Nutrient and Dissolved Oxygen TMDLs for Northgate Dam in Burke County, North Dakota

Final April 2006

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*This document also contains justification for de-listing Northgate Dam for sediment impairments

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1.0 INTRODUCTION AND DESCRIPTION OF THE WATERSHED

Northgate Dam is located in the Des Lacs sub-basin of the Souris River basin in northeastern Burke County, North Dakota, 12 miles northwest of Bowbells, ND (Figures 1 and 2). The reservoir was created for recreation in 1968 by the North Dakota Game and Fish. It has a surface area of 135.3 acres, an average depth of 10.2 feet and a maximum depth of 24.6 feet (Contour Map Appendix B). Table 1 summarizes some of the geographical, hydrological and physical characteristics of Northgate Dam. The Burke County Soil Conservation District Board has received much public comment on the importance of Northgate Dam as a recreation location, so there is a strong desire to maintain the fishery as well as keep the lake aesthetically pleasing for the people that use it.

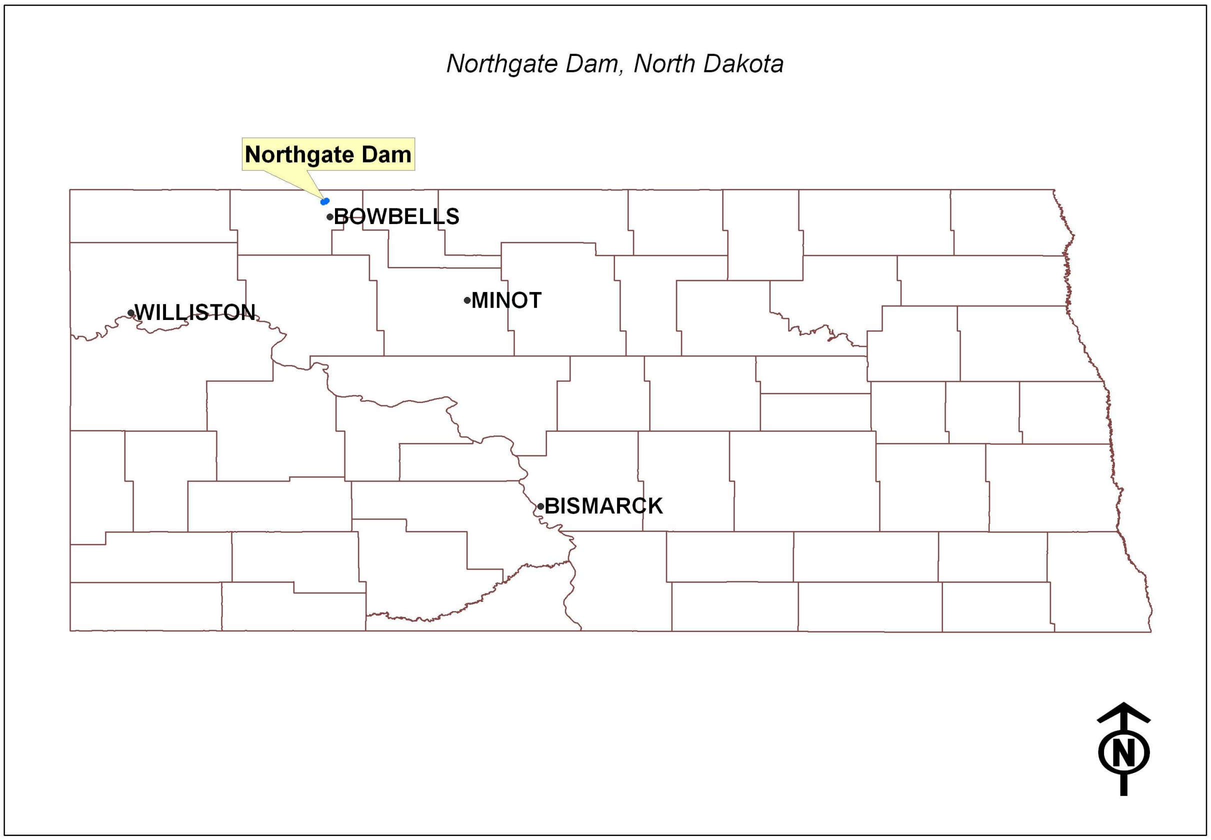


Figure 1. Location of Northgate Dam in North Dakota.

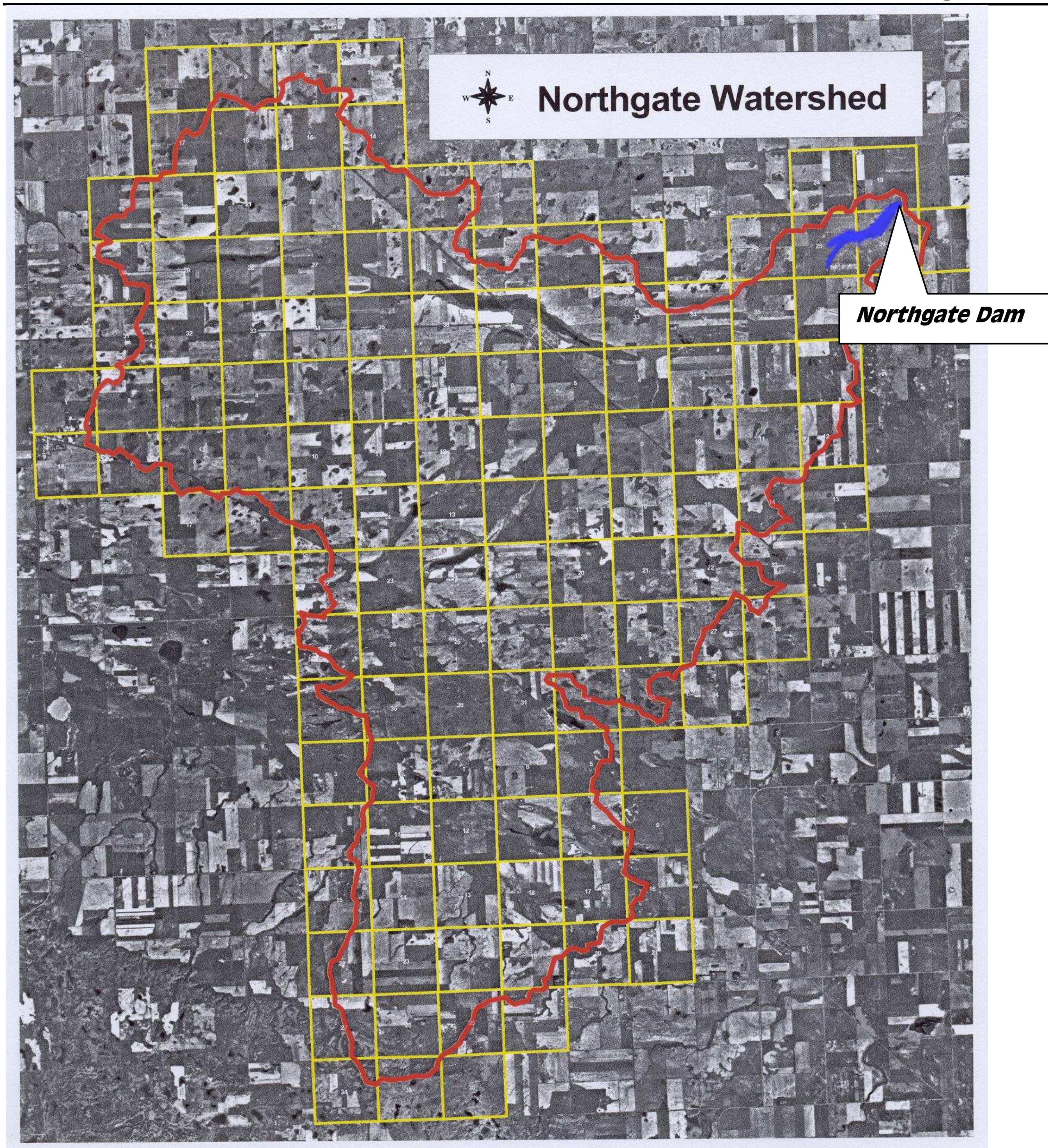


Figure 2. Location of Northgate Dam and Watershed.

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

Legal Name	Northgate Dam
Major Drainage Basin	Souris River
8-Digit HUC	09010002
Nearest Municipality	Bowbells, ND
County	Burke County, ND
Eco-region	Northern Dark Brown Prairie in the Northern Glaciated Plains
Latitude	48.92429
Longitude	-102.26945
Surface Area	135.3 acres
Watershed Area	66,392 acres
Average Depth	10.2 feet
Maximum Depth	24.6 Feet
Volume	1387.8 acre-feet
Tributaries	Un-named tributaries
Outlets	Stoney Run Creek to Souris River (in Saskatchewan, Canada)
Type of Waterbody	Constructed Reservoir
Fishery Type	Cool water – bluegill, largemouth bass, walleye
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

Based on the 2004 Section 303(d) List of Impaired Waters Needing TMDLs (NDDoH, 2004), the North Dakota Department of Health (NDDoH) has identified Northgate Dam as fully supporting, but threatened for aquatic life uses due to nutrients, sediment, and low dissolved oxygen levels, and fully supporting, but threatened for recreational uses due to nutrients. Table 2 details the TMDL listing information for Northgate Dam.

Table 2. 2004 Section 303(d) TMDL Listing Information for Northgate Dam.

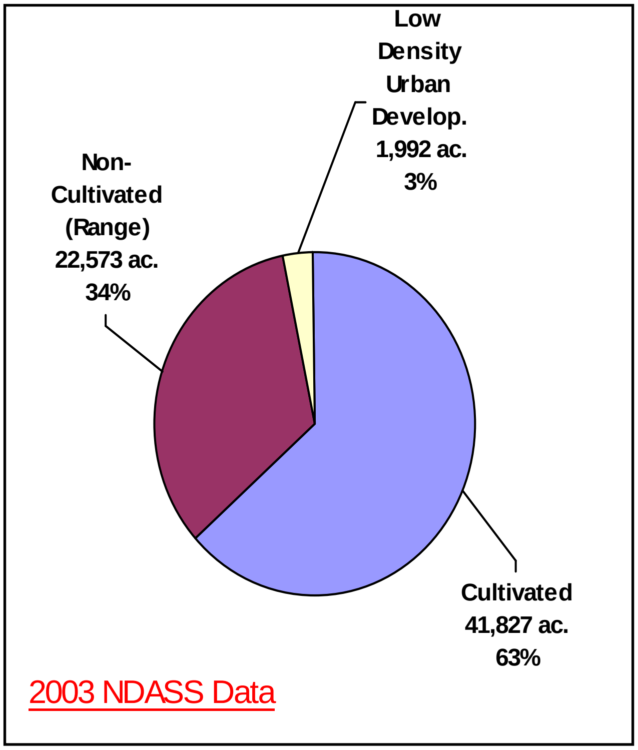
Assessment Unit ID	ND-09010002-002-L_00
Description	Northgate Dam
Size	135.3 acres
Impaired Designated Uses	Fish and Other Aquatic Biota; Recreation
Use Support	Fully Supporting but Threatened
Impairment	Nutrients, Sediment, and Dissolved Oxygen
Priority	1 (High)

1.2 Topography

Topography within this area of the Northern Glaciated Plains is generally flat with occasional "washboard" undulations. Local relief is typically less than 25 feet. It contains a high concentration of temporary and seasonal wetlands with a simple drainage pattern. Elevation ranges from 1980 to 2220 feet msl and the common soils include Williams, Bowbells, Zahl, and Noonan, with Hamerly and Parnell soils in low areas and depressions. 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)

1.3 Landuse/Land Cover in the Watershed

Information from the North Dakota Agricultural Statistics Service (NDASS, 2004) showed that in 2003 around 34 percent of the landuse was non-cultivated and 63 percent was cultivated, with around three percent low density urban development (Figures 3 and 4). Through the Northgate Watershed TMDL Assessment conducted in 2004, landuse was estimated at 15 percent non-cultivated, 82 percent cultivated, and three percent low density urban. The large difference between 2003 and 2004 in the amount of non-cultivated land can be attributed to different assessment types used for each year. The 2003 information was derived from satellite images, which are not always accurate in distinguishing between types of vegetation, especially if conservation practices such as minimum till or no till were used in the area. The 2004 survey, conducted in the fall of 2003, was an actual in-the-field survey, looking at each quarter section in the watershed area, conducted by a watershed technician working for the district, with the assistance of the NRCS. The 2004 data are assumed to be more representative and were the data used in the creation of the TMDL.



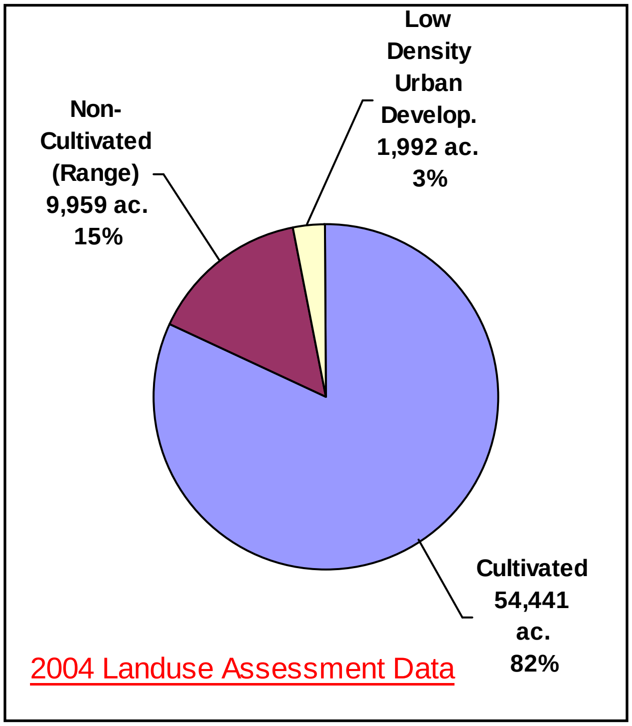


Figure 3. Landuse Data in Northgate Watershed, 2003 and 2004.

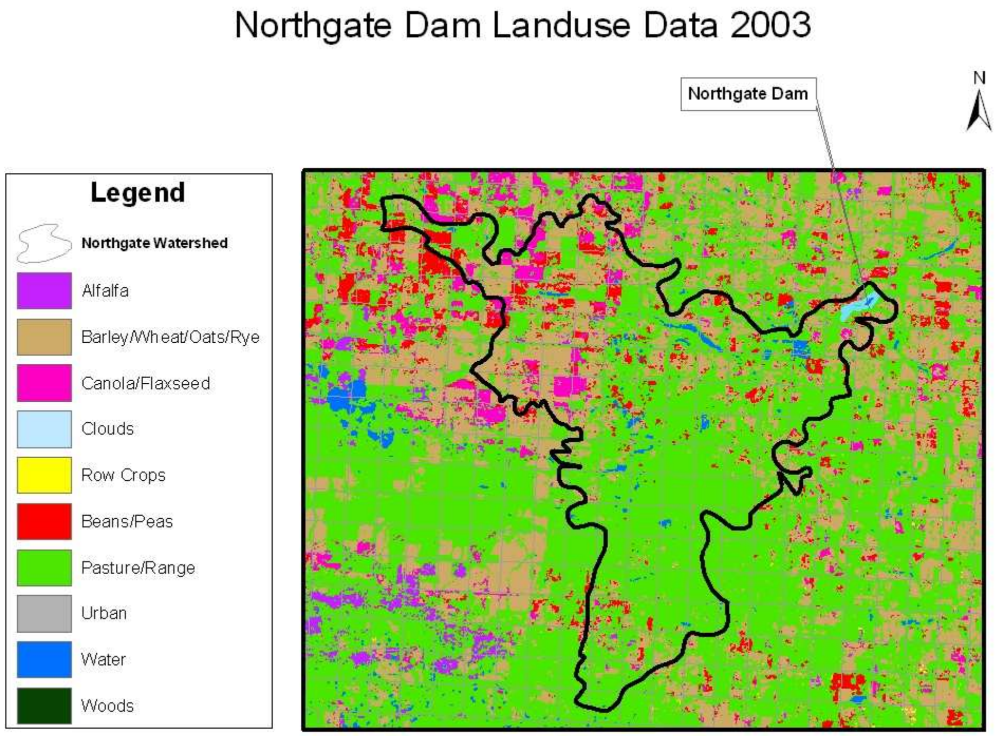


Figure 4. Northgate Watershed Landuse Data (NDASS, 2003).

1.3 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, 14 miles south of

Northgate Dam, is 38 degrees and average wind speed is 10.7 mph. Average annual precipitation ranges from 7 to 14 inches. November through February averages 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; over 50 percent of these events produce less than 0.10 inch (NDAWN, 2004).

1.5 Available Water Quality Data

1.5.1 Background on Nutrients, Dissolved Oxygen, and Sediment

Nutrients (nitrogen and phosphorus) are necessary for plant growth. Excessive amounts can cause abundant aquatic plant growth and algal blooms to occur. When plants die, their decay will accelerate the depletion of oxygen in the water (NDDoH, 1997). The breakdown of dead organic matter can also produced un-ionized ammonia, which can adversely affect aquatic life. Fish may suffer a reduction in hatching success, reductions in growth rate and morphological development, and injury to gill tissue, liver, and kidneys (USEPA, 1999a). The appearance and odors emitted by decaying plant matter also impair aesthetic uses of the waterbody.

Dissolved oxygen is oxygen in solution that has been mixed into the water by wave action on lakes, tumbling water in rivers, and photosynthesis by algae and rooted aquatic plants. Aquatic life needs oxygen to live. Fish, invertebrates, plants, and aerobic bacteria all require oxygen for respiration. The capacity of water to hold dissolved oxygen is dependant on the temperature and salinity of the water and atmospheric pressure (NDDoH, 1997).

Sediment, like nutrients, is a vital natural component of waterbodies. However, high concentrations of suspended sediment will absorb light. Waters then become warmer, which lessens the ability of water to hold oxygen necessary for aquatic life. Because aquatic plants also receive less light, photosynthesis decreases and less oxygen is produced. Excessive suspended sediment can also clog fish gills, reduce growth rates, decrease resistance to disease and prevent egg and larval development (NDDoH, 1997).

The Burke County Soil Conservation District (SCD) conducted a water quality assessment of Northgate Dam and its watershed from December 2002 through October 2003. Water quality samples were collected from the reservoir and two stream sites in the watershed using the methodology described in the *Quality Assurance Project Plan (QAPP) for the Northgate Dam TMDL Development Project* (NDDoH, 2002). These sites are identified in Table 3 and Figures 5 and 6. The data were analyzed and summarized by Mr. Peter Wax, Environmental Scientist, NDDoH and provided in this report.

Table 3. General Information for Water Sampling Sites for Northgate Dam.

Sampling Site	Site ID	Number of Samples Taken	Latitude (approx.)	Longitude (approx.)
In-lake	380845	51	48N 58’ 27”	-102W 16’ 10”
Upstream	385226	25	48N 53’ 55”	-102W 18’ 19”
Downstream	385227	25	48N 33’ 33”	-102W 15’ 50”

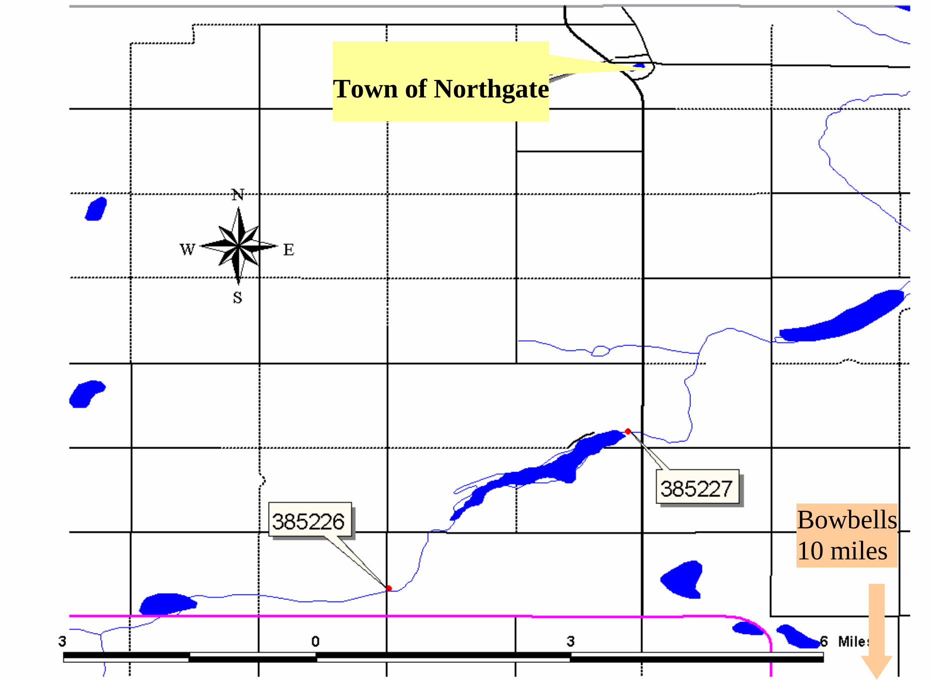


Figure 5. Northgate Dam Stream Sampling Locations.

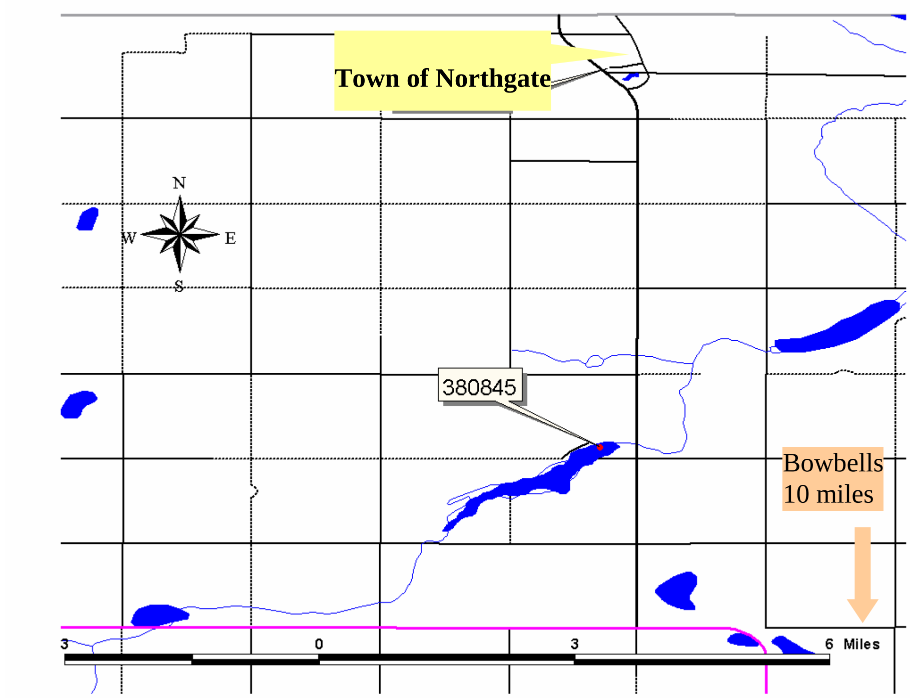


Figure 6. Northgate Dam Sampling Location.

1.5.2 Stream Data

The upstream site was located approximately one mile upstream of Northgate Dam at a location where three culverts pass under a gravel road just off of Highway 52. The downstream outlet site was located about 50 yards downstream of the dam face, on a lake access road. 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, and total suspended solids (Tables 4 and 5, and Figures). Most of the stream monitoring activities occurred between March and June, 2003. Flow in the stream stopped by July 8, 2003. 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 4. Summary of Stream Sampling Data, STORET # 385226 (Upstream Site).

Description	Total Nitrogen (mg/L)	TKN (mg/L)	Nitrate-Nitrite (mg/L)	Ammonia (mg/L)	Total Phosphorus (mg/L)	TSS (mg/L)
Minimum	1.36	1.34	0.02	0.01	0.104	5.0
Maximum	5.88	4.04	2.63	0.90	1.17	38.0
Median	2.04	1.97	0.02	0.04	0.22	5.0
Mean	2.447	2.188	0.261	0.144	0.356	7.8

Table 5. Summary of Stream Sampling Data, STORET # 385227 (Downstream Site).

Description	Total Nitrogen (mg/L)	TKN (mg/L)	Nitrate-Nitrite (mg/L)	Ammonia (mg/L)	Total Phosphorus (mg/L)	TSS (mg/L)
Minimum	1.40	1.20	0.20	0.01	0.154	5.0
Maximum	3.97	2.95	1.21	1.00	0.545	53.0
Median	1.76	1.58	0.20	0.98	0.347	12.0
Mean	2.04	1.75	0.29	0.20	0.353	16.0

1.5.3 Reservoir Data

The in-lake site is located in the deepest part of the reservoir at the north end near the dam. Lake monitoring occurred from December 17, 2002 through October 19, 2003, as outlined in the QAPP (NDDoH, 2002). Reservoir parameters included phytoplankton, chlorophyll a, pH, specific conductance, major cations and anions, total nitrogen, total Kjeldahl nitrogen, nitrate-nitrite, ammonia, phosphorus (total and dissolved), Secchi disk transparency, and temperature and dissolved oxygen profiles (Appendix B). The data collected characterized Northgate Dam as a hypereutrophic, nitrogen limited lake.

Northgate Dam was also compared to data from a study of similar North Dakota lakes (RLRSD, 2000). In general, when compared to other lakes in this region of the northwestern North Dakota glaciated plains, Northgate Dam had lower than average TKN and ammonia concentrations, similar nitrate/nitrite concentrations, and higher than average total phosphorus concentrations (Table 6).

Table 6. Regional Lake Water Quality compared to Northgate Dam Water Quality

Description	Total Phosphorus (mg/L)	Nitrate/ Nitrite (mg/L)	TKN (mg/L)	Ammonia (mg/L)	Chlorophyll-*a* (µg/L)	Secchi Disk Depth (meters)
Northgate Dam	0.489	0.044	1.70	0.100	20.17	1.42
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 Northgate Dam's TMDL Assessment (NDDoH, 2002.) was compared to data from this study. Northgate values are depth averaged except for nitrate/nitrite and chlorophyll-*a*.

2.0 WATER QUALITY STANDARDS

The Northgate Dam is a Class 2 lake with the following definition:

- *Cool water fishery. Waters capable of supporting growth and propagation of nonsalmonid fishes and marginal growth of salmonid 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 Northgate Dam 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 (North Dakota Century Code 33-16) establishes numeric standards for dissolved oxygen, total phosphorus, and nitrates (dissolved) (Table 7). 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 7. 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 7. Numeric Standards from *Standards of Quality for Waters of the State* (North Dakota Century code 33-16).

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 standard for nitrates (N) exceed 10 mg/L for waters used as municipal or domestic drinking water supply.

3.0 TMDL TARGETS

A TMDL target is the value that is 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 Northgate Dam based on its beneficial uses. If the specific target is met, it is assumed the reservoir will meet applicable water quality standards, including its designated beneficial uses.

3.1 Trophic State Index (Target for Nutrient and Dissloved Oxygen TMDLs)

The assessment methodology for lakes and reservoirs described in North Dakota's 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 (NDDoH, 1998; NDDoH, 2000; NDDoH, 2004). Trophic status is the measure of productivity of a lake or reservoir, and is directly related to the level of nutrients (phosphorus and nitrogen) entering the lake or reservoir from its watershed, 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).

The various TSI values were calculated for Northgate Dam using the data obtained from the assessment study. Table 8 shows that Northgate Dam is classified as a hypereutrophic lake.

Table 8. Carlson's Trophic State Indexes for Northgate Dam

Parameter	Relationship	Units	TSI Value[1]
Chlorophyll-*a*	TSI (Chl-a) = 30.6 + 9.81[ln(Chl-a)]	µg/L	60
Total Phosphorus (TP)	TSI (TP) = 4.15 + 14.42[ln(TP)]	µg/L	93
Secchi Depth (SD)	TSI (SD) = 60 - 14.41[ln(SD)]	meters	55

[1]TSI values were calculated using average surface values from the Northgate Dam in-lake monitoring station (see Table 6).
TSI < 40 = Oligotrophic (least productive)
TSI 40-50 = Mesotrophic
TSI 50-60 = Eutrophic
TSI > 60 = Hypereutrophic (most productive)

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 9 below (updated from Carlson 1983).

Table 9. 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.

It is possible that therefore, that the chlorophyll and transparency indices may be close together, but both will fall below the phosphorus curve. This suggests that the algae are nitrogen-limited. Intense zooplankton grazing, for example, may cause the chlorophyll and Secchi depth indices to fall below the phosphorus index as the zooplankton remove algal cells from the water or Secchi depth may fall below chlorophyll if the grazers selectively eliminate the smaller cells (Carlson 1996). This statement supports the data analysis and modeling that was done to indicate that Northgate Dam is a shallow nitrogen limited waterbody (Appendix B). Based on the above information and in order to easily and effectively measure the effects of reduction in external phosphorus loading, which directly equates to algal biomass, a TSI score of 55 for chlorophyll-a was chosen as a target.

Studies have also shown that in shallow lakes, the percent reduction in total phosphorus was not as great as the reduction in loading. (Cooke, et. al., 1986). This causes most total phosphorus TSI scores to be elevated above the other two TSI scores, therefore estimating a slightly higher trophic state for the lake than may actually be observed. Also the improvement in Secchi disk depth of the water is not linearly related with a reduction in total phosphorus concentrations (Carlson, 1977). 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).

Through analysis of assessment data, Northgate Dam 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. According to BATHTUB modeling results (see Appendix C), the average annual total phosphorus concentrations in the lake would decrease from 0.489 mg/L to 0.248 mg/L with a 50 percent reduction in external phosphorus loading. This would correspond to a chlorophyll-a TSI score of 55 (Table 10). It is likely that the average lake user will see a noticeable change in the lake as a result of this improvement in trophic state, and the decrease in phosphorus loading, and subsequent decrease in algal biomass, will also increase water clarity and improve dissolved oxygen levels. If this target is met, narrative standards will also be met (NDDoH, 2001) and the beneficial uses of aquatic life and recreation will be fully supported.

Table 10. Observed and Predicted TSI Scores Assuming a 50 Percent Reduction in External Phosphorus Loading.

Variable	TSI Score Observed	TSI Score Modeled with a 50% Reduction in External P Loading
Carlson's TSI for Phosphorus	93	84
Carlson's TSI for Chlorophyll-a	60	55
Carlson's TSI for Secchi Disk	55	49

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

While the target TSI score resulting from the 50 percent 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), 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 (135.3 acres), the likely amount of phosphorus in the bottom sediments available for internal cycling, the nearly constant wind in northwestern North Dakota causing a mixing effect, and few cost effective ways to reduce in-lake nutrient cycling, this was determined to be the best possible outcome for Northgate Dam, and allow it to meet the narrative standards relating to recreation and aquatic life beneficial uses.

3.2 Sediment Target

Due to the reasons explained in Section 5.3 of the data analysis section, it is the recommendation of the State to de-list Northgate Dam for sediment impairment. Therefore, no sediment target is set.

4.0 SIGNIFICANT SOURCES

4.1 Point Sources

The city of Flaxton's wastewater lagoons are the only point source discharge in the watershed. Flaxton is a community of about 140 people. Observation of the site shows it to be in good condition with no apparent leaks. There have been no reported discharges in over 15 years.

4.2 Nonpoint Sources

Non-point source pollution accounts for almost 100 percent of the nutrient and sediment loading to Northgate Dam. According to the 2004 assessment (the landuse portion of which was conducted in the fall of 2003), approximately 82 percent of the land upstream of the reservoir is farmed with an additional 15 percent used for pasture or with permanent cover. The remaining three percent is farmsteads or small towns. There are four small non-permitted concentrated feeding areas within the contributing drainage area. Currently there are few developed areas in the watershed.

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

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

The tributary data were analyzed and reduced by the FLUX program. FLUX uses tributary inflow and outflow water quality and flow data to estimate average mass discharge or loading that passes a river or stream site suing six calculation techniques. Load is therefore defined as the mass of pollutant during a given unit of time. In the case of Northgate Dam, the FLUX program came up with an annual phosphorus load of 1,897.70 kg/yr. The FLUX model then allows the user to pick the most appropriate load calculation technique with the smallest statistical error. Output for the FLUX program is then used to calibrate the BATHTUB model.

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

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

After calibration, the observed average annual concentration of total nitrogen and total phosphorus compared well with those of the BATHTUB model. The model's predictions and observed data are summarized in Table 9.

Table 9. Observed and Predicted Values for Selected Trophic Response Variables for the Calibrated BATHTUB Model.

	Value	
Variable	**Observed**	**Predicted**
Total Phosphorus as P (mg/L)	0.489[1]	0.489
Total Nitrogen as N (mg/L)	1.735[1]	1.736
Organic Nitrogen as N (mg/L)	1.593[1]	1.592
Chlorophyll-a (*u*g/L)	20.17[1]	20.31
Secchi Disk Transparency (m)	1.40[2]	1.41
Carlson's TSI for Phosphorus	93.44	93.45
Carlson's TSI for Chlorophyll-a	60.07	60.14
Carlson's TSI for Secchi Disk	55.15	55.00

1-Annual volume weighted averages
2-Average

As stated above, BATHTUB can compare predicted vs. actual conditions. After calibration, the model was run based on observed concentrations of phosphorus and nitrogen, to derive and estimated annual average total phosphorus load of 1,897.70 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.

For Northgate Dam, only external nutrient loads were addressed. Internal loadings are variable from year to year and are not controllable without taking special and often expensive measures (e.g. dredging, addition of chemical flocculants, etc.) External nutrient loads were addressed because they are known to cause eutrophication and because they are controllable through the implementation of watershed Best Management Practices (BMPs).

Predicted trophic response changes were evaluated by reducing externally derived phosphorus loads by 25, 50, and 75 percent. These reductions were simulated in the model by reducing the phosphorus concentrations in the contributing tributary and other external delivery sources by 25, 50, and 75

percent. Since there is no reliable means of estimating how much hydraulic discharge would be reduced through the implementation of BMPs, flow was held constant.
The model results indicate that if it were possible to reduce external phosphorus loading to Northgate Dam by 50 percent, the average annual total phosphorus and chlorophyll-a concentrations in the lake would decrease and Secchi disk transparency depth would increase significantly. Observed and predicted values are shown for comparison in Table 10.

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

Variable	Observed	Predicted		
		25% Reduction	50% Reduction	75% Reduction
Total Phosphorus as P (mg/L)[1]	0.489	0.369	0.248	0.128
Total Nitrogen as N (mg/L)[1]	1.735	1.463	1.149	0.767
Organic Nitrogen as N (mg/L)[1]	1.593	1.359	1.106	0.814
Chlorophyll-a (*u*g/L)[1]	20.17	16.17	11.89	6.85
Secchi Disk Transparency (m)[2]	1.42	1.70	2.16	3.17
Carlson's TSI for Phosphorus	93.44	89.37	83.66	74.06
Carlson's TSI for Chlorophyll-a	60.07	57.96	54.89	49.48
Carlson's TSI for Secchi Disk	55.15	52.38	48.87	43.37

1-Annual volume weighted average
2-Average

5.3 AGNPS Watershed Model

In order to identify significant NPS pollutant sources in the Northgate Dam watershed and to assess the relative reductions in nutrient (nitrogen and phosphorus) loading that can be expected from the implementation of BMPs in the watershed, the Agricultural Nonpoint Source Model (AGNPS) 3.65 developed by the United States Department of Agriculture, Agricultural Research Service, was employed.

The primary objectives for using the AGNPS model were to 1) evaluate NPS contributions within the watershed; 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 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 were 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 model was used in conjunction with an intensive landuse survey to determine critical areas within the Northgate Dam watershed. Criteria used during the landuse assessment were percent cover on cropland and pasture/range condition. These criteria were used to determine the C factor for each cell. The initial model was run using current conditions determined during the landuse assessment. A 25yr/24hr storm event (4.10 inches) in Burke County was applied to the model to evaluate relative pollutant yields from each 160-acre cell. Each quarter of land was given a cell number and each cell represents 160 acres of land. A total of 450 cells were input into the program, representing 72,000 acres. Since this model cannot follow curved lines, but only square cell blocks, this watershed area used in this model is slightly larger than the actual watershed area listed in Table 1.

To identify critical cells for nutrient (phosphorus) loading, knowing that there had to be a 50 percent reduction in phosphorus load in order to affect the needed change, the final output cell of the watershed was identified. Then beginning with cells that had greater than 5 lbs of sediment phosphorus, BMPs were applied through manipulation of the AGNPS model to those cells. The phosphorus loading in the final cell was noted and since it did not meet the 50 percent load reduction, the AGNPS model was re-run with BMP manipulations to cells that had greater than 4 lbs of sediment phosphorus. The final output cell was then again reviewed and this process continued with 3.5 lbs, 3.0 lbs, etc until 1.5 lbs sediment phosphorus cells, manipulated with BMPs, reached the targeted reduction. BMPs applied to cells with greater than 1.5 lbs sediment phosphorus achieved a slightly greater than 50 percent reduction in phosphorus loading. The BMPs used were no till, nutrient management, prescribed grazing, native grass seeding, and pasture/hayland forage plantings. Cells that had greater than 1.5 lbs sediment phosphorus were identified as critical cells (Figure 7). These 80 cells represent only 18 % of the watershed. Once nutrient loadings are decreased, algal biomass will decline, dissolved oxygen will increase, and the overall trophic status of the reservoir will improve.

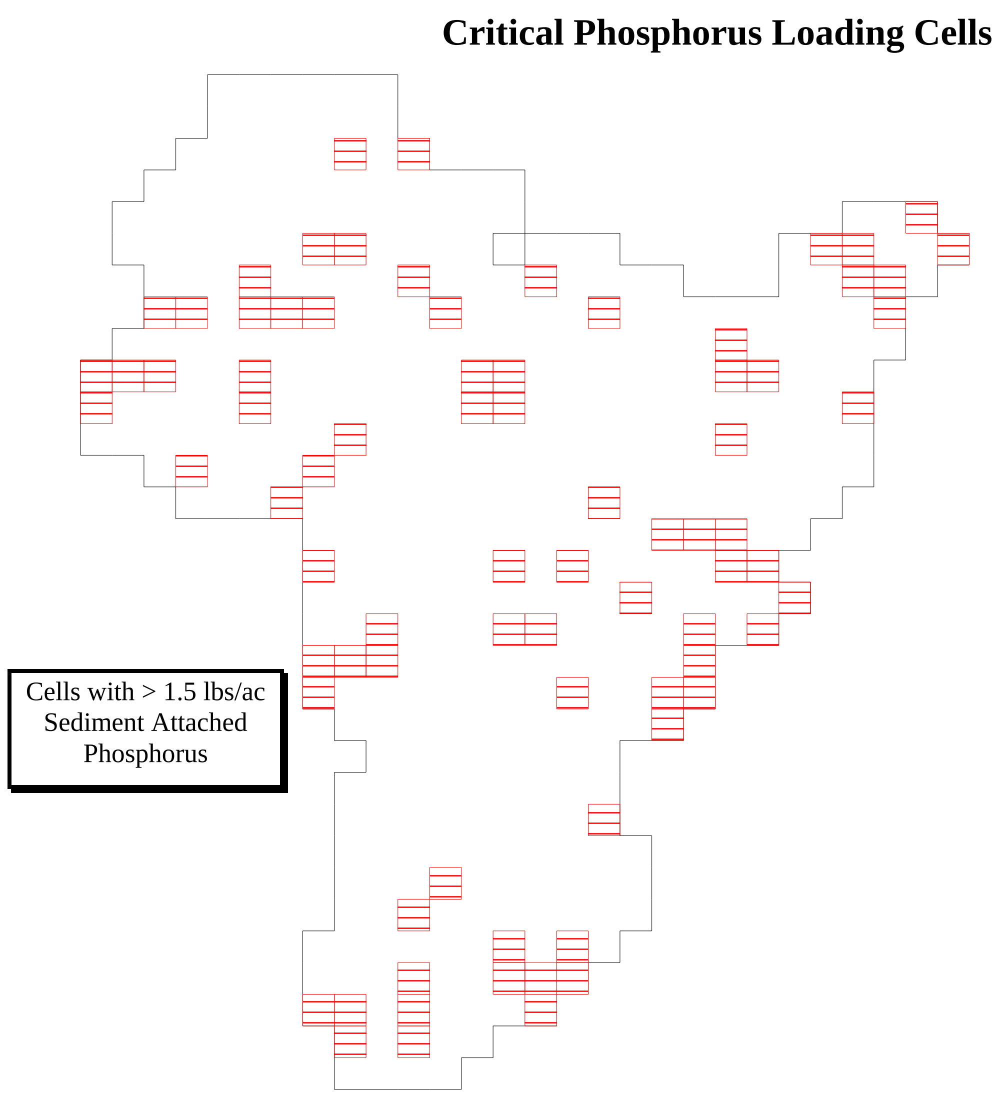


Figure 7. AGNPS Identified High Phosphorus Loading Areas.

5.4 Dissolved Oxygen

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

Carpenter et al. (1998), has shown that nonpoint sources of phosphorous has lead to eutrophic conditions for many lake/reservoirs across the U.S. One consequence of eutrophication is oxygen depletions caused by decomposition of algae and aquatic plants. They also document that a reduction in nutrients will eventually lead to the reversal of eutrophication and attainment of designated beneficial uses. However, the rates of recovery are variable among lakes/reservoirs. This supports the 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 DO 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 = 135.3 acres; 0.548 km^2), mean depth (z = 10.2 feet; 3.11 meters), and the ratio of mean depth to the surface area ($z/A_o^{0.5}$ = 4.2) for Northgate Dam which show that these parameters are within the range of lakes used by Nürnberg. Based on this information, NDDoH is confident that Nürnberg's empirical nutrient-oxygen relationship holds true for North Dakota lakes and reservoirs. NDDoH is also confident that prescribed BMPs will reduce external loading of nutrients to Northgate Dam which will reduce algae blooms and therefore increase oxygen levels over time.

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

It is expected that the substantial reductions in nutrient concentrations will result in increased dissolved oxygen levels by decreasing algal biomass in the water column. Since there is inadequate information at present to establish a quantitative relationship between the nutrient target and dissolved oxygen, it is the Department's best professional judgment that the prescribed reduction in phosphorus loading in Northgate Dam will address the dissolved oxygen impairment.

5.5 Sediment

A sediment balance was calculated for Northgate Dam (Table 11). The time period over which this amount of storage occurred was 0.244 years, therefore sediment accumulated within the reservoir at a rate of 43,253.07 kg/yr.

Table 11. Sediment Balance for Northgate Dam (2003).

Parameter	Inflow (kg)	Outflow (kg)	Storage (kg)
Total Suspended Solids	30,017.95	19,464.2	10,553.75

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

In order to perform the conversion from mass to depth, the particle density of soil is needed. In most mineral soils the average density of particles is in the range of 2.6 to 2.7 g/cm^3. This narrow range reflects the predominance of quartz and clay minerals in the soil matrix. Since soils in the Northgate Dam watershed are mineral soils, the particle density of silicate minerals can be used to calculate a depth of sediment accumulation within the reservoir. However, for the sake of providing an implicit margin of safety, the low end of the range (2.6 g/cm^3) will be used to calculate the equivalent depth of 43,253.07 kg of sediment in Northgate Dam.

Based on a sediment loading rage of 43,253, 070 g/yr times a sediment density of 2.60 g/cm^3, the sediment volume deposited in Northgate Dam is 16,635,796 cm^3 each year.

$$43{,}253{,}070 \text{ g/yr} * (2.60 \text{ g/cm}^3)^{-1} = 16{,}635{,}796 \text{ cm}^3\text{/yr}$$

Based on a surface area of 135.3 acres (5,475,396,739.51 cm^2), the annual sedimentation rate is 0.003038 cm per year [(16,635,796 cm^3/yr)/ (5,475,396,739.51 cm^2)]. This estimated annual sediment accumulation rate is well below the average sedimentation rate of typical reservoirs.

Further support for the removal of sediment as a pollutant of concern can also be found in literature. As Waters (1995) states, suspended sediment concentration less than 25 mg L^{-1} is not harmful to fisheries; between 25 and 80 mg L^{-1} reduces fish yield; between 80 and 400 mg L^{-1} is unlikely to display a good fishery; and suspended sediment concentration greater than 400 mg L^{-1} will exhibit a poor fishery. Therefore, research by Waters (1995) supports the view that the mean TSS concentration in Northgate Dam of 7.8 mg L^{-1} is not considered harmful to fisheries. While five samples out of twenty-four exceeded the 25 mg L^{-1} concentration stated by Waters (1995) as reducing fish yield, no samples exceeded the 80 mg L^{-1} deemed unlikely to display a good fishery Therefore, it is the recommendation of the TMDL that, in the next North Dakota 303(d) list cycle, Northgate Dam should be de-listed for sediment impairments.

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

Assuming Watershed Area = 66,392 acres = 103.74 mi^2 = 2.892035 x 10^9 ft^2
and,
NRCS Sedimentation Rate equals 1/8 inch = 0.125 inch = 0.01041667 ft over 50 years
then,
NRCS Sediment Standard Volume =

$$2.892035 \times 10^{9} \text{ ft}^2 * 0.01041667 \text{ ft} = 30{,}125{,}380 \text{ ft}^3$$

$$\text{where : } 30{,}125{,}380 \text{ ft}^3 = \mathbf{8.53055767591361 \times 10^{11} \text{ cm}^3}$$

Compare this to the calculated annual sedimentation rate from observed data entering Northgate Dam over 50 years:
Calculated Sediment Volume from data = 16,635,796 cm^3/yr * 50 yr = **8.317898 x 10^8 cm^3.**

Using the NRCS Sedimentation Rate Standard of 1/8 inch over 50 years, Northgate Dam's predicted sediment accumulation rate would be 8.53055767591361 x 10^{11} cm^3. When compared to the current sedimentation rate over 50 years using assessment data, 8.317898 x 10^8 cm^3, Northgate Dam appears to be well under the predicted sedimentation rate standard.

6.0 MARGIN OF SAFETY AND SEASONALITY

6.1 Margin of Safety

Section 303(d) of the Clean Water Act and EPA's regulations require that "TMDLs 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 1897.70 kg/yr, a 50 percent reduction is equivalent to 948.85 kg/yr and will be achieved through the implementation of best management practices affecting agricultural land in the watershed. An additional 10 percent load reduction, or 94.89 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.

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 Northgate Dam 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 Northgate Dam in terms of loading capacity, wasteload allocations, load allocations, and a margin of safety. The TMDL can be generically described by the following equation:

TMDL = LC = WLA + LA + MOS where:

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

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

LA load allocation, or the portion of the TMDL allocated to existing or future 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 analytical assumptions or explicitly by reserving a portion of loading capacity.

7.1 Nutrient TMDL

Table 12 summarizes the nutrient TMDL for Northgate Dam in terms of loading capacity, wasteload allocations, load allocations, and a margin of safety.

Table 12. Summary of the Nutrient TMDL for Northgate Dam.

Category	Total Phosphorus (kg/yr)	Explanation
Existing Load	1897.70	From observed data
Loading Capacity	948.85	50% reduction based on BATHTUB model simulations
Wasteload Allocation	0	No point sources
Load Allocation	853.96	Entire loading capacity minus MOS is allocated to nonpoint sources
MOS	94.89	Explicit ten percent (10%) MOS.

Based on data collected in 2002 and 2003, the existing load to Northgate Dam is estimated at 1,897.7 kg/yr. Assuming a 50 percent reduction based on BATHTUB and AgNPS modeling results reaching a total phosphorus concentration of 0.248 mg/L, then the TMDL or loading capacity is 948.85 kg/yr. Assuming 10 percent (94.89 kg/yr) is assigned to the MOS and there are no point sources in the watershed, all of the remaining loading capacity (53.96 kg/yr) is assigned to the load allocation.

7.2 Dissolved Oxygen TMDL

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

The cycling of nutrients in aquatic ecosystems is largely determined by oxidation-reduction (redox) potential and the distribution of dissolved oxygen and oxygen-demanding particles (Dodds, 2002). Dissolved oxygen gas has a strong affinity for electrons, and thus influences biogeochemical cycling and the biological availability of nutrients to primary producers such as algae. High levels of nutrients can lead to eutrophication, which is defined as the undesirable growth of algae and other aquatic plants. In turn, eutrophication can lead to increased biological oxygen demand and oxygen depletion due to the respiration of microbes that decompose the dead algae and other organic material.

As a result of this direct influence it is anticipated that meeting the phosphorus load reduction target in

Northgate Dam will address the dissolved oxygen impairment. A reduction in total phosphorus load to Northgate Dam would be expected to lower algal biomass levels in the water column thereby reducing the biological oxygen demand exerted by the decomposition of these primary producers. The reduction in biological oxygen demand is therefore assumed to result in attainment of the dissolved oxygen standard.

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.

Table 13. Summary of the Dissolved Oxygen TMDL for Northgate Dam, Using Phosphorus as a Surrogate.

Category	Total Phosphorus (kg/yr)	Explanation
Existing Load	1897.7	From observed data
Loading Capacity	948.85	50% reduction based on BATHTUB model simulations
Wasteload Allocation	0	No point sources
Load Allocation	853.96	Entire loading capacity minus MOS is allocated to nonpoint sources
MOS	94.89	Explicit ten percent (10%) MOS.

7.3 De-List for Sediment TMDL

No reduction necessary. De-list for sediment.

8.0 ALLOCATION

Northgate Dam's watershed is small and supports extensive agriculture where cropland constitutes a majority of the landuse. Sub-dividing it into smaller units, based on hydrology or type of conservation practice implemented, would not be practical. This TMDL will be implemented by several parties on a volunteer basis. Phosphorus loads into the reservoir will be reduced by 50 percent by treating the AgNPS identified critical cells (Figure 7). There are 80 cells within the Northgate Dam watershed identified as "critical" by AgNPS modeling. These cells represent a total area of 12,800 acres or 18 percent of the watershed. If 18 percent or more of the critical areas in the watershed can be treated with BMPs (no till, nutrient management, grazing systems, native/tame grass seeding on steep slopes, etc.), then the specified reduction is possible. Also, by effectively using the hypolimnetic draw-down according to the recommendations from the NDDoH and the North Dakota Game and Fish, there will be an additional phosphorus load decrease and possible additional improvement in winter dissolved oxygen levels.

9.0 PUBLIC PARTICIPATION

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

Burke County Soil Conservation District (chairman)
Burke County Water Resource Board
Natural Resources Conservation Service (Burke County Field Offices)

North Dakota Game and Fish Department (Save Our Lakes Program)
U.S. Fish and Wildlife Service
U.S. Environmental Protection Agency, Region 8

In addition to the mailed copies, the TMDL for Northgate Dam has 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 published in the local Bowbells, ND and Stanley, ND newspapers, the Bismarck Tribune, and the Minot Daily Herald.

The 30 day public notice was held from March 14 to April 14, 2006 and comments were received from the following agencies: North Dakota Game and Fish and U.S. Environmental Protection Agency, Region 8. Public comments received and the North Dakota Department of Health's response those comments received are provided in Appendix D.

10.0 MONITORING

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

Specifically, monitoring will be conducted for all variables that are currently causing impairments to the beneficial uses of the waterbody. These include, but are not limited to nutrients (i.e. nitrogen and phosphorus) and dissolved oxygen. Once a watershed restoration plan (e.g. Section 319 Nonpoint Source Project Implementation Plan [PIP]) is implemented, monitoring will be conducted in the lake/reservoir beginning two years after implementation and extending five years after the implementation project is complete

11.0 TMDL IMPLEMENTATION STRATEGY

Implementation of TMDLs is dependent upon the availability of Section 319 NPS funds or other watershed restoration programs (e.g. USDA EQIP), as well as securing a local project sponsor and 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 PIP is voluntary. Therefore, success of any TMDL implementation project is ultimately dependant on the ability of the local project sponsor to find cooperating producers.

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

12.0 ENDANGERED SPECIES ACT COMPLIANCE

States are encouraged to participate with the U.S. Fish and Wildlife Service and EPA in the Endangered Species Act consultation process to document, adversely or beneficially, the potential effects the TMDL may have on threatened or endangered species. In an effort to assist with this process, a request for a list of endangered and/or threatened species was made to the US Fish and Wildlife Service (Figure 8.) A hard copy of the draft TMDL report was sent to the U.S. Fish and Wildlife Service's Endangered Species Office in Bismarck, ND for review. The following is a list of threatened or endangered species specific to the Northgate Dam watershed and Burke County.

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

OFFICE TRANSMITTAL

To: Heather Duchscherer
ND Department of Health
Towner, ND

☐ Action
■ Information

From: Kevin Johnson Division: Ecological Services Date: 6-21-05

Attached is the information you requested in you April 12, 2005, letter on TMDL for several watersheds in northwestern North Dakota.

If you need any other information, please let us know.

Figure 8. Notification Received from the U.S. Fish and Wildlife Service

The following items were enclosed with the above memo:

FEDERAL THREATENED, ENDANGERED, AND CANDIDATE SPECIES
AND DESIGNATED CRITICAL HABITAT FOUND IN
BURKE COUNTY, NORTH DAKOTA
June 2005

ENDANGERED SPECIES

Birds

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

Mammals

Gray wolf (Canis lupus): Occasional visitor in North Dakota. Most frequently observed in the Turtle Mountains area.

THREATENED SPECIES

Birds

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

Piping plover (Charadrius melodus): Nests on midstream sandbars of the Missouri and Yellowstone Rivers and along shorelines of saline wetlands. More nest in North Dakota than any other state.

CANDIDATE SPECIES

Invertebrates

Dakota skipper (Hesperia dacotae): Found in native prairie containing a high diversity of wildflowers and grasses. Habitat includes two prairie types: 1) low (wet) prairie dominated by bluestem grasses, wood lily, harebell, and smooth camas; 2) upland (dry) prairie on ridges and hillsides dominated by bluestem grasses, needlegrass, pale purple and upright coneflowers and blanketflower.

DESIGNATED CRITICAL HABITAT

Birds

Piping Plover - Alkali Lakes and Wetlands - Critical habitat includes: (1) shallow, seasonally to permanently flooded, mixosaline to hypersaline wetlands with sandy to gravelly, sparsely vegetated beaches, salt-encrusted mud flats, and/or gravelly salt flats; (2) springs and fens along edges of alkali lakes and wetlands; and (3) adjacent uplands 200 feet (61 meters) above the high water mark of the alkali lake or wetland.

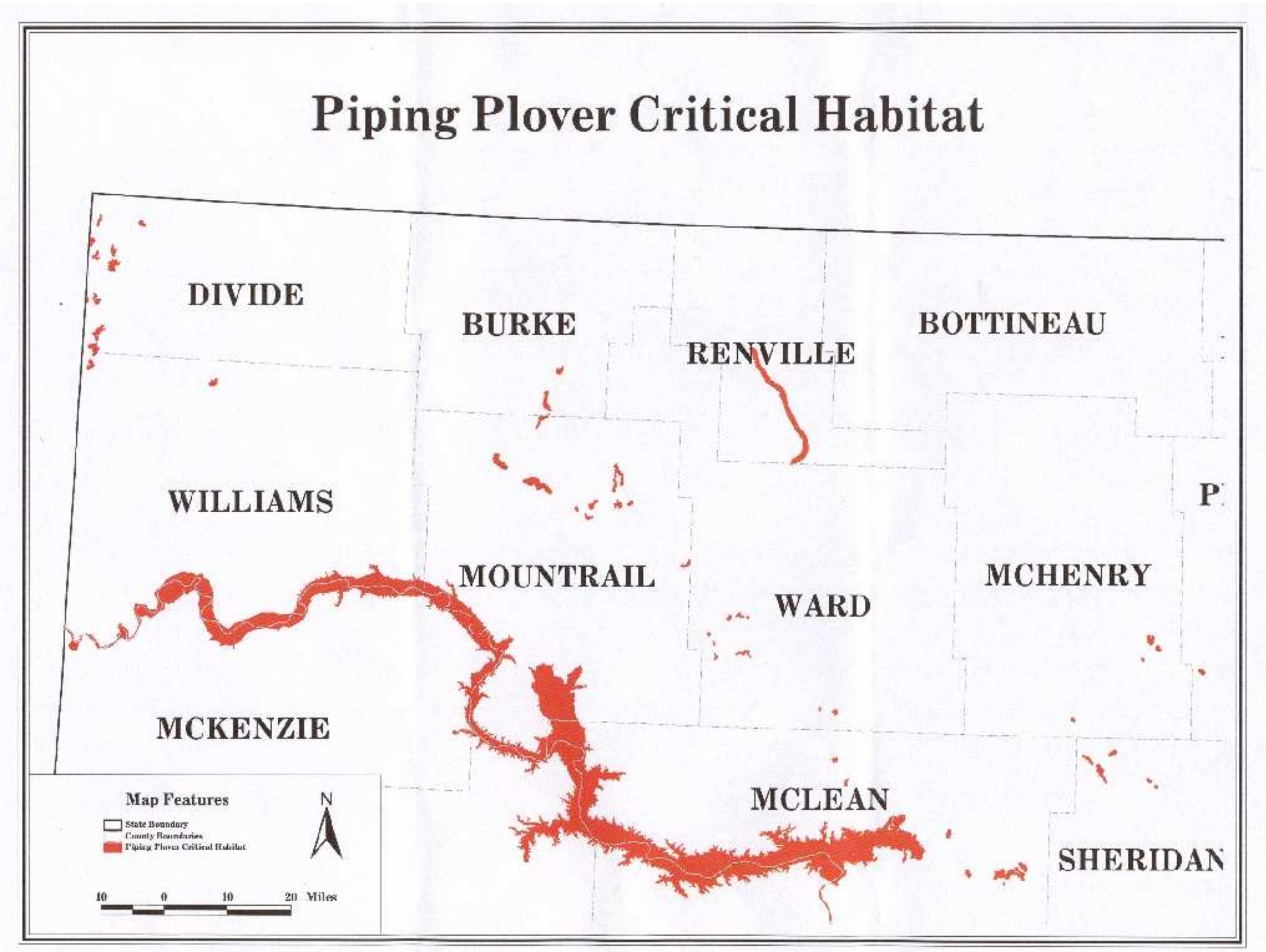


Figure 9. Map of Piping Plover Critical Habitat.

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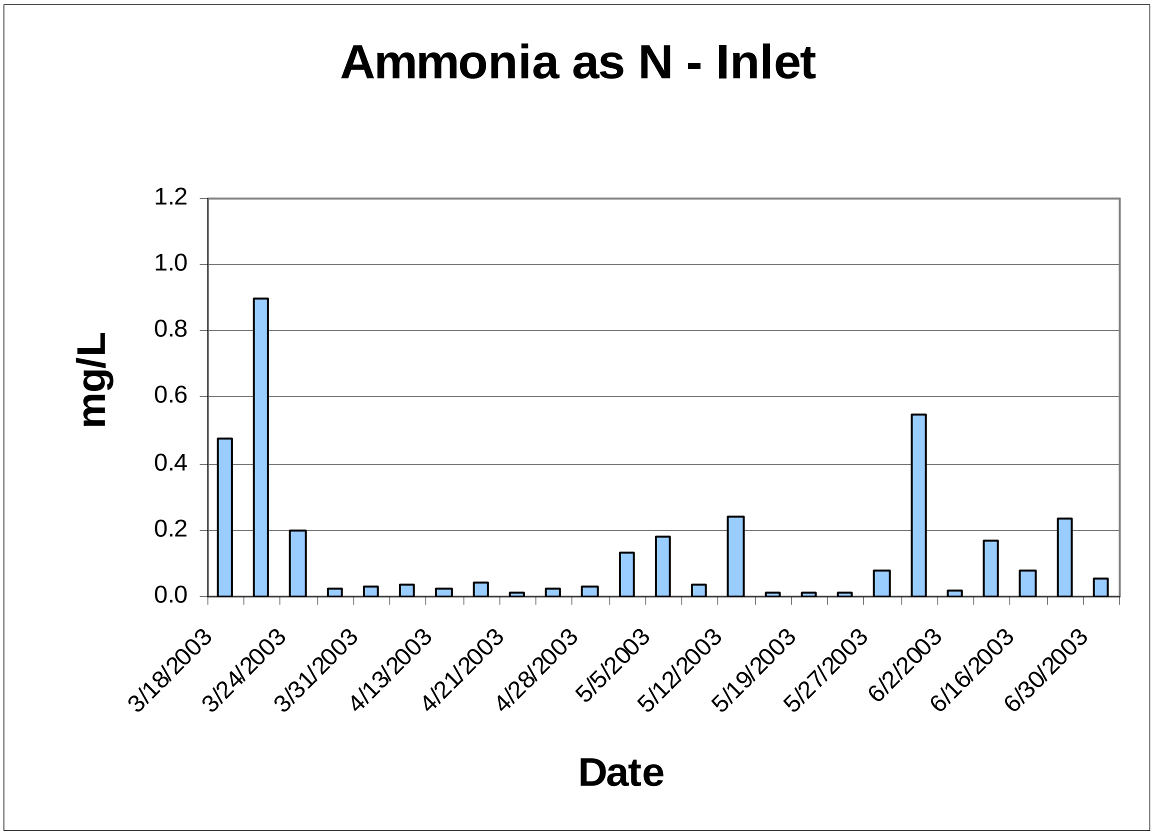
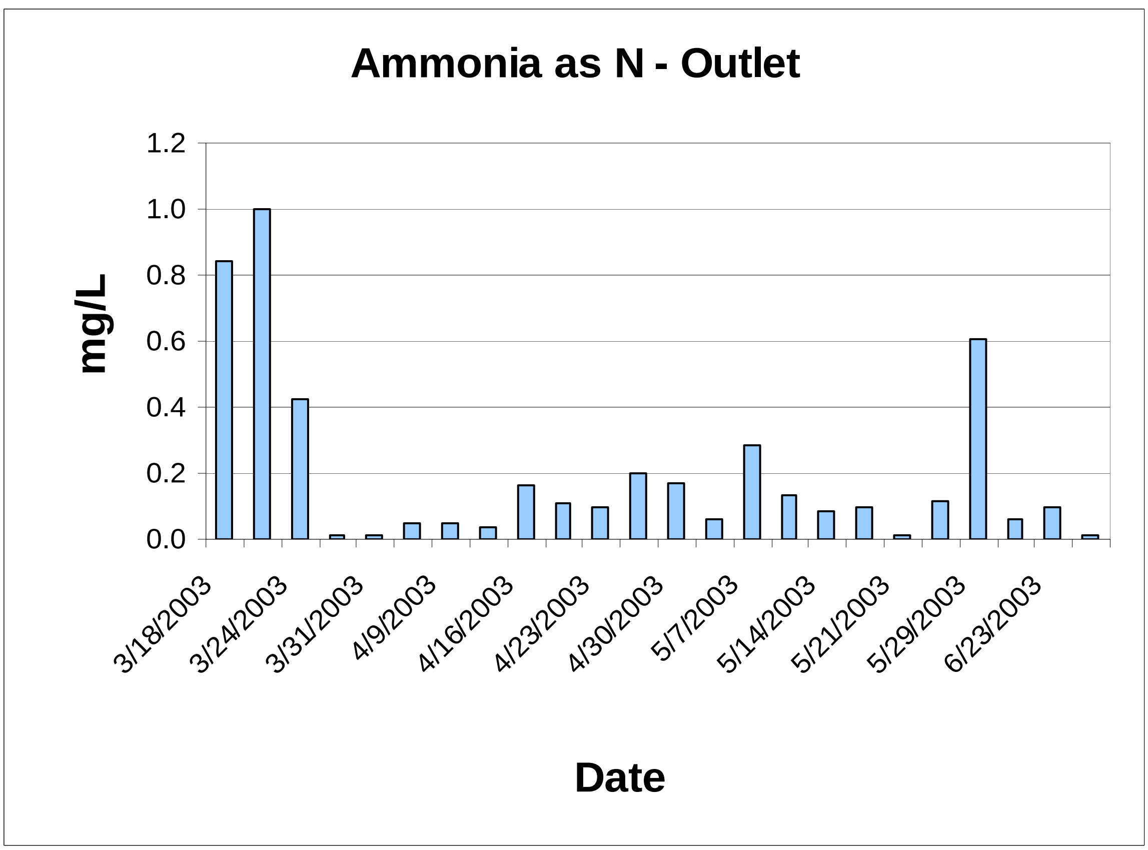
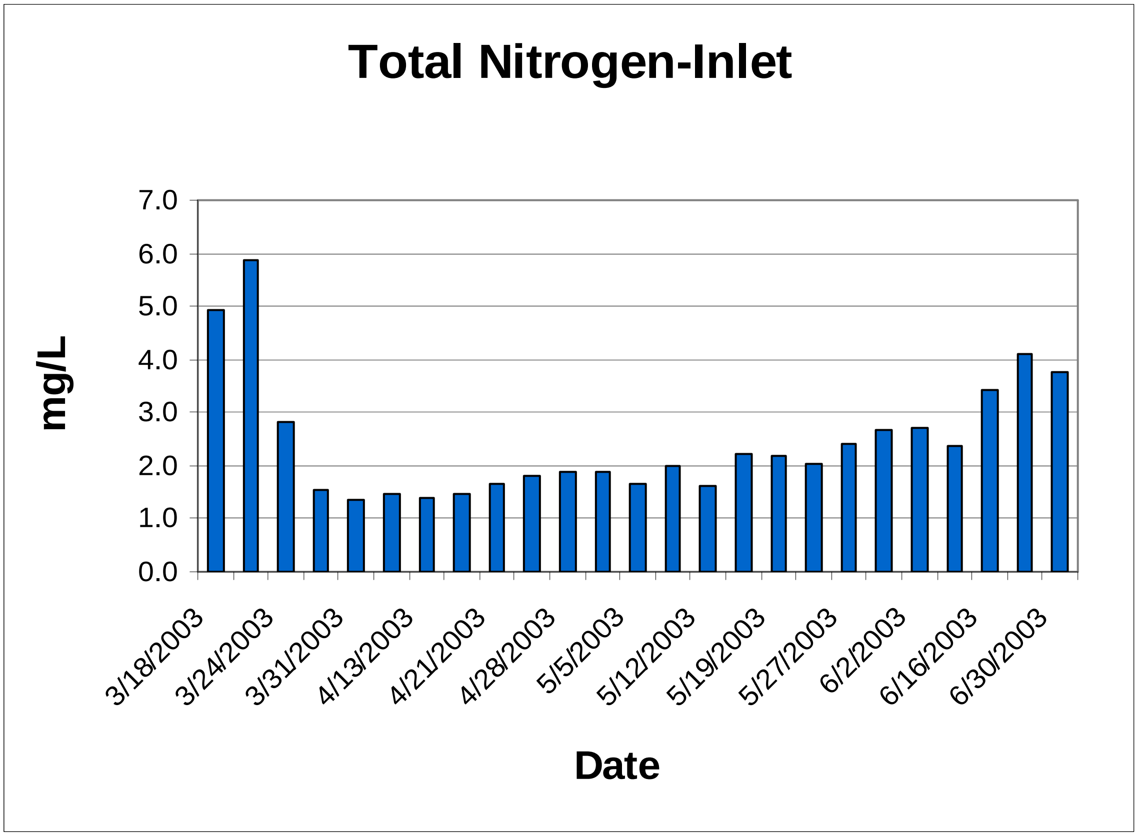
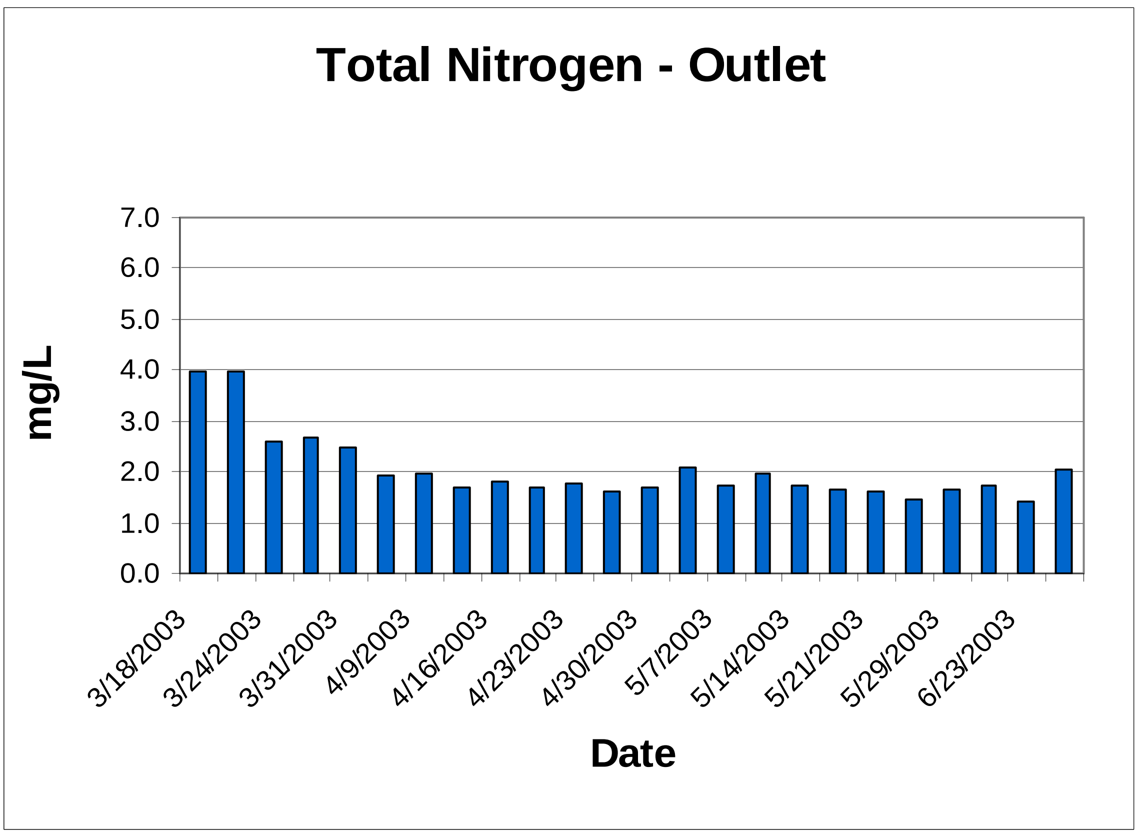
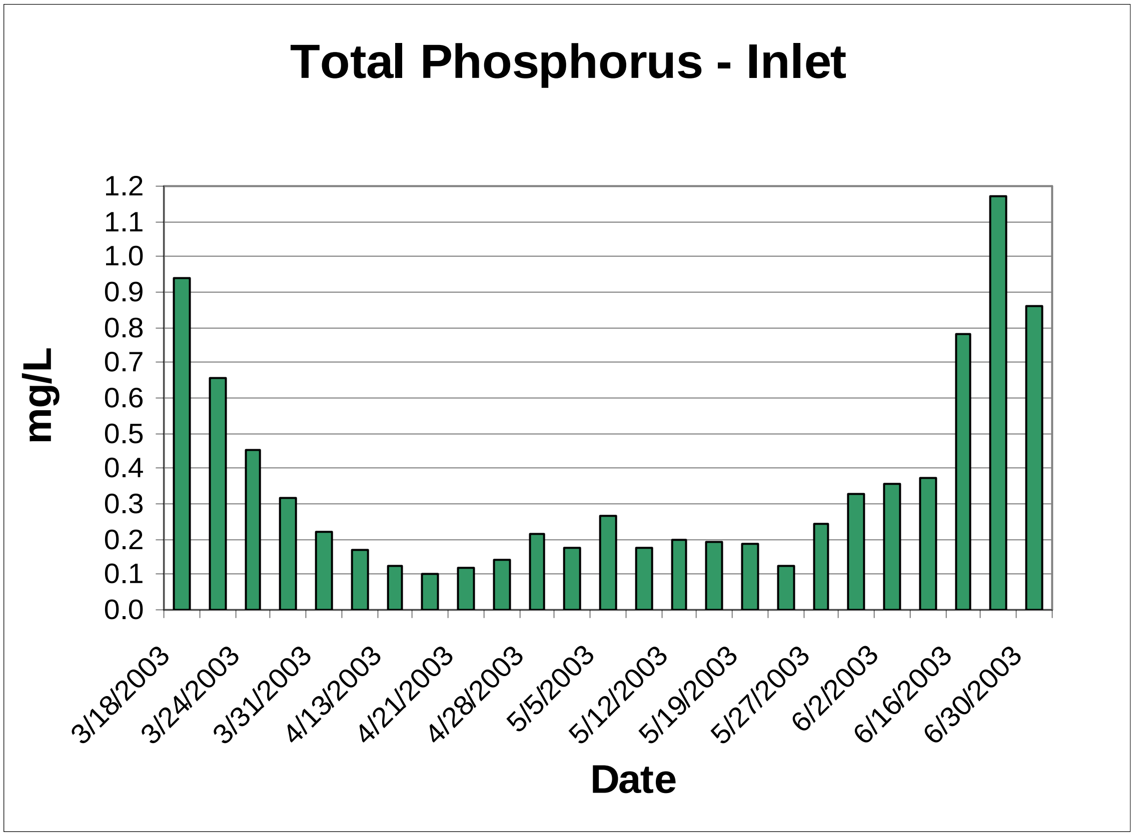
Appendix A
Graphs of Stream Data

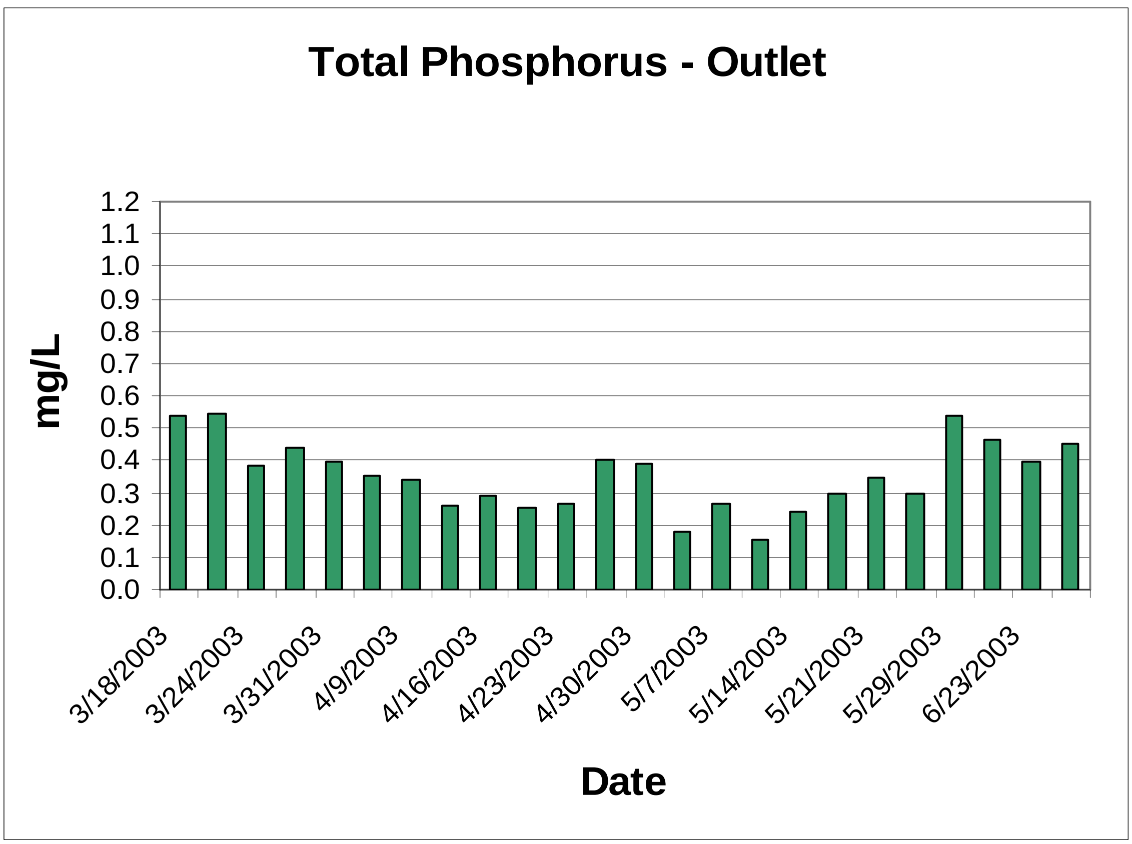

Ammonia as N - Inlet
mg/L
1.2
1.0
0.8
0.6
0.4
0.2
0.0
3/18/2003
3/24/2003
3/31/2003
4/13/2003
4/21/2003
4/28/2003
5/5/2003
5/12/2003
5/19/2003
5/27/2003
6/2/2003
6/16/2003
6/30/2003
Date


Ammonia as N - Outlet
mg/L
1.2
1.0
0.8
0.6
0.4
0.2
0.0
3/18/2003
3/24/2003
3/31/2003
4/9/2003
4/16/2003
4/23/2003
4/30/2003
5/7/2003
5/14/2003
5/21/2003
5/29/2003
6/23/2003
Date

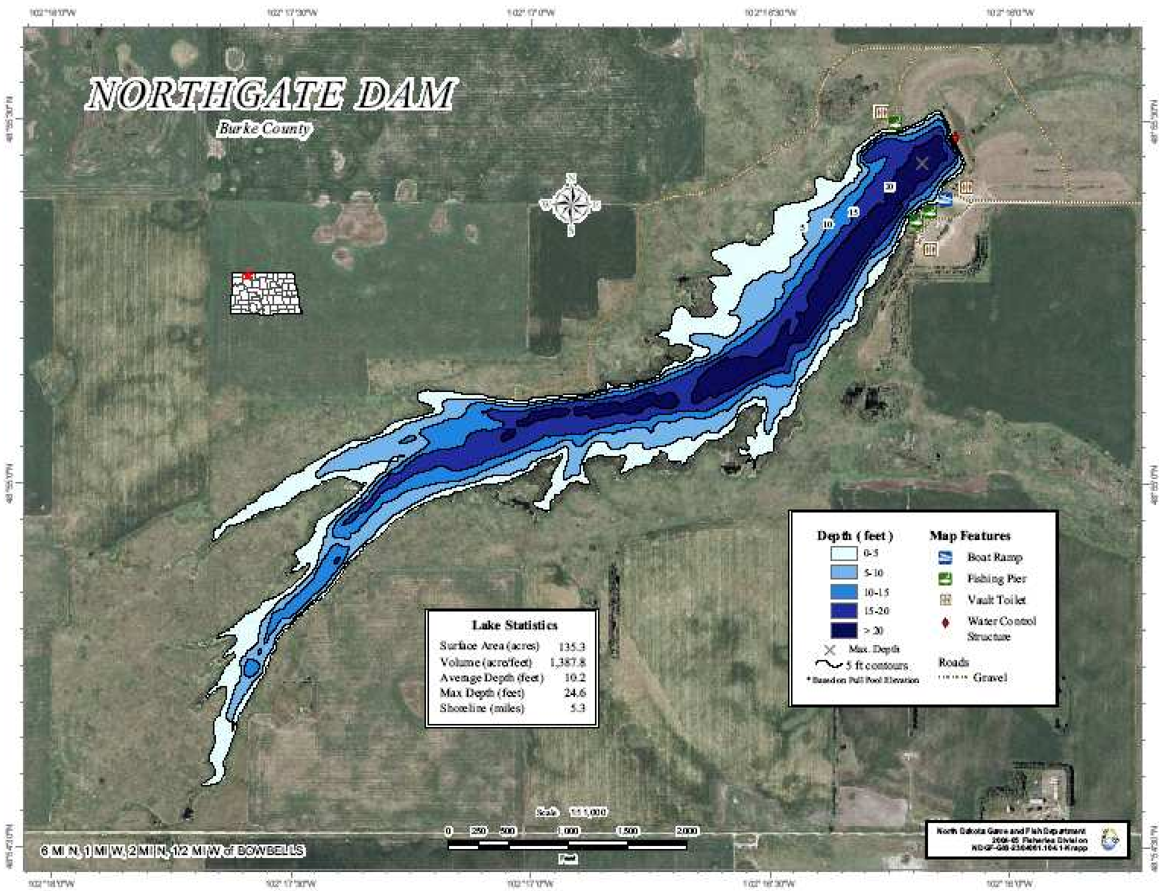

Total Nitrogen-Inlet
mg/L
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
3/18/2003
3/24/2003
3/31/2003
4/13/2003
4/21/2003
4/28/2003
5/5/2003
5/12/2003
5/19/2003
5/27/2003
6/2/2003
6/16/2003
6/30/2003
Date

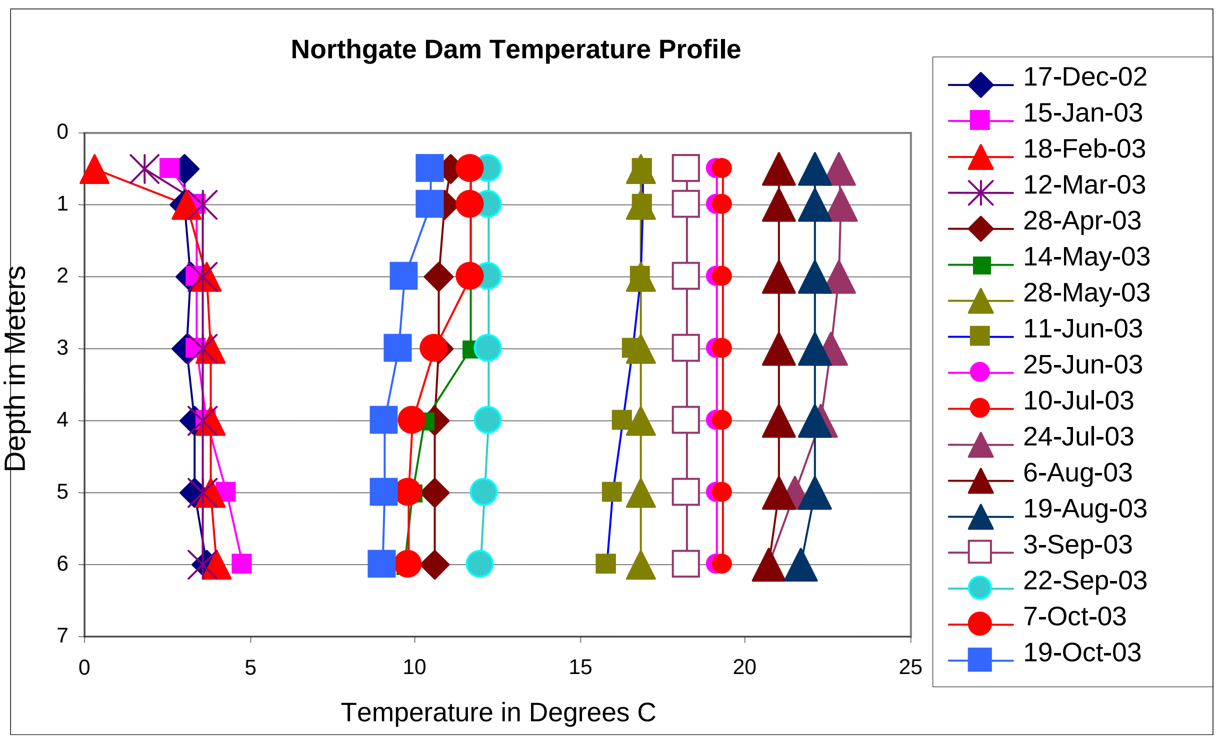

Total Nitrogen - Outlet
mg/L
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
3/18/2003
3/24/2003
3/31/2003
4/9/2003
4/16/2003
4/23/2003
4/30/2003
5/7/2003
5/14/2003
5/21/2003
5/29/2003
6/23/2003
Date

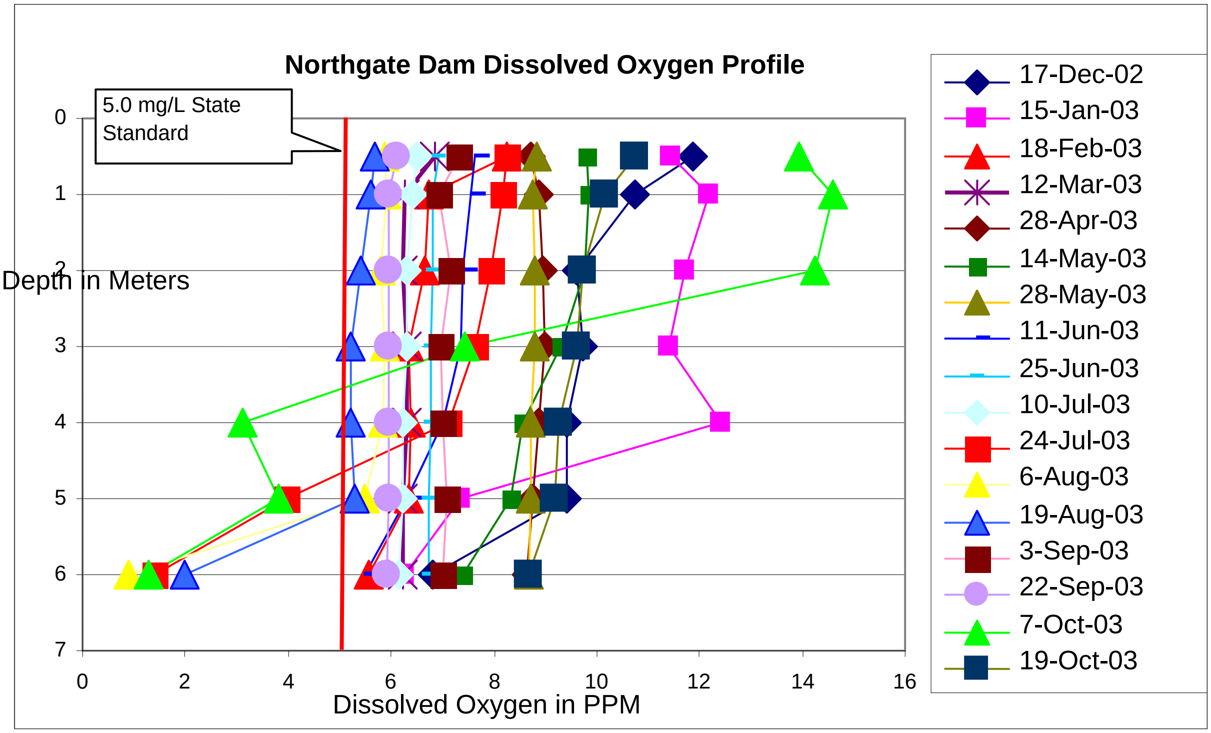

Total Phosphorus - Inlet
mg/L
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
3/18/2003
3/24/2003
3/31/2003
4/13/2003
4/21/2003
4/28/2003
5/5/2003
5/12/2003
5/19/2003
5/27/2003
6/2/2003
6/16/2003
6/30/2003
Date

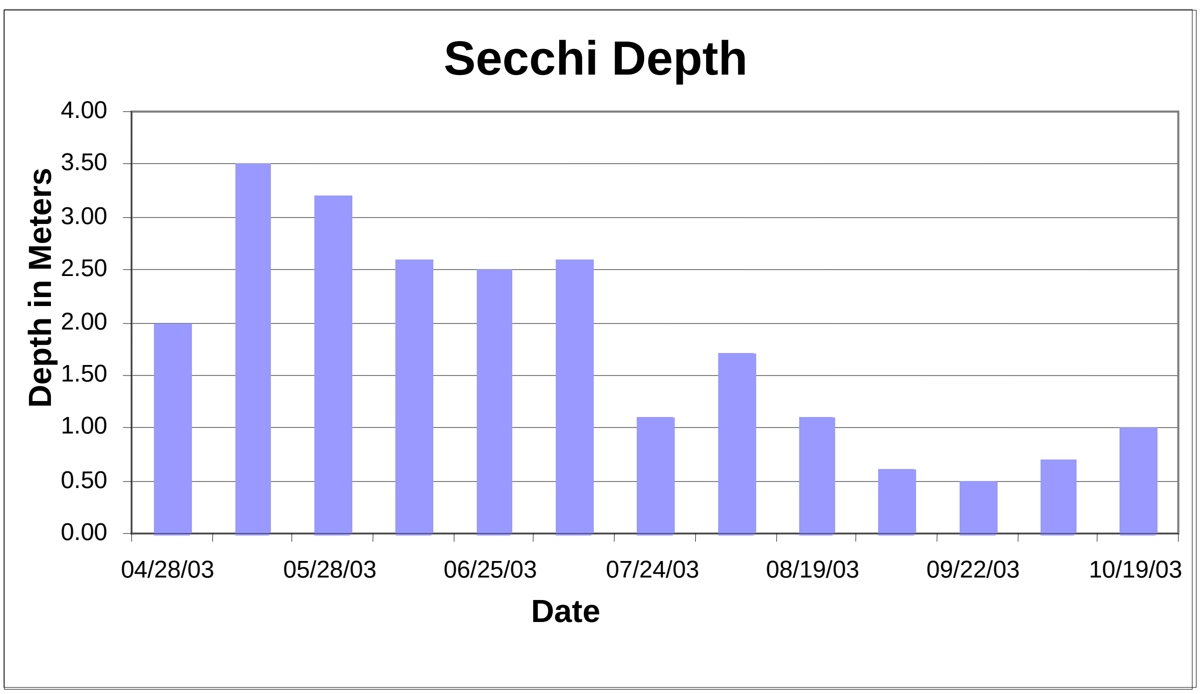

Total Phosphorus - Outlet
mg/L
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
3/18/2003
3/24/2003
3/31/2003
4/9/2003
4/16/2003
4/23/2003
4/30/2003
5/7/2003
5/14/2003
5/21/2003
5/29/2003
6/23/2003
Date

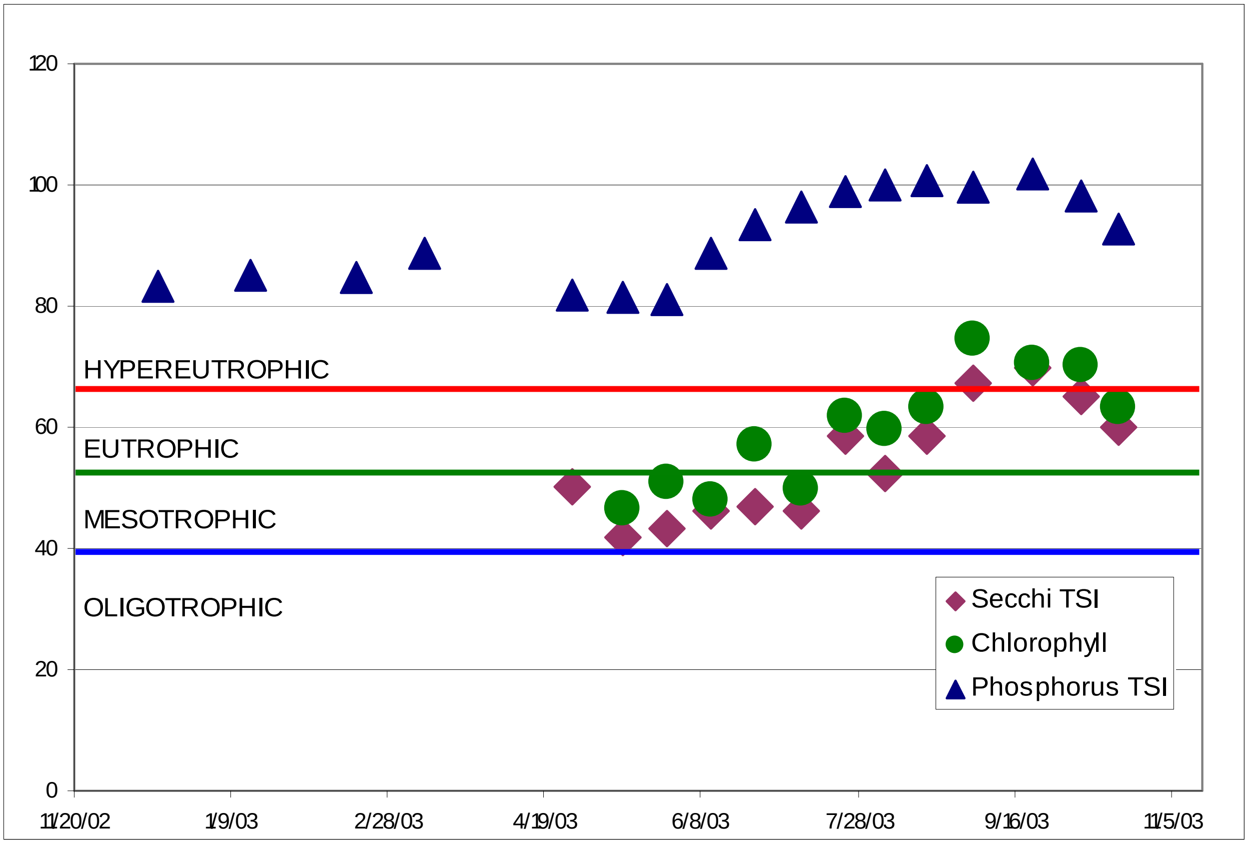
Appendix B
Lake Data

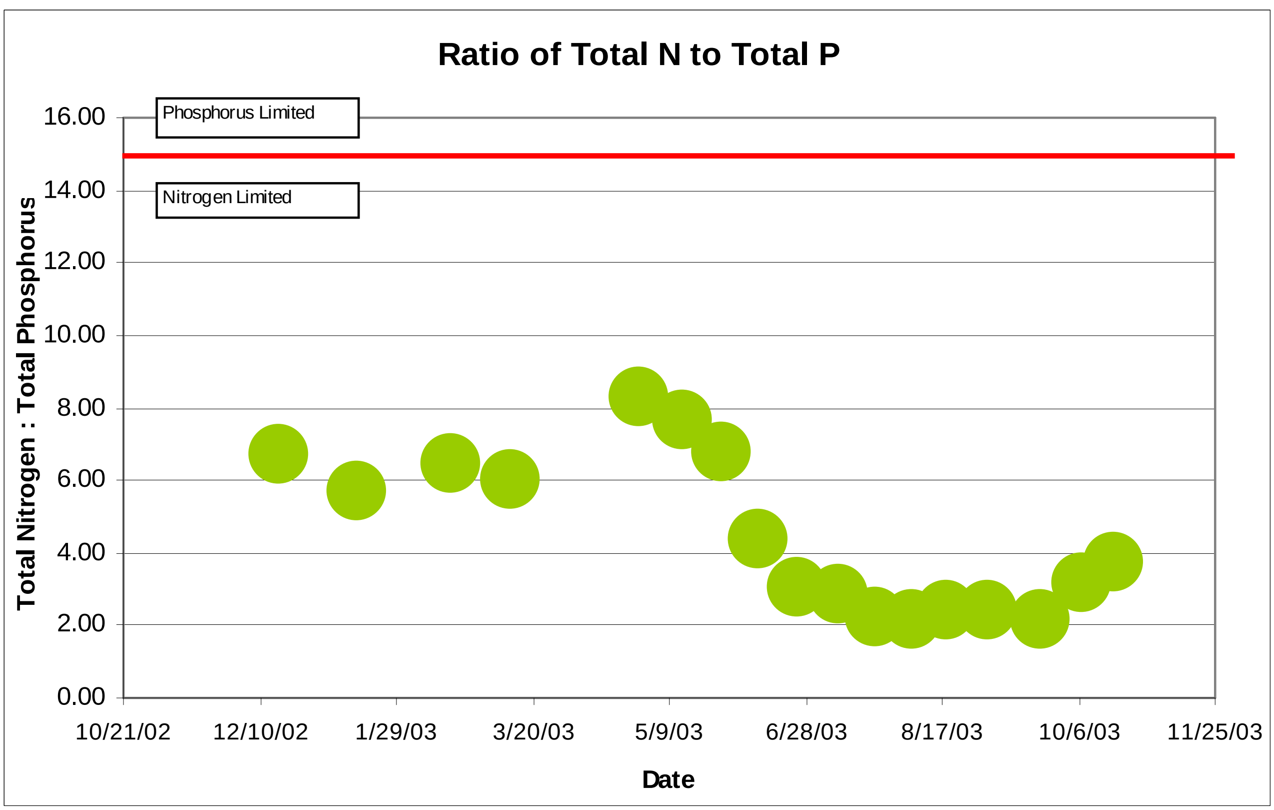

NORTHGATE DAM
Burke County
Lake Statistics
Surface Area (acres) 135.3
Volume (acre/feet) 1,387.8
Average Depth (feet) 10.2
Max Depth (feet) 24.6
Shoreline (miles) 5.3
Depth (feet)
0-5
5-10
10-15
15-20
> 20
Max. Depth
5 ft contours
Map Features
Boat Ramp
Fishing Pier
Vault Toilet
Water Control Structure
Roads
Gravel
Scale 1:11,000
0 250 500 1,000 1,500 2,000
Feet
6 MI N, 1 MI W, 2 MI N, 1/2 MI W of BOWBELLS

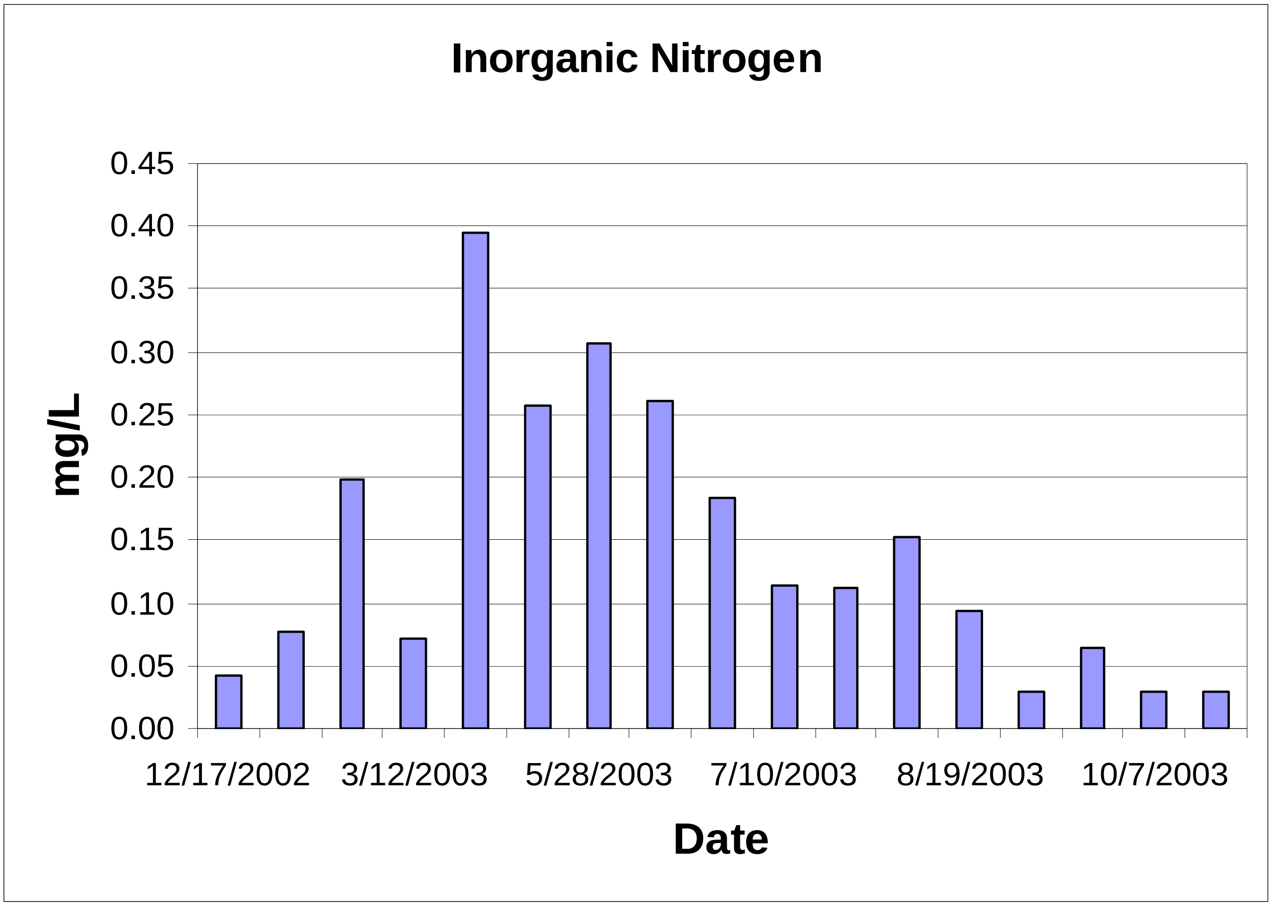

Northgate Dam Temperature Profile
Depth in Meters
0
1
2
3
4
5
6
7
Temperature in Degrees C
0
5
10
15
20
25
17-Dec-02
15-Jan-03
18-Feb-03
12-Mar-03
28-Apr-03
14-May-03
28-May-03
11-Jun-03
25-Jun-03
10-Jul-03
24-Jul-03
6-Aug-03
19-Aug-03
3-Sep-03
22-Sep-03
7-Oct-03
19-Oct-03

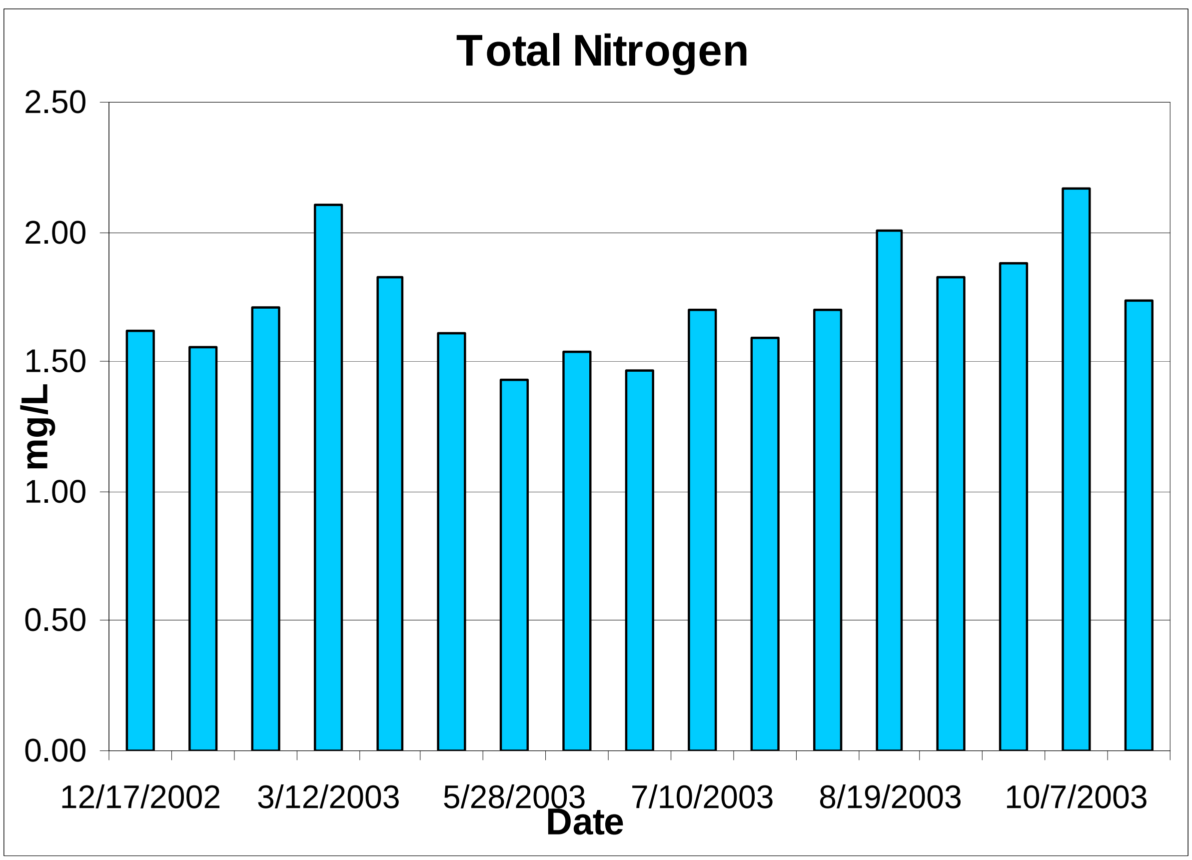

Northgate Dam Dissolved Oxygen Profile
5.0 mg/L State Standard
Depth in Meters
Dissolved Oxygen in PPM
0
1
2
3
4
5
6
7
0
2
4
6
8
10
12
14
16
17-Dec-02
15-Jan-03
18-Feb-03
12-Mar-03
28-Apr-03
14-May-03
28-May-03
11-Jun-03
25-Jun-03
10-Jul-03
24-Jul-03
6-Aug-03
19-Aug-03
3-Sep-03
22-Sep-03
7-Oct-03
19-Oct-03

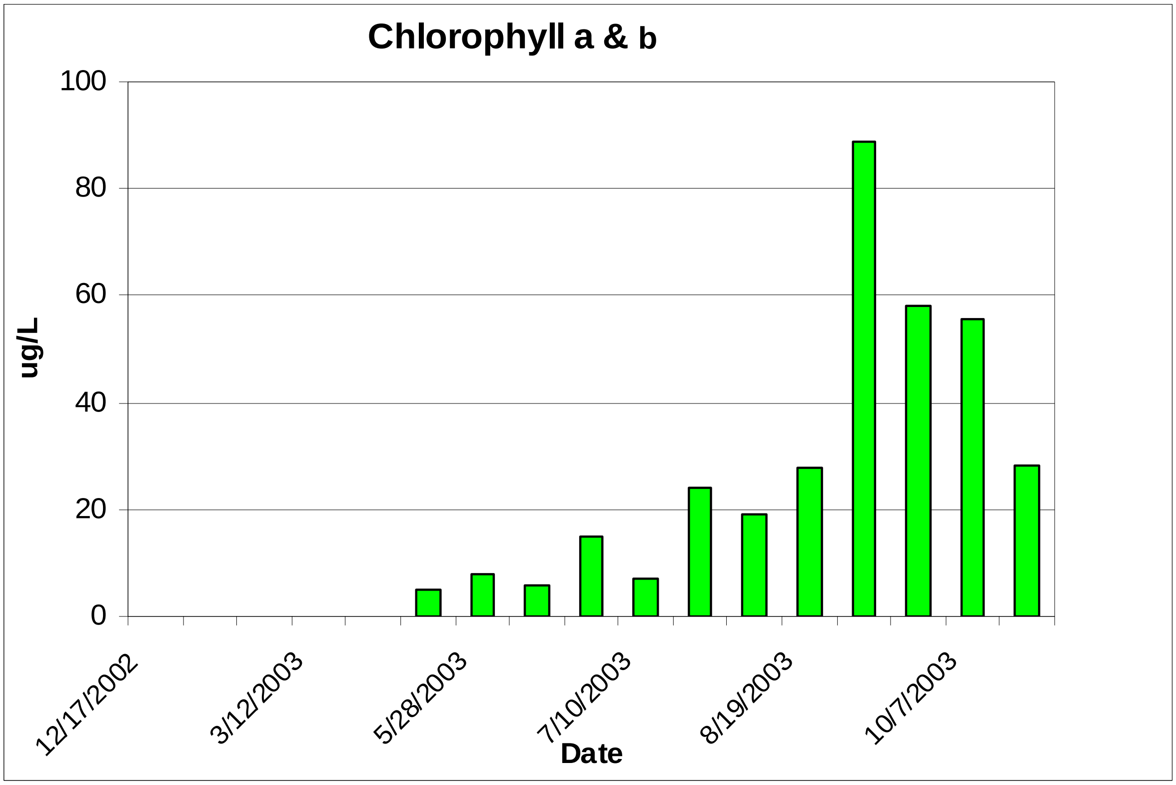

Secchi Depth
Depth in Meters
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
04/28/03
05/28/03
06/25/03
07/24/03
08/19/03
09/22/03
10/19/03
Date

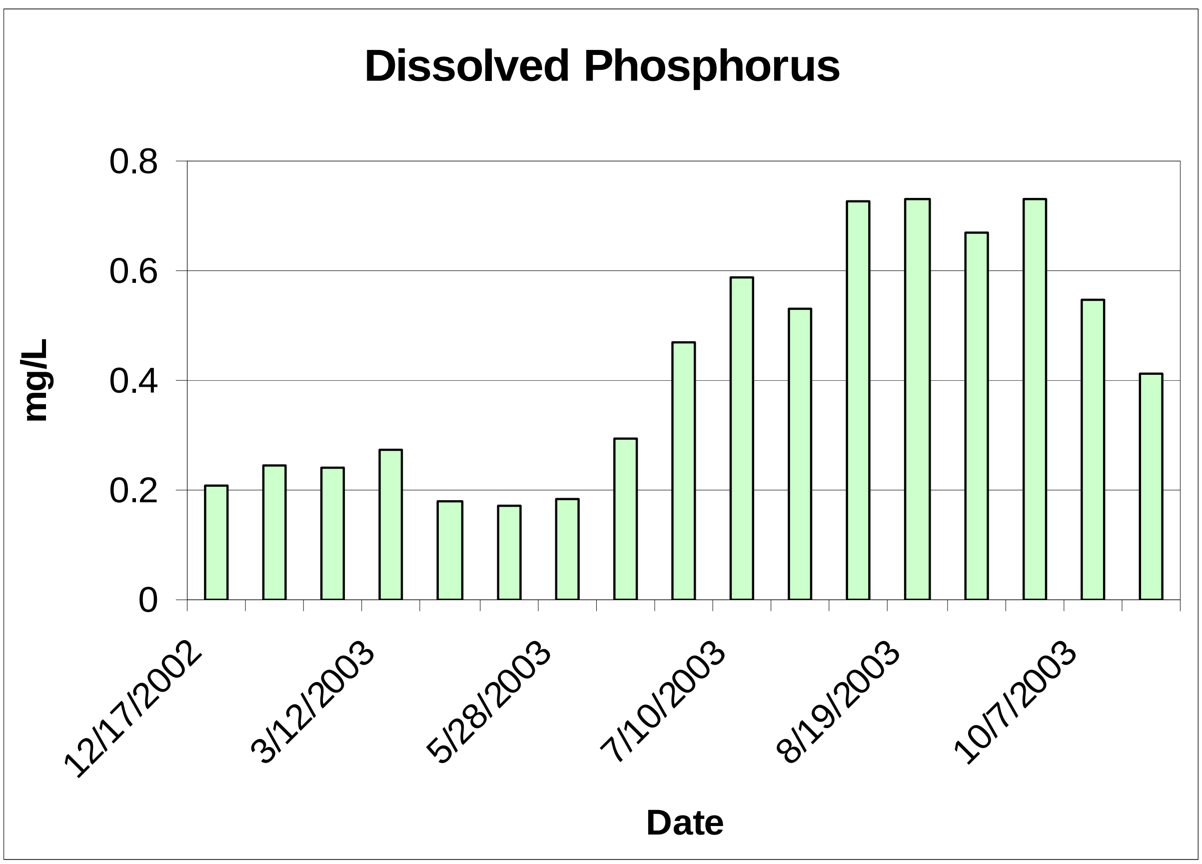

120
100
80
60
40
20
0
HYPEREUTROPHIC
EUTROPHIC
MESOTROPHIC
OLIGOTROPHIC
Secchi TSI
Chlorophyll
Phosphorus TSI
11/20/02
1/9/03
2/28/03
4/19/03
6/8/03
7/28/03
9/16/03
11/5/03

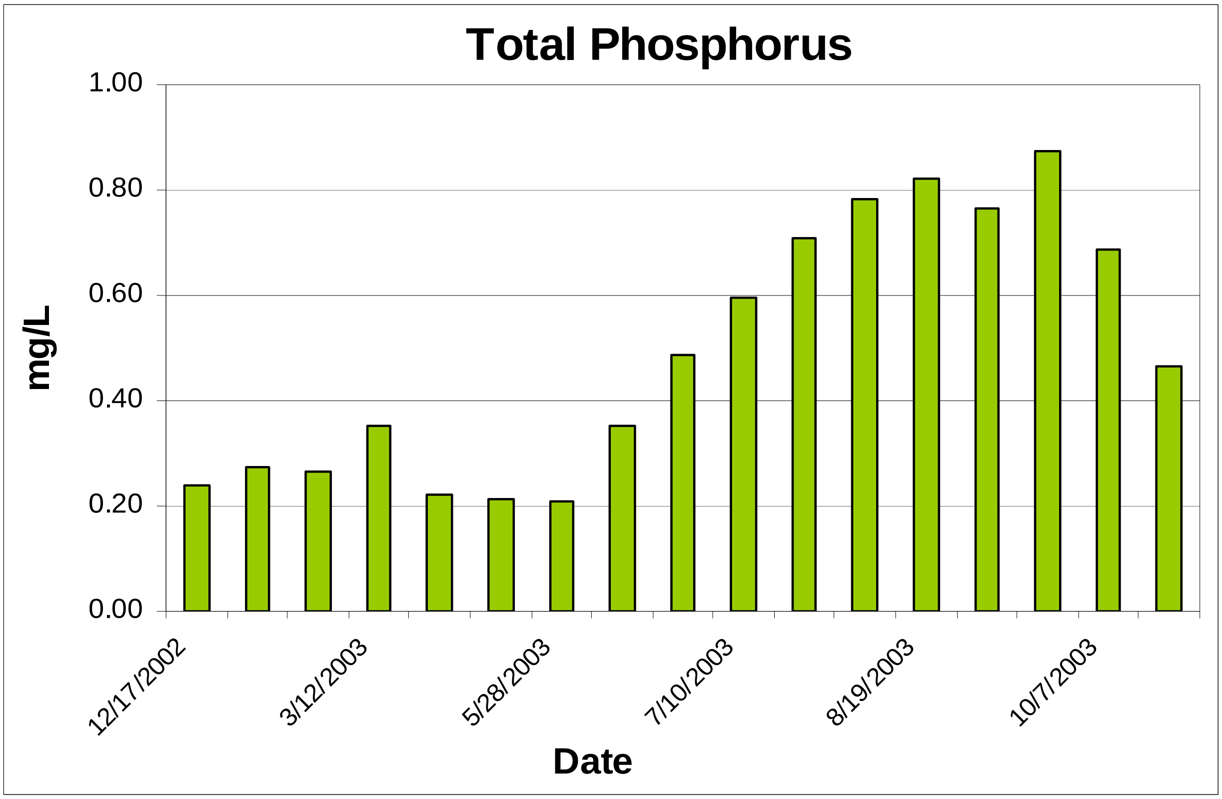

Ratio of Total N to Total P
Phosphorus Limited
Nitrogen Limited
Total Nitrogen : Total Phosphorus
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
10/21/02
12/10/02
1/29/03
3/20/03
5/9/03
6/28/03
8/17/03
10/6/03
11/25/03
Date


Inorganic Nitrogen
mg/L
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
12/17/2002
3/12/2003
5/28/2003
7/10/2003
8/19/2003
10/7/2003
Date


Total Nitrogen
mg/L
2.50
2.00
1.50
1.00
0.50
0.00
12/17/2002
3/12/2003
5/28/2003
7/10/2003
8/19/2003
10/7/2003
Date


Chlorophyll a & b
100
80
60
40
20
0
ug/L
12/17/2002
3/12/2003
5/28/2003
7/10/2003
8/19/2003
10/7/2003
Date


Dissolved Phosphorus
0.8
0.6
0.4
0.2
0
mg/L
12/17/2002
3/12/2003
5/28/2003
7/10/2003
8/19/2003
10/7/2003
Date


Total Phosphorus
mg/L
1.00
0.80
0.60
0.40
0.20
0.00
12/17/2002
3/12/2003
5/28/2003
7/10/2003
8/19/2003
10/7/2003
Date

Appendix C
BATHTUB Model Data

385226-2003-Northgate Inlet VAR=NH3-4 METHOD= 2 Q WTD C

TABULATION OF MISSING DAILY FLOWS:

Flow File =385226_q.wk1 , Station =Discharge
Daily Flows from 20030312 to 20030626

Summary:
Reported Flows = 107
Missing Flows = 0
Zero Flows = 0
Positive Flows = 107

385226-2003-Northgate Inlet VAR=NH3-4 METHOD= 2 Q WTD C
COMPARISON OF SAMPLED AND TOTAL FLOW DISTRIBUTIONS

STR	NQ	NC	NE	VOL%	TOTAL FLOW	SAMPLED FLOW	C/Q SLOPE	SIGNIF
1	107	24	24	100.0	42.942	47.718	-.058	.705
***	107	24	24	100.0	42.942	47.718		

FLOW STATISTICS
FLOW DURATION = 107.0 DAYS = .293 YEARS
MEAN FLOW RATE = 42.942 HM3/YR
TOTAL FLOW VOLUME = 12.58 HM3
FLOW DATE RANGE = 20030312 TO 20030626
SAMPLE DATE RANGE = 20030318 TO 20030623

METHOD	MASS (KG)	FLUX (KG/YR)	FLUX VARIANCE	CONC (PPB)	CV
1 AV LOAD	3507.5	11972.9	.4079E+08	278.82	.533
2 Q WTD C	3156.4	10774.6	.2240E+08	250.91	.439
3 IJC	3282.0	11203.1	.2408E+08	260.89	.438
4 REG-1	3175.9	10841.0	.2320E+08	252.46	.444
5 REG-2	3104.1	10596.2	.2564E+08	246.76	.478
6 REG-3	1888.2	6445.3	.1094E+08	150.09	.513

385226-2003-Northgate Inlet VAR=NO2-NO3 METHOD= 2 Q WTD C

TABULATION OF MISSING DAILY FLOWS:

Flow File =385226_q.wk1 , Station =Discharg
Daily Flows from 20030312 to 20030626

Summary:
Reported Flows = 107
Missing Flows = 0
Zero Flows = 0
Positive Flows = 107

385226-2003-Northgate Inlet VAR=NO2-NO3 METHOD= 2 Q WTD C
COMPARISON OF SAMPLED AND TOTAL FLOW DISTRIBUTIONS

STR	NQ	NC	NE	VOL%	TOTAL FLOW	SAMPLED FLOW	C/Q SLOPE	SIGNIF
1	107	24	24	100.0	42.942	47.718	.260	.125
***	107	24	24	100.0	42.942	47.718		

FLOW STATISTICS
FLOW DURATION = 107.0 DAYS = .293 YEARS
MEAN FLOW RATE = 42.942 HM3/YR
TOTAL FLOW VOLUME = 12.58 HM3
FLOW DATE RANGE = 20030312 TO 20030626
SAMPLE DATE RANGE = 20030318 TO 20030623

METHOD	MASS (KG)	FLUX (KG/YR)	FLUX VARIANCE	CONC (PPB)	CV
1 AV LOAD	10682.0	36463.7	.4842E+09	849.14	.603
2 Q WTD C	9612.9	32814.2	.2791E+09	764.15	.509
3 IJC	10124.5	34560.5	.3016E+09	804.82	.502
4 REG-1	9353.1	31927.1	.2537E+09	743.50	.499
5 REG-2	10407.7	35527.3	.3602E+09	827.34	.534
6 REG-3	2516.1	8588.9	.5179E+08	200.01	.838

385226-2003-Northgate Inlet VAR=INORG-N METHOD= 2 Q WTD C

TABULATION OF MISSING DAILY FLOWS:

Flow File =385226_q.wk1 , Station =Discharge
Daily Flows from 20030312 to 20030626

Summary:
Reported Flows = 107
Missing Flows = 0
Zero Flows = 0
Positive Flows = 107

385226-2003-Northgate Inlet VAR=INORG-N METHOD= 2 Q WTD C
COMPARISON OF SAMPLED AND TOTAL FLOW DISTRIBUTIONS

STR	NQ	NC	NE	VOL%	TOTAL FLOW	SAMPLED FLOW	C/Q SLOPE	SIGNIF
1	107	24	24	100.0	42.942	47.718	.068	.676
***	107	24	24	100.0	42.942	47.718		

FLOW STATISTICS
FLOW DURATION = 107.0 DAYS = .293 YEARS
MEAN FLOW RATE = 42.942 HM3/YR
TOTAL FLOW VOLUME = 12.58 HM3
FLOW DATE RANGE = 20030312 TO 20030626
SAMPLE DATE RANGE = 20030318 TO 20030623

METHOD	MASS (KG)	FLUX (KG/YR)	FLUX VARIANCE	CONC (PPB)	CV
1 AV LOAD	14189.5	48436.6	.7986E+09	1127.96	.583
2 Q WTD C	12769.3	43588.8	.4517E+09	1015.07	.488
3 IJC	13406.5	45763.6	.4869E+09	1065.71	.482
4 REG-1	12678.2	43277.6	.4417E+09	1007.82	.486

5 REG-2	13033.7	44491.2	.5532E+09	1036.08	.529
6 REG-3	4846.9	16545.0	.1249E+09	385.29	.675

385226-2003-Northgate Inlet VAR=T-N METHOD= 2 Q WTD C

TABULATION OF MISSING DAILY FLOWS:

Flow File =385226_q.wk1 , Station =Discharge
Daily Flows from 20030312 to 20030626

Summary:
Reported Flows = 107
Missing Flows = 0
Zero Flows = 0
Positive Flows = 107

385226-2003-Northgate Inlet VAR=T-N METHOD= 2 Q WTD C
COMPARISON OF SAMPLED AND TOTAL FLOW DISTRIBUTIONS

STR	NQ	NC	NE	VOL%	TOTAL FLOW	SAMPLED FLOW	C/Q SLOPE	SIGNIF
1	107	24	24	100.0	42.942	47.718	-.053	.226
***	107	24	24	100.0	42.942	47.718		

FLOW STATISTICS
FLOW DURATION = 107.0 DAYS = .293 YEARS
MEAN FLOW RATE = 42.942 HM3/YR
TOTAL FLOW VOLUME = 12.58 HM3
FLOW DATE RANGE = 20030312 TO 20030626
SAMPLE DATE RANGE = 20030318 TO 20030623

METHOD	MASS (KG)	FLUX (KG/YR)	FLUX VARIANCE	CONC (PPB)	CV
1 AV LOAD	40092.4	136857.4	.2358E+10	3187.04	.355
2 Q WTD C	36079.7	123159.9	.7421E+09	2868.06	.221
3 IJC	36850.3	125790.3	.8075E+09	2929.32	.226
4 REG-1	36283.6	123856.0	.7879E+09	2884.27	.227
5 REG-2	35529.8	121282.8	.8713E+09	2824.35	.243
6 REG-3	28031.6	95687.4	.2123E+09	2228.30	.152

385226-2003-Northgate Inlet VAR=TD-P METHOD= 2 Q WTD C

TABULATION OF MISSING DAILY FLOWS:

Flow File =385226_q.wk1 , Station =Discharge
Daily Flows from 20030312 to 20030626

Summary:
Reported Flows = 107
Missing Flows = 0
Zero Flows = 0
Positive Flows = 107

385226-2003-Northgate Inlet VAR=TD-P METHOD= 2 Q WTD C
COMPARISON OF SAMPLED AND TOTAL FLOW DISTRIBUTIONS

STR	NQ	NC	NE	VOL%	TOTAL FLOW	SAMPLED FLOW	C/Q SLOPE	SIGNIF
1	107	24	24	100.0	42.942	47.718	-.155	.024
***	107	24	24	100.0	42.942	47.718		

FLOW STATISTICS
FLOW DURATION = 107.0 DAYS = .293 YEARS
MEAN FLOW RATE = 42.942 HM3/YR
TOTAL FLOW VOLUME = 12.58 HM3
FLOW DATE RANGE = 20030312 TO 20030626
SAMPLE DATE RANGE = 20030318 TO 20030623

METHOD	MASS (KG)	FLUX (KG/YR)	FLUX VARIANCE	CONC (PPB)	CV
1 AV LOAD	4137.6	14123.8	.2910E+08	328.90	.382
2 Q WTD C	3723.4	12710.2	.1075E+08	295.99	.258
3 IJC	3814.5	13021.1	.1198E+08	303.23	.266
4 REG-1	3784.8	12919.7	.1247E+08	300.86	.273
5 REG-2	3572.5	12194.9	.1306E+08	283.99	.296
6 REG-3	2779.3	9487.2	.3643E+07	220.93	.201

385226-2003-Northgate Inlet VAR=T-P METHOD= 2 Q WTD C

TABULATION OF MISSING DAILY FLOWS:

Flow File =385226_q.wk1 , Station =Discharge
Daily Flows from 20030312 to 20030626

Summary:
Reported Flows = 107
Missing Flows = 0
Zero Flows = 0
Positive Flows = 107

385226-2003-Northgate Inlet VAR=T-P METHOD= 2 Q WTD C
COMPARISON OF SAMPLED AND TOTAL FLOW DISTRIBUTIONS

STR	NQ	NC	NE	VOL%	TOTAL FLOW	SAMPLED FLOW	C/Q SLOPE	SIGNIF
1	107	24	24	100.0	42.942	47.718	-.148	.039
***	107	24	24	100.0	42.942	47.718		

FLOW STATISTICS
FLOW DURATION = 107.0 DAYS = .293 YEARS
MEAN FLOW RATE = 42.942 HM3/YR
TOTAL FLOW VOLUME = 12.58 HM3
FLOW DATE RANGE = 20030312 TO 20030626
SAMPLE DATE RANGE = 20030318 TO 20030623

METHOD	MASS (KG)	FLUX (KG/YR)	FLUX VARIANCE	CONC (PPB)	CV
1 AV LOAD	5410.6	18469.3	.6080E+08	430.10	.422
2 Q WTD C	4869.1	16620.8	.2599E+08	387.05	.307

3 IJC	5014.1	17116.1	.2931E+08	398.59	.316
4 REG-1	4945.7	16882.4	.2935E+08	393.15	.321
5 REG-2	4679.2	15972.6	.3035E+08	371.96	.345
6 REG-3	3370.5	11505.3	.7059E+07	267.93	.231

385226-2003-Northgate Inlet VAR=TSS METHOD= 2 Q WTD C

TABULATION OF MISSING DAILY FLOWS:

Flow File =385226_q.wk1 , Station =Discharg
Daily Flows from 20030312 to 20030626

Summary:
Reported Flows = 107
Missing Flows = 0
Zero Flows = 0
Positive Flows = 107

385226-2003-Northgate Inlet VAR=TSS METHOD= 2 Q WTD C
COMPARISON OF SAMPLED AND TOTAL FLOW DISTRIBUTIONS

STR	NQ	NC	NE	VOL%	TOTAL FLOW	SAMPLED FLOW	C/Q SLOPE	SIGNIF
1	107	24	24	100.0	42.942	47.718	-.085	.124
***	107	24	24	100.0	42.942	47.718		

FLOW STATISTICS
FLOW DURATION = 107.0 DAYS = .293 YEARS
MEAN FLOW RATE = 42.942 HM3/YR
TOTAL FLOW VOLUME = 12.58 HM3
FLOW DATE RANGE = 20030312 TO 20030626
SAMPLE DATE RANGE = 20030318 TO 20030623

METHOD	MASS (KG)	FLUX (KG/YR)	FLUX VARIANCE	CONC (PPB)	CV
1 AV LOAD	102349.0	349373.7	.9000E+10	8135.97	.272
2 Q WTD C	92105.3	314406.3	.3281E+10	7321.68	.182
3 IJC	92172.5	314635.5	.3328E+10	7327.01	.183
4 REG-1	92934.6	317237.0	.3358E+10	7387.60	.183
5 REG-2	89924.7	306962.5	.3576E+10	7148.33	.195
6 REG-3	85541.2	291999.1	.2568E+10	6799.87	.174

385227-2003-Northgate Outlet VAR=NH3-4 METHOD= 2 Q WTD C

TABULATION OF MISSING DAILY FLOWS:

Flow File =385227_q.wk1 , Station =Discharg
Daily Flows from 20030314 to 20030610

Summary:
Reported Flows = 89

Missing Flows = 0
Zero Flows = 23
Positive Flows = 66

385227-2003-Northgate Outlet VAR=NH3-4 METHOD= 2 Q WTD C
COMPARISON OF SAMPLED AND TOTAL FLOW DISTRIBUTIONS

STR	NQ	NC	NE	VOL%	TOTAL FLOW	SAMPLED FLOW	C/Q SLOPE	SIGNIF
1	89	19	19	100.0	8.476	17.312	.179	.048
***	89	19	19	100.0	8.476	17.312		

FLOW STATISTICS
FLOW DURATION = 89.0 DAYS = .244 YEARS
MEAN FLOW RATE = 8.476 HM3/YR
TOTAL FLOW VOLUME = 2.07 HM3
FLOW DATE RANGE = 20030314 TO 20030610
SAMPLE DATE RANGE = 20030318 TO 20030521

METHOD	MASS (KG)	FLUX (KG/YR)	FLUX VARIANCE	CONC (PPB)	CV
1 AV LOAD	3229.9	13255.1	.7554E+08	1563.82	.656
2 Q WTD C	1581.4	6489.9	.2068E+07	765.66	.222
3 IJC	1638.6	6724.7	.1228E+07	793.37	.165
4 REG-1	1391.3	5709.6	.7623E+06	673.61	.153
5 REG-2	1694.8	6955.5	.3641E+07	820.60	.274
6 REG-3	1062.0	4358.3	.7390E+07	514.19	.624

385227-2003-Northgate Outlet VAR=NO2+NO3 METHOD= 2 Q WTD C

TABULATION OF MISSING DAILY FLOWS:

Flow File =385227_q.wk1 , Station =Discharg
Daily Flows from 20030314 to 20030610

Summary:
Reported Flows = 89
Missing Flows = 0
Zero Flows = 23
Positive Flows = 66

385227-2003-Northgate Outlet VAR=NO2+NO3 METHOD= 2 Q WTD C
COMPARISON OF SAMPLED AND TOTAL FLOW DISTRIBUTIONS

STR	NQ	NC	NE	VOL%	TOTAL FLOW	SAMPLED FLOW	C/Q SLOPE	SIGNIF
1	89	19	19	100.0	8.476	17.312	.157	.081
***	89	19	19	100.0	8.476	17.312		

FLOW STATISTICS
FLOW DURATION = 89.0 DAYS = .244 YEARS
MEAN FLOW RATE = 8.476 HM3/YR
TOTAL FLOW VOLUME = 2.07 HM3
FLOW DATE RANGE = 20030314 TO 20030610
SAMPLE DATE RANGE = 20030318 TO 20030521

METHOD	MASS (KG)	FLUX (KG/YR)	FLUX VARIANCE	CONC (PPB)	CV
1 AV LOAD	4129.6	16947.7	.1102E+09	1999.47	.619
2 Q WTD C	2021.9	8297.8	.1621E+07	978.96	.153
3 IJC	2070.9	8499.0	.1069E+07	1002.70	.122
4 REG-1	1807.5	7417.7	.1020E+07	875.13	.136
5 REG-2	2165.4	8886.8	.3913E+07	1048.45	.223
6 REG-3	1638.1	6722.8	.7309E+07	793.15	.402

385227-2003-Northgate Outlet VAR=T-INOR-N METHOD= 2 Q WTD C

TABULATION OF MISSING DAILY FLOWS:

Flow File =385227_q.wk1 , Station =Discharg
Daily Flows from 20030314 to 20030610

Summary:
Reported Flows = 89
Missing Flows = 0
Zero Flows = 23
Positive Flows = 66

385227-2003-Northgate Outlet VAR=T-INOR-N METHOD= 2 Q WTD C
COMPARISON OF SAMPLED AND TOTAL FLOW DISTRIBUTIONS

STR	NQ	NC	NE	VOL%	TOTAL FLOW	SAMPLED FLOW	C/Q SLOPE	SIGNIF
1	89	19	19	100.0	8.476	17.312	.163	.040
***	89	19	19	100.0	8.476	17.312		

FLOW STATISTICS
FLOW DURATION = 89.0 DAYS = .244 YEARS
MEAN FLOW RATE = 8.476 HM3/YR
TOTAL FLOW VOLUME = 2.07 HM3
FLOW DATE RANGE = 20030314 TO 20030610
SAMPLE DATE RANGE = 20030318 TO 20030521

METHOD	MASS (KG)	FLUX (KG/YR)	FLUX VARIANCE	CONC (PPB)	CV
1 AV LOAD	7359.5	30202.8	.3677E+09	3563.28	.635
2 Q WTD C	3603.3	14787.7	.7295E+07	1744.63	.183
3 IJC	3709.5	15223.7	.4526E+07	1796.06	.140
4 REG-1	3206.8	13160.4	.3641E+07	1552.64	.145
5 REG-2	3860.5	15843.0	.1512E+08	1869.14	.245
6 REG-3	2488.1	10211.1	.1778E+08	1204.70	.413

385227-2003-Northgate Outlet   VAR=TN   METHOD= 2 Q WTD C

TABULATION OF MISSING DAILY FLOWS:

Flow File =385227_q.wk1   ,   Station =Discharg
Daily Flows from 20030314 to 20030610

Summary:
Reported Flows =   89
Missing Flows =   0
Zero Flows =   23
Positive Flows =   66

385227-2003-Northgate Outlet   VAR=TN   METHOD= 2 Q WTD C

COMPARISON OF SAMPLED AND TOTAL FLOW DISTRIBUTIONS

STR	NQ	NC	NE	VOL%	TOTAL FLOW	SAMPLED FLOW	C/Q SLOPE	SIGNIF
1	89	19	19	100.0	8.476	17.312	.065	.000
***	89	19	19	100.0	8.476	17.312		

FLOW STATISTICS
FLOW DURATION =   89.0 DAYS =   .244 YEARS
MEAN FLOW RATE =   8.476 HM3/YR
TOTAL FLOW VOLUME =   2.07 HM3
FLOW DATE RANGE   = 20030314 TO 20030610
SAMPLE DATE RANGE = 20030318 TO 20030521

METHOD	MASS (KG)	FLUX (KG/YR)	FLUX VARIANCE	CONC (PPB)	CV
1 AV LOAD	15153.3	62188.1	.1433E+10	7336.87	.609
2 Q WTD C	7419.2	30448.0	.1349E+08	3592.22	.121
3 IJC	7576.7	31094.1	.7696E+07	3668.44	.089
4 REG-1	7084.5	29074.4	.6234E+07	3430.16	.086
5 REG-2	7761.8	31853.9	.2517E+08	3758.08	.157
6 REG-3	6098.2	25026.8	.1462E+08	2952.62	.153

385227-2003-Northgate Outlet VAR=TDP METHOD= 2 Q WTD C

TABULATION OF MISSING DAILY FLOWS:

Flow File =385227_q.wk1 , Station =Discharg
Daily Flows from 20030314 to 20030610

Summary:
Reported Flows = 89
Missing Flows = 0
Zero Flows = 23
Positive Flows = 66

385227-2003-Northgate Outlet VAR=TDP METHOD= 2 Q WTD C
COMPARISON OF SAMPLED AND TOTAL FLOW DISTRIBUTIONS

STR	NQ	NC	NE	VOL%	TOTAL FLOW	SAMPLED FLOW	C/Q SLOPE	SIGNIF
1	89	19	19	100.0	8.476	17.312	.059	.005
***	89	19	19	100.0	8.476	17.312		

FLOW STATISTICS
FLOW DURATION = 89.0 DAYS = .244 YEARS
MEAN FLOW RATE = 8.476 HM3/YR
TOTAL FLOW VOLUME = 2.07 HM3
FLOW DATE RANGE = 20030314 TO 20030610
SAMPLE DATE RANGE = 20030318 TO 20030521

METHOD	MASS (KG)	FLUX (KG/YR)	FLUX VARIANCE	CONC (PPB)	CV
1 AV LOAD	1584.7	6503.3	.1509E+08	767.25	.597
2 Q WTD C	775.9	3184.1	.1760E+06	375.66	.132
3 IJC	787.7	3232.8	.1415E+06	381.41	.116
4 REG-1	744.0	3053.5	.1210E+06	360.25	.114
5 REG-2	809.3	3321.2	.2999E+06	391.83	.165
6 REG-3	676.4	2776.1	.1984E+06	327.52	.160

385227-2003-Northgate Outlet VAR=TP METHOD= 2 Q WTD C

TABULATION OF MISSING DAILY FLOWS:

Flow File =385227_q.wk1 , Station =Discharg
Daily Flows from 20030314 to 20030610

Summary:
Reported Flows = 89
Missing Flows = 0
Zero Flows = 23
Positive Flows = 66

385227-2003-Northgate Outlet VAR=TP METHOD= 2 Q WTD C
COMPARISON OF SAMPLED AND TOTAL FLOW DISTRIBUTIONS

STR	NQ	NC	NE	VOL%	TOTAL FLOW	SAMPLED FLOW	C/Q SLOPE	SIGNIF
1	89	19	19	100.0	8.476	17.312	.040	.089
***	89	19	19	100.0	8.476	17.312		

FLOW STATISTICS
FLOW DURATION = 89.0 DAYS = .244 YEARS
MEAN FLOW RATE = 8.476 HM3/YR
TOTAL FLOW VOLUME = 2.07 HM3
FLOW DATE RANGE = 20030314 TO 20030610
SAMPLE DATE RANGE = 20030318 TO 20030521

METHOD	MASS (KG)	FLUX (KG/YR)	FLUX VARIANCE	CONC (PPB)	CV
1 AV LOAD	2093.3	8590.7	.2669E+08	1013.52	.601
2 Q WTD C	1024.9	4206.1	.2012E+06	496.23	.107
3 IJC	1043.8	4283.8	.1137E+06	505.39	.079
4 REG-1	995.9	4087.1	.1140E+06	482.19	.083
5 REG-2	1057.8	4341.1	.3311E+06	512.16	.133
6 REG-3	851.1	3493.0	.2894E+06	412.10	.154

385227-2003-Northgate Outlet VAR=TSS METHOD= 2 Q WTD C

TABULATION OF MISSING DAILY FLOWS:

Flow File =385227_q.wk1 , Station =Discharg
Daily Flows from 20030314 to 20030610

Summary:
Reported Flows = 89
Missing Flows = 0
Zero Flows = 23
Positive Flows = 66

385227-2003-Northgate Outlet VAR=TSS METHOD= 2 Q WTD C
COMPARISON OF SAMPLED AND TOTAL FLOW DISTRIBUTIONS

STR	NQ	NC	NE	VOL%	TOTAL FLOW	SAMPLED FLOW	C/Q SLOPE	SIGNIF
1	89	19	19	100.0	8.476	17.312	-.094	.085
***	89	19	19	100.0	8.476	17.312		

FLOW STATISTICS
FLOW DURATION = 89.0 DAYS = .244 YEARS
MEAN FLOW RATE = 8.476 HM3/YR
TOTAL FLOW VOLUME = 2.07 HM3
FLOW DATE RANGE = 20030314 TO 20030610
SAMPLE DATE RANGE = 20030318 TO 20030521

METHOD	MASS (KG)	FLUX (KG/YR)	FLUX VARIANCE	CONC (PPB)	CV
1 AV LOAD	39674.9	162822.9	.8789E+10	19209.61	.576
2 Q WTD C	19425.3	79720.0	.2557E+09	9405.25	.201
3 IJC	19474.6	79922.4	.3073E+09	9429.13	.219
4 REG-1	20774.3	85256.2	.3040E+09	10058.40	.204
5 REG-2	16847.5	69140.9	.5996E+09	8157.14	.354
6 REG-3	19041.8	78146.5	.3311E+09	9219.61	.233

385226 Northgate Inlet (2003) VAR=NH3-4 METHOD= 2 Q WTD C

TABULATION OF MISSING DAILY FLOWS:

Flow File =385226_q.wk1 , Station =Discharg
Daily Flows from 20030308 to 20030712

Summary:
Reported Flows = 127
Missing Flows = 0
Zero Flows = 7
Positive Flows = 120

385226 Northgate Inlet (2003) VAR=NH3-4 METHOD= 2 Q WTD C

STRATIFICATION SCHEME:

	---- DATE ----		-- SEASON --		-------- FLOW --------	
STR	>=MIN	< MAX	>=MIN	< MAX	>=MIN	< MAX
1			0	0	.00	2.82
2			0	0	2.82	11.27
3			0	0	11.27	78.89

STR	SAMPLES	EVENTS	FLOWS	VOLUME %
1	11	11	79	9.07
2	10	10	37	29.25
3	3	3	11	61.68
EXCLUDED	0	0	0	.00

TOTAL	24	24	127	100.00

385226 Northgate Inlet (2003) VAR=NH3-4 METHOD= 2 Q WTD C

COMPARISON OF SAMPLED AND TOTAL FLOW DISTRIBUTIONS

STR	NQ	NC	NE	VOL%	TOTAL FLOW	SAMPLED FLOW	C/Q SLOPE	SIGNIF
1	79	11	11	9.1	.822	1.199	-.435	.094
2	37	10	10	29.3	5.660	5.172	.482	.649
3	11	3	3	61.7	40.143	49.031	1.971	.125
***	127	24	24	100.0	5.637	8.833		

FLOW STATISTICS
FLOW DURATION = 127.0 DAYS = .348 YEARS
MEAN FLOW RATE = 5.637 HM3/YR
TOTAL FLOW VOLUME = 1.96 HM3
FLOW DATE RANGE = 20030308 TO 20030712
SAMPLE DATE RANGE = 20030318 TO 20030623

METHOD	MASS (KG)	FLUX (KG/YR)	FLUX VARIANCE	CONC (PPB)	CV
1 AV LOAD	995.2	2862.1	.2164E+07	507.69	.514
2 Q WTD C	827.3	2379.2	.5567E+06	422.04	.314
3 IJC	855.4	2460.0	.6687E+06	436.37	.332
4 REG-1	586.4	1686.5	.2078E+12	299.16	270.319
5 REG-2	576.0	1656.7	.1012E+15	293.87	6072.808
6 REG-3	745.2	2143.2	.5380E+21	380.17	********

385226 Northgate Inlet (2003) VAR=NO2-NO3 METHOD= 2 Q WTD C

TABULATION OF MISSING DAILY FLOWS:

Flow File =385226_q.wk1 , Station =Discharg
Daily Flows from 20030308 to 20030712

Summary:
Reported Flows = 127
Missing Flows = 0
Zero Flows = 7
Positive Flows = 120

385226 Northgate Inlet (2003) VAR=NO2-NO3 METHOD= 2 Q WTD C

STRATIFICATION SCHEME:

	---- DATE ----		-- SEASON --		-------- FLOW --------	
STR	>=MIN	< MAX	>=MIN	< MAX	>=MIN	< MAX
1			0	0	.00	2.82
2			0	0	2.82	11.27
3			0	0	11.27	78.89

STR	SAMPLES	EVENTS	FLOWS	VOLUME %
1	11	11	79	9.07
2	10	10	37	29.25
3	3	3	11	61.68
EXCLUDED	0	0	0	.00
TOTAL	24	24	127	100.00

385226 Northgate Inlet (2003) VAR=NO2-NO3 METHOD= 2 Q WTD C

COMPARISON OF SAMPLED AND TOTAL FLOW DISTRIBUTIONS

STR	NQ	NC	NE	VOL%	TOTAL FLOW	SAMPLED FLOW	C/Q SLOPE	SIGNIF
1	79	11	11	9.1	.822	1.199	-.159	.000
2	37	10	10	29.3	5.660	5.172	1.628	.159
3	11	3	3	61.7	40.143	49.031	2.846	.041
***	127	24	24	100.0	5.637	8.833		

FLOW STATISTICS
FLOW DURATION = 127.0 DAYS = .348 YEARS
MEAN FLOW RATE = 5.637 HM3/YR
TOTAL FLOW VOLUME = 1.96 HM3
FLOW DATE RANGE = 20030308 TO 20030712
SAMPLE DATE RANGE = 20030318 TO 20030623

METHOD	MASS (KG)	FLUX (KG/YR)	FLUX VARIANCE	CONC (PPB)	CV
1 AV LOAD	3261.6	9380.4	.2115E+08	1663.96	.490
2 Q WTD C	2698.4	7760.6	.1665E+07	1376.62	.166
3 IJC	2805.2	8067.7	.1311E+07	1431.09	.142
4 REG-1	1596.5	4591.6	.1382E+11	814.48	25.599
5 REG-2	1563.3	4496.0	.7327E+12	797.52	190.386
6 REG-3	2166.3	6230.3	.2452E+15	1105.18	2513.460

385226 Northgate Inlet (2003) VAR=INORG-N METHOD= 2 Q WTD C

TABULATION OF MISSING DAILY FLOWS:

Flow File =385226_q.wk1 , Station =Discharg
Daily Flows from 20030308 to 20030712

Summary:
Reported Flows = 127
Missing Flows = 0
Zero Flows = 7
Positive Flows = 120

385226 Northgate Inlet (2003) VAR=INORG-N METHOD= 2 Q WTD C

STRATIFICATION SCHEME:

	---- DATE ----		-- SEASON --		-------- FLOW --------	
STR	>=MIN	< MAX	>=MIN	< MAX	>=MIN	< MAX
1			0	0	.00	2.82
2			0	0	2.82	11.27
3			0	0	11.27	78.89

STR	SAMPLES	EVENTS	FLOWS	VOLUME %
1	11	11	79	9.07
2	10	10	37	29.25
3	3	3	11	61.68
EXCLUDED	0	0	0	.00
TOTAL	24	24	127	100.00

385226 Northgate Inlet (2003) VAR=INORG-N METHOD= 2 Q WTD C
COMPARISON OF SAMPLED AND TOTAL FLOW DISTRIBUTIONS

STR	NQ	NC	NE	VOL%	TOTAL FLOW	SAMPLED FLOW	C/Q SLOPE	SIGNIF
1	79	11	11	9.1	.822	1.199	-.330	.086
2	37	10	10	29.3	5.660	5.172	1.090	.321
3	11	3	3	61.7	40.143	49.031	2.523	.057
***	127	24	24	100.0	5.637	8.833		

FLOW STATISTICS
FLOW DURATION = 127.0 DAYS = .348 YEARS
MEAN FLOW RATE = 5.637 HM3/YR
TOTAL FLOW VOLUME = 1.96 HM3
FLOW DATE RANGE = 20030308 TO 20030712
SAMPLE DATE RANGE = 20030318 TO 20030623

METHOD	MASS (KG)	FLUX (KG/YR)	FLUX VARIANCE	CONC (PPB)	CV
1 AV LOAD	4256.8	12242.5	.3627E+08	2171.65	.492
2 Q WTD C	3525.7	10139.8	.3977E+07	1798.66	.197
3 IJC	3660.5	10527.7	.3816E+07	1867.46	.186
4 REG-1	2224.3	6396.9	.2040E+12	1134.73	70.601
5 REG-2	2180.7	6271.7	.3145E+14	1112.51	894.122
6 REG-3	2914.9	8383.2	.4818E+18	1487.06	********

385226 Northgate Inlet (2003)   VAR=T-N   METHOD= 2 Q WTD C

TABULATION OF MISSING DAILY FLOWS:

Flow File =385226_q.wk1 , Station =Discharg
Daily Flows from 20030308 to 20030712

Summary:
Reported Flows = 127
Missing Flows = 0
Zero Flows = 7
Positive Flows = 120

385226 Northgate Inlet (2003)   VAR=T-N   METHOD= 2 Q WTD C

STRATIFICATION SCHEME:

STR	DATE >=MIN	DATE < MAX	SEASON >=MIN	SEASON < MAX	FLOW >=MIN	FLOW < MAX
1			0	0	.00	2.82
2			0	0	2.82	11.27
3			0	0	11.27	78.89

STR	SAMPLES	EVENTS	FLOWS	VOLUME %
1	11	11	79	9.07
2	10	10	37	29.25
3	3	3	11	61.68
EXCLUDED	0	0	0	.00
TOTAL	24	24	127	100.00

385226 Northgate Inlet (2003)   VAR=T-N   METHOD= 2 Q WTD C
COMPARISON OF SAMPLED AND TOTAL FLOW DISTRIBUTIONS

STR	NQ	NC	NE	VOL%	TOTAL FLOW	SAMPLED FLOW	C/Q SLOPE	SIGNIF
1	79	11	11	9.1	.822	1.199	-.164	.007
2	37	10	10	29.3	5.660	5.172	.134	.479
3	11	3	3	61.7	40.143	49.031	.801	.088
***	127	24	24	100.0	5.637	8.833		

FLOW STATISTICS
FLOW DURATION = 127.0 DAYS = .348 YEARS
MEAN FLOW RATE = 5.637 HM3/YR
TOTAL FLOW VOLUME = 1.96 HM3
FLOW DATE RANGE = 20030308 TO 20030712
SAMPLE DATE RANGE = 20030318 TO 20030623

METHOD	MASS (KG)	FLUX (KG/YR)	FLUX VARIANCE	CONC (PPB)	CV
1 AV LOAD	9000.0	25883.9	.1009E+09	4591.44	.388
2 Q WTD C	7582.1	21806.1	.4628E+07	3868.09	.099
3 IJC	7761.1	22320.7	.3484E+07	3959.38	.084
4 REG-1	6714.3	19310.2	.1070E+11	3425.36	5.357
5 REG-2	6655.4	19140.9	.1835E+12	3395.32	22.382
6 REG-3	6963.0	20025.4	.3563E+13	3552.23	94.266

385226 Northgate Inlet (2003) VAR=TD-P METHOD= 2 Q WTD C

TABULATION OF MISSING DAILY FLOWS:

Flow File =385226_q.wk1 , Station =Discharg
Daily Flows from 20030308 to 20030712

Summary:
Reported Flows = 127
Missing Flows = 0
Zero Flows = 7
Positive Flows = 120

385226 Northgate Inlet (2003) VAR=TD-P METHOD= 2 Q WTD C

STRATIFICATION SCHEME:

	---- DATE ----		-- SEASON --		-------- FLOW --------	
STR	>=MIN	< MAX	>=MIN	< MAX	>=MIN	< MAX
1			0	0	.00	2.82
2			0	0	2.82	11.27
3			0	0	11.27	78.89

STR	SAMPLES	EVENTS	FLOWS	VOLUME %
1	11	11	79	9.07
2	10	10	37	29.25
3	3	3	11	61.68
EXCLUDED	0	0	0	.00
TOTAL	24	24	127	100.00

385226 Northgate Inlet (2003) VAR=TD-P METHOD= 2 Q WTD C
COMPARISON OF SAMPLED AND TOTAL FLOW DISTRIBUTIONS

STR	NQ	NC	NE	VOL%	TOTAL FLOW	SAMPLED FLOW	C/Q SLOPE	SIGNIF
1	79	11	11	9.1	.822	1.199	-.360	.002
2	37	10	10	29.3	5.660	5.172	.371	.284
3	11	3	3	61.7	40.143	49.031	.982	.056
***	127	24	24	100.0	5.637	8.833		

FLOW STATISTICS
FLOW DURATION = 127.0 DAYS = .348 YEARS
MEAN FLOW RATE = 5.637 HM3/YR
TOTAL FLOW VOLUME = 1.96 HM3
FLOW DATE RANGE = 20030308 TO 20030712
SAMPLE DATE RANGE = 20030318 TO 20030623

METHOD	MASS (KG)	FLUX (KG/YR)	FLUX VARIANCE	CONC (PPB)	CV
1 AV LOAD	933.1	2683.4	.1191E+07	476.00	.407
2 Q WTD C	784.2	2255.4	.7528E+05	400.08	.122
3 IJC	806.1	2318.5	.5999E+05	411.26	.106
4 REG-1	679.3	1953.5	.1146E+07	346.53	.548
5 REG-2	670.3	1927.9	.3960E+05	341.97	.103
6 REG-3	708.3	2037.2	.5969E+05	361.37	.120

385226 Northgate Inlet (2003)   VAR=T-P   METHOD= 2 Q WTD C

TABULATION OF MISSING DAILY FLOWS:

Flow File =385226_q.wk1   ,   Station =Discharg
Daily Flows from 20030308 to 20030712

Summary:
Reported Flows = 127
Missing Flows =   0
Zero Flows =   7
Positive Flows = 120

385226 Northgate Inlet (2003)   VAR=T-P   METHOD= 2 Q WTD C

STRATIFICATION SCHEME:

	---- DATE ----		-- SEASON --		-------- FLOW --------	
STR	>=MIN	< MAX	>=MIN	< MAX	>=MIN	< MAX
1			0	0	.00	2.82
2			0	0	2.82	11.27
3			0	0	11.27	78.89

STR	SAMPLES	EVENTS	FLOWS	VOLUME %
1	11	11	79	9.07
2	10	10	37	29.25
3	3	3	11	61.68
EXCLUDED	0	0	0	.00
TOTAL	24	24	127	100.00

385226 Northgate Inlet (2003)   VAR=T-P   METHOD= 2 Q WTD C
COMPARISON OF SAMPLED AND TOTAL FLOW DISTRIBUTIONS

STR	NQ	NC	NE	VOL%	TOTAL FLOW	SAMPLED FLOW	C/Q SLOPE	SIGNIF
1	79	11	11	9.1	.822	1.199	-.383	.001
2	37	10	10	29.3	5.660	5.172	.392	.229
3	11	3	3	61.7	40.143	49.031	1.096	.095
***	127	24	24	100.0	5.637	8.833		

FLOW STATISTICS
FLOW DURATION =   127.0 DAYS =   .348 YEARS
MEAN FLOW RATE =   5.637 HM3/YR
TOTAL FLOW VOLUME =   1.96 HM3
FLOW DATE RANGE   = 20030308 TO 20030712
SAMPLE DATE RANGE = 20030318 TO 20030623

METHOD	MASS (KG)	FLUX (KG/YR)	FLUX VARIANCE	CONC (PPB)	CV
1 AV LOAD	1274.0	3664.0	.2553E+07	649.94	.436
2 Q WTD C	1067.7	3070.8	.2958E+06	544.71	.177
3 IJC	1100.8	3165.9	.3036E+06	561.59	.174
4 REG-1	901.9	2593.9	.2696E+07	460.11	.633
5 REG-2	889.8	2559.0	.6252E+06	453.92	.309
6 REG-3	955.9	2749.3	.2090E+06	487.68	.166

385226 Northgate Inlet (2003)   VAR=TSS   METHOD= 2 Q WTD C

TABULATION OF MISSING DAILY FLOWS:

Flow File =385226_q.wk1 , Station =Discharg
Daily Flows from 20030308 to 20030712

Summary:
Reported Flows = 127
Missing Flows = 0
Zero Flows = 7
Positive Flows = 120

385226 Northgate Inlet (2003)   VAR=TSS   METHOD= 2 Q WTD C

STRATIFICATION SCHEME:

	---- DATE ----		-- SEASON --		-------- FLOW --------	
STR	>=MIN	< MAX	>=MIN	< MAX	>=MIN	< MAX
1			0	0	.00	2.82
2			0	0	2.82	11.27
3			0	0	11.27	78.89

STR	SAMPLES	EVENTS	FLOWS	VOLUME %
1	11	11	79	9.07
2	10	10	37	29.25
3	3	3	11	61.68
EXCLUDED	0	0	0	.00
TOTAL	24	24	127	100.00

385226 Northgate Inlet (2003)   VAR=TSS   METHOD= 2 Q WTD C
COMPARISON OF SAMPLED AND TOTAL FLOW DISTRIBUTIONS

STR	NQ	NC	NE	VOL%	TOTAL FLOW	SAMPLED FLOW	C/Q SLOPE	SIGNIF
1	79	11	11	9.1	.822	1.199	-.158	.040
2	37	10	10	29.3	5.660	5.172	-.544	.346
3	11	3	3	61.7	40.143	49.031	.245	.649
***	127	24	24	100.0	5.637	8.833		

FLOW STATISTICS
FLOW DURATION = 127.0 DAYS = .348 YEARS
MEAN FLOW RATE = 5.637 HM3/YR
TOTAL FLOW VOLUME = 1.96 HM3
FLOW DATE RANGE = 20030308 TO 20030712
SAMPLE DATE RANGE = 20030318 TO 20030623

METHOD	MASS (KG)	FLUX (KG/YR)	FLUX VARIANCE	CONC (PPB)	CV
1 AV LOAD	17183.9	49420.6	.3163E+09	8766.51	.360
2 Q WTD C	14937.2	42959.2	.1203E+09	7620.36	.255
3 IJC	15045.3	43270.0	.1499E+09	7675.49	.283
4 REG-1	14350.0	41270.5	.4084E+09	7320.80	.490
5 REG-2	14270.1	41040.6	.2180E+09	7280.01	.360
6 REG-3	15039.4	43253.1	.1144E+09	7672.49	.247

Northgate Outlet 2003 (2 strats) VAR=NH3-4   METHOD= 2 Q WTD C

TABULATION OF MISSING DAILY FLOWS:

Flow File =385227_q.wk1 , Station =Discharg
Daily Flows from 20030314 to 20030610

Summary:

Reported Flows = 89
Missing Flows = 0
Zero Flows = 23
Positive Flows = 66

Northgate Outlet 2003 (2 strats) VAR=NH3-4 METHOD= 2 Q WTD C

STRATIFICATION SCHEME:

STR	DATE >=MIN	DATE < MAX	SEASON >=MIN	SEASON < MAX	FLOW >=MIN	FLOW < MAX
1			0	0	.00	8.48
2			0	0	8.48	160.15

STR	SAMPLES	EVENTS	FLOWS	VOLUME %
1	15	15	76	3.43
2	4	4	13	96.57
EXCLUDED	0	0	0	.00
TOTAL	19	19	89	100.00

Northgate Outlet 2003 (3 strats) VAR=NH3-4 METHOD= 2 Q WTD C
COMPARISON OF SAMPLED AND TOTAL FLOW DISTRIBUTIONS

STR	NQ	NC	NE	VOL%	TOTAL FLOW	SAMPLED FLOW	C/Q SLOPE	SIGNIF
1	76	15	15	3.4	.340	.422	-.027	.855
2	13	4	4	96.6	56.038	80.651	.877	.454
***	89	19	19	100.0	8.476	17.312		

FLOW STATISTICS
FLOW DURATION = 89.0 DAYS = .244 YEARS
MEAN FLOW RATE = 8.476 HM3/YR
TOTAL FLOW VOLUME = 2.07 HM3
FLOW DATE RANGE = 20030314 TO 20030610
SAMPLE DATE RANGE = 20030318 TO 20030521

METHOD	MASS (KG)	FLUX (KG/YR)	FLUX VARIANCE	CONC (PPB)	CV
1 AV LOAD	2243.3	9206.4	.2378E+08	1086.16	.530
2 Q WTD C	1559.5	6400.0	.1434E+07	755.06	.187
3 IJC	1630.9	6693.3	.6426E+06	789.66	.120
4 REG-1	1134.7	4656.8	.8962E+07	549.40	.643
5 REG-2	1168.0	4793.2	.5516E+07	565.50	.490
6 REG-3	3053.9	12532.8	.5048E+09	1478.61	1.793

Northgate Outlet 2003 (3 strats) VAR=NH3-4 METHOD= 2 Q WTD C

TABULATION OF MISSING DAILY FLOWS:

Flow File =385227_q.wk1 , Station =Discharg
Daily Flows from 20030314 to 20030610

Summary:
Reported Flows = 89
Missing Flows = 0
Zero Flows = 23
Positive Flows = 66

Northgate Outlet 2003 (3 strats) VAR=NH3-4 METHOD= 2 Q WTD C

STRATIFICATION SCHEME:

STR	DATE >=MIN	DATE < MAX	SEASON >=MIN	SEASON < MAX	FLOW >=MIN	FLOW < MAX
1			0	0	.00	8.48

2			0	0	8.48	160.15

STR	SAMPLES	EVENTS	FLOWS	VOLUME %
1	15	15	76	3.43
2	4	4	13	96.57
EXCLUDED	0	0	0	.00
TOTAL	19	19	89	100.00

Northgate Outlet 2003 (3 strats) VAR=NH3-4 METHOD= 2 Q WTD C

COMPARISON OF SAMPLED AND TOTAL FLOW DISTRIBUTIONS

STR	NQ	NC	NE	VOL%	TOTAL FLOW	SAMPLED FLOW	C/Q SLOPE	SIGNIF
1	76	15	15	3.4	.340	.422	-.027	.855
2	13	4	4	96.6	56.038	80.651	.877	.454
***	89	19	19	100.0	8.476	17.312		

FLOW STATISTICS
FLOW DURATION = 89.0 DAYS = .244 YEARS
MEAN FLOW RATE = 8.476 HM3/YR
TOTAL FLOW VOLUME = 2.07 HM3
FLOW DATE RANGE = 20030314 TO 20030610
SAMPLE DATE RANGE = 20030318 TO 20030521

METHOD	MASS (KG)	FLUX (KG/YR)	FLUX VARIANCE	CONC (PPB)	CV
1 AV LOAD	2243.3	9206.4	.2378E+08	1086.16	.530
2 Q WTD C	1559.5	6400.0	.1434E+07	755.06	.187
3 IJC	1630.9	6693.3	.6426E+06	789.66	.120
4 REG-1	1134.7	4656.8	.8962E+07	549.40	.643
5 REG-2	1168.0	4793.2	.5516E+07	565.50	.490
6 REG-3	3053.9	12532.8	.5048E+09	1478.61	1.793

Northgate Outlet 2003 (3 strats) VAR=NO2+NO3 METHOD= 2 Q WTD C

TABULATION OF MISSING DAILY FLOWS:

Flow File =385227_q.wk1 , Station =Discharg
Daily Flows from 20030314 to 20030610

Summary:
Reported Flows = 89
Missing Flows = 0
Zero Flows = 23
Positive Flows = 66

Northgate Outlet 2003 (3 strats) VAR=NO2+NO3 METHOD= 2 Q WTD C

STRATIFICATION SCHEME:

	---- DATE ----		-- SEASON --		-------- FLOW --------	
STR	>=MIN	< MAX	>=MIN	< MAX	>=MIN	< MAX
1			0	0	.00	8.48
2			0	0	8.48	160.15

STR	SAMPLES	EVENTS	FLOWS	VOLUME %
1	15	15	76	3.43
2	4	4	13	96.57
EXCLUDED	0	0	0	.00
TOTAL	19	19	89	100.00

Northgate Outlet 2003 (3 strats) VAR=NO2+NO3 METHOD= 2 Q WTD C

COMPARISON OF SAMPLED AND TOTAL FLOW DISTRIBUTIONS

STR	NQ	NC	NE	VOL%	TOTAL FLOW	SAMPLED FLOW	C/Q SLOPE	SIGNIF
1	76	15	15	3.4	.340	.422	-.218	.158
2	13	4	4	96.6	56.038	80.651	.389	.236
***	89	19	19	100.0	8.476	17.312		

FLOW STATISTICS
FLOW DURATION = 89.0 DAYS = .244 YEARS
MEAN FLOW RATE = 8.476 HM3/YR
TOTAL FLOW VOLUME = 2.07 HM3
FLOW DATE RANGE = 20030314 TO 20030610
SAMPLE DATE RANGE = 20030318 TO 20030521

METHOD	MASS (KG)	FLUX (KG/YR)	FLUX VARIANCE	CONC (PPB)	CV
1 AV LOAD	2868.4	11771.6	.3078E+08	1388.80	.471
2 Q WTD C	1994.0	8183.4	.1097E+07	965.46	.128
3 IJC	2050.6	8415.4	.6553E+06	992.84	.096
4 REG-1	1731.9	7107.5	.2733E+07	838.54	.233
5 REG-2	1751.7	7189.0	.1329E+07	848.15	.160
6 REG-3	1821.2	7474.3	.1443E+07	881.80	.161

Northgate Outlet 2003 (3 strats) VAR=T-INOR-N METHOD= 2 Q WTD C

TABULATION OF MISSING DAILY FLOWS:

Flow File =385227_q.wk1 , Station =Discharg
Daily Flows from 20030314 to 20030610

Summary:
Reported Flows = 89
Missing Flows = 0
Zero Flows = 23
Positive Flows = 66

Northgate Outlet 2003 (3 strats) VAR=T-INOR-N METHOD= 2 Q WTD C

STRATIFICATION SCHEME:

	---- DATE ----		-- SEASON --		-------- FLOW --------	
STR	>=MIN	< MAX	>=MIN	< MAX	>=MIN	< MAX
1			0	0	.00	8.48
2			0	0	8.48	160.15

STR	SAMPLES	EVENTS	FLOWS	VOLUME %
1	15	15	76	3.43
2	4	4	13	96.57
EXCLUDED	0	0	0	.00
TOTAL	19	19	89	100.00

Northgate Outlet 2003 (3 strats) VAR=T-INOR-N METHOD= 2 Q WTD C
COMPARISON OF SAMPLED AND TOTAL FLOW DISTRIBUTIONS

STR	NQ	NC	NE	VOL%	TOTAL FLOW	SAMPLED FLOW	C/Q SLOPE	SIGNIF
1	76	15	15	3.4	.340	.422	-.142	.287
2	13	4	4	96.6	56.038	80.651	.522	.311
***	89	19	19	100.0	8.476	17.312		

FLOW STATISTICS
FLOW DURATION = 89.0 DAYS = .244 YEARS
MEAN FLOW RATE = 8.476 HM3/YR
TOTAL FLOW VOLUME = 2.07 HM3
FLOW DATE RANGE = 20030314 TO 20030610
SAMPLE DATE RANGE = 20030318 TO 20030521

METHOD	MASS (KG)	FLUX (KG/YR)	FLUX VARIANCE	CONC (PPB)	CV
1 AV LOAD	5111.7	20978.1	.1086E+09	2474.96	.497
2 Q WTD C	3553.5	14583.3	.4990E+07	1720.52	.153
3 IJC	3681.5	15108.7	.2548E+07	1782.50	.106
4 REG-1	2941.1	12070.2	.1741E+08	1424.03	.346
5 REG-2	2989.6	12269.2	.8185E+07	1447.50	.233
6 REG-3	3401.9	13961.0	.1407E+08	1647.10	.269

Northgate Outlet 2003 (3 strats) VAR=TN   METHOD= 2 Q WTD C

TABULATION OF MISSING DAILY FLOWS:

Flow File =385227_q.wk1   ,   Station =Discharg
Daily Flows from 20030314 to 20030610

Summary:
Reported Flows =   89
Missing Flows =   0
Zero Flows =   23
Positive Flows =   66

Northgate Outlet 2003 (3 strats) VAR=TN   METHOD= 2 Q WTD C

STRATIFICATION SCHEME:

	---- DATE ----		-- SEASON --		-------- FLOW --------	
STR	>=MIN	< MAX	>=MIN	< MAX	>=MIN	< MAX
1			0	0	.00	8.48
2			0	0	8.48	160.15

STR	SAMPLES	EVENTS	FLOWS	VOLUME %
1	15	15	76	3.43
2	4	4	13	96.57
EXCLUDED	0	0	0	.00
TOTAL	19	19	89	100.00

Northgate Outlet 2003 (3 strats) VAR=TN   METHOD= 2 Q WTD C
COMPARISON OF SAMPLED AND TOTAL FLOW DISTRIBUTIONS

STR	NQ	NC	NE	VOL%	TOTAL FLOW	SAMPLED FLOW	C/Q SLOPE	SIGNIF
1	76	15	15	3.4	.340	.422	.050	.012
2	13	4	4	96.6	56.038	80.651	.327	.242
***	89	19	19	100.0	8.476	17.312		

FLOW STATISTICS
FLOW DURATION =   89.0 DAYS =   .244 YEARS
MEAN FLOW RATE =   8.476 HM3/YR
TOTAL FLOW VOLUME =   2.07 HM3
FLOW DATE RANGE   = 20030314 TO 20030610
SAMPLE DATE RANGE = 20030318 TO 20030521

METHOD	MASS (KG)	FLUX (KG/YR)	FLUX VARIANCE	CONC (PPB)	CV
1 AV LOAD	10585.8	43443.3	.3964E+09	5125.37	.458
2 Q WTD C	7378.0	30278.7	.9443E+07	3572.23	.101
3 IJC	7589.0	31144.7	.3520E+07	3674.41	.060
4 REG-1	6565.4	26943.8	.2602E+08	3178.79	.189
5 REG-2	6635.9	27233.4	.1065E+08	3212.96	.120
6 REG-3	6771.1	27788.2	.9391E+07	3278.41	.110

Northgate Outlet 2003 (3 strats) VAR=TN   METHOD= 2 Q WTD C

```
TABULATION OF MISSING DAILY FLOWS:

Flow File =385227_q.wk1                    ,   Station =Discharg
Daily Flows from 20030314 to 20030610

Summary:
Reported Flows =   89
Missing Flows =     0
Zero Flows =       23
Positive Flows =   66

Northgate Outlet 2003 (3 strats)  VAR=TN        METHOD= 2 Q WTD C

STRATIFICATION SCHEME:
       ---- DATE ----   -- SEASON --  -------- FLOW --------
STR    >=MIN    < MAX  >=MIN  < MAX       >=MIN       < MAX
  1                       0      0          .00        8.48
  2                       0      0         8.48      160.15

STR   SAMPLES    EVENTS     FLOWS  VOLUME %
  1        15        15        76      3.43
  2         4         4        13     96.57
EXCLUDED    0         0         0       .00
   TOTAL   19        19        89    100.00


Northgate Outlet 2003 (3 strats)  VAR=TN        METHOD= 2 Q WTD C
COMPARISON OF SAMPLED AND TOTAL FLOW DISTRIBUTIONS
STR       NQ  NC  NE  VOL%   TOTAL FLOW SAMPLED FLOW   C/Q SLOPE SIGNIF
 1        76  15  15   3.4         .340         .422        .050   .012
 2        13   4   4  96.6       56.038       80.651        .327   .242
***       89  19  19 100.0        8.476       17.312

FLOW STATISTICS
FLOW DURATION =      89.0 DAYS  =   .244 YEARS
MEAN FLOW RATE =     8.476 HM3/YR
TOTAL FLOW VOLUME =       2.07 HM3
FLOW DATE RANGE   = 20030314 TO 20030610
SAMPLE DATE RANGE = 20030318 TO 20030521

METHOD          MASS (KG)   FLUX (KG/YR)  FLUX VARIANCE CONC (PPB)      CV
1 AV LOAD         10585.8        43443.3      .3964E+09    5125.37    .458
2 Q WTD C          7378.0        30278.7      .9443E+07    3572.23    .101
3 IJC              7589.0        31144.7      .3520E+07    3674.41    .060
4 REG-1            6565.4        26943.8      .2602E+08    3178.79    .189
5 REG-2            6635.9        27233.4      .1065E+08    3212.96    .120
6 REG-3            6771.1        27788.2      .9391E+07    3278.41    .110

Northgate Outlet 2003 (3 strats)  VAR=TDP       METHOD= 2 Q WTD C

TABULATION OF MISSING DAILY FLOWS:

Flow File =385227_q.wk1                    ,   Station =Discharg
Daily Flows from 20030314 to 20030610

Summary:
Reported Flows =   89
Missing Flows =     0
Zero Flows =       23
Positive Flows =   66
```

Northgate Outlet 2003 (3 strats) VAR=TDP   METHOD= 2 Q WTD C

STRATIFICATION SCHEME:

	---- DATE ----		-- SEASON --		-------- FLOW --------	
STR	>=MIN	< MAX	>=MIN	< MAX	>=MIN	< MAX
1			0	0	.00	8.48
2			0	0	8.48	160.15

STR	SAMPLES	EVENTS	FLOWS	VOLUME %
1	15	15	76	3.43
2	4	4	13	96.57
EXCLUDED	0	0	0	.00
TOTAL	19	19	89	100.00

Northgate Outlet 2003 (3 strats) VAR=TDP   METHOD= 2 Q WTD C

COMPARISON OF SAMPLED AND TOTAL FLOW DISTRIBUTIONS

STR	NQ	NC	NE	VOL%	TOTAL FLOW	SAMPLED FLOW	C/Q SLOPE	SIGNIF
1	76	15	15	3.4	.340	.422	.052	.112
2	13	4	4	96.6	56.038	80.651	.242	.448
***	89	19	19	100.0	8.476	17.312		

FLOW STATISTICS
FLOW DURATION =   89.0 DAYS =   .244 YEARS
MEAN FLOW RATE =   8.476 HM3/YR
TOTAL FLOW VOLUME =   2.07 HM3
FLOW DATE RANGE   = 20030314 TO 20030610
SAMPLE DATE RANGE = 20030318 TO 20030521

METHOD	MASS (KG)	FLUX (KG/YR)	FLUX VARIANCE	CONC (PPB)	CV
1 AV LOAD	1108.7	4549.9	.4023E+07	536.79	.441
2 Q WTD C	773.2	3173.2	.1330E+06	374.37	.115
3 IJC	789.8	3241.2	.1011E+06	382.39	.098
4 REG-1	709.5	2911.8	.4673E+06	343.53	.235
5 REG-2	715.2	2935.3	.2504E+06	346.30	.170
6 REG-3	743.6	3051.5	.2904E+06	360.01	.177

Northgate Outlet 2003 (3 strats) VAR=TDP   METHOD= 2 Q WTD C

COMPARISON OF SAMPLED AND TOTAL FLOW DISTRIBUTIONS

STR	NQ	NC	NE	VOL%	TOTAL FLOW	SAMPLED FLOW	C/Q SLOPE	SIGNIF
1	76	15	15	3.4	.340	.422	.052	.112
2	13	4	4	96.6	56.038	80.651	.242	.448
***	89	19	19	100.0	8.476	17.312		

FLOW STATISTICS
FLOW DURATION =   89.0 DAYS =   .244 YEARS
MEAN FLOW RATE =   8.476 HM3/YR
TOTAL FLOW VOLUME =   2.07 HM3
FLOW DATE RANGE   = 20030314 TO 20030610
SAMPLE DATE RANGE = 20030318 TO 20030521

METHOD	MASS (KG)	FLUX (KG/YR)	FLUX VARIANCE	CONC (PPB)	CV
1 AV LOAD	1108.7	4549.9	.4023E+07	536.79	.441
2 Q WTD C	773.2	3173.2	.1330E+06	374.37	.115
3 IJC	789.8	3241.2	.1011E+06	382.39	.098
4 REG-1	709.5	2911.8	.4673E+06	343.53	.235
5 REG-2	715.2	2935.3	.2504E+06	346.30	.170
6 REG-3	743.6	3051.5	.2904E+06	360.01	.177

Northgate Outlet 2003 (3 strats) VAR=TP   METHOD= 2 Q WTD C

TABULATION OF MISSING DAILY FLOWS:

Flow File =385227_q.wk1 , Station =Discharg
Daily Flows from 20030314 to 20030610

Summary:
Reported Flows = 89
Missing Flows = 0
Zero Flows = 23
Positive Flows = 66

Northgate Outlet 2003 (3 strats) VAR=TP METHOD= 2 Q WTD C

STRATIFICATION SCHEME:

	---- DATE ----		-- SEASON --		-------- FLOW --------	
STR	>=MIN	< MAX	>=MIN	< MAX	>=MIN	< MAX
1			0	0	.00	8.48
2			0	0	8.48	160.15

STR	SAMPLES	EVENTS	FLOWS	VOLUME %
1	15	15	76	3.43
2	4	4	13	96.57
EXCLUDED	0	0	0	.00
TOTAL	19	19	89	100.00

Northgate Outlet 2003 (3 strats) VAR=TP METHOD= 2 Q WTD C
COMPARISON OF SAMPLED AND TOTAL FLOW DISTRIBUTIONS

STR	NQ	NC	NE	VOL%	TOTAL FLOW	SAMPLED FLOW	C/Q SLOPE	SIGNIF
1	76	15	15	3.4	.340	.422	-.001	.976
2	13	4	4	96.6	56.038	80.651	.275	.275
***	89	19	19	100.0	8.476	17.312		

FLOW STATISTICS
FLOW DURATION = 89.0 DAYS = .244 YEARS
MEAN FLOW RATE = 8.476 HM3/YR
TOTAL FLOW VOLUME = 2.07 HM3
FLOW DATE RANGE = 20030314 TO 20030610
SAMPLE DATE RANGE = 20030318 TO 20030521

METHOD	MASS (KG)	FLUX (KG/YR)	FLUX VARIANCE	CONC (PPB)	CV
1 AV LOAD	1463.6	6006.4	.7206E+07	708.63	.447
2 Q WTD C	1020.5	4187.9	.1429E+06	494.08	.090
3 IJC	1046.4	4294.5	.5207E+05	506.66	.053
4 REG-1	925.8	3799.4	.4372E+06	448.25	.174
5 REG-2	933.3	3830.3	.1894E+06	451.89	.114
6 REG-3	945.4	3880.0	.1705E+06	457.75	.106

Northgate Outlet 2003 (3 strats) VAR=TSS METHOD= 2 Q WTD C

TABULATION OF MISSING DAILY FLOWS:

Flow File =385227_q.wk1 , Station =Discharg
Daily Flows from 20030314 to 20030610

Summary:
Reported Flows = 89
Missing Flows = 0
Zero Flows = 23
Positive Flows = 66

Northgate Outlet 2003 (3 strats) VAR=TSS METHOD= 2 Q WTD C

STRATIFICATION SCHEME:

	---- DATE ----		-- SEASON --		-------- FLOW --------	
STR	>=MIN	< MAX	>=MIN	< MAX	>=MIN	< MAX
1			0	0	.00	8.48
2			0	0	8.48	160.15

STR	SAMPLES	EVENTS	FLOWS	VOLUME %
1	15	15	76	3.43
2	4	4	13	96.57
EXCLUDED	0	0	0	.00
TOTAL	19	19	89	100.00

Northgate Outlet 2003 (3 strats) VAR=TSS METHOD= 2 Q WTD C

COMPARISON OF SAMPLED AND TOTAL FLOW DISTRIBUTIONS

STR	NQ	NC	NE	VOL%	TOTAL FLOW	SAMPLED FLOW	C/Q SLOPE	SIGNIF
1	76	15	15	3.4	.340	.422	-.197	.086
2	13	4	4	96.6	56.038	80.651	.180	.613
***	89	19	19	100.0	8.476	17.312		

FLOW STATISTICS
FLOW DURATION = 89.0 DAYS = .244 YEARS
MEAN FLOW RATE = 8.476 HM3/YR
TOTAL FLOW VOLUME = 2.07 HM3
FLOW DATE RANGE = 20030314 TO 20030610
SAMPLE DATE RANGE = 20030318 TO 20030521

METHOD	MASS (KG)	FLUX (KG/YR)	FLUX VARIANCE	CONC (PPB)	CV
1 AV LOAD	27861.6	114342.2	.2172E+10	13489.93	.408
2 Q WTD C	19464.2	79879.7	.2030E+09	9424.09	.178
3 IJC	19575.5	80336.5	.2667E+09	9477.99	.203
4 REG-1	18312.6	75153.9	.4815E+09	8866.55	.292
5 REG-2	18269.9	74978.5	.3452E+09	8845.86	.248
6 REG-3	20410.4	83763.0	.5560E+09	9882.24	.282

CASE: Northgate Less 25% Nutrients
HYDRAULIC AND DISPERSION PARAMETERS:

		NET INFLOW	RESIDENCE TIME	OVERFLOW RATE	MEAN VELOCITY	----DISPERSION----- ESTIMATED	NUMERIC	EXCHANGE RATE
SEG	OUT	HM3/YR	YRS	M/YR	KM/YR	KM2/YR	KM2/YR	HM3/YR
1	0	2.24	.73727	3.7	3.7	0.	5.	0.

CASE: Northgate Less 25% Nutrients
GROSS WATER BALANCE:

ID	T	LOCATION	DRAINAGE AREA KM2	---- FLOW (HM3/YR) ---- MEAN	VARIANCE	CV	RUNOFF M/YR
1	1	385226	262.240	1.960	.000E+00	.000	.007
2	1	Ungauged Shed	29.140	.190	.000E+00	.000	.007
3	4	385227 (Outlet)	291.990	2.070	.000E+00	.000	.007
PRECIPITATION			.610	.244	.238E-02	.200	.400
TRIBUTARY INFLOW			291.380	2.150	.000E+00	.000	.007
***TOTAL INFLOW			291.990	2.394	.238E-02	.020	.008
GAUGED OUTFLOW			291.990	2.070	.000E+00	.000	.007
ADVECTIVE OUTFLOW			.000	-.012	.448E-02	5.799	-40.539
***TOTAL OUTFLOW			291.990	2.058	.448E-02	.033	.007
***EVAPORATION			.000	.153	.209E-02	.300	.000
***STORAGE INCREASE			.000	.183	.000E+00	.000	.000

GROSS MASS BALANCE BASED UPON OBSERVED CONCENTRATIONS

COMPONENT: TOTAL P

ID	T	LOCATION	LOADING KG/YR	LOADING %(I)	VARIANCE KG/YR**2	VARIANCE %(I)	CV	CONC MG/M3	EXPORT KG/KM2
1	1	385226	1297.5	89.4	.450E+05	98.7	.164	662.0	4.9
2	1	Ungauged Shed	125.8	8.7	.423E+03	.9	.164	662.0	4.3
3	4	385227 (Outlet)	1048.8	72.3	.309E+04	6.8	.053	506.7	3.6
		PRECIPITATION	27.4	1.9	.187E+03	.4	.500	112.1	44.9
		TRIBUTARY INFLOW	1423.3	98.1	.455E+05	99.6	.150	662.0	4.9
		***TOTAL INFLOW	1450.7	100.0	.456E+05	100.0	.147	605.9	5.0
		GAUGED OUTFLOW	1012.2	69.8	.000E+00	.0	.000	489.0	3.5
		ADVECTIVE OUTFLOW	-5.6	-.4	.107E+04	2.3	5.799	489.0	-19823.7
		***TOTAL OUTFLOW	1006.6	69.4	.107E+04	2.3	.033	489.0	3.4
		***STORAGE INCREASE	67.5	4.7	.268E+03	.6	.242	368.6	.0
		***RETENTION	376.6	26.0	.426E+05	93.4	.548	.0	.0

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 -
3.67	.7373	489.0	.5571	1.7951	.2596

GROSS MASS BALANCE BASED UPON OBSERVED 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	385226	5820.4	83.2	.239E+06	71.5	.084	2969.6	22.2
2	1	Ungauged Shed	564.2	8.1	.225E+04	.7	.084	2969.6	19.4
3	4	385227 (Outlet)	7606.0	108.7	.208E+06	62.3	.060	3674.4	26.0
		PRECIPITATION	610.3	8.7	.931E+05	27.8	.500	2500.0	1000.0
		TRIBUTARY INFLOW	6384.6	91.3	.241E+06	72.2	.077	2969.6	21.9
		***TOTAL INFLOW	6994.9	100.0	.334E+06	100.0	.083	2921.7	24.0
		GAUGED OUTFLOW	3591.4	51.3	.000E+00	.0	.000	1735.0	12.3
		ADVECTIVE OUTFLOW	-20.0	-.3	.135E+05	4.0	5.799	1735.0	-70335.8
		***TOTAL OUTFLOW	3571.4	51.1	.135E+05	4.0	.033	1735.0	12.2
		***STORAGE INCREASE	267.8	3.8	.284E+04	.8	.199	1462.9	.0
		***RETENTION	3155.7	45.1	.333E+06	99.7	.183	.0	.0

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 -
3.67	.7373	1735.0	.4099	2.4396	.4511

CASE: Northgate Less 25% Nutrients

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

SEGMENT: 1 Northgate Dam

VARIABLE		----- VALUES ----- OBSERVED	ESTIMATED	--- RANKS (%) ---- OBSERVED	ESTIMATED
TOTAL P	MG/M3	489.00	368.63	99.5	98.8
TOTAL N	MG/M3	1735.00	1462.87	80.5	72.3
C.NUTRIENT	MG/M3	127.51	104.88	94.4	91.1
CHL-A	MG/M3	20.17	16.27	84.0	76.2
SECCHI	M	1.40	1.70	63.4	72.4
ORGANIC N	MG/M3	1593.00	1359.19	99.1	98.1
TP-ORTHO-P	MG/M3	65.00	51.47	79.2	71.5
ANTILOG PC-1		1073.19	733.17	87.0	79.9
ANTILOG PC-2		12.16	12.11	88.7	88.6
(N - 150) / P		3.24	3.56	.7	1.1
INORGANIC N / P		.33	.33	.0	.0
TURBIDITY	1/M	.10	.10	2.0	2.0
ZMIX * TURBIDITY		.27	.27	.1	.1
ZMIX / SECCHI		1.93	1.60	6.0	3.0
CHL-A * SECCHI		28.24	27.61	92.5	92.0
CHL-A / TOTAL P		.04	.04	.7	1.0
FREQ(CHL-a>10) %		79.44	68.27	.0	.0
FREQ(CHL-a>20) %		38.34	26.02	.0	.0
FREQ(CHL-a>30) %		17.09	9.73	.0	.0
FREQ(CHL-a>40) %		7.86	3.91	.0	.0
FREQ(CHL-a>50) %		3.80	1.70	.0	.0
FREQ(CHL-a>60) %		1.93	.79	.0	.0
CARLSON TSI-P		93.44	89.37	.0	.0
CARLSON TSI-CHLA		60.07	57.96	.0	.0
CARLSON TSI-SEC		55.15	52.38	.0	.0

Northgate Less 25% Nutrients

SEGMENT NETWORK: FLOWS IN HM3/YR

*************** SEGMENT:	1 Northgate Dam	INFLOW	OUTFLOW	EXCHANGE
PRECIP AND EVAPORATION:		.24	.15	
INCREASE IN STORAGE:			.18	
EXTERNAL INFLOW:	1 385226	1.96		
EXTERNAL INFLOW:	2 Ungauged Shed	.19		
OUTFLOW / WITHDRAWAL:	3 385227 (Outlet)		2.07	
DISCHARGE OUT OF SYSTEM:			-.01	

CASE: Northgate Less 50% Nutrients

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	2.24	.73727	3.7	3.7	0.	5.	0.

CASE: Northgate Less 50% Nutrients

GROSS WATER BALANCE:

ID	T	LOCATION	DRAINAGE AREA KM2	---- FLOW (HM3/YR) ---- MEAN	VARIANCE	CV	RUNOFF M/YR
1	1	385226	262.240	1.960	.000E+00	.000	.007
2	1	Ungauged Shed	29.140	.190	.000E+00	.000	.007
3	4	385227 (Outlet)	291.990	2.070	.000E+00	.000	.007
PRECIPITATION			.610	.244	.238E-02	.200	.400
TRIBUTARY INFLOW			291.380	2.150	.000E+00	.000	.007
***TOTAL INFLOW			291.990	2.394	.238E-02	.020	.008
GAUGED OUTFLOW			291.990	2.070	.000E+00	.000	.007
ADVECTIVE OUTFLOW			.000	-.012	.448E-02	5.799	-40.539

***TOTAL OUTFLOW	291.990	2.058	.448E-02	.033	.007
***EVAPORATION	.000	.153	.209E-02	.300	.000
***STORAGE INCREASE	.000	.183	.000E+00	.000	.000

GROSS MASS BALANCE BASED UPON OBSERVED CONCENTRATIONS

COMPONENT: TOTAL P

ID	T	LOCATION	LOADING KG/YR	LOADING %(I)	VARIANCE KG/YR**2	VARIANCE %(I)	CV	CONC MG/M3	EXPORT KG/KM2
1	1	385226	865.0	88.6	.200E+05	98.2	.164	441.3	3.3
2	1	Ungauged Shed	83.8	8.6	.188E+03	.9	.164	441.3	2.9
3	4	385227 (Outlet)	1048.8	107.4	.309E+04	15.2	.053	506.7	3.6
		PRECIPITATION	27.4	2.8	.187E+03	.9	.500	112.1	44.9
		TRIBUTARY INFLOW	948.8	97.2	.202E+05	99.1	.150	441.3	3.3
		***TOTAL INFLOW	976.2	100.0	.204E+05	100.0	.146	407.7	3.3
		GAUGED OUTFLOW	1012.2	103.7	.000E+00	.0	.000	489.0	3.5
		ADVECTIVE OUTFLOW	-5.6	-.6	.107E+04	5.3	5.799	489.0	-19823.7
		***TOTAL OUTFLOW	1006.6	103.1	.107E+04	5.3	.033	489.0	3.4
		***STORAGE INCREASE	45.4	4.7	.121E+03	.6	.242	248.1	.0
		***RETENTION	-75.8	-7.8	.196E+05	96.2	1.847	.0	.0

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 -
3.67	.7373	489.0	.8278	1.2080	-.0777

GROSS MASS BALANCE BASED UPON OBSERVED 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	385226	3880.2	79.7	.106E+06	53.0	.084	1979.7	14.8
2	1	Ungauged Shed	376.1	7.7	.998E+03	.5	.084	1979.7	12.9
3	4	385227 (Outlet)	7606.0	156.3	.208E+06	104.0	.060	3674.4	26.0
		PRECIPITATION	610.3	12.5	.931E+05	46.5	.500	2500.0	1000.0
		TRIBUTARY INFLOW	4256.4	87.5	.107E+06	53.5	.077	1979.7	14.6
		***TOTAL INFLOW	4866.6	100.0	.200E+06	100.0	.092	2032.8	16.7
		GAUGED OUTFLOW	3591.4	73.8	.000E+00	.0	.000	1735.0	12.3
		ADVECTIVE OUTFLOW	-20.0	-.4	.135E+05	6.7	5.799	1735.0	-70335.8
		***TOTAL OUTFLOW	3571.4	73.4	.135E+05	6.7	.033	1735.0	12.2
		***STORAGE INCREASE	210.3	4.3	.156E+04	.8	.188	1148.8	.0
		***RETENTION	1084.9	22.3	.203E+06	101.4	.415	.0	.0

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 -
3.67	.7373	1735.0	.5892	1.6973	.2229

CASE: Northgate Less 50% Nutrients

OBSERVED AND PREDICTED DIAGNOSTIC VARIABLES

RANKED AGAINST CE MODEL DEVELOPMENT DATA SET

SEGMENT: 1 Northgate Dam

VARIABLE		VALUES OBSERVED	VALUES ESTIMATED	RANKS (%) OBSERVED	RANKS (%) ESTIMATED
TOTAL P	MG/M3	489.00	248.06	99.5	96.6
TOTAL N	MG/M3	1735.00	1148.82	80.5	58.5
C.NUTRIENT	MG/M3	127.51	78.91	94.4	83.9
CHL-A	MG/M3	20.17	11.89	84.0	62.1
SECCHI	M	1.40	2.16	63.4	82.0
ORGANIC N	MG/M3	1593.00	1105.85	99.1	95.2
TP-ORTHO-P	MG/M3	65.00	36.74	79.2	58.5
ANTILOG PC-1		1073.19	432.03	87.0	66.8
ANTILOG PC-2		12.16	11.80	88.7	87.6
(N - 150) / P		3.24	4.03	.7	1.7
INORGANIC N / P		.33	.20	.0	.0
TURBIDITY	1/M	.10	.10	2.0	2.0
ZMIX * TURBIDITY		.27	.27	.1	.1
ZMIX / SECCHI		1.93	1.25	6.0	1.1
CHL-A * SECCHI		28.24	25.74	92.5	90.5
CHL-A / TOTAL P		.04	.05	.7	1.3
FREQ(CHL-a>10) %		79.44	48.79	.0	.0
FREQ(CHL-a>20) %		38.34	12.54	.0	.0
FREQ(CHL-a>30) %		17.09	3.58	.0	.0
FREQ(CHL-a>40) %		7.86	1.17	.0	.0
FREQ(CHL-a>50) %		3.80	.43	.0	.0
FREQ(CHL-a>60) %		1.93	.18	.0	.0
CARLSON TSI-P		93.44	83.66	.0	.0
CARLSON TSI-CHLA		60.07	54.89	.0	.0
CARLSON TSI-SEC		55.15	48.87	.0	.0

Northgate Less 50% Nutrients

SEGMENT NETWORK: FLOWS IN HM3/YR

*************** SEGMENT:	1 Northgate Dam	INFLOW	OUTFLOW	EXCHANGE
PRECIP AND EVAPORATION:		.24	.15	
INCREASE IN STORAGE:			.18	
EXTERNAL INFLOW:	1 385226	1.96		
EXTERNAL INFLOW:	2 Ungauged Shed	.19		
OUTFLOW / WITHDRAWAL:	3 385227 (Outlet)		2.07	
DISCHARGE OUT OF SYSTEM:			-.01	

CASE: Northgate Less 75% Nutrients

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	DISPERSION NUMERIC KM2/YR	EXCHANGE RATE HM3/YR
1	0	2.24	.73727	3.7	3.7	0.	5.	0.

CASE: Northgate Less 75% Nutrients

GROSS WATER BALANCE:

ID	T	LOCATION	DRAINAGE AREA KM2	FLOW (HM3/YR) MEAN	FLOW (HM3/YR) VARIANCE	CV	RUNOFF M/YR
1	1	385226	262.240	1.960	.000E+00	.000	.007
2	1	Ungauged Shed	29.140	.190	.000E+00	.000	.007
3	4	385227 (Outlet)	291.990	2.070	.000E+00	.000	.007
		PRECIPITATION	.610	.244	.238E-02	.200	.400
		TRIBUTARY INFLOW	291.380	2.150	.000E+00	.000	.007
		***TOTAL INFLOW	291.990	2.394	.238E-02	.020	.008
		GAUGED OUTFLOW	291.990	2.070	.000E+00	.000	.007
		ADVECTIVE OUTFLOW	.000	-.012	.448E-02	5.799	-40.539

***TOTAL OUTFLOW	291.990	2.058	.448E-02	.033	.007
***EVAPORATION	.000	.153	.209E-02	.300	.000
***STORAGE INCREASE	.000	.183	.000E+00	.000	.000

GROSS MASS BALANCE BASED UPON OBSERVED CONCENTRATIONS
COMPONENT: TOTAL P

ID	T	LOCATION	LOADING KG/YR	LOADING %(I)	VARIANCE KG/YR**2	VARIANCE %(I)	CV	CONC MG/M3	EXPORT KG/KM2
1	1	385226	432.5	86.2	.500E+04	95.5	.164	220.7	1.6
2	1	Ungauged Shed	41.9	8.4	.470E+02	.9	.164	220.7	1.4
3	4	385227 (Outlet)	1048.8	209.0	.309E+04	59.0	.053	506.7	3.6
PRECIPITATION			27.4	5.5	.187E+03	3.6	.500	112.1	44.9
TRIBUTARY INFLOW			474.4	94.5	.505E+04	96.4	.150	220.7	1.6
***TOTAL INFLOW			501.8	100.0	.524E+04	100.0	.144	209.6	1.7
GAUGED OUTFLOW			1012.2	201.7	.000E+00	.0	.000	489.0	3.5
ADVECTIVE OUTFLOW			-5.6	-1.1	.107E+04	20.4	5.799	489.0	-19823.7
***TOTAL OUTFLOW			1006.6	200.6	.107E+04	20.4	.033	489.0	3.4
***STORAGE INCREASE			23.3	4.7	.316E+02	.6	.241	127.5	.0
***RETENTION			-528.2	-105.3	.582E+04	111.1	.144	.0	.0

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 -
3.67	.7373	489.0	1.6105	.6209	-1.0526

GROSS MASS BALANCE BASED UPON OBSERVED 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	385226	1940.2	70.8	.266E+05	22.1	.084	989.9	7.4
2	1	Ungauged Shed	188.1	6.9	.250E+03	.2	.084	989.9	6.5
3	4	385227 (Outlet)	7606.0	277.7	.208E+06	173.7	.060	3674.4	26.0
PRECIPITATION			610.3	22.3	.931E+05	77.6	.500	2500.0	1000.0
TRIBUTARY INFLOW			2128.3	77.7	.268E+05	22.4	.077	989.9	7.3
***TOTAL INFLOW			2738.6	100.0	.120E+06	100.0	.126	1143.9	9.4
GAUGED OUTFLOW			3591.4	131.1	.000E+00	.0	.000	1735.0	12.3
ADVECTIVE OUTFLOW			-20.0	-.7	.135E+05	11.2	5.799	1735.0	-70335.8
***TOTAL OUTFLOW			3571.4	130.4	.135E+05	11.2	.033	1735.0	12.2
***STORAGE INCREASE			140.3	5.1	.614E+03	.5	.177	766.6	.0
***RETENTION			-973.2	-35.5	.125E+06	103.9	.363	.0	.0

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 -
3.67	.7373	1735.0	1.0470	.9551	-.3554

CASE: Northgate Less 75% Nutrients

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

SEGMENT: 1 Northgate Dam

VARIABLE	VALUES OBSERVED	VALUES ESTIMATED	RANKS (%) OBSERVED	RANKS (%) ESTIMATED
TOTAL P MG/M3	489.00	127.51	99.5	86.2
TOTAL N MG/M3	1735.00	766.56	80.5	33.8
C.NUTRIENT MG/M3	127.51	47.66	94.4	64.1
CHL-A MG/M3	20.17	6.85	84.0	34.1
SECCHI M	1.40	3.17	63.4	92.2
ORGANIC N MG/M3	1593.00	813.98	99.1	85.6
TP-ORTHO-P MG/M3	65.00	19.78	79.2	33.0
ANTILOG PC-1	1073.19	177.30	87.0	40.2
ANTILOG PC-2	12.16	11.02	88.7	84.7
(N - 150) / P	3.24	4.84	.7	3.2
INORGANIC N / P	.33	.01	.0	.0
TURBIDITY 1/M	.10	.10	2.0	2.0
ZMIX * TURBIDITY	.27	.27	.1	.1
ZMIX / SECCHI	1.93	.85	6.0	.2
CHL-A * SECCHI	28.24	21.72	92.5	85.7
CHL-A / TOTAL P	.04	.05	.7	2.1
FREQ(CHL-a>10) %	79.44	17.87	.0	.0
FREQ(CHL-a>20) %	38.34	2.08	.0	.0
FREQ(CHL-a>30) %	17.09	.36	.0	.0
FREQ(CHL-a>40) %	7.86	.08	.0	.0
FREQ(CHL-a>50) %	3.80	.02	.0	.0
FREQ(CHL-a>60) %	1.93	.01	.0	.0
CARLSON TSI-P	93.44	74.06	.0	.0
CARLSON TSI-CHLA	60.07	49.48	.0	.0
CARLSON TSI-SEC	55.15	43.37	.0	.0

Northgate Less 75% Nutrients

SEGMENT NETWORK: FLOWS IN HM3/YR

*************** SEGMENT:	1 Northgate Dam	INFLOW	OUTFLOW	EXCHANGE
PRECIP AND EVAPORATION:		.24	.15	
INCREASE IN STORAGE:			.18	
EXTERNAL INFLOW:	1 385226	1.96		
EXTERNAL INFLOW:	2 Ungauged Shed	.19		
OUTFLOW / WITHDRAWAL:	3 385227 (Outlet)		2.07	
DISCHARGE OUT OF SYSTEM:			-.01	

CASE: Northgate Calibrate

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	DISPERSION NUMERIC KM2/YR	EXCHANGE RATE HM3/YR
1	0	2.24	.73727	3.7	3.7	0.	5.	0.

CASE: Northgate Calibrate

GROSS WATER BALANCE:

ID	T	LOCATION	DRAINAGE AREA KM2	FLOW (HM3/YR) MEAN	FLOW (HM3/YR) VARIANCE	CV	RUNOFF M/YR
1	1	385226	262.240	1.960	.000E+00	.000	.007
2	1	Ungauged Shed	29.140	.190	.000E+00	.000	.007
3	4	385227 (Outlet)	291.990	2.070	.000E+00	.000	.007
PRECIPITATION			.610	.244	.238E-02	.200	.400
TRIBUTARY INFLOW			291.380	2.150	.000E+00	.000	.007
***TOTAL INFLOW			291.990	2.394	.238E-02	.020	.008
GAUGED OUTFLOW			291.990	2.070	.000E+00	.000	.007
ADVECTIVE OUTFLOW			.000	-.012	.448E-02	5.799	-40.539

***TOTAL OUTFLOW	291.990	2.058	.448E-02	.033	.007
***EVAPORATION	.000	.153	.209E-02	.300	.000
***STORAGE INCREASE	.000	.183	.000E+00	.000	.000

GROSS MASS BALANCE BASED UPON OBSERVED CONCENTRATIONS

COMPONENT: TOTAL P

ID	T	LOCATION	LOADING KG/YR	LOADING %(I)	VARIANCE KG/YR**2	VARIANCE %(I)	CV	CONC MG/M3	EXPORT KG/KM2
1	1	385226	1730.0	89.9	.800E+05	98.8	.164	882.6	6.6
2	1	Ungauged Shed	167.7	8.7	.752E+03	.9	.164	882.6	5.8
3	4	385227 (Outlet)	1048.8	54.5	.309E+04	3.8	.053	506.7	3.6
		PRECIPITATION	27.4	1.4	.187E+03	.2	.500	112.1	44.9
		TRIBUTARY INFLOW	1897.7	98.6	.808E+05	99.8	.150	882.6	6.5
		***TOTAL INFLOW	1925.0	100.0	.810E+05	100.0	.148	804.1	6.6
		GAUGED OUTFLOW	1012.2	52.6	.000E+00	.0	.000	489.0	3.5
		ADVECTIVE OUTFLOW	-5.6	-.3	.107E+04	1.3	5.799	489.0	-19823.7
		***TOTAL OUTFLOW	1006.6	52.3	.107E+04	1.3	.033	489.0	3.4
		***STORAGE INCREASE	89.6	4.7	.473E+03	.6	.243	489.2	.0
		***RETENTION	828.9	43.1	.749E+05	92.4	.330	.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 -
3.67	.7373	489.0	.4198	2.3821	.4306

GROSS MASS BALANCE BASED UPON OBSERVED 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	385226	7760.4	85.1	.425E+06	81.4	.084	3959.4	29.6
2	1	Ungauged Shed	752.3	8.2	.399E+04	.8	.084	3959.4	25.8
3	4	385227 (Outlet)	7606.0	83.4	.208E+06	39.9	.060	3674.4	26.0
		PRECIPITATION	610.3	6.7	.931E+05	17.8	.500	2500.0	1000.0
		TRIBUTARY INFLOW	8512.7	93.3	.429E+06	82.2	.077	3959.4	29.2
		***TOTAL INFLOW	9122.9	100.0	.522E+06	100.0	.079	3810.6	31.2
		GAUGED OUTFLOW	3591.4	39.4	.000E+00	.0	.000	1735.0	12.3
		ADVECTIVE OUTFLOW	-20.0	-.2	.135E+05	2.6	5.799	1735.0	-70335.8
		***TOTAL OUTFLOW	3571.4	39.1	.135E+05	2.6	.033	1735.0	12.2
		***STORAGE INCREASE	317.8	3.5	.434E+04	.8	.207	1735.9	.0
		***RETENTION	5233.7	57.4	.516E+06	98.9	.137	.0	.0

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 -
3.67	.7373	1735.0	.3143	3.1817	.5737

CASE: Northgate Calibrate

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

SEGMENT: 1 Northgate Dam

VARIABLE		----- VALUES ----- OBSERVED	ESTIMATED	--- RANKS (%) ---- OBSERVED	ESTIMATED
TOTAL P	MG/M3	489.00	489.17	99.5	99.5
TOTAL N	MG/M3	1735.00	1735.87	80.5	80.5
C.NUTRIENT	MG/M3	127.51	127.58	94.4	94.4
CHL-A	MG/M3	20.17	20.31	84.0	84.2
SECCHI	M	1.40	1.41	63.4	63.9
ORGANIC N	MG/M3	1593.00	1592.91	99.1	99.1
TP-ORTHO-P	MG/M3	65.00	65.06	79.2	79.2
ANTILOG PC-1		1073.19	1072.24	87.0	87.0
ANTILOG PC-2		12.16	12.30	88.7	89.1
(N - 150) / P		3.24	3.24	.7	.7
INORGANIC N / P		.33	.34	.0	.0
TURBIDITY	1/M	.10	.10	2.0	2.0
ZMIX * TURBIDITY		.27	.27	.1	.1
ZMIX / SECCHI		1.93	1.91	6.0	5.8
CHL-A * SECCHI		28.24	28.74	92.5	92.8
CHL-A / TOTAL P		.04	.04	.7	.7
FREQ(CHL-a>10) %		79.44	79.76	.0	.0
FREQ(CHL-a>20) %		38.34	38.77	.0	.0
FREQ(CHL-a>30) %		17.09	17.38	.0	.0
FREQ(CHL-a>40) %		7.86	8.03	.0	.0
FREQ(CHL-a>50) %		3.80	3.89	.0	.0
FREQ(CHL-a>60) %		1.93	1.98	.0	.0
CARLSON TSI-P		93.44	93.45	.0	.0
CARLSON TSI-CHLA		60.07	60.14	.0	.0
CARLSON TSI-SEC		55.15	55.00	.0	.0

Northgate Calibrate

SEGMENT NETWORK: FLOWS IN HM3/YR

*************** SEGMENT:	1 Northgate Dam	INFLOW	OUTFLOW	EXCHANGE
PRECIP AND EVAPORATION:		.24	.15	
INCREASE IN STORAGE:			.18	
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OUTFLOW / WITHDRAWAL:	3 385227 (Outlet)		2.07	
DISCHARGE OUT OF SYSTEM:			-.01	

Appendix D
Public Comments on the Draft Northgate Dam Nutrient and Dissolved Oxygen TMDL and the North Dakota Department of Health's Response to Comments

During the 30 day public notice soliciting comment and participation for the Northgate Dam Nutrient and Dissolved Oxygen TMDLs, the NDDoH received a formal letter from Mr. Fred Ryckman, NW District Fisheries Supervisor for the North Dakota Game and Fish office, as well as from Mr. Vern Berry, US EPA Region 8. The following are their comments and the Department's response to those comments.

NDG&F:

Section 1.0 Page 3, Table 1. "The NDG&F has recently remapped this dam. This very precise mapping effort provided revised physical data for the dam, which the NDG&F now uses. ….Your table on this page also lists the watershed area as 28,160 acres, which is 44 square miles. SWC information states that Northgate has a watershed area of 72 square miles, with 14 of this being non-contributing. Of most concern is the watershed map (Figure 2). Since much of the report's subsequent information and analysis is predicated upon the correct watershed size, this major discrepancy simply much (sic) be addressed. If the watershed assessment did not include all of the watershed area, then it is likely that major portions of the report and its conclusion will need to be rewritten.

NDDoH Response: Tables 1 and 2 were adjusted to reflect NDG&F data on surface area, volume, average depth and max depth. The contour map was not easily added to the main body of the document, so it was added in Appendix B. Could not find any mention in State Water Commission information about a portion of the Northgate Dam being non-contributing. The watershed area listed in Table 1 (28,160 acres) was in error and based on data from a 1992 report. The number used for calculations and pollution reduction estimates throughout the TMDL was based on the information collected in the field for the AgNPS model. The model uses a watershed area of 72,000 acres. The actual size of the watershed used in the calculations is 66,392 acres (104 sq.mi.). The reason the AgNPS model shows a greater size is because the cells are 160 acre blocks, and sometimes only a portion of the cell is within the watershed boundary (see Figure 2).

Further research indicated that the State Water Commission data (1968) describes Northgate Dam as having a 152 acre surface area under normal conditions, with a volume of 1,280 ac-ft. This is different than the NDG&F number of 135.3 acres and 1,387.8 ac-ft, as well as being different from the NDDoH original numbers of 150.8 acres and 1,087 ac-ft. It is understandable that based on different methods of measurement one can arrive at different numbers, but they are all very similar. NDDoH is keeping their estimate of watershed size (with the exception of the corrections in Tables 1 and 2) for two reasons. First, it is larger than the 1968 SWC estimate, and it adds to the margin of safety to include more instead of running the risk of missing a portion of the watershed. Second, our data was collected in the field in 2003 with each quarter section visited to determine all the data needed for input into the model. The initial map was given to us by the NRCS and they assisted with the training while it was field-truthed.

Page 6: The text notes that the 2003 NDASS land use data is inferior to the 2004 TMDL land use assessment information. So then why does Figure 4 show 2003 land use information instead of the more accurate 2004 information?

NDDoH Response: The 1992 data was removed from the document due to incompatible watershed size.. The 2003 NDASS data, as it is explained in the document, is satellite image data. The data collected in 2004 was on the ground data put into a field sheet with number tallied. We have no 2004 satellite image data. Figure 4 was added to use with the pie chart in Figure 3 as a visual reference of where the heavily cropped areas are in the watershed. We do not feel the 2003 NDASS data is inferior, just possibly a bit inaccurate.

Section 2 Page 14, Table 7: The measured P values at Northgate are nearly five fold higher than the SHD's numeric standard for Total P. Shouldn't a P value that so greatly exceeds the stat's water quality standards mandate some type of corrective action?

NDDoH Response: (Assuming that the G&F is referring to Tables 6 and 7 on pages 9 and 10.) As it states in this document, the limits for total nitrates(N) and total 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. Because of the characteristics of this reservoir, it can be reasonably expected that it will have higher total phosphorus values than those of average lakes in the area.

The process of having an approved TMDL is taking a corrective action. If sponsors are found and a 319 grant for implementation is approved, the guidelines set forth in this document will lower the total phosphorus concentration from 0.489 mg/L to 0.248 mg/L. This will bring the lake down from hypereutrophic to eutrophic state, and the beneficial uses of aquatic life and recreation will be attained as required by state water quality standards.

Section 5 page 22 (pg 20 in this document): last paragraph (and elsewhere). Although I understand that there is some value in comparing sedimentation rates across the state or region, I see little value or reason for including wording on a "50-year life expectancy of a reservoir". I have no idea what criteria were used to determine that a lake would somehow "die" at 50? With several hundred thousand dollars of structural and facility development at Northgate, I sure wouldn't want to try and convince anyone that this investment would somehow become moot in a little more than a decade from now?

NDDoH Response: The justification brought forth in the 6th paragraph of Section 5.5 is only one of three used for the rational of de-listing Northgate Dam due to sediment impairment. This information was provided by a NRCS regional Engineer and is the NRCS's Sedimentation Rate Standard for Reservoirs. Their information states that most of the reservoirs built in the 60's were constructed with a 50 year time frame in mind. It was assumed that there would be 50 years before any large scale maintenance (i.e. dredging) would have to take place, and the depth of the dam was built accordingly based on a series of complex equations taking into account flow, run off, and erosion. Reservoirs are hugely different from natural lakes in terms of sedimentation and its associated nutrient loads. Watershed size of a constructed reservoir for recreation is typically 10 times greater than the watershed of a natural lake. Along with this are higher rates of sedimentation, typically huge in the first few years that a reservoir is established, tapering off after about five years or so. Also, the 50 year life doesn't mean that it is dead at the end of 50 years. It just means that over the course of the natural cycle of lakes from mesotrophic to hypereutrophic, this timeframe is when the lake is most viable for the purpose for which it was constructed.

Luckily times have changed since the 1960's and conservation practices in place before the advent of TMDLs have already reduced erosion and extended the life of the Northgate Dam, so it would be highly unlikely that the reservoir would not be worth the current investment in it after the next 10 years.

Page 27: first paragraph (and elsewhere). I think that it is important somewhere within the document to identify specific "Best Management Practices" which need to be implemented in order to improve Northgate Dam.

NDDoH Response: Specific BMPs were added to this document.

Page 30, first paragraph, line 4: should state "poor fishery", not "poor fisher". I'd agree with the conclusion that Northgate Dam could be de-listed as being sediment impaired, but I'd also add working within this paragraph that poorer land use , especially a major shift in land use towards black fallow or fall tillage could cause much greater erosion rates and consequent sedimentation within the reservoir.

NDDoH Response: (page 20 this document): Typo was changed. Lots of things could cause harm to the reservoir and it would take up too much space to list them all.

Pages 31 & 31, watershed model discussion: Single storm events can indeed have a tremendous impact on receiving waters, and thus are the critical times which should be assessed by AGNPS. I'd simply add some additional language that storm evens do not necessarily have to be so detrimental; adequate land cover at all times during the year is simply needed to prevent major erosion and nutrient runoff. I think a "tolerable" soil loss rate of 3-5 tones/acre is again simple planning to fail. Much lower losses are easily attainable through good land stewardship. Carbury needs to be changed to Northgate.

NDDoH Response: Due to modeling limitations, the only currently available model we have is a single storm even model. Work is ongoing in the NDDoH to switch to an annualized version of this model. Since this document asks to de-list Northgate Dam for sediment, the section explaining acceptable NRCS soil loss rates was removed. This TMDL is written to determine the maximum loading capacity of the Northgate Dam watershed. It is assumed that the reader will understand that if conservation practices are put in place to reduce runoff during these critical times, the runoff from everyday rain showers will naturally be less as well. The typo was changed.

Pages 35, 36 & 38: The critical soil loss areas closely mirror the critical phosphorus loading cells, which is certainly appropriate. Again I'd encourage that the TMDL project implementation plan specifically list the recommended TMDLS which must be implemented to address both excessive soil erosion and phosphorus runoff.

NDDoH Response: Major portions on the discussion of sediment have been deemed unnecessary and removed from this document due to the request to de-list Northgate Dam. The diagrams of the critical soil loss areas were part of that which was removed. The TMDL does not have a project implementation plan, the grant application for 319 funds requires it. The TMDLs which must be implemented are the Nutrient and Dissolved Oxygen TMDLs. Soil erosion was not deemed to need a TMDL at this time.

Page 40, first paragraph: This contains a reference to the hypolimnetic discharge system (HDS), but I didn't note within the report whether there was any specific water quality data for discharges from this system during the period of sampling? If this data existed, it would be good to include an analysis of the value of the HDS within the TMDL report.

NDDoH Response: The period during which the assessment occurred was during a very dry year and they HDS system was not used due to already low water levels. If we had data, it would have been included.

Appendix C: I'd recommend that this entire 40+ page appendix be deleted from the report. It would be more than sufficient to simply state within the report that copies of the bathtub model data could be obtained from the SHD, if anyone was interested in reviewing this data.

NDDoH Response: Due to several questions about how the TMDL reductions were chosen, it was determined important to include the information in Appendix C.

Comments from EPA, Region 8 (Vern Berry)

1. **The document proposes to delist Northgate Dam for sediment impairment. Therefore, we do not consider this a sediment TMDL and our approval will not include sediment.**

   NDDoH Response: Sediment TMDL was taken out of the title and unnecessary data was removed.

2. **Page 22, Part 3.3 Sediment Target:** The sediment target is not necessary because Section 5.3 makes the point that Northgate Dam is no impaired by sediment and will be removed from the state's 303(d) list in the future. We recommend that Section 3.3 be deleted from the Northgate Dam TMDL.

   NDDoH Response: Because Northgate Dam is currently listed on the 303(d) list for requiring a sediment TMDL, Section 3.3 was left in for information purposes, but the wording was changed to "Due to the reasons explained in Section 5.3 of the data analysis section, it is the recommendation of the State to de-list Northgate Dam for sediment impairment. Therefore, no sediment target is set."

3. **The technical analysis for dissolved oxygen needs to include the write-up we agreed on as a result of the TMDL meeting in Cheyenne. Also, because of the uncertainties associated with being able to meet the dissolved oxygen standards with the proposed reductions in phosphorus, it is necessary to include a monitoring plan in accordance with the phased TMDL approach.**

   NDDoH Response: Write-up changed to as agreed in the technical analysis section regarding dissolved oxygen. A monitoring section was added (Section 10) and a TMDL implementation strategy section was added (Section 11).