P		7.75	7.75	12.4	12.4
INORGANIC N / P		14.24	14.24	23.0	23.0
TURBIDITY	1/M	.20	.20	10.3	10.3
ZMIX * TURBIDITY		.34	.34	.2	.2
ZMIX / SECCHI		7.77	7.43	79.9	77.7
CHL-A * SECCHI		8.87	9.36	42.1	45.2
CHL-A / TOTAL P		.13	.13	26.1	26.6
FREQ(CHL-a>10) %		97.37	97.46	.0	.0
FREQ(CHL-a>20) %		79.39	79.84	.0	.0
FREQ(CHL-a>30) %		56.60	57.22	.0	.0
FREQ(CHL-a>40) %		38.28	38.88	.0	.0
CARLSON TSI-P		86.82	86.83	.0	.0
CARLSON TSI-CHLA		66.86	66.96	.0	.0
CARLSON TSI-SEC		81.82	81.18	.0	.0

OUTPUT FORMAT: 8 OPTION: 1
CASE: Calibrated Model
PREDICTED CONCENTRATIONS:

VARIABLE	SEGMENT-->	1
TOTAL P	MG/M3	309.22
TOTAL N	MG/M3	2545.22
C.NUTRIENT	MG/M3	167.70
CHL-A	MG/M3	40.70
SECCHI	M	.23
ORGANIC N	MG/M3	181.49
TP-ORTHO-P	MG/M3	143.23

Model: 0% Internal/ 90% External

OUTPUT FORMAT: 2 OPTION: 1
CASE: POWLK 90% load, Zero internal
HYDRAULIC AND DISPERSION PARAMETERS:

SEG	OUT	NET INFLOW HM3/YR	RESIDENCE TIME YRS	OVERFLOW RATE M/YR	MEAN VELOCITY KM/YR	----DISPERSION----- ESTIMATED KM2/YR	NUMERIC KM2/YR	EXCHANGE RATE HM3/YR
1	0	4.43	1.48326	1.2	6.1	1000.	27.	0.

OUTPUT FORMAT: 3 OPTION: 2
CASE: POWLK 90% load, Zero internal
GROSS WATER BALANCE:

ID	T	LOCATION	DRAINAGE AREA KM2	---- FLOW (HM3/YR) ---- MEAN	VARIANCE	CV	RUNOFF M/YR
1	1	385035	19.430	1.150	.000E+00	.000	.059
2	1	385036	88.100	1.500	.000E+00	.000	.017
3	1	385037	14.300	.477	.000E+00	.000	.033
4	1	385038	8.420	1.300	.000E+00	.000	.154
5	4	385039	134.090	4.580	.000E+00	.000	.034
		PRECIPITATION	3.840	.000	.000E+00	.000	.000
		EXTERNAL INFLOW	130.250	4.427	.000E+00	.000	.034
		***TOTAL INFLOW	134.090	4.427	.000E+00	.000	.033
		GAUGED OUTFLOW	134.090	4.580	.000E+00	.000	.034
		UNGAUGED OUTFLOW	.000	-.153	.000E+00	.000	.000
		***TOTAL OUTFLOW	134.090	4.427	.000E+00	.000	.033
		***EVAPORATION	.000	.000	.000E+00	.000	.000
		***STORAGE INCREASE	.000	.000	.000E+00	.000	.000

GROSS MASS BALANCE BASED UPON ESTIMATED CONCENTRATIONS
COMPONENT: TOTAL P

ID	T	LOCATION	----- LOADING ---- KG/YR	%(I)	--- VARIANCE --- KG/YR**2	%(I)	CV	CONC MG/M3	EXPORT KG/KM2
1	1	385035	629.6	22.5	.000E+00	.0	.000	547.5	32.4
2	1	385036	976.6	34.9	.000E+00	.0	.000	651.1	11.1
3	1	385037	349.4	12.5	.000E+00	.0	.000	732.4	24.4
4	1	385038	723.7	25.9	.000E+00	.0	.000	556.7	86.0
5	4	385039	283.7	10.2	.352E+04	106.1	.209	62.0	2.1
		PRECIPITATION	115.2	4.1	.332E+04	100.0	.500	.0	30.0
		EXTERNAL INFLOW	2679.3	95.9	.000E+00	.0	.000	605.2	20.6
		***TOTAL INFLOW	2794.5	100.0	.332E+04	100.0	.021	631.2	20.8
		GAUGED OUTFLOW	283.7	10.2	.352E+04	106.1	.209	62.0	2.1
		UNGAUGED OUTFLOW	-9.5	-.3	.393E+01	.1	.209	62.0	.0
		***TOTAL OUTFLOW	274.3	9.8	.329E+04	99.2	.209	62.0	2.0
		***STORAGE INCREASE	.0	.0	.000E+00	.0	.000	.0	.0
		***NET RETENTION	2520.3	90.2	.627E+04	188.9	.031	.0	.0

HYDRAULIC		------- TOTAL P -------			
OVERFLOW RATE	RESIDENCE TIME	POOL CONC	RESIDENCE TIME	TURNOVER RATIO	RETENTION COEF
M/YR	YRS	MG/M3	YRS	-	-
1.15	1.4833	62.0	.1456	6.8695	.9019

GROSS MASS BALANCE BASED UPON ESTIMATED CONCENTRATIONS
COMPONENT: TOTAL N

ID	T	LOCATION	LOADING KG/YR	LOADING %(I)	VARIANCE KG/YR**2	VARIANCE %(I)	CV	CONC MG/M3	EXPORT KG/KM2
1	1	385035	2074.6	16.9	.000E+00	.0	.000	1804.0	106.8
2	1	385036	2941.5	23.9	.000E+00	.0	.000	1961.0	33.4
3	1	385037	1029.5	8.4	.000E+00	.0	.000	2158.2	72.0
4	1	385038	2407.6	19.6	.000E+00	.0	.000	1852.0	285.9
5	4	385039	3074.6	25.0	.585E+06	15.9	.249	671.3	22.9
		PRECIPITATION	3840.0	31.2	.369E+07	100.0	.500	.0	1000.0
		EXTERNAL INFLOW	8453.2	68.8	.000E+00	.0	.000	1909.5	64.9
		***TOTAL INFLOW	12293.2	100.0	.369E+07	100.0	.156	2776.9	91.7
		GAUGED OUTFLOW	3074.6	25.0	.585E+06	15.9	.249	671.3	22.9
		UNGAUGED OUTFLOW	-102.7	-.8	.653E+03	.0	.249	671.3	.0
		***TOTAL OUTFLOW	2971.9	24.2	.547E+06	14.8	.249	671.3	22.2
		***STORAGE INCREASE	.0	.0	.000E+00	.0	.000	.0	.0
		***NET RETENTION	9321.3	75.8	.322E+07	87.4	.193	.0	.0

HYDRAULIC		------- TOTAL N -------			
OVERFLOW RATE	RESIDENCE TIME	POOL CONC	RESIDENCE TIME	TURNOVER RATIO	RETENTION COEF
M/YR	YRS	MG/M3	YRS	-	-
1.15	1.4833	671.3	.3586	2.7888	.7583

OUTPUT FORMAT: 4 OPTION: 2
CASE: POWLK 90% load, Zero internal
SEGMENT BALANCE BASED UPON ESTIMATED CONCENTRATIONS
COMPONENT: TOTAL P SEGMENT: 1 deepest

ID	T	LOCATION	FLOW HM3/YR	FLOW %	LOAD KG/YR	LOAD %	CONC MG/M3
1	1	385035	1.15	26.0	629.6	22.5	547.5
2	1	385036	1.50	33.9	976.6	34.9	651.1
3	1	385037	.48	10.8	349.4	12.5	732.4
4	1	385038	1.30	29.4	723.7	25.9	556.7
5	4	385039	4.58	103.5	283.7	10.2	62.0
		PRECIPITATION	.00	.0	115.2	4.1	.0
		EXTERNAL INFLOW	4.43	100.0	2679.3	95.9	605.2
		***TOTAL INFLOW	4.43	100.0	2794.5	100.0	631.2
		GAUGED OUTFLOW	4.58	103.5	283.7	10.2	62.0
		UNGAUGED OUTFLOW	-.15	-3.5	-9.5	-.3	62.0
		***TOTAL OUTFLOW	4.43	100.0	274.3	9.8	62.0
		***NET RETENTION	.00	.0	2520.3	90.2	.0

RESID. TIME = 1.483 YRS, OVERFLOW RATE = 1.2 M/YR, DEPTH = 1.7 M

SEGMENT BALANCE BASED UPON ESTIMATED CONCENTRATIONS
COMPONENT: TOTAL N   SEGMENT: 1 deepest

ID	T	LOCATION	FLOW HM3/YR	FLOW %	LOAD KG/YR	LOAD %	CONC MG/M3
1	1	385035	1.15	26.0	2074.6	16.9	1804.0
2	1	385036	1.50	33.9	2941.5	23.9	1961.0
3	1	385037	.48	10.8	1029.5	8.4	2158.2
4	1	385038	1.30	29.4	2407.6	19.6	1852.0
5	4	385039	4.58	103.5	3074.6	25.0	671.3

	FLOW HM3/YR	FLOW %	LOAD KG/YR	LOAD %	CONC MG/M3
PRECIPITATION	.00	.0	3840.0	31.2	.0
EXTERNAL INFLOW	4.43	100.0	8453.2	68.8	1909.5
***TOTAL INFLOW	4.43	100.0	12293.2	100.0	2776.9
GAUGED OUTFLOW	4.58	103.5	3074.6	25.0	671.3
UNGAUGED OUTFLOW	-.15	-3.5	-102.7	-.8	671.3
***TOTAL OUTFLOW	4.43	100.0	2971.9	24.2	671.3
***NET RETENTION	.00	.0	9321.3	75.8	.0

RESID. TIME =   1.483 YRS, OVERFLOW RATE =   1.2 M/YR, DEPTH =   1.7 M

OUTPUT FORMAT: 6 OPTION: 1
CASE: POWLK 90% load, Zero internal

T STATISTICS COMPARE OBSERVED AND PREDICTED MEANS
USING THE FOLLOWING ERROR TERMS:
1 = OBSERVED WATER QUALITY ERROR ONLY
2 = ERROR TYPICAL OF MODEL DEVELOPMENT DATA SET
3 = OBSERVED AND PREDICTED ERROR

SEGMENT: 1 deepest

VARIABLE		OBSERVED MEAN	OBSERVED CV	ESTIMATED MEAN	ESTIMATED CV	RATIO	T STATISTICS 1	T STATISTICS 2	T STATISTICS 3
TOTAL P	MG/M3	309.0	.00	62.0	.21	4.99	.00	5.97	7.68
TOTAL N	MG/M3	2545.0	.00	671.3	.25	3.79	.00	6.06	5.36
C.NUTRIENT	MG/M3	167.7	.00	35.6	.23	4.71	.00	7.71	6.82
CHL-A	MG/M3	40.3	.00	19.4	.45	2.08	.00	2.12	1.65
SECCHI	M	.2	.00	1.5	.34	.15	.00	-6.76	-5.64
ORGANIC N	MG/M3	181.0	.00	613.5	.34	.30	.00	-4.88	-3.57
TP-ORTHO-P	MG/M3	143.0	.00	35.1	.46	4.07	.00	3.84	3.04

OUTPUT FORMAT: 7 OPTION: 1
CASE: POWLK 90% load, Zero internal

OBSERVED AND PREDICTED DIAGNOSTIC VARIABLES
RANKED AGAINST CE MODEL DEVELOPMENT DATA SET

SEGMENT: 1 deepest

	VALUES		RANKS (%)	
VARIABLE	OBSERVED	ESTIMATED	OBSERVED	ESTIMATED
TOTAL P MG/M3	309.00	61.95	98.1	61.3
TOTAL N MG/M3	2545.00	671.30	92.7	26.6
C.NUTRIENT MG/M3	167.65	35.57	97.3	49.8
CHL-A MG/M3	40.30	19.36	97.1	82.6
SECCHI M	.22	1.46	1.8	65.5
ORGANIC N MG/M3	181.00	613.54	3.0	69.4
TP-ORTHO-P MG/M3	143.00	35.11	95.0	56.6
ANTILOG PC-1	2034.08	346.69	94.7	60.5
ANTILOG PC-2	3.73	13.55	15.0	92.2
(N - 150) / P	7.75	8.41	12.4	15.1
INORGANIC N / P	14.24	2.15	23.0	.4
TURBIDITY 1/M	.20	.20	10.3	10.3
ZMIX * TURBIDITY	.34	.34	.2	.2
ZMIX / SECCHI	7.77	1.17	79.9	.8
CHL-A * SECCHI	8.87	28.31	42.1	92.5
CHL-A / TOTAL P	.13	.31	26.1	76.8
FREQ(CHL-a>10) %	97.37	77.51	.0	.0
FREQ(CHL-a>20) %	79.39	35.86	.0	.0
FREQ(CHL-a>30) %	56.60	15.47	.0	.0
FREQ(CHL-a>40) %	38.28	6.94	.0	.0
CARLSON TSI-P	86.82	63.65	.0	.0
CARLSON TSI-CHLA	66.86	59.67	.0	.0
CARLSON TSI-SEC	81.82	54.53	.0	.0

Model: 50% Internal/ 50% External

OUTPUT FORMAT: 2 OPTION: 1
CASE: 50% external 50% Internal
HYDRAULIC AND DISPERSION PARAMETERS:

		NET	RESIDENCE	OVERFLOW	MEAN	----DISPERSION-----		EXCHANGE
		INFLOW	TIME	RATE	VELOCITY	ESTIMATED	NUMERIC	RATE
SEG	OUT	HM3/YR	YRS	M/YR	KM/YR	KM2/YR	KM2/YR	HM3/YR
1	0	4.43	1.48326	1.2	6.1	1000.	27.	0.

OUTPUT FORMAT: 3 OPTION: 2
CASE: 50% external 50% Internal
GROSS WATER BALANCE:

			DRAINAGE AREA	---- FLOW (HM3/YR) ----			RUNOFF
ID	T	LOCATION	KM2	MEAN	VARIANCE	CV	M/YR
1	1	385035	19.430	1.150	.000E+00	.000	.059
2	1	385036	88.100	1.500	.000E+00	.000	.017
3	1	385037	14.300	.477	.000E+00	.000	.033
4	1	385038	8.420	1.300	.000E+00	.000	.154
5	4	385039	134.090	4.580	.000E+00	.000	.034
PRECIPITATION			3.840	.000	.000E+00	.000	.000
EXTERNAL INFLOW			130.250	4.427	.000E+00	.000	.034
***TOTAL INFLOW			134.090	4.427	.000E+00	.000	.033
GAUGED OUTFLOW			134.090	4.580	.000E+00	.000	.034
UNGAUGED OUTFLOW			.000	-.153	.000E+00	.000	.000
***TOTAL OUTFLOW			134.090	4.427	.000E+00	.000	.033
***EVAPORATION			.000	.000	.000E+00	.000	.000
***STORAGE INCREASE			.000	.000	.000E+00	.000	.000

GROSS MASS BALANCE BASED UPON ESTIMATED CONCENTRATIONS
COMPONENT: TOTAL P

			----- LOADING ----		--- VARIANCE ---			CONC	EXPORT
ID	T	LOCATION	KG/YR	%(I)	KG/YR**2	%(I)	CV	MG/M3	KG/KM2
1	1	385035	315.1	21.7	.000E+00	.0	.000	274.0	16.2
2	1	385036	489.0	33.6	.000E+00	.0	.000	326.0	5.6
3	1	385037	174.6	12.0	.000E+00	.0	.000	366.0	12.2
4	1	385038	361.4	24.8	.000E+00	.0	.000	278.0	42.9
5	4	385039	278.1	19.1	.307E+04	92.5	.199	60.7	2.1
PRECIPITATION			115.2	7.9	.332E+04	100.0	.500	.0	30.0
EXTERNAL INFLOW			1340.1	92.1	.000E+00	.0	.000	302.7	10.3
***TOTAL INFLOW			1455.3	100.0	.332E+04	100.0	.040	328.7	10.9
GAUGED OUTFLOW			278.1	19.1	.307E+04	92.5	.199	60.7	2.1
UNGAUGED OUTFLOW			-9.3	-.6	.342E+01	.1	.199	60.7	.0
***TOTAL OUTFLOW			268.8	18.5	.287E+04	86.4	.199	60.7	2.0
***STORAGE INCREASE			.0	.0	.000E+00	.0	.000	.0	.0
***NET RETENTION			1186.5	81.5	.551E+04	166.1	.063	.0	.0

HYDRAULIC		------------- TOTAL P -------------			
OVERFLOW	RESIDENCE	POOL	RESIDENCE	TURNOVER	RETENTION
RATE	TIME	CONC	TIME	RATIO	COEF
M/YR	YRS	MG/M3	YRS	-	-
1.15	1.4833	60.7	.2740	3.6497	.8153

GROSS MASS BALANCE BASED UPON ESTIMATED CONCENTRATIONS
COMPONENT: TOTAL N

ID	T	LOCATION	LOADING KG/YR	LOADING %(I)	VARIANCE KG/YR**2	VARIANCE %(I)	CV	CONC MG/M3	EXPORT KG/KM2
1	1	385035	1037.3	12.9	.000E+00	.0	.000	902.0	53.4
2	1	385036	1471.5	18.2	.000E+00	.0	.000	981.0	16.7
3	1	385037	514.7	6.4	.000E+00	.0	.000	1079.0	36.0
4	1	385038	1203.8	14.9	.000E+00	.0	.000	926.0	143.0
5	4	385039	3206.5	39.7	.657E+06	17.8	.253	700.1	23.9
PRECIPITATION			3840.0	47.6	.369E+07	100.0	.500	.0	1000.0
EXTERNAL INFLOW			4227.3	52.4	.000E+00	.0	.000	954.9	32.5
***TOTAL INFLOW			8067.3	100.0	.369E+07	100.0	.238	1822.3	60.2
GAUGED OUTFLOW			3206.5	39.7	.657E+06	17.8	.253	700.1	23.9
UNGAUGED OUTFLOW			-107.1	-1.3	.733E+03	.0	.253	700.1	.0
***TOTAL OUTFLOW			3099.4	38.4	.614E+06	16.7	.253	700.1	23.1
***STORAGE INCREASE			.0	.0	.000E+00	.0	.000	.0	.0
***NET RETENTION			4967.9	61.6	.255E+07	69.3	.322	.0	.0

HYDRAULIC		------------- TOTAL N -------------			
OVERFLOW	RESIDENCE	POOL	RESIDENCE	TURNOVER	RETENTION
RATE	TIME	CONC	TIME	RATIO	COEF
M/YR	YRS	MG/M3	YRS	-	-
1.15	1.4833	700.1	.5699	1.7548	.6158

OUTPUT FORMAT: 6 OPTION: 1
CASE: 50% external 50% Internal

T STATISTICS COMPARE OBSERVED AND PREDICTED MEANS
USING THE FOLLOWING ERROR TERMS:
1 = OBSERVED WATER QUALITY ERROR ONLY
2 = ERROR TYPICAL OF MODEL DEVELOPMENT DATA SET
3 = OBSERVED AND PREDICTED ERROR

SEGMENT: 1 deepest

VARIABLE		OBSERVED MEAN	OBSERVED CV	ESTIMATED MEAN	ESTIMATED CV	RATIO	T STATISTICS 1	2	3
TOTAL P	MG/M3	309.0	.00	60.7	.20	5.09	.00	6.05	8.17
TOTAL N	MG/M3	2545.0	.00	700.1	.25	3.64	.00	5.87	5.11
C.NUTRIENT	MG/M3	167.7	.00	36.6	.22	4.58	.00	7.57	6.98
CHL-A	MG/M3	40.3	.00	10.6	.36	3.82	.00	3.87	3.73
SECCHI	M	.2	.00	.6	.23	.38	.00	-3.47	-4.30
ORGANIC N	MG/M3	181.0	.00	412.7	.24	.44	.00	-3.30	-3.41
TP-ORTHO-P	MG/M3	143.0	.00	19.4	.38	7.36	.00	5.45	5.27

OUTPUT FORMAT: 7 OPTION: 1

CASE: 50% external 50% Internal

OBSERVED AND PREDICTED DIAGNOSTIC VARIABLES

RANKED AGAINST CE MODEL DEVELOPMENT DATA SET

SEGMENT: 1 deepest

VARIABLE	VALUES OBSERVED	VALUES ESTIMATED	RANKS (%) OBSERVED	RANKS (%) ESTIMATED
TOTAL P MG/M3	309.00	60.72	98.1	60.4
TOTAL N MG/M3	2545.00	700.11	92.7	28.8
C.NUTRIENT MG/M3	167.65	36.59	97.3	51.2
CHL-A MG/M3	40.30	10.55	97.1	56.0
SECCHI M	.22	.58	1.8	20.8
ORGANIC N MG/M3	181.00	412.69	3.0	39.3
TP-ORTHO-P MG/M3	143.00	19.43	95.0	32.4
ANTILOG PC-1	2034.08	337.91	94.7	59.7
ANTILOG PC-2	3.73	4.46	15.0	24.4
(N - 150) / P	7.75	9.06	12.4	17.8
INORGANIC N / P	14.24	6.96	23.0	7.2
TURBIDITY 1/M	.20	.20	10.3	10.3
ZMIX * TURBIDITY	.34	.34	.2	.2
ZMIX / SECCHI	7.77	2.94	79.9	20.2
CHL-A * SECCHI	8.87	6.14	42.1	23.7
CHL-A / TOTAL P	.13	.17	26.1	42.5
FREQ(CHL-a>10) %	97.37	41.17	.0	.0
FREQ(CHL-a>20) %	79.39	8.99	.0	.0
FREQ(CHL-a>30) %	56.60	2.30	.0	.0
FREQ(CHL-a>40) %	38.28	.70	.0	.0
CARLSON TSI-P	86.82	63.36	.0	.0
CARLSON TSI-CHLA	66.86	53.72	.0	.0
CARLSON TSI-SEC	81.82	67.80	.0	.0

Model: 50% Internal/ 75% External

OUTPUT FORMAT: 2 OPTION: 1
CASE: 50% internal 75% External
HYDRAULIC AND DISPERSION PARAMETERS:

SEG	OUT	NET INFLOW HM3/YR	RESIDENCE TIME YRS	OVERFLOW RATE M/YR	MEAN VELOCITY KM/YR	----DISPERSION----- ESTIMATED KM2/YR	NUMERIC KM2/YR	EXCHANGE RATE HM3/YR
1	0	3.77	2.95874	.6	3.0	1000.	14.	0.

OUTPUT FORMAT: 3 OPTION: 2
CASE: 50% external 75% Internal
GROSS WATER BALANCE:

ID	T	LOCATION	DRAINAGE AREA KM2	---- FLOW (HM3/YR) ---- MEAN	VARIANCE	CV	RUNOFF M/YR
1	1	385035	19.430	1.150	.000E+00	.000	.059
2	1	385036	88.100	1.500	.000E+00	.000	.017
3	1	385037	14.300	.477	.000E+00	.000	.033
4	1	385038	8.420	1.300	.000E+00	.000	.154
5	4	385039	134.090	4.580	.000E+00	.000	.034
PRECIPITATION			6.530	1.959	.154E+00	.200	.300
EXTERNAL INFLOW			130.250	4.427	.000E+00	.000	.034
***TOTAL INFLOW			136.780	6.386	.154E+00	.061	.047
GAUGED OUTFLOW			134.090	4.580	.000E+00	.000	.034
UNGAUGED OUTFLOW			2.690	-.806	.768E+00	1.087	-.300
***TOTAL OUTFLOW			136.780	3.774	.768E+00	.232	.028
***EVAPORATION			.000	2.612	.614E+00	.300	.000
***STORAGE INCREASE			.000	.000	.000E+00	.000	.000

GROSS MASS BALANCE BASED UPON ESTIMATED CONCENTRATIONS
COMPONENT: TOTAL P

ID	T	LOCATION	----- LOADING ---- KG/YR	%(I)	--- VARIANCE --- KG/YR**2	%(I)	CV	CONC MG/M3	EXPORT KG/KM2
1	1	385035	314.9	20.5	.000E+00	.0	.000	273.8	16.2
2	1	385036	489.0	31.8	.000E+00	.0	.000	326.0	5.6
3	1	385037	174.7	11.4	.000E+00	.0	.000	366.2	12.2
4	1	385038	361.9	23.6	.000E+00	.0	.000	278.4	43.0
5	4	385039	314.8	20.5	.413E+04	43.1	.204	68.7	2.3
PRECIPITATION			195.9	12.8	.959E+04	100.0	.500	100.0	30.0
EXTERNAL INFLOW			1340.5	87.2	.000E+00	.0	.000	302.8	10.3
***TOTAL INFLOW			1536.4	100.0	.959E+04	100.0	.064	240.6	11.2
GAUGED OUTFLOW			314.8	20.5	.413E+04	43.1	.204	68.7	2.3
UNGAUGED OUTFLOW			-55.4	-3.6	.391E+04	40.7	1.128	68.7	-20.6
***TOTAL OUTFLOW			259.4	16.9	.577E+04	60.2	.293	68.7	1.9
***STORAGE INCREASE			.0	.0	.000E+00	.0	.000	.0	.0
***NET RETENTION			1276.9	83.1	.136E+05	141.7	.091	.0	.0

HYDRAULIC		TOTAL P			
OVERFLOW RATE	RESIDENCE TIME	POOL CONC	RESIDENCE TIME	TURNOVER RATIO	RETENTION COEF
M/YR	YRS	MG/M3	YRS	-	-
.58	2.9587	68.7	.4996	2.0015	.8311

GROSS MASS BALANCE BASED UPON ESTIMATED CONCENTRATIONS
COMPONENT: TOTAL N

ID	T	LOCATION	LOADING KG/YR	LOADING %(I)	VARIANCE KG/YR**2	VARIANCE %(I)	CV	CONC MG/M3	EXPORT KG/KM2
1	1	385035	1037.3	9.6	.000E+00	.0	.000	902.0	53.4
2	1	385036	1471.5	13.7	.000E+00	.0	.000	981.0	16.7
3	1	385037	514.7	4.8	.000E+00	.0	.000	1079.0	36.0
4	1	385038	1203.8	11.2	.000E+00	.0	.000	926.0	143.0
5	4	385039	4218.5	39.2	.146E+07	13.7	.286	921.1	31.5
PRECIPITATION			6530.0	60.7	.107E+08	100.0	.500	3333.3	1000.0
EXTERNAL INFLOW			4227.3	39.3	.000E+00	.0	.000	954.9	32.5
***TOTAL INFLOW			10757.3	100.0	.107E+08	100.0	.304	1684.5	78.6
GAUGED OUTFLOW			4218.5	39.2	.146E+07	13.7	.286	921.1	31.5
UNGAUGED OUTFLOW			-742.4	-6.9	.754E+06	7.1	1.169	921.1	-276.0
***TOTAL OUTFLOW			3476.1	32.3	.139E+07	13.1	.339	921.1	25.4
***STORAGE INCREASE			.0	.0	.000E+00	.0	.000	.0	.0
***NET RETENTION			7281.1	67.7	.796E+07	74.7	.388	.0	.0

HYDRAULIC		TOTAL N			
OVERFLOW RATE	RESIDENCE TIME	POOL CONC	RESIDENCE TIME	TURNOVER RATIO	RETENTION COEF
M/YR	YRS	MG/M3	YRS	-	-
.58	2.9587	921.1	.9561	1.0459	.6769

OUTPUT FORMAT: 6 OPTION: 1
CASE: 50% internal 75% External

T STATISTICS COMPARE OBSERVED AND PREDICTED MEANS
USING THE FOLLOWING ERROR TERMS:
1 = OBSERVED WATER QUALITY ERROR ONLY
2 = ERROR TYPICAL OF MODEL DEVELOPMENT DATA SET
3 = OBSERVED AND PREDICTED ERROR

SEGMENT: 1 deepest

VARIABLE		OBSERVED MEAN	OBSERVED CV	ESTIMATED MEAN	ESTIMATED CV	RATIO	T STATISTICS 1	T STATISTICS 2	T STATISTICS 3
TOTAL P	MG/M3	309.0	.00	68.7	.20	4.50	.00	5.59	7.36
TOTAL N	MG/M3	2545.0	.00	921.1	.29	2.76	.00	4.62	3.55
C.NUTRIENT	MG/M3	167.7	.00	46.9	.21	3.57	.00	6.33	6.12
CHL-A	MG/M3	40.3	.00	17.8	.34	2.26	.00	2.36	2.37
SECCHI	M	.2	.00	.7	.25	.31	.00	-4.20	-4.61
ORGANIC N	MG/M3	181.0	.00	215.9	.27	.84	.00	-.70	-.65
TP-ORTHO-P	MG/M3	143.0	.00	55.7	.37	2.57	.00	2.58	2.56

OUTPUT FORMAT: 7 OPTION: 1
CASE: 50% internal 75% External

OBSERVED AND PREDICTED DIAGNOSTIC VARIABLES
RANKED AGAINST CE MODEL DEVELOPMENT DATA SET

SEGMENT: 1 deepest

VARIABLE	----- VALUES ----- OBSERVED	ESTIMATED	--- RANKS (%) ---- OBSERVED	ESTIMATED
TOTAL P MG/M3	309.00	68.74	98.1	65.6
TOTAL N MG/M3	2545.00	921.08	92.7	44.8
C.NUTRIENT MG/M3	167.65	46.94	97.3	63.4
CHL-A MG/M3	40.30	17.84	97.1	79.8
SECCHI M	.22	.71	1.8	29.2
ORGANIC N MG/M3	181.00	215.86	3.0	6.1
TP-ORTHO-P MG/M3	143.00	55.71	95.0	74.3
ANTILOG PC-1	2034.08	376.33	94.7	62.8
ANTILOG PC-2	3.73	6.28	15.0	48.2
(N - 150) / P	7.75	11.22	12.4	27.1
INORGANIC N / P	14.24	54.10	23.0	72.7
TURBIDITY 1/M	.20	.20	10.3	10.3
ZMIX * TURBIDITY	.34	.34	.2	.2
ZMIX / SECCHI	7.77	2.40	79.9	11.9
CHL-A * SECCHI	8.87	12.70	42.1	62.2
CHL-A / TOTAL P	.13	.26	26.1	67.0
FREQ(CHL-a>10) %	97.37	73.35	.0	.0
FREQ(CHL-a>20) %	79.39	31.03	.0	.0
FREQ(CHL-a>30) %	56.60	12.53	.0	.0
FREQ(CHL-a>40) %	38.28	5.34	.0	.0
CARLSON TSI-P	86.82	65.15	.0	.0
CARLSON TSI-CHLA	66.86	58.86	.0	.0
CARLSON TSI-SEC	81.82	64.89	.0	.0

OUTPUT FORMAT: 8 OPTION: 1
CASE: 50% internal 75% Exnternal
PREDICTED CONCENTRATIONS:

VARIABLE SEGMENT-->	1
TOTAL P MG/M3	68.74
TOTAL N MG/M3	921.08
C.NUTRIENT MG/M3	46.94
CHL-A MG/M3	17.84
SECCHI M	.71
ORGANIC N MG/M3	215.86
TP-ORTHO-P MG/M3	55.71

Model: 50% Internal/ 90% External

OUTPUT FORMAT: 2 OPTION: 1
CASE: 50% Internal 90% External
HYDRAULIC AND DISPERSION PARAMETERS:

SEG	OUT	NET INFLOW HM3/YR	RESIDENCE TIME YRS	OVERFLOW RATE M/YR	MEAN VELOCITY KM/YR	----DISPERSION----- ESTIMATED KM2/YR	NUMERIC KM2/YR	EXCHANGE RATE HM3/YR
1	0	4.43	1.48326	1.2	6.1	1000.	27.	0.

OUTPUT FORMAT: 3 OPTION: 2
CASE: 50% Internal 90% External
GROSS WATER BALANCE:

ID	T	LOCATION	DRAINAGE AREA KM2	---- FLOW (HM3/YR) ---- MEAN	VARIANCE	CV	RUNOFF M/YR
1	1	385035	19.430	1.150	.000E+00	.000	.059
2	1	385036	88.100	1.500	.000E+00	.000	.017
3	1	385037	14.300	.477	.000E+00	.000	.033
4	1	385038	8.420	1.300	.000E+00	.000	.154
5	4	385039	134.090	4.580	.000E+00	.000	.034
PRECIPITATION			3.840	.000	.000E+00	.000	.000
EXTERNAL INFLOW			130.250	4.427	.000E+00	.000	.034
***TOTAL INFLOW			134.090	4.427	.000E+00	.000	.033
GAUGED OUTFLOW			134.090	4.580	.000E+00	.000	.034
UNGAUGED OUTFLOW			.000	-.153	.000E+00	.000	.000
***TOTAL OUTFLOW			134.090	4.427	.000E+00	.000	.033
***EVAPORATION			.000	.000	.000E+00	.000	.000
***STORAGE INCREASE			.000	.000	.000E+00	.000	.000

GROSS MASS BALANCE BASED UPON ESTIMATED CONCENTRATIONS
COMPONENT: TOTAL P

ID	T	LOCATION	----- LOADING ---- KG/YR	%(I)	--- VARIANCE --- KG/YR**2	%(I)	CV	CONC MG/M3	EXPORT KG/KM2
1	1	385035	315.1	21.7	.000E+00	.0	.000	274.0	16.2
2	1	385036	489.0	33.6	.000E+00	.0	.000	326.0	5.6
3	1	385037	174.6	12.0	.000E+00	.0	.000	366.0	12.2
4	1	385038	361.4	24.8	.000E+00	.0	.000	278.0	42.9
5	4	385039	901.0	61.9	.138E+05	414.5	.130	196.7	6.7
PRECIPITATION			115.2	7.9	.332E+04	100.0	.500	.0	30.0
EXTERNAL INFLOW			1340.1	92.1	.000E+00	.0	.000	302.7	10.3
***TOTAL INFLOW			1455.3	100.0	.332E+04	100.0	.040	328.7	10.9
GAUGED OUTFLOW			901.0	61.9	.138E+05	414.5	.130	196.7	6.7
UNGAUGED OUTFLOW			-30.1	-2.1	.153E+02	.5	.130	196.7	.0
***TOTAL OUTFLOW			870.9	59.8	.128E+05	387.3	.130	196.7	6.5
***STORAGE INCREASE			.0	.0	.000E+00	.0	.000	.0	.0
***NET RETENTION			584.4	40.2	.133E+05	401.9	.198	.0	.0

HYDRAULIC OVERFLOW RATE M/YR	HYDRAULIC RESIDENCE TIME YRS	TOTAL P POOL CONC MG/M3	TOTAL P RESIDENCE TIME YRS	TOTAL P TURNOVER RATIO -	TOTAL P RETENTION COEF -
1.15	1.4833	196.7	.8876	1.1266	.4016

GROSS MASS BALANCE BASED UPON ESTIMATED CONCENTRATIONS
COMPONENT: TOTAL N

ID	T	LOCATION	LOADING KG/YR	LOADING %(I)	VARIANCE KG/YR**2	VARIANCE %(I)	CV	CONC MG/M3	EXPORT KG/KM2
1	1	385035	1037.3	12.9	.000E+00	.0	.000	902.0	53.4
2	1	385036	1471.5	18.2	.000E+00	.0	.000	981.0	16.7
3	1	385037	514.7	6.4	.000E+00	.0	.000	1079.0	36.0
4	1	385038	1203.8	14.9	.000E+00	.0	.000	926.0	143.0
5	4	385039	7844.0	97.2	.316E+07	85.6	.226	1712.7	58.5
PRECIPITATION			3840.0	47.6	.369E+07	100.0	.500	.0	1000.0
EXTERNAL INFLOW			4227.3	52.4	.000E+00	.0	.000	954.9	32.5
***TOTAL INFLOW			8067.3	100.0	.369E+07	100.0	.238	1822.3	60.2
GAUGED OUTFLOW			7844.0	97.2	.316E+07	85.6	.226	1712.7	58.5
UNGAUGED OUTFLOW			-262.0	-3.2	.352E+04	.1	.226	1712.7	.0
***TOTAL OUTFLOW			7581.9	94.0	.295E+07	80.0	.226	1712.7	56.5
***STORAGE INCREASE			.0	.0	.000E+00	.0	.000	.0	.0
***NET RETENTION			485.4	6.0	.104E+06	2.8	.663	.0	.0

HYDRAULIC OVERFLOW RATE M/YR	HYDRAULIC RESIDENCE TIME YRS	TOTAL N POOL CONC MG/M3	TOTAL N RESIDENCE TIME YRS	TOTAL N TURNOVER RATIO -	TOTAL N RETENTION COEF -
1.15	1.4833	1712.7	1.3940	.7173	.0602

OUTPUT FORMAT: 6 OPTION: 1
CASE: 50% Internal 90% External

T STATISTICS COMPARE OBSERVED AND PREDICTED MEANS
USING THE FOLLOWING ERROR TERMS:
1 = OBSERVED WATER QUALITY ERROR ONLY
2 = ERROR TYPICAL OF MODEL DEVELOPMENT DATA SET
3 = OBSERVED AND PREDICTED ERROR

SEGMENT: 1 deepest

VARIABLE		OBSERVED MEAN	OBSERVED CV	ESTIMATED MEAN	ESTIMATED CV	RATIO	T STATISTICS 1	T STATISTICS 2	T STATISTICS 3
TOTAL P	MG/M3	309.0	.00	196.7	.13	1.57	.00	1.68	3.47
TOTAL N	MG/M3	2545.0	.00	1712.7	.23	1.49	.00	1.80	1.75
C.NUTRIENT	MG/M3	167.7	.00	108.6	.18	1.54	.00	2.16	2.47
CHL-A	MG/M3	40.3	.00	30.5	.29	1.32	.00	.81	.95
SECCHI	M	.2	.00	.3	.25	.78	.00	-.87	-.98
ORGANIC N	MG/M3	181.0	.00	866.9	.26	.21	.00	-6.27	-5.94
TP-ORTHO-P	MG/M3	143.0	.00	54.9	.33	2.61	.00	2.62	2.93

OUTPUT FORMAT: 7 OPTION: 1
CASE: 50% Internal 90% External

OBSERVED AND PREDICTED DIAGNOSTIC VARIABLES
RANKED AGAINST CE MODEL DEVELOPMENT DATA SET

SEGMENT: 1 deepest

VARIABLE	VALUES OBSERVED	VALUES ESTIMATED	RANKS (%) OBSERVED	RANKS (%) ESTIMATED
TOTAL P MG/M3	309.00	196.71	98.1	94.2
TOTAL N MG/M3	2545.00	1712.65	92.7	79.9
C.NUTRIENT MG/M3	167.65	108.58	97.3	91.8
CHL-A MG/M3	40.30	30.48	97.1	93.7
SECCHI M	.22	.28	1.8	3.8
ORGANIC N MG/M3	181.00	866.91	3.0	88.2
TP-ORTHO-P MG/M3	143.00	54.89	95.0	73.8
ANTILOG PC-1	2034.08	2114.63	94.7	95.0
ANTILOG PC-2	3.73	5.11	15.0	33.1
(N - 150) / P	7.75	7.94	12.4	13.2
INORGANIC N / P	14.24	5.96	23.0	5.3
TURBIDITY 1/M	.20	.20	10.3	10.3
ZMIX * TURBIDITY	.34	.34	.2	.2
ZMIX / SECCHI	7.77	6.09	79.9	66.3
CHL-A * SECCHI	8.87	8.55	42.1	40.2
CHL-A / TOTAL P	.13	.15	26.1	35.6
FREQ(CHL-a>10) %	97.37	93.16	.0	.0
FREQ(CHL-a>20) %	79.39	64.41	.0	.0
FREQ(CHL-a>30) %	56.60	38.79	.0	.0
FREQ(CHL-a>40) %	38.28	22.70	.0	.0
CARLSON TSI-P	86.82	80.31	.0	.0
CARLSON TSI-CHLA	66.86	64.12	.0	.0
CARLSON TSI-SEC	81.82	78.31	.0	.0

Appendix B

FLUX Model Data

(Full Set Available on Request)

385035 Northeast trib VAR=nh3-4 METHOD= 6 REG-3

TABULATION OF MISSING DAILY FLOWS:

Flow File =5035_q.wk1 , Station =cfs
Daily Flows from 990310 to 991030

Summary:
Reported Flows = 235
Missing Flows = 0
Zero Flows = 5
Positive Flows = 230

385035 Northeast trib VAR=nh3-4 METHOD= 5 REG-2

STRATIFICATION SCHEME:

	-- DATE --		-- SEASON --		-------- FLOW --------	
STR	>=MIN	< MAX	>=MIN	< MAX	>=MIN	< MAX
1	0	0	0	0	.00	1.78
2	0	0	0	0	1.78	46.37

STR	SAMPLES	EVENTS	FLOWS	VOLUME %
1	25	25	198	17.29
2	8	8	37	82.71
EXCLUDED	0	0	0	.00
TOTAL	33	33	235	100.00

385035 Northeast trib VAR=nh3-4 METHOD= 5 REG-2
Comparison of Sampled & Total Flow Distributions

	------ SAMPLED -----			------- TOTAL ------					
STRAT	N	MEAN	STD DEV	N	MEAN	STD DEV	DIFF	T	PROB(>T)
1	25	.63	.68	198	.37	.57	.26	-1.82	.076
2	8	16.62	18.29	37	9.37	12.40	7.25	-1.07	.314
***	33	4.50	11.05	235	1.78	5.89	2.72	-1.39	.171

Average Sample Interval = 6.6 Days, Date Range = 990313 to 991016
Maximum Sample Interval = 34 Days, Date Range = 990911 to 991016
Percent of Total Flow Volume Occuring In This Interval = .1%

Total Flow Volume on Sampled Days = 148.6 hm3
Total Flow Volume on All Days = 419.3 hm3
Percent of Total Flow Volume Sampled = 35.4%

Maximum Sampled Flow Rate = 42.16 hm3/yr
Maximum Total Flow Rate = 42.16 hm3/yr
Number of Days when Flow Exceeded Maximum Sampled Flow = 0 out of 235
Percent of Total Flow Volume Occurring at Flow Rates Exceeding the
Maximum Sampled Flow Rate = .0%

385035 Northeast trib VAR=nh3-4 METHOD= 5 REG-2

COMPARISON OF SAMPLED AND TOTAL FLOW DISTRIBUTIONS

STR	NQ	NC	NE	VOL%	TOTAL FLOW	SAMPLED FLOW	C/Q SLOPE	SIGNIF
1	198	25	25	17.3	.366	.625	-.035	.717
2	37	8	8	82.7	9.374	16.622	.189	.497
***	235	33	33	100.0	1.784	4.503		

FLOW STATISTICS

FLOW DURATION = 235.0 DAYS = .643 YEARS

MEAN FLOW RATE = 1.784 HM3/YR

TOTAL FLOW VOLUME = 1.15 HM3

FLOW DATE RANGE = 990310 TO 991030

SAMPLE DATE RANGE = 990313 TO 991016

METHOD	MASS (KG)	FLUX (KG/YR)	FLUX VARIANCE	CONC (PPB)	CV
1 AV LOAD	165.7	257.6	.1361E+05	144.34	.453
2 Q WTD C	94.2	146.3	.3068E+04	82.01	.379
3 IJC	94.1	146.3	.3358E+04	81.99	.396
4 REG-1	86.8	134.9	.1821E+04	75.61	.316
5 REG-2	90.0	139.8	.2027E+04	78.37	.322
6 REG-3	86.7	134.8	.3449E+04	75.56	.436

Appendix C

Powers Lake Section 319 Project Implementation Plan

Quality Assurance Project Plan for the Section 319 Powers Lake Watershed Project Implementation

Prepared for:

Powers Lake Watershed Advisory Board
218 N. Main, P.O. Box 275
Powers Lake, ND 58773

Amended/ Updated by
Heather Duchscherer
April 2006

Surface Water Quality Management Program
Division of Water Quality
North Dakota Department of Health
Bismarck, ND

This quality assurance project plan (QAPP) has been prepared according to guidance provided in the EPA document entitled "EPA Requirements for Quality Assurance Project Plans" (EPA, March 2001) to ensure that environmental and related data collected, compiled, and/or generated for this program/project are complete, accurate, and of the type, quantity, and quality required for their intended use. The work conducted by the North Dakota Department of Health will be in conformance with the Quality Management Plan for the Environmental Health Section (ND/EHS Revision 5, 29 June 2000) and with the procedures described in this QAPP.

Approvals:

Michael J. Ell Program Manager Surface Water Quality Management Program Division of Water Quality North Dakota Department of Health Bismarck, ND	Date	Dana K. Mount, P.E. Quality Assurance Coordinator Environmental Health Section North Dakota Department of Health Bismarck, ND	Date

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Powers Lake, ND 58773

A. Project Management

A1. Project/Task Organization

This Quality Assurance Project Plan (QAPP) describes the quality assurance (QA) and quality control (QC) activities/procedures that will be used while collecting samples for the Powers Lake Project Implementation Plan (PIP). The purpose of this document is to describe the methods and procedures that will be used to collect physical, chemical, and biological samples and measurements for Powers Lake and its tributaries in support of the Powers Lake PIP and the quality assurance procedures that will be employed for those methods and procedures.

The US Environmental Protection Agency (EPA) Region 8 has provided funding for this project through the North Dakota Department of Health's (NDDoH) Section 319 Non-Point Source (NPS) Pollution Management Program. The Project Officer for the US EPA is Roger Dean.

Overall organization for the North Dakota Department Health's (NDDoH) Environmental Health Section (EHS) is detailed in the Quality Management Plan (QMP) for the Environmental Health Section (NDDoH, June 2000)[1]. The Environmental Health Section is one of four sections in the Department. Within the EHS there are five divisions, including the Divisions of Air Quality, Municipal Facilities, Waste Management, Water Quality, and Chemistry. Martin Schock is the Quality Assurance Coordinator (QAC) for the EHS. The QAC is located in the EHS Chiefs Office and reports directly to the Chief of the EHS. The EHS Chief's Office through the QAC is responsible for oversight of the EHS's quality system for QA and QC as delineated in the QMP for the EHS, including approving project QAPPs. It is the policy of the EHS that the primary responsibility for QA resides among program staff and Designated Project Managers (DPMs) in each division, therefore each program is responsible for the preparation, implementation, and assessment of its QAPP(s).

Within the EHS, the Division of Water Quality is organized in three programs, the North Dakota Permit Discharge Elimination System (NDPDES) Program, the Groundwater Program, and the Surface Water Quality Management Program (SWQMP). The Powers Lake PIP is the responsibility of the SWQMP. The organization structure for the Powers Lake PIP is outlined in Figure 1.

[1] This QAPP was prepared according to the EPA Quality Manual for Environmental Programs (EPA, May 2000) and the EPA document entitled EPA Requirements for Quality Assurance Project Plans (QA/R-5) (EPA, March, 2001).

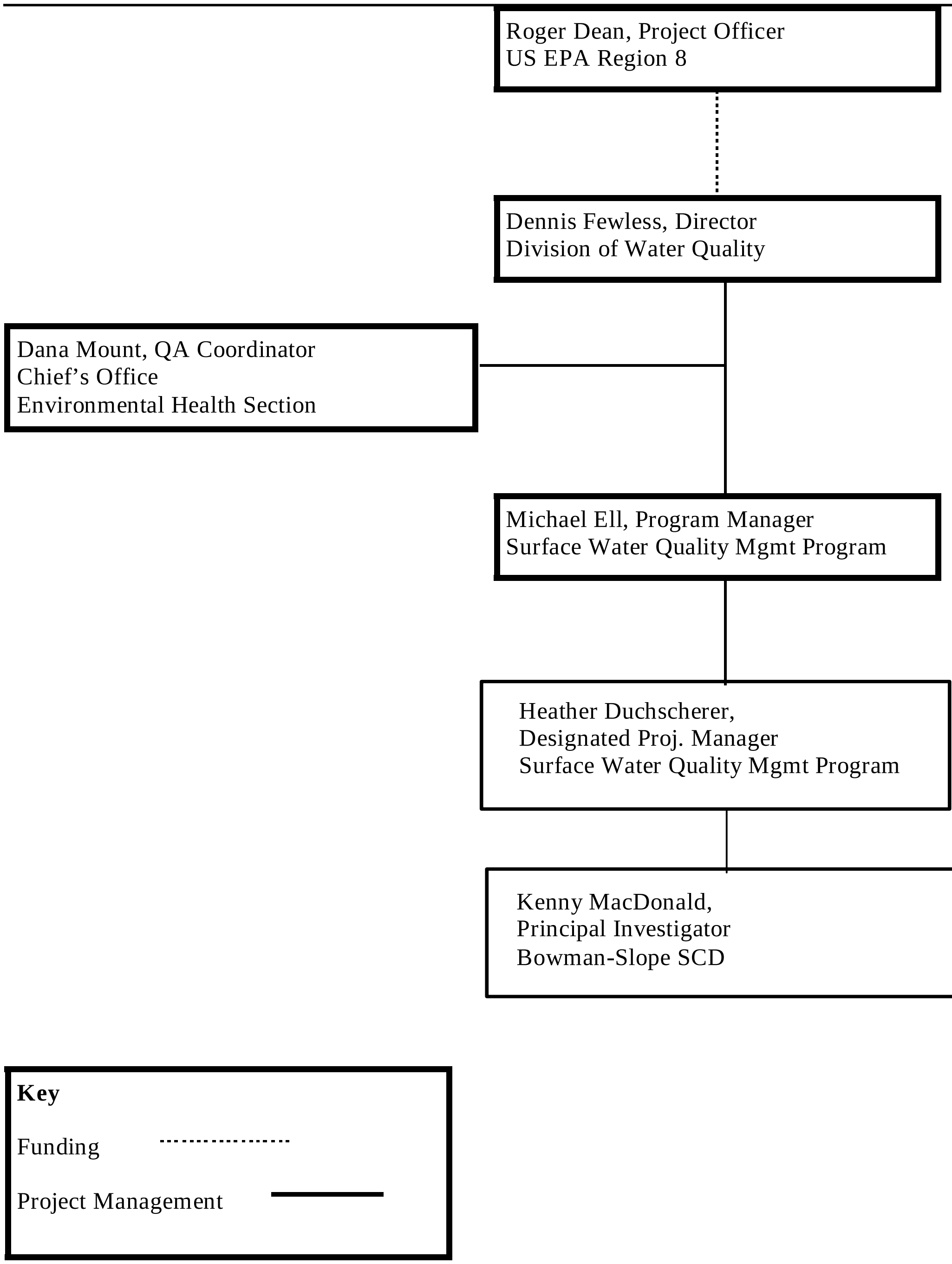

Figure 1. Organizational Diagram for the Powers Lake Watershed PIP

Michael J. Ell is Program Manager for the SWQMP. As Program Manager in the SWQMP he has the following responsibilities:

- review and edit the QAPP;
- providing oversight for study design, site selection, and adherence to design objectives;
- reviewing and approving the final project work plan and other materials to support the project (e.g., standard operating procedures);
- selecting appropriate project subcontractors, as needed; and
- coordinating with contractors, reviewers, and US EPA to ensure technical quality and contract adherence.

Heather Duchscherer is an Environmental Scientist with the SWQMP and is the Designated Project Manager (DPM) for the Powers Lake Implementation Project. As such, she is responsible for overall project coordination and supervision, including the reduction and analysis of project data and the preparation of the final report.

For purposes of this project, funding for the project implementation has been contracted to the Mountrail County Soil Conservation District (SCD). Kenny MacDonald, the Watershed Coordinator for the Powers Lake Implementation Project and the Principle Investigator (PI) for assessment, will be responsible for day-to-day project oversight, data collection, and sample custody. Decision making and general project oversite falls under the jurisdiction of the Powers Lake Watershed Advisory Board. The SWQMP and the Kenny MacDonald will be responsible for data interpretation and report preparation.

A2. Problem Definition / Background

Powers Lake borders the southern edge of the community of Powers Lake in northwestern North Dakota (Appendix A). The lake lies on an unnamed tributary of the White Earth River, a tributary to Missouri River that discharges to Lake Sakakawea. Powers Lake watershed is 69.5 $miles^2$ (44,458 acres) of nearly 100 percent agricultural or low density rural development. Powers Lake has always been recognized as a high priority natural resource by the surrounding community and particularly to the city of Powers Lake.

Powers Lake is a natural glacial lake formed during the late Wisconsin Era ice age. It is shallow and wind swept with a maximum depth of eight a half feet and a surface area of 1,616 acres at an elevation of 2190 M.S.L. Currently it is managed by the North Dakota Game and Fish Department (NDG&F) as a warm water fishery with yellow perch and northern pike being the principle game species.

In recent history, Powers Lake has experienced a series of partial summer and winter fish die offs related to drought and increased eutrophication. The effects of eutrophication have progressed to the point that the lake experiences a near continuous algal bloom from late June to early September.

In 1999 the City of Powers Lake approached the North Dakota Department of Health (NDDH) for help in addressing the declining water quality condition of Powers Lake. The results of the discussions was to implement a lake and watershed assessment project with the goal of identifying the affects of stored and contributing pollutants on Powers Lake trophic condition and to the extent possible the sources of pollutants within the surrounding watershed.

The project was initially scheduled to begin during the winter of 1999-2000 and continue through the open water period of 2000. However, a drought that began in the winter 1999-2000 and continued through the summer of 2000 prevented open water data collection from the contributing watershed. This forced the project to be extended through the open water period of 2001.

In 2004, the Powers Lake Watershed was awarded a Section 319 grant from the NDDoH to reduce nonpoint source pollution in the watershed. In 2005, the Powers Lake Watershed Committee was able to hire a Watershed Coordinator to administer the Section 319 grant it received for implementation of conservation practices to improve the water quality.

A3. Project Monitoring Goals/Objectives/Tasks Description

The primary monitoring goal of this project is to measure and document the effectiveness of installed Best Management Practices (BMP) and technical assistance at reducing the pollutant levels to the targets stated in the Powers Lake PIP and restoring impaired water quality and beneficial uses within the Powers Lake watershed. The beneficial uses of primary concern and focus for this watershed project are aquatic life and recreation uses.

The Powers Lake Project Implementation Plan (PIP) has been written as a five year project (2005-2009). The following objectives and tasks are intended to achieve the monitoring goal of the project.

Objective 1: Collect and analyze chemical, physical and biological data to calculate TSI scores for the purpose of measuring the effectiveness of installed BMPs in the project area at improving water quality and restoring impaired beneficial uses.

Task 1. (2006 Sampling Season): Collect and analyze 12 to 15 water quality samples (May – March) from the lake sampling site. Water quality samples will be analyzed for total nitrogen, total kjeldahl nitrogen, nitrate-nitrite, ammonia, total phosphorus, total dissolved phosphorus, total suspended sediment, and chlorophyll-a. Also, measurements of the temperature and dissolved oxygen profiles, as well as Secchi disk readings and pH will be taken.

Product: Water quality data for lake sampling site to calculate TSI scores.

Milestone: May 2006-March 2007

Task 2. (2007 Sampling Season): Collect and analyze 12 to 18 water quality samples (April – October) from the lake sampling site. Water quality samples will be analyzed for total nitrogen, total kjeldahl nitrogen, nitrate-nitrite, ammonia, total phosphorus, total suspended sediment, and chlorophyll-a. Also, measurements of the temperature and dissolved oxygen profiles, as well as Secchi disk readings and pH will be taken.

Poduct: Water quality data for lake sampling site to calculate TSI scores

Milestone: April 2007 – October 2007

Task 3 (2007 Sampling Season): Collect daily stream stage data and a minimum of three discharge measurements from each of five selected sampling sites (Appendix A). The three discharge measurements will be collected from approximately different flow magnitudes (i.e. low, moderate, and high) and will be used to adjust and improve the rating curves for the sampling sites.

Product: Daily stream stage/ discharge from the selected sites.

Milestone: April 2007 – October 2007.

Task 4 (2007 Sampling Season) Collect and analyze 12 to 20 water quality samples annually from each sampling site. Water quality samples will be analyzed for total nitrogen, total kjeldahl nitrogen, nitrate-nitrite, ammonia, total phosphorus, total suspended sediment, and fecal coliform bacteria.

Product: Water quality data for each sampling site

Milestone: October 2005-2009

Task 5: Review data collected previous year and determine changes needed in water quality (lake and tributaries) schedule. Amend QAPP accordingly.

Product: Data review and amended QAPP if needed.

Milestone: January 2007- January 2009

Task 6: Document type, acreage, and location of planned and installed BMPs to assess progress and target areas for annual work activities. Monitor operation and maintenance of Section 319 cost-share practices in accordance with ND NPS Management Plan. This includes establishment of photo points.

Product: Database report of location and acres of planned and/or installed BMPs. A BMP installation report should be provided to NDDoH on an annual basis.

Milestone: May 2005 – October 2009

Task 7: Collect, identify, and analyze the benthic macroinvertebrate invertebrate assemblage from the selected sampling sites a minimum of once in late July during the last year of the project (2009). The identification of the macroinvertebrates will be contracted out to Dr. Andre Delorme of Valley City State University. NDDoH personnel with the assistance of the principle investigator and/or field investigator will collect macroinvertebrate samples and calculate Index of Biotic Integrity (IBI) scores in order to assess aquatic life uses for each sample site and event. In addition, NDDoH personnel will analyze any historical macroinvertebrate data available for the area.

Product: Macroinvertebrate IBI scores for each sample site

Milestone: February 2010

Task 8: Conduct a riparian assessment using the Bureau of Land Management (BLM) "Process for Assessing Proper Functioning Condition". The assessment will be performed cooperatively between the NRCS and the SCD as their workloads permit. The riparian assessment conducted in 2001 will be compared to the 2009 assessment to determine if there has been an improvement or decline in the riparian area.

Product: Riparian assessment data and report for the Powers Lake watershed in Mountrail and Burke Counties.

Milestone: October 2009

Task 9: Compile chemical, physical, and biological stream data in preparation of semi-annual, annual and final reports summarizing impacts of the implementation of BMPs on water quality.

Product: Annual data summaries and a final report analyzing the chemical, physical and biological stream data of Powers Lake.

Milestone: Data Summaries - October 2005-2009, Final Report - March 2010

A4. Data Quality Objectives and Criteria for Measurement Data

A4.1 Data Quality Objectives

It is the policy of the US EPA and the Department's EHS that data quality Objectives (DQOs) be developed for all environmental data collection activities. Data of known quality are essential to the success of any monitoring or sampling project. Data quality objectives are qualitative and quantitative statements that clarify the intended use of the data, define the type of data needed to support the decision, identify the conditions under which the data should be collected, and specify tolerable limits on the probability of making a decision error due to uncertainty in the data. DQOs are developed by data users to specify the data quality needed to support specific decisions. Sources of error or uncertainty include the following:

- Sampling error: The difference between sample values and *in situ* true values from unknown biases due to collection methods and sampling design;

- Measurement error: The difference between sample values and *in situ* true values associated with the measurement process;

- Natural variation: Natural spatial heterogeneity and temporal variability in population abundance and distribution; and

- Error sources or biases associated with compositing, sampling handling, storage, and preservation.

The primary data quality objective of this project is to determine, through the collection of chemical, physical and biological data, the effectiveness of BMPs installed at reducing the pollutant levels to the targets set in the Powers Lake PIP and restoring the impaired water quality and beneficial uses of Powers Lake. Methods and procedures described in this document are intended to reduce the magnitude of the sources of uncertainty (and their frequency of occurrence) by applying the following approaches:

- use of standardized sample collection, handling, and analysis procedures; and

- use of trained scientists and technicians to perform the sample collection and handling activities.

A4.2 Measurement Performance Criteria

In order to meet the DQO for the project, the types of data needed for this project and their intended use are described in Table 1. For each of these data, a discussion of the measurement performance criteria or data quality indicators is provided. Data quality indicators include the following:

- precision;
- accuracy;
- representativeness;
- completeness; and
- comparability.

This QAPP does not address measurement performance criteria for the laboratory analysis of chemical samples. Measurement performance criteria for all lab analysis are described in the NDDoH, Division of Chemistry, Quality Assurance Plan (NDDH 2000).

Table 1. Project data needs and intended use.

Data Needed	Intended Use
Stream Chemical Characteristics: (e.g. nutrients, total suspended solids)	Characterize temporal and spatial trends of the nutrient and total suspended solids concentrations in Powers Lake and its tributaries. Combine daily discharge data with concentration to provide estimates of nutrient and sediment loading and yields.
Stream pathogen characteristics (e.g. fecal coliform)	Characterize temporal and spatial variations in stream water quality, based on fecal coliform bacteria, and assess recreational use impairment.
Stream Stage/Discharge: (e.g. water level, flows)	Adjust and improve the stage-discharge rating curve developed for the selected sampling sites and estimate the daily discharge based on stream stage.
Benthic Macroinvertebrate Assemblage (e.g. Index of Biotic Integrity).	Characterize temporal and spatial trends in the macroinvertebrate Index of Biotic Integrity (IBI) scores for the Powers Lake and its tributaries.
Riparian Assessment Data: (e.g. channel condition, riparian zone, hydrologic alteration, in-stream habitat)	Characterize and assess on a basic level the ecological condition of Powers Lake in 2009 to compare results from the 2001 assessment.

Precision is a measure of mutual agreement among individual measurements or enumerated values of the same property of a sample, usually under demonstrated similar conditions. Precision is best measured in terms of the standard deviation. For purposes of this project, precision of biological samples and chemical analysis will be calculated from replicate samples and expressed as relative percent difference (RPD), if it is calculated from duplicate samples, or as relative standard deviation (RSD), if it is to be calculated from three or more samples. Table 2 provides a summary of the precision requirements for data collected for this project.

Accuracy is the degree of agreement between an observed or measured value and the true or expected value of the measured quality. Many kinds of error, including unintentional bias affect the inherent accuracy of data. Unfortunately, the investigator almost never knows true population values. This is especially true when working with natural biological communities. Therefore, the best an investigator can do is to avoid bias by assuring consistency of sampling and sample processing and striving for repeatability of measurements. Table 2 provides a summary of the accuracy requirements for data collected for this project.

Representativeness expresses the degree to which data accurately and precisely represent a characteristic of a population, parameter, variation at a sampling point, process condition or an environmental condition. The representativeness of the project relies in part, on the selection of sample sites and the collection of a significant number of samples.

Completeness is defined as the percentage of measurements made that are judged to be valid according to specific criteria and entered into the data management system. To optimize completeness, every effort is made to avoid sample and/or data loss. Accidents during sample transport or lab activities that cause the loss of the original samples will result in irreparable loss of data, which will reduce the ability to perform analysis, integrate results, and prepare reports. In order to maximize completeness, all samples will be stored and transported in unbreakable (plastic) containers.

Percent completeness (%C) for measurement parameters and samples is defined as:

$$\%C = v/T \times 100$$

Where v = the number of measurements or samples judged valid; and
T = the total number of measurements of samples collected.

In order to fulfill statistical criteria, samples will be collected at 100% of the sites unless unanticipated conditions (i.e. bad weather) prevent sampling. Table 2 provides a summary of the completeness requirements for data collected for this project.

Comparability is a measure of the confidence with which one data set can be compared to another. Comparability is dependent on the proper design of the sampling program and on strict adherence to accepted sampling techniques, standard operating procedures, and quality assurance guidelines. For this project, comparability of data will be accomplished by standardizing the sampling season, the geographic extent of the project, the field sampling methods and the field training as follows:

- All samples will be collected from specific stream sites located within the Powers Lake watershed (Appendix A). The project-sampling period will be between May 2006 and June 2009.

- Standard sampling and analytical methods, as well as standard units of reporting for all parameters sampled will be used (Appendices B-G).

- All field personnel involved with sampling will have adequate training and experience.

Table 2. Summary of precision, accuracy, and completeness requirements for measurement data.

Measurement Parameter	Precision	*Accuracy*	**Percent Completeness**
Stream Water Chemistry & Pathogens.	20 %	NA	95 %
Stream Stage/Discharge	+/- 5 %	0.1 ft/0.1 cfs	99 %
Benthic Macroinvertebrate Assemblage			
# of individuals	25%	NA	100%
# of taxa	10%	NA	100%
Riparian Assessment	NA	NA	100%

A5. Special Training/Certification

The Principal Investigator (PI) will be responsible for all field data collection including water quality, riparian assessment, and stream stage/discharge. NDDoH personnel with the assistance of the project field staff will collect and transfer the macroinvertebrate samples. The field sampling crew is required to have the necessary knowledge and experience to perform all field activities. Training in the proper methods for sample collection, preservation, and the transfer of water chemistry will be provided by Heather Duchscherer, Designated Project Manager (DPM). Ms. Duchscherer will also be responsible for assisting the PI with the installation of stream stage recording equipment as well as providing training in its operation and the measurement of stream discharge.

A6.Documents and Records

Thorough documentation of all field sampling and handling activities is necessary for proper processing in the laboratory, data reduction and, ultimately, for the interpretation of study results. Field sample collection and handling will be documented in writing (the following forms and labels will be used):

- a set of Sample Identification/Custody Record forms that accompanies each water chemistry or sediment samples submitted to the Division of Chemistry laboratory for analysis (Appendix B);

- a Sample Identification Label that accompanies and identifies all water samples (Appendix B);

- a Stream Discharge Recording form to calculate instantaneous stream discharge (Appendix C)

Each sample collected will be uniquely identified on the sample label and field custody forms by specifying the site ID and location; sample depth; and sample date and time.

B. Data Generation and Acquisition

B1. Sampling Process Design

B1.1 Monitoring Goal

The primary monitoring goal of this project is to measure and document the effectiveness of installed BMPs and technical assistance at reducing the pollutant levels to the targets stated in the Powers Lake PIP and restoring the impaired water quality and beneficial uses within Powers Lake. This goal will be accomplished by:

1) Collecting and analyzing chemical, physical, and biological data at selected sites on Powers Lake and its tributaries;

2) Documenting acreage, location, and type of installed BMPs in the watershed; and

3) Compiling, analyzing, and integrating the chemical, physical, biological, and BMP installation data in order to characterize the temporal and spatial trends in water quality as a variety of BMPs are installed over time throughout the watershed.

B1.2 Water Quality Sampling Locations

There is one lake site located at the deepest part of Powers Lake. There are four stream sites representing each of the subwatersheds, and one stream site at the lake outlet. These are identified in Table 3 and Figure 2 below.

Table 3. Water Quality Sampling Locations

Sampling Site	**STORET Site ID**	**Latitude (approx.)**	**Longitude (approx.)**
Northeast Tributary	385035	48^{o} N 33’ 18”	-102^{o} W 37’ 30”
Lunds Valley Tributary	385036	48^{o} N 31’ 18”	-102^{o} W 34’ 53”
West Tributary	385037	48^{o} N 32’ 7”	-102^{o} W 39’ 7”
South Tributary	385038	48^{o} N 29’ 19”	-102^{o} W 36’ 8”
Lake Outlet	385039	48^{o} N 33’ 25”	-102^{o} W 39’ 16”
In Lake	380870	48^{o} N 32’ 17”	-102^{o} W 36’ 36”

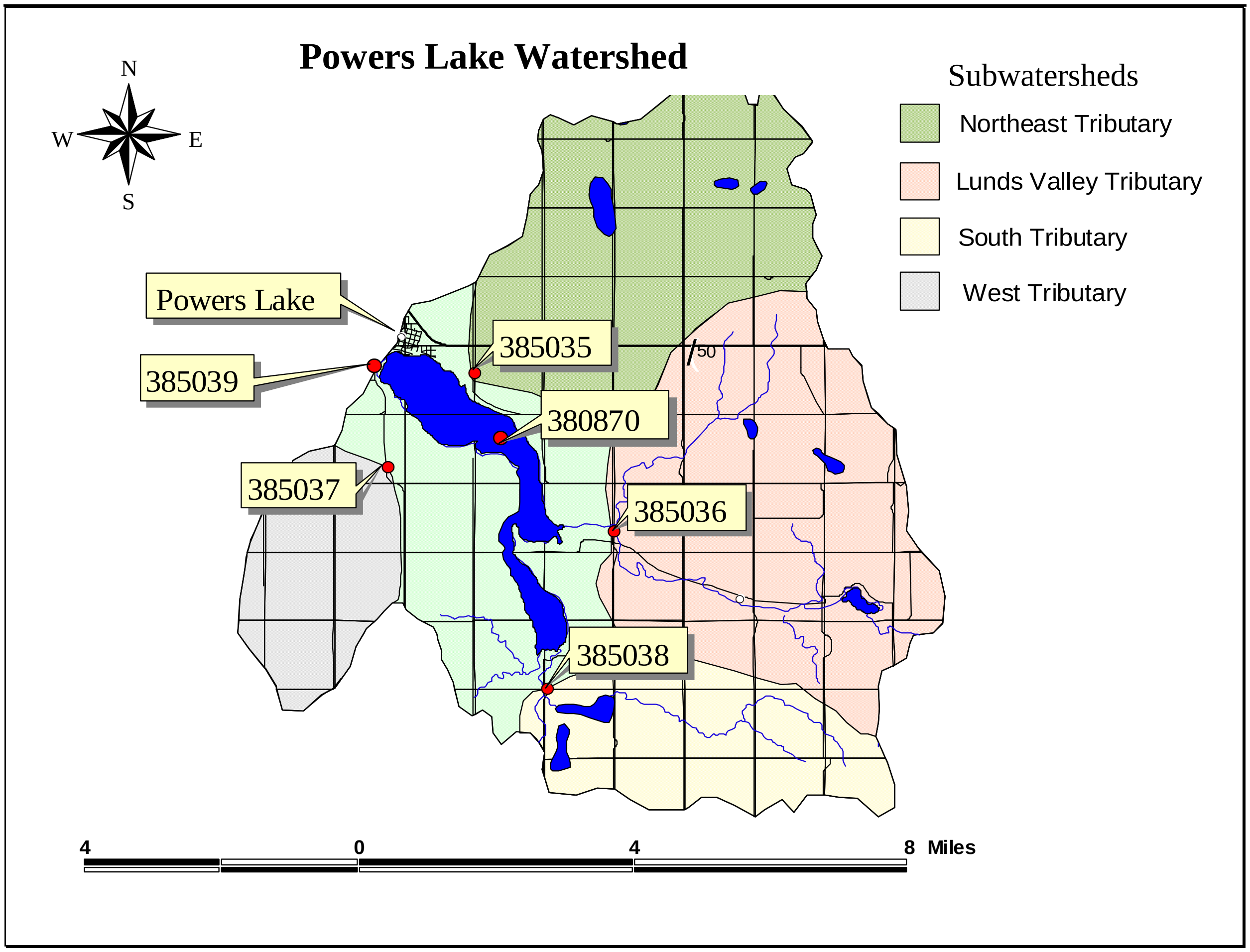

Figure 2. Location of Water Quality Sampling Sites within Powers Lake Watershed.

B1.3 Sampling Frequency

Lake Water Quality Sampling

One lake sampling site will be sampled throughout the open water season of 2006 (approx. May - October), for nutrients, total suspended solids, chlorophyll-a, TSS, temperature, dissolved oxygen, pH, and Secchi disk depth. Sampling will take place twice a month. Additional samples will be taken once a month after ice is formed, as safety permits. Lake sampling will continue in this fashion, starting during the open water season (approx. March – April) until the projects ends in 2009, as the data warrants.

Stream Water Quality Sampling

Five stream sites will be sampled a minimum of 36 times each during the open water season in 2007, continuing through 2009 if data warrants. Sampling frequency for the stream sampling sites will be stratified to coincide with the typical hydrograph for the region. This sampling design will result in more frequent sampling during the spring and early summer, typically when stream discharge is greatest, and less frequent sampling during the summer and fall. Sampling will be discontinued during the winter ice cover.

Sampling will also be terminated if the stream stops flowing. If the stream should begin flowing again, water quality sampling will be reinitiated. An additional 3 samples will also be collected from each site that are related to storm events. A storm event is defined as a precipitation event (either form direct rainfall or snow melt) large enough to cause a 0.2-foot increase in stream stage. Table 4 provides a summary of the stream sampling frequency.

Table 4. Sampling Frequency for Stream Water Quality Monitoring.

Sampling Period	Date	Frequency
1st and 2nd month	April – May, 2005	twice per week
3rd month	June, 2005	once per week
4th –8th month	July- November	once per month

Note: This schedule is to be used only as a guide. Actual sampling dates may and probably will differ quite dramatically due to climatic and ice conditions. Under *NO* conditions will the safety of the sampler be compromised!

During each stream sampling trip, field measurements of temperature, pH, and dissolved oxygen will be taken. The measurements will be taken below the water's surface, in the center of the stream. Stream discharge will also be measured every time that the stream chemistry is sampled at the sites. Stream stage will be measured using an automated stage recorder with a standard manual stage gage as a backup.

Benthic Macroinvertebrate Community

The macroinvertebrate community will be sampled once in September 2005.

Note: The sampling schedule is primarily a guide and the dates may differ under actual conditions. However, the scheduled intervals between samples should be maintained unless dangerous or no-flow conditions prevent it. Under NO conditions will the safety of the sampler be compromised!

B2. Sampling Methods

Table 5 provides a summary of project sampling methods. Detailed descriptions of all field-sampling methods are described in Appendices B through K.

Table 5. Summary of project sampling methods

Matrix/ Substrate	Parameter	Sampling Equipment	Max Holding Time	Sample Container	Sample Preservation and Care
Lake Water	Chemistry	1	2	2	2
Stream Water	Chemistry	3	2	2	2
Stream Water	Pathogens	3	2	2	2
Stream Water	Discharge	4	NA	NA	NA
Stream Water	Stage	4	NA	NA	NA
Stream Substrate	Macro-invertebrates	5	NA	5	5

1 - See Appendix B, C, and H
2 - See Appendix I
3 - See Appendices D and E
4 - See Appendices F and G
5 - See Appendix J and K

B3. Sample Handling and Custody Requirements

Analysis of all water quality samples collected from monitoring sites will be performed by the NDDoH, Division of Chemistry. Immediately after collection, water chemistry samples and sample custody reports will be sent delivery to the Division of Chemistry laboratory in Bismarck, ND at the following address:

N.D. Department of Health
Division of Chemistry
26355 East Main------------UPS
Bismarck, ND 58502-0937

Analysis of all fecal coliform bacteria samples collected from monitoring sites will be performed by the NDDoH, Division of Microbiology. Immediately after collection, fecal coliform bacteria samples and sample custody reports will be sent overnight delivery to the Division of Microbiology in Bismarck, ND at the following address:

N.D. Department of Health
Division of Microbiology
2635 East Main--------------UPS
Bismarck, ND 58502-0937

Samples must be collected and sent on Mondays, Tuesdays or Wednesdays to insure proper delivery is made.

All macroinvertebrate samples will be hand delivered or express mailed to Dr. Andre Delorme of Valley City State University for storage and identification.

B4. Analytical Methods Requirements

All water samples will be analyzed according to methods and procedures described in the NDDoH Division of Chemistry's Quality Assurance Plan (NDDoH, 2000). The macroinvertebrate samples will be processed according to the NDDoH Division of Water Quality's Standard Operating Procedures for Laboratory Processing of Macroinvertebrate Samples (Appendix K).

B5. Quality Control

For this project, a single person will take the majority of the measurements and samples (i.e. water samples, discharge, stage, etc.) in the field. Equipment used for field measurement will be calibrated according to manufacture specifications immediately before and after each sampling trip. Furthermore, field duplicate samples will be collected with ten percent of the stream samples collected for chemical analysis.

Quality control will be assured for macroinvertebrate samples by maintaining a macroinvertebrate voucher collection for all taxa identified in the laboratory, sub-sampling replicate field samples, performing replicate sub-samples on ten percent of field samples, and removing and identifying all organisms from ten percent of the field samples (Appendix F). Voucher collections will be cataloged and placed in the North Dakota River and Stream Macroinvertebrate Collection located at Valley City State University by Dr. Andre DeLorme, Ph.D.

B6. Instrument/Equipment Testing, Inspection and Maintenance

All field equipment will be inspected prior to sampling activities to ensure that proper use requirements are met (e.g., water samplers are without defects, current meter functioning properly). Inspection of field equipment will occur in advance of field activities to allow time for replacement or repair of defective equipment. The Field Investigator should gather and inspect all equipment prior to each sampling trip. All field equipment will be maintained according to manufacture's specifications.

B7. Instrument Calibration and Frequency

As part of instrument and equipment maintenance, the stream stage automated recorder and discharge meters will be calibrated according to the manufacturer's specifications.

B8. Inspection/Acceptance of Supplies and Consumables

Careful and thorough planning is necessary to ensure the efficient completion of the field sample collection tasks. A general checklist of field equipment and supplies is provided in the description of the SOPs (Appendices B-K). It is the responsibility of the Field Investigator to gather and inspect the necessary sampling gear prior to each sampling trip.

B9. Data Acquisition Requirements (Non-direct Measurements)

Non-direct measurements will include identification and/or verification of each sample location (i.e., latitude and longitude). The latitude and longitude coordinates, in decimal degrees, will be recorded. A hard copy table of the location of each sampling site and a map depicting each location will be provided by the DPM to the Principle Investigator.

B10. Data Management

Samples will be documented and tracked through sample identification labels, field and laboratory recording forms and sample identification/custody forms. Water samples collected for chemical analysis will be transported or sent to the Division of Chemistry laboratory in Bismarck, ND by field personnel.

Results of chemical analysis of water samples are transmitted from the Division of Chemistry to the SWQMP Program Manager via hard copy report and electronically as an ASCII text file. Results transmitted electronically are stored by the Division of Water Quality's SWQMP in an Access 2000 based data management system, termed Sample Identification Database (SID). After review by the SWQMP Program Manager, sample results will be retained by the DPM for data reduction and analysis.

Dr. Andre Delorme of Valley City State University will process the macroinvertebrate samples. Laboratory processing will entail identification to lowest taxonomic level practical (Genus level preferred) and the enumeration of all macroinvertebrates in each sample by taxon. Results from each sample will be recorded on a lab data sheet and entered by Dr. Delorme into the Ecological Data Application System (EDAS), a Microsoft Access 2000 database provide by SWQMP. Upon completion of the laboratory analysis of the macroinvertebrate samples, copies of the field and lab recording forms and database will be transmitted to the DPM where the hard copy results will be kept on file by the Division of Water's SWQMP.

C. Assessment and Oversight

C1. Assessment and Response Actions

Assessment activities and corrective actions have been identified to ensure that sample collection activities are conducted as prescribed and that the measurement quality objectives and data quality objectives established by this QAPP are met. The QA program under which this project will operate includes performance and system audits with independent checks of the data obtained from sampling activities. Either type of audit could indicate the need for corrective action. The essential steps in the program are as follows:

- identify and define the problem;
- assign responsibility for investigating the problem;

- investigate and determine the cause of the problem;
- assign and accept responsibility for implementing appropriate corrective action;
- establish effectiveness of and implement the corrective action; and
- verify that the corrective action has eliminated the problem.

Immediate corrective actions form the part of normal operating procedures and are noted on project field and laboratory recording forms and will be the responsibility of the PI. Problems not solved this way may require more formalized long-term corrective action. In the event that quality problems requiring attention are identified, the DPM will determine whether attainment of acceptable data quality requires either short- or long-

term actions. Failures in the chemical analysis system (e.g., performance requirements are not met) and corrective actions for those failures are beyond the scope of this QAPP.

Communication and oversight will proceed from the PI to the DPM. The DPM will be available throughout the entire sampling period to address questions and receive communications of sampling status from the field personnel. The PI will communicate the status of the sampling activities to the DPM on a weekly basis. During this time the PI will communicate any sampling difficulties encountered during the sampling and the corrective actions taken. In most cases the PI will initiate corrective actions when a problem is immediately identified and note the problem and corrective action in his logbook. In the event the problem cannot be corrected immediately, the PI will contact the DPM to determine the best way to rectify the problem and obtain accurate and useable data. When corrective actions have been taken and a sufficient time period has elapsed that allows a response, the response will be compared with project goals by the DPM. The DPM will verify that the corrective action has been appropriately addressed to eliminate the problem. The DPM has the authority to stop work on the project if problems affecting data quality are identified that will require extensive effort to resolve. When the PI contacts the DPM with a problem, the PI will make a record of the problem and the corrective action taken.

Performance audits are qualitative checks on different segments of project activities, and are most appropriate for field sampling and laboratory analysis activities. A field audit of field sampling activities will be conducted at least once during the project. This audit will be conducted early during the project field season in case any problems are identified they can be corrected quickly to minimize the possibility of compromising data. Field audit techniques include checks on sampling equipment and the review of sampling methods.

System audits are qualitative reviews of project activity to check that overall project quality is functioning and that the appropriate QC measures identified in the QAPP are being implemented. The DPM will conduct semi-annual internal system audits during the project and report all deficiencies to the SWQMP Program Manager and the EPA Project Officer during semi-annual reporting.

C2. Reports to Management

Problems and corrective actions identified by the PI will be reported to the DPM each week during the field season. Significant problems identified by the field personnel as well as problems and corrective actions identified by the DPM during the field audit will be reported to the SWQMP Program Manager and the EPA Project Officer as part of annual reports.

D. Data Validation and Usability

D1. Data Review, Validation, and Verification Requirements

Data review and validation services provide a method for determining the usability and limitations of data, and provide a standardized data quality assessment. The PI and the DPM will review all field and laboratory report forms, while all sample custody forms for chemical analysis will be reviewed by the DPM for completeness and correctness. The PI will be responsible for reviewing all data entries and transmittals for completeness and adherence to QA requirements. Data quality will be assessed by comparing entered data to original data or by comparing results with the measurement performance criteria summarized in Section A4.2 to determine whether to accept, reject, or qualify the data. Results of the review and validation processes will be reported to the DPM.

D2. Verification and Validation Methods

The PI will review all field and laboratory record forms. The DPM will review a minimum of five percent of field and laboratory record forms and all of the sample custody forms for chemical analysis. Any discrepancies in the records will be reconciled with the field personnel and recorded in the logbook.

Analytical validation and verification methods are outside the scope of the QAPP. The submission of samples to the Division of Chemistry laboratory will include a Sample Identification/Custody Record sheet documenting the site location, sampling date and time. The Division of Chemistry laboratory to ensure that holding times have not been exceeded will check this information. The laboratory will report violations of holding times to the DPM. The DPM, in consultation with Division of Chemistry personnel, will determine whether or not to proceed with the analysis of that sample and/or analyte.

D3. Reconciliation with Data Quality Objectives

As soon as possible after each sampling event or the analysis of each sample, calculations and determinations for precision, completeness, and accuracy will be made by the PI and compared to the criteria discussed in Section A4. This will represent the final determination of whether the data collected are of the correct type, quantity, and quality to support their intended use for this project. Any problems in meeting the performance criteria (or uncertainties and limitations in the use of the data) will be discussed with the Principle Investigator and the DPM, and will be reconciled, if possible.

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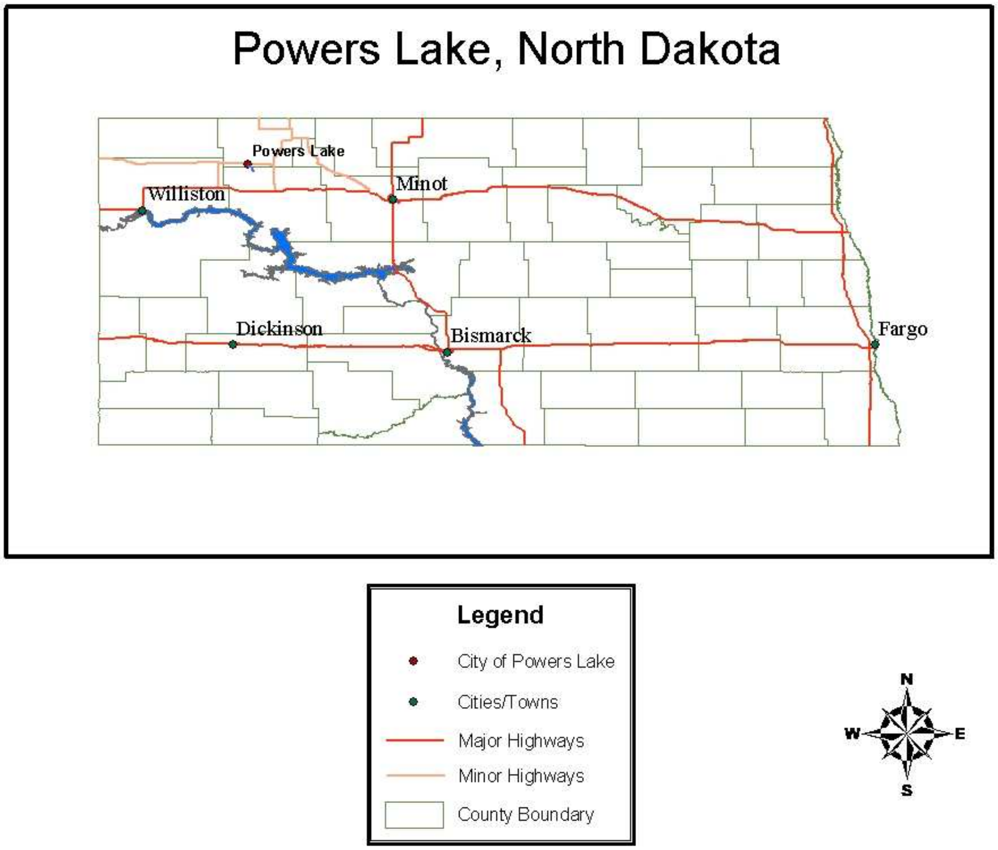
319 QAPP Appendix A

Water Quality Sampling
Site Locations for the Powers Lake Watershed


Powers Lake, North Dakota
Powers Lake
Minot
Williston
Dickinson
Bismarck
Fargo
Legend
City of Powers Lake
Cities/Towns
Major Highways
Minor Highways
County Boundary
N
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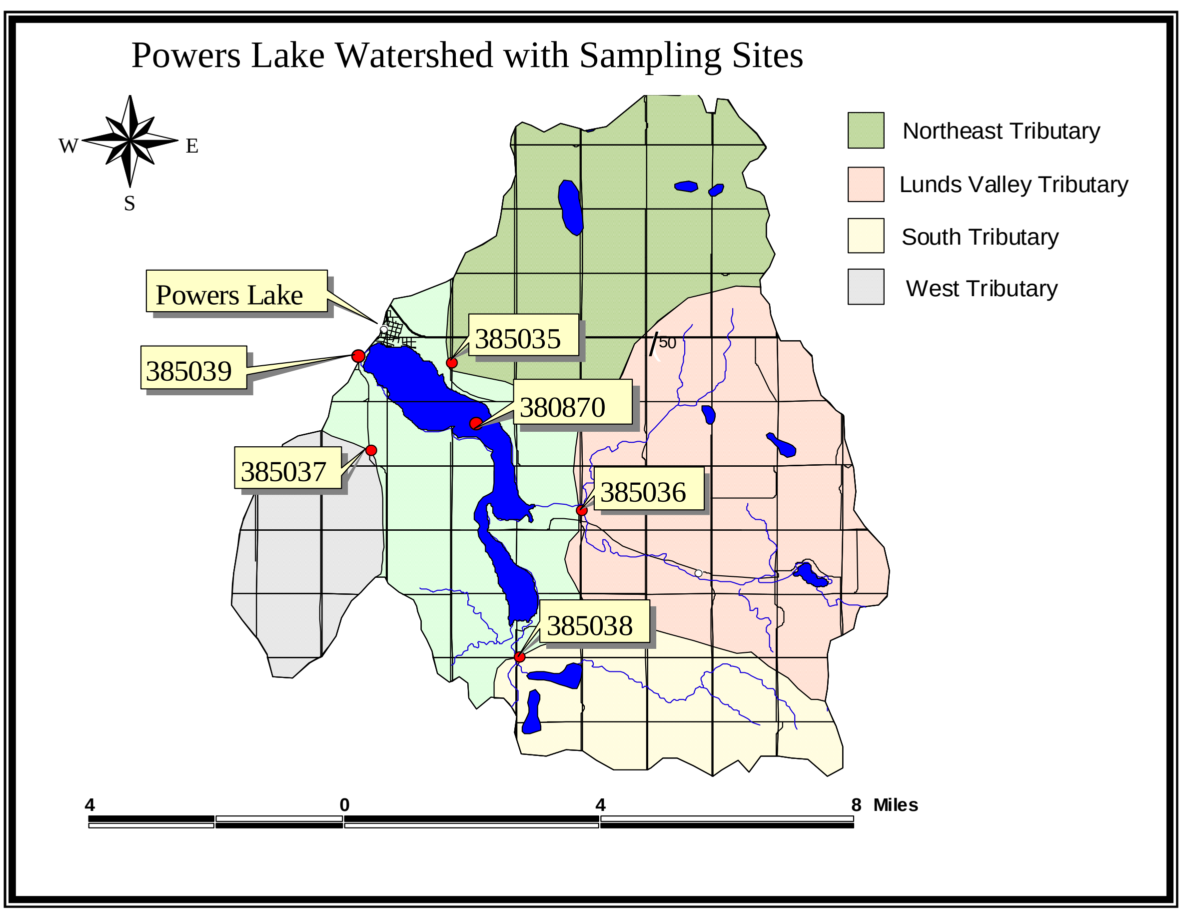

Powers Lake Watershed with Sampling Sites
W
E
S
Northeast Tributary
Lunds Valley Tributary
South Tributary
West Tributary
Powers Lake
385035
385039
380870
385037
385036
385038
50
4
0
4
8 Miles

319 QAPP Appendices B-F
Standard Operating Procedures
(Available on Request)

Appendix D

County Occurrence of Endangered, Threatened, and Candidate Species and Designated Critical Habitat in North Dakota

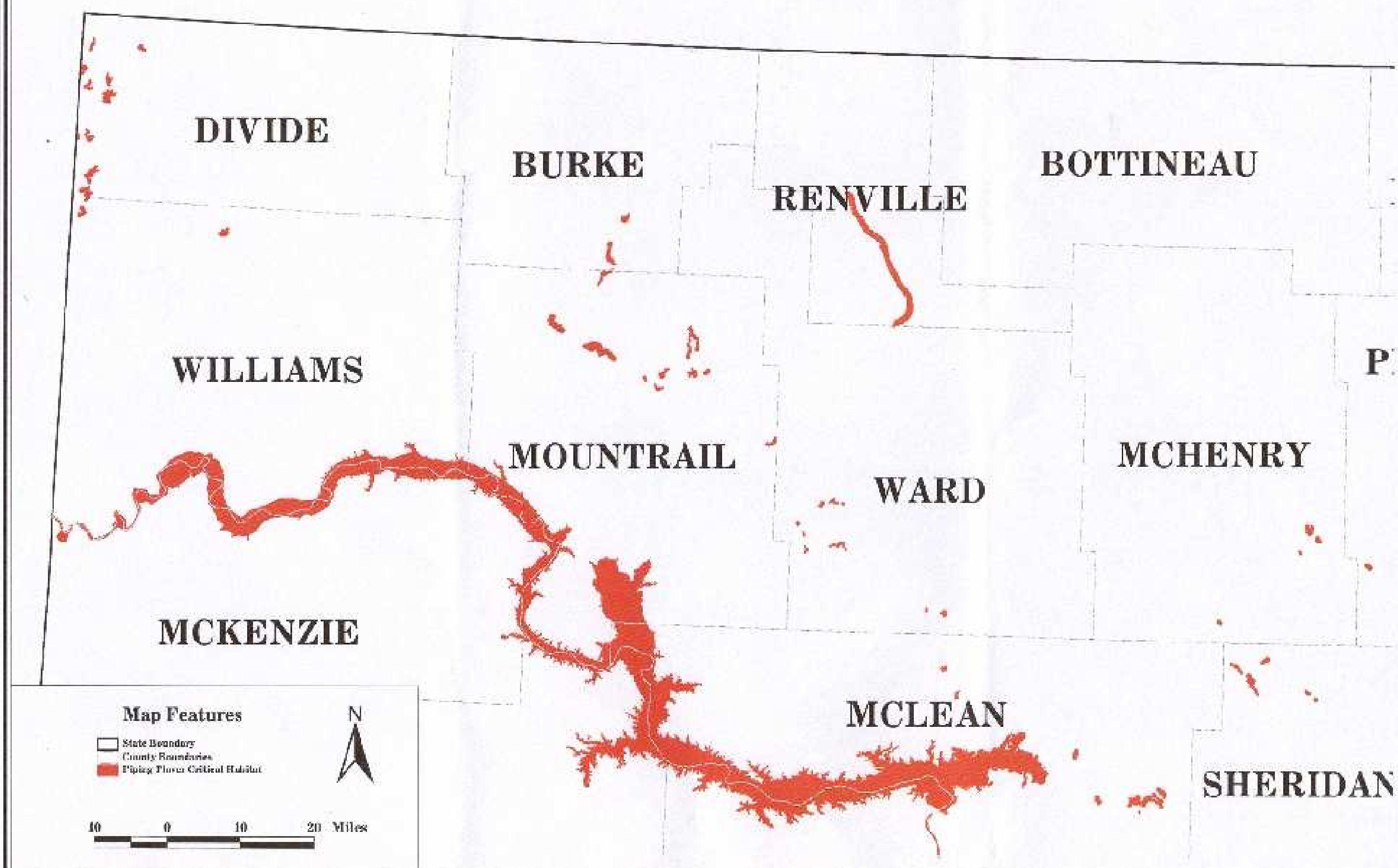
County Occurrence of Endangered, Threatened and Candidate Species and Designated Critical Habitat in North Dakota (March 2006)

Species E – Endangered T – Threatened C - Candidate	Adams	Barnes	Benson	Billings	Bottineau	Bowman	Burke	Burleigh	Cass	Cavalier	Dickey	Divide	Dunn	Eddy	Emmons	Foster	Go. Valley	Gr. Forks	Grant	Griggs	Hettinger	Kidder	Lamoure	Logan	McHenry	McIntosh	McKenzie
Interior Least Tern - E								X					X		X												X
Whooping Crane - E	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X
Black Footed Ferret - E	X			X		X							X				X		X		X						X
Pallid Sturgeon – E								X					X		X												X
Gray Wolf – T					X		X		X	X	X	X	X					X							X	X	X
Bald Eagle - T	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Piping Plover – T			X				X	X				X	X	X	X	X						X		X	X	X	X
Western Prairie Fringed Orchid - T																											
Dakota Skipper - C							X							X											X		X
Designated Critical Habitat																											
Piping Plover			X				X	X				X	X	X	X							X		X	X	X	X

County Occurrence of Endangered, Threatened and Candidate Species and Designated Critical Habitat in North Dakota (March 2006)

Species E – Endangered T – Threatened C - Candidate	McLean	Mercer	Morton	Mountrail	Nelson	Oliver	Pembina	Pierce	Ramsey	Ransom	Renville	Richland	Rolette	Sargent	Sheridan	Sioux	Slope	Stark	Steele	Stutsman	Towner	Traill	Walsh	Ward	Wells	Williams
Interior Least Tern - E	X	X	X	X		X										X										X
Whooping Crane - E	X	X	X	X		X		X			X		X		X	X	X	X		X	X			X	X	X
Black Footed Ferret - E		X	X			X										X	X	X								
Pallid Sturgeon – E	X	X	X	X		X										X										X
Gray Wolf – T	X		X	X	X		X	X	X		X	X	X	X	X						X		X	X		X
Bald Eagle - T	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Piping Plover – T	X	X	X	X		X		X			X				X	X				X				X	X	X
Western Prairie Fringed Orchid - T										X		X														
Dakota Skipper - C										X		X	X	X						X				X	X	
Designated Critical Habitat																										
Piping Plover																										X

Piping Plover Critical Habitat



Appendix E
Review Comments Provided by the US EPA Region 8

EPA REGION VIII TMDL REVIEW FORM

Document Name:	**Powers Lake Nutrient and Dissolved Oxygen TMDLs**
Submitted by:	**Mike Ell, NDDoH**
Date Received:	**August 25, 2008**
Review Date:	**September 3, 2008**
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 11 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

Each of the 11 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 – Powers Lake is located near the town of Powers Lake in Burke and Mountrail Counties, North Dakota. It is a 1,616 acre natural lake in the Northern Missouri Coteau region of North Dakota (HUC 10110101). Four small, unnamed tributaries drain into the lake. Although Powers Lake is within the Missouri River basin, most of the drainage in the county is internal. Powers Lake is listed on the State's 2008 303(d) list as fully supporting but threatened for fish and other aquatic biota uses by nutrient/eutrophication biological indicators, dissolved oxygen and sedimentation/siltation, and as fully supported but threatened for recreational uses by nutrient/eutrophication biological indicators (ND-10110101-001-L_00). Approximately 44,458 acres of land drain to the lake from the watershed. Powers Lake 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 cropland (approximately 66 percent), and pasturelands and haylands (approximately 23 percent).

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 – Powers Lake is listed as impaired for nutrients/eutrophication, dissolved oxygen 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 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.

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

Other applicable water quality standards are included on pages 14 - 15 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.

The mean chlorophyll-*a* TSI for Powers Lake during the period of the assessment was 72.37. 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 internal loading plus a 75% reduction in external phosphorous loading to the lake will achieve a Chl-*a* TSI of 55.02, which corresponds to a phosphorous concentration of 0.041 mg/L. This target is based on best professional judgement and will fully support its beneficial uses.

The water quality targets used in this TMDL are: **maintain a mean annual chlorophyll-*a* TSI at or below 55.02; maintain a dissolved oxygen level of not less than 5 mg/L.**

COMMENTS – Powers Lake is listed as impaired for sedimentation/siltation in addition to nutrients and dissolved oxygen. However, the TMDL does not contain a target for sediment, nor a justification that the lake is not impaired by sediment nor a statement that the sediment impairment will be addressed in a separate, future document. The TMDL needs to include an explanation of how the sedimentation/siltation impairment will be addressed.

The TMDL shows that pH data was collected in Powers Lake, but it does not summarize or mention the pH results or whether its meeting the applicable pH WQS. A few sentences need to be added to the TMDL to summarize the pH readings in the lake and compare them with the pH WQS.

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 66% of the landuse is cropland and 23% is pastureland and hayland in the watershed.

5. Technical Analysis

Criterion Description – Technical Analysis
TMDLs must be supported by an appropriate level of technical analysis. ***.*** *It applies to* ***<u>all</u>*** *of the components of a TMDL document. It is vitally important that the technical basis for* ***<u>all</u>*** *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 The technical analysis addresses linkage between the water quality target and the identified sources of nutrients, and describes the models or methods used to derive the TMDL loads that will ensure that the water quality standards are met. To determine the cause and effect relationship between the water quality target and the identified sources various models and loading analysis were utilized.

The FLUX model was used to facilitate the analysis and reduction of tributary inflow and outflow nutrient and sediment loadings for Powers Lake. Output from the FLUX program is then provided as an input file to calibrate the BATHTUB eutrophication response model. The BATHTUB model was used to evaluate and predict the effects of various nutrient reduction scenarios on the response in Powers Lake.

The Agricultural Non-Point Source Model (AGNPS) 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 (i.e., those with sediment phosphorous loading rates above 2.5 lbs/acre - TMDL Figure 19). A portion of the initial load reductions under this TMDL will be achieved through controls on the critical cells within the watershed to improve pasture conditions or improve tillage practices.

Improvements in the dissolved oxygen concentration of the lake can be achieved through reduction of organic loading to the lake 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 Powers Lake will address the dissolved oxygen impairment.

COMMENTS – Similar to the comment above in the Water Quality Targets section, the TMDL fails include a discussion of the sedimentation/siltation impairment in the Technical Analysis section. The Technical Analysis section should include a sub-section addressing the sediment impairment. This may include, as appropriate, a justification that the lake is not impaired by sediment, or a statement that the sediment impairment will be addressed in a separate, future document.

The modeled Secchi disk depth in Table 23 seems to be in error (70.32 meters), please correct. How could the predicted Secchi depth be nearly nineteen times higher than the maximum depth of the lake?

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 5% explicit margin (95.19 kg/yr) of safety is included in the phosphorus TMDL. An implicit margin of safety is also included through conservative assumptions in the derivation of the target and in the modeling. Additionally, some load reduction is possible from controls on areas not included in the modeling (e.g., runoff from the town of Powers Lake), and ongoing monitoring has been proposed to assure water quality goals are achieved. 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 Powers Lake is a 1903.85 kg/yr (5.22 kg/day) total phosphorus load to the lake (50% reduction in internal and 75% 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 NDDoH believes that describing the phosphorus load as an annual load is more realistic and protective of the waterbody. Most phosphorus based eutrophication models use annual phosphorus loads, and seasonality and unpredictable precipitation patterns make a daily load unrealistic. EPA recognizes that, under the specific circumstances, the state may deem the annual load the most appropriate timeframe (i.e., the TSI water quality target is based on an interpretation of narrative water quality standards which naturally does not include an averaging period). EPA notes that the Powers Lake TMDL calculations for phosphorus include an approximated daily load derived through simple division of the annual load by the number of days in a year**.** This should be considered an "average" daily load that typically will not match the actual phosphorus load reaching the lake on a given day.

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 Powers Lake. The allocations in the TMDL include a "load allocation" attributed agricultural to nonpoint sources, and an explicit margin of safety. There are no point source discharges of phosphorus in this watershed. The source allocations for phosphorous are assigned to the critical loading cells that contribute greater than 2.5 tons/acre of sediment phosphorous as shown by the shaded areas in Figure 19 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 the public comment period. Also, the draft TMDL was posted on NDoDH's Water Quality Division website, and a public notice for comment was published in the newspaper.

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.

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 has already awarded a Section 319 Nonpoint Source Management grant for implementation of BMPs in the watershed. The Section 319 Project Implementation Plan is included in Appendix C of the TMDL document.

Appendix F
Review Comments Provided by the US Fish and Wildlife Service

United States Department of the Interior

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

SEP - 4 2008

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 the draft Brewer Lake and the draft Powers Lake Nutrient and Dissolved Oxygen Total Maximum Daily Load reports, and offers the following comments.

The North Dakota Department of Health (Department) has identified Brewer Lake, Cass County, and Powers Lake, in Burke and Mountrail Counties, as being water quality limited and needing total maximum daily loads (TMDL). Brewer Lake, a man-made reservoir, and Powers Lake, a natural lake, are on the Department's Section 303(d) List of Impaired Waters. Aquatic life in the two waterbodies is listed as impaired due to nutrients, sedimentation, and low dissolved oxygen. The draft TMDL reports indicate there are no waste allocations from point sources in the watersheds. Pollutant loads are attributed to nonpoint sources.

The draft documents provide discussion on identifying the pollutant reductions needed and actions that should be taken to achieve water quality standards for Brewer and Powers Lakes. The Service supports the Department's efforts to restore water quality to fully support aquatic life within the two lakes.

The Service concurs with the Department's assessment that the Brewer Lake TMDL and the Powers Lake TMDL will have no adverse effect to federally listed threatened or endangered species.

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 at 701-250-4481, or at the letterhead address.

Sincerely,

Jeffrey K. Towner
Field Supervisor
North Dakota Field Office

Appendix G

Department Response to Comments

Department Response to Comments

During the 30 day public notice soliciting comment and participation for the Powers Lake Nutrient and Dissolved Oxygen TMDL, the North Dakota Department of Health received comments from the US EPA (see Appendix E) and from Scott Elstad with the North Dakota Game and Fish Department in the form of hand written comments in the margins of the draft report. Below are the comments provided and the departments' response.

Comment from US EPA: "Powers Lake is listed as impaired for sedimentation/siltation in addition to nutrients and dissolved oxygen. However, the TMDL does not contain a target for sediment, nor a justification that the lake is not impaired by sediment nor a statement that the sediment impairment will be addressed in a separate, future document. The TMDL needs to include an explanation of how the sedimentation/siltation impairment will be addressed."

NDDoH Response: Additional language has been added to Section 1.1, Clean Water Act Section 303(d) Listing Information, stating that the purpose of this TMDL report is for the pollutants, nutrients and low dissolved oxygen and that the sediment listing will be addressed as additional data become available.

Comment from US EPA: "The TMDL shows that pH data was collected in Powers Lake, but it does not summarize or mention the pH results or whether its meeting the applicable pH WQS. A few sentences need to be added to the TMDL to summarize the pH readings in the lake and compare them with the pH WQS."

NDDoH Response: The reference to pH and conductivity data having been collected as well as general cations and anions was incorrect. Upon further investigation into the data collected in 2000 and 2001 it was determined that only chlorophyll-a and the nutrient species were collected and analyzed. Language in Section 1.5.2, Lake Data, has been clarifying by removing this reference.

Comment from US EPA: "The modeled Secchi disk depth in Table 23 seems to be in error (70.32 meters), please correct. How could the predicted Secchi depth be nearly nineteen times higher than the maximum depth of the lake?"

NDDoH Response: The correct value should be 0.32 meters not 70.32 meters, the table has been corrected.

Comment from NDGF: "Powers Lake Watershed Committee has commissioned and received a report from Houston Engineering (July 18, 2008) on nutrient management alternatives – should that be referenced/addressed?"

NDDoH Response: The conclusions presented in this report are beyond the scope of the TMDL. The nutrient reductions that formed the basis for this TMDL are based on a 50 percent reduction in internal phosphorus loading and a 75 percent reduction in external loading. The purpose of the Houston Engineering report is to determine cost effective alternatives to achieve the internal nutrient reduction goal of this TMDL.

Comment from NDGF: Lake statistics cited in Section 1.0, Introduction and Description of Watershed, do not match statistics provided in Figure 3 or Table 1.

NDDoH Response: Statistic cited in text in Section 1.0 were changed to reflect correct information provided in Figure 3 and Table 1.

Comment from NDGF: In Section 4.1, Point Sources, of the TMDL report it states that "No permitted livestock feeding areas are located in the Powers Lake watershed." The commenter asks how many non-permitted CAFO's/AFO's?

NDDoH Response: By definition, CAFO's are livestock feeding facilities that contain an equivalent of 1000 beef cattle for at least 45 day per year. There are no permitted facilities in the Powers Lake watershed that meet this criteria. There is one permitted AFO in the watershed. Other non-permitted AFOs in the watershed were inventoried and accounted for in the AGNPS watershed model. Language in Section 4.1 has been changed to reflect this inventory.

Comment from NDGF: In reference to Section 4.2.1, Stormwater Runoff,, of the TMDL report, the commenter asks if the city of Powers Lake still dumps their snow on the lake or where runoff/sediment from snowmelt can flow into the lake. The commenter also provided a copy of a hand out obtained the city of Pwers Lake that suggests the lake as an appropriate place to dump snow.

NDDoH Response: The department has received assurances from city officials that the no longer dump there snow where it can negatively impact the lake.

Comment from NDGF: In the last paragraph of Section 5.2, BATHTUB Trophic Response Model, on page 30 of the draft report it is stated that "Using the AGNPS model, it was determined that if 87 percent of the moderate to high sediment and nutrient loading cells were addressed through BMPs, then the sediment load would decrease by 57 percent, and phosphorus load would decrease by 76 percent. This exceeds the reduction determined necessary to reach the desired trophic state and will allow the lake to reach the chlorophyll-a TSI target value of 55.02 determined in Section 3.1." The commenter asks if this is a "reachable/reasonable goal?..by landowners in the area?", especially with commodity prices on the rise.

NDDoH Response: By definition and rule, the pollutant reduction goal of the TMDL is set so the waterbody will meet water quality standards. The TMDL goal and accompanying pollutant reduction targets do not have to be achievable. If it is determined that the current water quality standards and beneficial use designations can not be met based on achievable pollutant load reductions, then the department must do a use attainability determination and change the standard(s) for the waterbody.