TOTAL MAXIMUM DAILY LOAD EVALUATION

For

TOTAL PHOSPHORUS (TSI TREND)

In

LAKE HERMAN

(HUC 10170203)

LAKE COUNTY, SOUTH DAKOTA

SOUTH DAKOTA DEPARTMENT OF ENVIRONMENT AND NATURAL RESOURCES

March, 2004

Lake Herman Total Maximum Daily Load March, 2004

Waterbody Type:	Natural lake (Glacial)
303(d) Listing Parameters:	Total phosphorus (TSI trend),
Designated Uses:	Warmwater semi-permanent fish life propagation; Immersion recreation water; Limited contact recreation waters; Wildlife propagation and stock watering Irrigation Waters
Size of Waterbody:	1,350 acres
Size of Watershed :	43,000 acres
Water Quality Standards:	Narrative
Indicators:	Average TSI
Analytical Approach:	AGNPS and BATHTUB
Location:	HUC Code: 10170203

TMDL Goal

Total Phosphorus:

Recommended Goal 45 % reduction in total phosphorus loads (3,417 kg/yr.)

TMDL Target

Total Phosphorus:

Recommended Target 73.93 mean TSI (4,194 kg/yr.)

Objective:

The intent of this summary is to clearly identify the components of the TMDL submittal to support adequate public participation and facilitate the US Environmental Protection Agency (EPA) review and approval. The TMDL was developed in accordance with Section 303(d) of the federal Clean Water Act and guidance developed by EPA.

Introduction

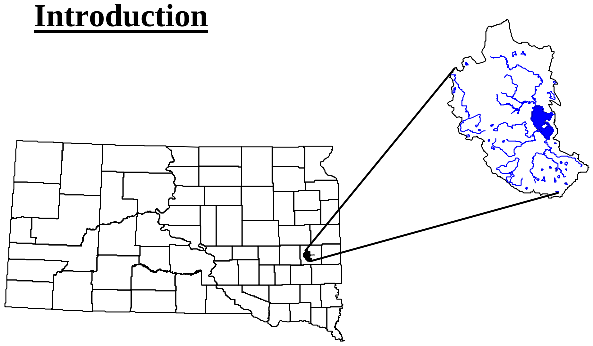

Figure 1. Lake Herman watershed location in South Dakota

Lake Herman is a 1,350-acre glacial lake located in central Lake County, South Dakota. The 1998 South Dakota 303(d) Waterbody List (page 19) initially identified Lake Herman for TMDL development for trophic state index (TSI) and increasing eutrophication trend. Lake Herman was again listed in the South Dakota Total Maximum Daily Load Waterbody List 2002.

The lake has the following geomorphic characteristics: an average depth of 1.7 meters (5.6 feet), 15.3 kilometers (9.5 miles) of shoreline, a maximum depth of 2.4 meters (8.0 feet), and a total volume of 7,425 acre-feet of water. The fetch or longest distance between shorelines of the lake (wind exposure) is approximately 4.2 km. The lack of depth and fetch of the lake do not allow season long thermal stratification. Lake Herman is the source for Silver Creek, which flows through the city of Madison, and into Lakes Madison, Round, and Brant. Lake Herman is the first lake in this “chain of lakes” located in Lake County, South Dakota.

Problem Identification

The watershed for Lake Herman drains predominantly agricultural land. Based on the 1997 Natural Resources Inventory (NRI) completed by the Natural Resources Conservation Service (NRCS), approximately 84% of the land in Lake County is managed for some agricultural purpose. This percentage has remained relatively constant throughout the 1990's. Both feedlots and winter feeding areas for livestock are present within the watershed. The intermittent streams in the Lake Herman watershed carry nutrient (total phosphorus) loads degrading the water quality of the lake, and cause increased eutrophication. Based on loading calculations derived from data collected during the 1993 Phase III Post-Implementation Project, the total phosphorus load to Lake Herman was 7,611 kilograms per year. This amount plus the phosphorus contained in the lake sediments does not allow the lake to meet its designated uses.

The ecoregion target set for Lake Herman is a mean TSI value of 65 (Stueven et.al, 2000). Based on an ecoregional comparison of other lakes, a mean TSI of 65 would result in the lake fully supporting all of its beneficial uses. Total phosphorus loads need to be reduced by 6,317 kilograms (83%) before a corresponding mean TSI of 65 can be reached. However, based on the water quality analysis discussed in this submittal, only a reduction of 3,417 kilograms is possible. This 45% reduction will result in a total phosphorus TMDL of a mean Trophic State Index (TSI) of 73.93 (4,194 kilogram per year).

Description of Applicable Water Quality Standards & Numeric Water Quality Targets

Lake Herman has been assigned beneficial uses by the state of South Dakota Surface Water Quality Standards regulations. Along with these assigned uses are narrative and numeric criteria that define the desired water quality of the lake. These criteria must be maintained for the lake to satisfy its assigned beneficial uses, which are listed below:

(5) Warm water semi-permanent fish life propagation water;
(7) Immersion recreation water;
(8) Limited contact recreation water;
(9) Wildlife propagation and stock watering; and
(10) Irrigation water.

Other parameters, including the lake's mean TSI value, help determine the ability of the waterbody to maintain compliance with the water quality standards and support it's beneficial uses. Prairie lakes such as Lake Herman that are located in agricultural landscapes experience nutrient enrichment and some nuisance algal blooms, which are typical signs of the eutrophication process. Lake Herman was identified in both the 2002 South Dakota 303(d) Waterbody List and "Ecoregion Targeting for Impaired Lakes in South Dakota" as unable to fully support its beneficial uses.

South Dakota has several applicable narrative standards that may be applied to the undesirable eutrophication of lakes and streams. Administrative Rules of South Dakota Article 74:51 contains language that prohibits the existence of materials causing pollutants to form, visible pollutants, taste and odor producing materials, and nuisance aquatic life.

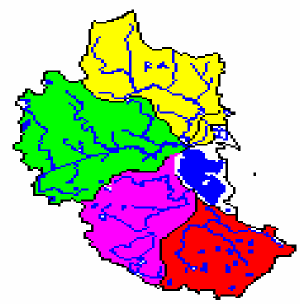

Figure 2. Lake Herman watershed and subwatersheds

If adequate numeric criteria are not available, the South Dakota Department of Environment and Natural Resources (SD DENR) uses surrogate measures to assess the trophic status of a lake. SD DENR uses the mean (combined) Trophic State Index or TSI (Carlson, 1977) which incorporates a combination of Secchi depth, chlorophyll-*a* and total phosphorus concentrations. SD DENR has developed an EPA-approved protocol that establishes desired TSI levels for lakes based on ecoregional targets. Using this approach the impairment was identified and a numeric target for Lake Herman was developed.

The observed data collected during the Phase III Post Implementation Project was used to derive expected values through the modeling process. Lake Herman exhibited a total phosphorus TSI (TSI-TP) of 87.15, a chlorophyll-*a* TSI (TSI-Chl *a*) of 68.16 and a Secchi TSI (TSI-Z_{sd}) of 75.81. These three TSI values result in a mean TSI of 77.04 (Wittmuss, 1994). In comparison, the most recent State Lake Assessment Report

(Stewart, Stueven, 1996) indicated a TSI-TP of 88.18, a TSI-Chl *a* of 66.97, and a TSI-z_{sd} of 67.73 resulting in a mean TSI of 74.29. Both sets of TSI measurements indicate high levels of primary productivity. Assessment monitoring indicated that the primary cause of high productivity is high total phosphorus loads from the watershed and resuspension of phosphorus from the lake sediments.

SD DENR-recommended specific TSI parameters for Lake Herman are: 79.02 for total phosphorus, 68.05 for chlorophyll-*a* and 74.72 for Secchi visibility with a mean TSI of 73.93. These recommended TSI values still fall within the ecoregion targeting range of non-support status for Lake Herman. In order to achieve full support status, Lake Herman requires a mean TSI of 65. However, based on the modeling process and the analysis of water quality data a mean TSI of 73.93 is the attainable goal and has therefore been identified as the final target. The remaining 38% of the overall reduction required for Lake Herman has been classified as the unachievable portion of the goal and is attributed to natural/background levels and levels not reachable due to economic and social constraints. Attempting to reduce the TSI below 65 (full support for this ecoregion) is cost prohibitive and would not result in noticeable differences in the frequency or intensity of algal blooms to visitors at this waterbody. The modeling process via the Agricultural Nonpoint source model (AGNPS) and the BATHTUB indicated that the 45% reduction can be attained through acceptable implementation measures.

After the implementation process has been completed, a continual and long-term assessment should be conducted to determine the effectiveness of the best management practices and how much of the reduction goal has been attained. Post-implementation monitoring will also determine if other measures may be needed to help reduce of the total phosphorus loadings.

Pollutant Assessment

Point Sources

There are no point sources of pollutants of concern in this watershed.

Nonpoint Sources/ Background Sources

The 7,611 kg in total phosphorus loadings to Lake Herman are from agricultural sources. Conversations with local conservation districts and land owners have found that the required 83% reduction in loads is an unrealistic goal. The agricultural community needs to maintain its livelihood and it is not possible to revert the entire watershed into a pristine grass condition. Analysis of the watershed through the use of the Agricultural Non-Point Source (AGNPS) model indicated the following cost effective and best attainable reductions for the lake. This was based on expected participation rates in an implementation program.

Approximately 3% of the total phosphorus load was the result of livestock feeding area discharge, 12.8% from inadequate cropland tillage practices, 12.3% from high rates of fertilizer application, and 12.3% from improper residue management. Other tributary phosphorus loads were estimated by using expected reductions from BMPs within critical areas using published data (CTIC, 2002). Inadequate buffers and filter strips within the critical cell areas resulting in 4.6% of the total phosphorus load.

Linkage Analysis

Water quality data was collected from 13 monitoring sites within the Lake Herman watershed. Samples collected at each site were taken according to South Dakota's EPA-approved Standard Operating Procedures for Field Samplers. Water samples were sent to the State Health Laboratory in Pierre for analysis. Quality Assurance/Quality Control samples were collected on approximately 10% of the samples according to South Dakota's EPA-approved Clean Lakes Quality Assurance/ Quality Control Plan. Details concerning water sampling techniques, analysis, and quality control are addressed on pages 6 through 17 of the assessment final report (Wittmuss, 1994).

In addition to water quality monitoring, data was collected to complete a watershed landuse model. Using this landuse data, critical cells were identified using a 25-year storm event. Those cells exceeding the mean erosion rate for phosphorus for the Lake Herman watershed were deemed critical. The AGNPS (Agricultural Nonpoint Source) model was used to estimate potential nutrient load reductions from the removal of feedlots waste, changes in tillage practice, and fertilizer reductions within the watershed through the implementation of various BMPs. These BMPs included the installation of animal waste management systems and buffer strips, improved tillage practices (no till), and reductions in the rate of fertilizer application.

The current total phosphorus load of 7,611 kg/yr will be reduced by a minimum of 45% (3,417 kg/yr) to 4,194 kg/yr. This load reduction will result in a change in the mean TSI value from 77.04 to 73.93. The 45% reduction in total phosphorus loading is an achievable water quality target based on current watershed/lake conditions and the expected participation rates for an implementation program. This TSI reduction will prevent further degradation and will maintain the current beneficial uses designated for the lake.

Lake Herman has a surface area of 1,350 acres with a mean depth of 1.7 meters. The lack of depth and large surface area of the lake prohibit inlake management techniques such as dredging and alum treatment. In addition, because the shallow nature of Lake Herman prevents stratification, aeration would be an ineffective management technique as well. The TMDL is based on the analysis of the water quality data and modeling which was used to derive an achievable target.

TMDL and Allocations

TMDL

Total phosphorus (kg) = 45% reduction

	0 kg/yr		(WLA)
+	4,194 kg/yr		(LA)
+	0 kg/yr		(Background)
+	0 kg/yr	Implicit	(MOS)
	4,194 kg/yr		(TMDL) [1]

[1] = TMDL Equation implies a 45% (3,417 kg/yr) in total phosphorus reduction with the implementation of all possible BMPs. The TMDL also includes an implied margin of safety.

Wasteload Allocations (WLAs)

There are no point sources of pollutants of concern in this watershed. Therefore, the "wasteload allocation" component of these TMDLs is considered a zero value. The TMDLs are considered wholly included within the "load allocation" component.

Load Allocations (LAs)

The results of the AGNPS model indicated that a 12.8% (974 kg/yr) and 12.3% (936 kg/yr) reduction in total phosphorus loading to the lake could be achieved through the improvement of tillage practices and reductions in the rate of fertilizer applications within the watershed. An additional 12.3% (936 kg/yr) could be achieved through improved residue management.

Removal of two animal feeding operations within the watershed would account for an additional 3.0% (221 kg/yr) of the total phosphorus load to the lake.

Tributary total phosphorus reductions for riparian management and buffer strips constituted 4.6% (350 kg/yr) of the overall loadings. This reduction was estimated using literature values and best professional judgement.

These BMPs are expected to result in a total phosphorus load of 4,194 kg/yr and result in a change in the mean TSI value from 77.04 to 73.93.

Seasonal Variation

Different seasons of the year can yield differences in water quality due to changes in temperature, precipitation and agricultural practices. To determine seasonal differences, Lake Herman samples were separated into spring (March-May), summer (June-August), fall (September-November) and winter (December). The TMDL targets the most productive period of the year (May through September). Not only is this the period of peak recreational use, but it is also the period during which most impairments occur to this lake. The TMDL targets this period assuming support during the growing season will result in year round support of all beneficial uses.

Margin of Safety

All total phosphorus reductions were calculated based on extremely conservative estimations built into the model and conservative total phosphorus reduction percentages using best professional judgement (implied margin of safety).

Critical Conditions

Based upon subsequent sampling data through the 1990's, impairments to Lake Herman are most severe during the mid-late summer and early fall. This is the result of warm water temperatures and increased algal growth.

Follow-Up Monitoring

Lake Herman should continue to be monitored through the statewide lake assessment project and the South Dakota Game, Fish and Parks normal lake survey to monitor and evaluate long-term trophic status, biological communities and ecological trends.

Once the implementation project is completed, post-implementation modeling will be necessary to assure that the achievable loading reductions for TMDL have been reached.

Public Participation

The water quality assessment project was initiated during the spring of 1992 with local funds (Lake County, East Dakota Water Development District, and the City of Madison) that remained after the Lake Herman dredging project was completed 1989. Lake Herman was on the priority list of Section 319 Nonpoint Pollution Control projects. In 1992 the Lake County Conservation District agreed to sponsor the project and provided the local funds and in-kind services necessary to complete the project. Funds were used for water quality analyses, equipment, supplies, travel, and wages for the local coordinator.

Efforts taken to gain public education, review, and comment during development of the TMDL involved:

1. Lake County Conservation District Board Meetings (1)
2. Public Meeting for the Lake Madison/Brant Lake Final Report which included discussions concerning Lake Herman (1)
3. Articles in the Madison Daily Paper (1)
4. SDDENR TMDL Public Notification Webpage

The findings from these public meetings and comments from the webpage have been taken into consideration in the development of the Lake Herman TMDL.

Implementation Plan

The South Dakota DENR is already working with the Lake County Conservation District and several Federal, State, and Local agencies on an implementation project that began in 2000. The overall goal of the restoration effort is to decrease the phosphorus loading to Lake Madison and Brant Lake by 50%. This watershed (including Lake Herman, Silver Creek, Lake Madison, Round Lake, and Brant Lake) received $660,245 in Section 319 funds to help implement the TMDL. As the headwaters of Silver Creek/Lake Madison/Brant Lake complex, Lake Herman has been included in this implementation project. Remediation efforts identified in the workplan include BMPs that will be used to help achieve the 45% reduction in phosphorus loading to Lake Herman. The 45% reduction will increase the margin of safety identified in the Lake Madison/Brant Lake TMDLs increasing probability of achieving stated water quality goal for all of the stated water bodies.

According to the EPA Section 319 approved and amended workplan, the project is expected to continue through the 2005 calendar year. A copy of the Implementation plan is enclosed with the TMDL submittal listing the project objectives.

STUDY ADDENDUM:

AGRICULTURAL NONPOINT SOURCE COMPUTER MODELING (AGNPS) V3.65 RESULTS FOR THE LAKE HERMAN PHASE III POST-IMPLEMENTATION INVESTIGATION FINAL REPORT

INTRODUCTION

The Lake Herman Phase III Post Implementation Investigation Project was completed in 1994. The project was initiated in March of 1992 to determine the long term effects of the Model Implementation Program (MIP) project that was completed for the watershed in 1977. The MIP Project was a joint effort between the U.S. Department of Agriculture (USDA) and the U.S. Environmental Protection Agency (EPA) originally designed to coordinate between the various soil conservation and water quality management programs available in the two agencies (Wittmuss, 1994).

The primary goal of the Phase III project was to quantify reduction in loadings and change in water quality in the lake and watershed as a result of the Lake Herman Model Implementation Project (MIP). The second goal was to assess the effectiveness of Best Management Practices (BMPs) implemented in the Lake Herman Watershed during the MIP project. A final report based on the water quality monitoring and AGNPS (v3.65) modeling was completed in 1994. The AGNPS modeling completed for this project was used to identify the effectiveness of BMPs and did not predict reductions in the phosphorus loadings to Lake Herman.

Based on data collected during the MIP project and the subsequent statewide lakes assessment monitoring Lake Herman was placed on the 1998 South Dakota 303(d) Waterbody List (page 19) for trophic state index (TSI) and increasing eutrophication trend. It became necessary to develop a TMDL for these two water quality problems identified for Lake Herman. In order to complete the TMDL the water quality data collected during the MIP project was analyzed in conjunction with AGNPS data to estimate how much reduction must occur before Lake Herman achieves full support status of its beneficial uses. Full, partial, or non-support status criteria were based on TSI data for all lakes located within the Northern Glaciated Plains Ecoregion. By comparing lakes within an ecoregion, attainable water quality targets can be set based on the best possible condition for that ecoregion (Stueven et al., 2000).

Using the 1992-93 water quality and land use data, AGNPS v3.65 estimated a 44.9% reduction in phosphorus loadings from the watershed. The next step was to calculate the corresponding reduction that would occur on the inlake data and Carlson's Trophic Status Index (TSI) using the BATHTUB modeling software developed by U.S. Army Corps of Engineers (Walker, 1996). In order to achieve full support status, Lake Herman requires a mean TSI of 64.95. The BATHTUB modeling indicated that a 44.9% reduction in the phosphorus loadings would result in a mean TSI of 73.93. This disparity between TSI values of 64.95 versus 73.93 can be attributed to natural background sources. The modeling process via AGNPS and BATHTUB indicated that the 44.9% reduction can be readily attained through standard implementation measures. Achieving higher reductions would be extremely cost prohibitive and unattainable based on the water quality and monitoring results.

AGNPS DISCUSSION

AGNPS (Agricultural Non-Point Source Pollution Model) is an event-based model that simulates surface runoff, sediment, and nutrient transport from agricultural watersheds. The nutrients considered include nitrogen (N) and phosphorus (P), both are essential algal nutrients and major contributors to the trophic status (TSI) problems documented for Lake Herman, especially phosphorus (Wittmuss, 1994). The model operates on a geographic cell basis where the watershed is split into cells ranging from 2.5 acres up to 40 acres. For watershed exceeding 2000 acres, cell sizes of 40 acres are recommended which was used for Lake Herman (watershed size = 44,000 acres) (Figure 1) (Scholtes, 1994).

Each of the 40-acre cells within the watershed requires twenty-one different items of information shown in Table 1. It is beyond the scope of this particular addendum to discuss each of the input parameters or the model in detail. For further discussion of these parameters and the AGNPS v3.65 model please refer to SDDENR, 1996.

Table 1. AGNPS Input Parameters

SCS Curve Number	**Land Slope**	**Land Slope Shape Factor**
Field Slope Length	**Channel Slope**	**Channel Sideslope**
Manning's Roughness Coefficient	**Soil Erodibility Factor**	**Cover and Management Factor**

Support Practice Factor	**Surface Condition Constant**	**Aspect**
Soil Texture	**Fertilization Level**	**Fertilization Availability Factor**
Point Source indicator	**Gully Source Level**	**Chemical Oxygen Demand**
Impoundment Factor	**Channel Indicator**	

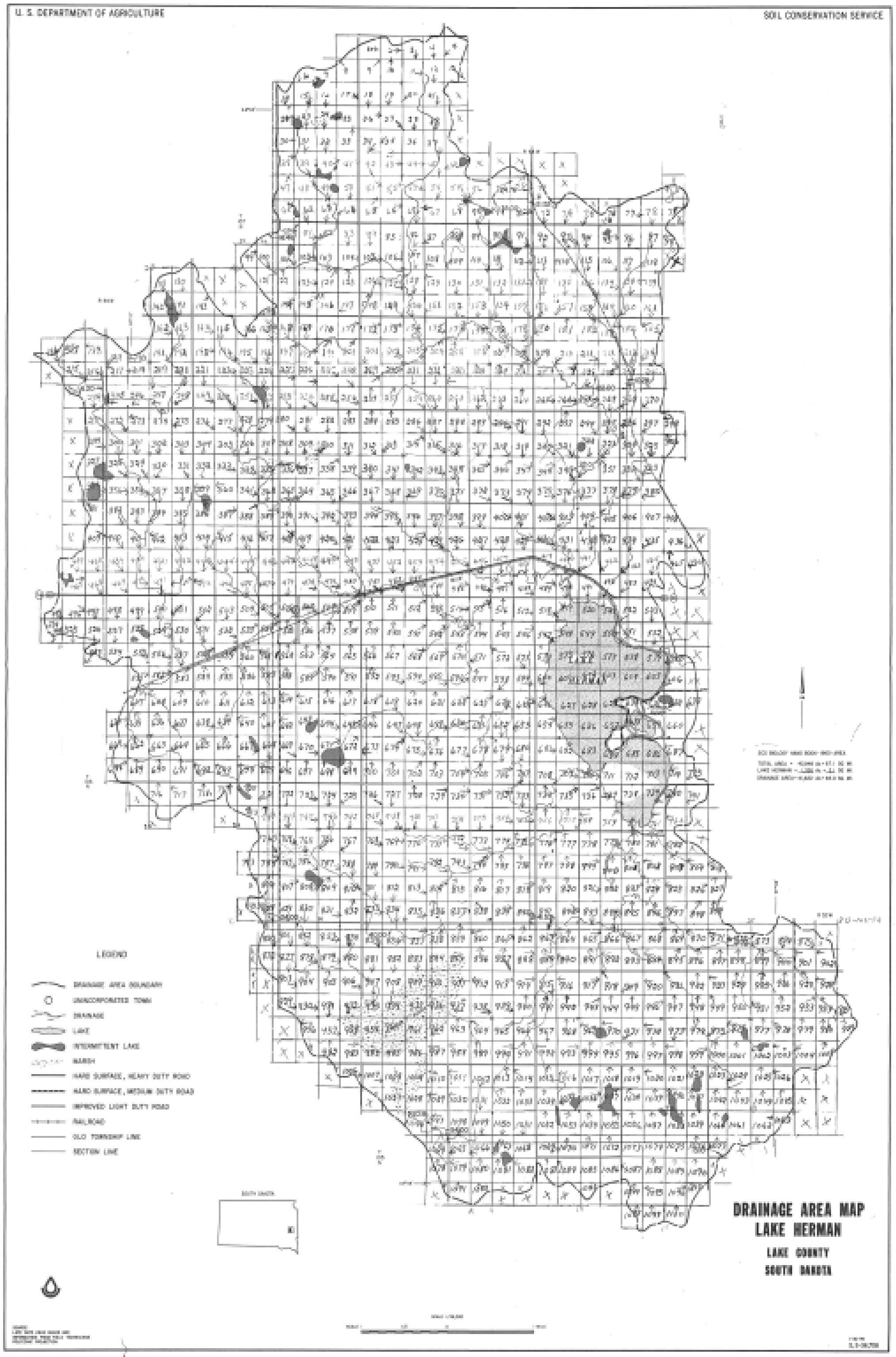

Figure 1. AGNPS v3.65 40-acre cells for the Lake Herman Watershed, 1994.

A reanalysis of the original AGNPS v3.65 modeling results from Lake Herman was conducted to identify the critical phosphorus cells within the watershed. The process also estimated the reduction that could be achieved on the total phosphorus loadings from the critical cells using improved farming practices (BMPs).

The 154 critical phosphorus cells were identified using a 25-year storm event (Type II, Energy Intensity value of 133.5) with the AGNPS (v3.65) model. The mean phosphorus output (lbs/acre) and its standard deviation were calculated using all 1100 cells within the Lake Herman Watershed ($\bar{x}$ =3.13, *s* = 2.14). All 40-acre cells exhibiting an output greater than one standard deviation above the mean were deemed critical. The 154 critical cells with their phosphorus output (lbs/acre) can be found in Appendix I.

In order to model phosphorus reductions from each critical cell, certain AGNPS input parameters were changed to reflect possible best management practice (BMP) installation. Table 3 shows the descriptive statistics for the 154 cells for the Runoff Curve Number, Cropping or Cover Management Factor, Fertilization Rate and Feedlots prior to changes. Table 4 shows the changes in the descriptive statistics to these same four variables if farming practices were improved..

To simulate the effect from adjusting the various parameters discussed below, i.e. estimating reductions from BMPs, an average year of rainfall was estimated in AGNPS v3.65 using the following criteria:

1. The Antecedent Moisture Condition was assumed to Type II. The moisture status of the soil is called "Antecendent Moisture Condition" (AMC). Traditionally, 3 distinct AMCs are distinguished: AMC I (dry), AMC II (average) and AMC III (wet).
2. The Annual Rainfall Factor "R" was set at 110 for Lake County, South Dakota. R is defined as the rainfall erosivity index calculated from the annual summation of rainfall energy in every storm (SD Technical Guide for NRCS).
3. The individual Energy Intensity (EI) values from various storms for an average year when summed need to equal the "R" or 110 (AMC Type II area). The following EI values were used to simulate the average annual precipitation rate for Lake County:
   - ? 10 1-month events (0.8" of rainfall), EI = 3.0 per storm = 30.0
   - ? 4 6-month events (1.6" of rainfall), EI = 13.4 per storm = 53.6
   - ? 1 1-year event (2.2" of rainfall), EI = 26.8 per storm = <u>26.8</u>

   Total = 110.4

<u>Runoff Curve Number (CN)</u> – SCS Curve Numbers were developed to classify the runoff potential of different soil types with different land cover. These curve numbers are a function of:

1. Hydrologic soil group – classified as A, B, C, and D where A has the lowest runoff potential and D has the highest runoff potential. The hydrologic soil group was determined from the soil characteristics (sand, silt, clay composition), minimum infiltration rate, county soil surveys, and soil databases. This is based on soil characteristics and cannot be changed.
2. Land Cover – determined from the inspection of the land surface. Three factors are used when determining the land cover. The land use, land treatment or practices, and the hydrologic conditions. The land use is subdivided into urban vs. agricultural vs. non-developed land uses. The urban and agricultural land uses are further subdivided into land practices. The hydrologic conditions refer to the quality or density of the vegetation or ground cover which is classified into good, fair, or poor. This can be changed through improved farming or land practices (see Table 2 below). For the critical phosphorus cells identified within the Lake Herman Watershed the CN may have originally been documented as row crop with straight rows (Hydrologic Group A (CN) = **<u>67</u>**). The land treatment in the 40-acre cell was then changed to a **<u>65</u>** based on row crop with rows planted in a contoured fashion (Table 2). On average the CN was reduced 2-3 points to reflect changes in farming practices.

Table 2. SCS Runoff Curve Numbers Land Treatment Example.

Land Practice	Surface Condition Constant	Runoff Curve Number (soil group)			
		A	**B**	**C**	**D**
Fallow	**0.22**	**77**	**86**	**91**	**94**
Row Crop:					
Straight	**0.05**	67	**78**	**85**	**89**
Contoured	**0.29**	65	**75**	**82**	**86**
Small Grain	**0.29**	**63**	**74**	**82**	**85**
Legumes or rotation meadow	**0.29**	**58**	**72**	**81**	**85**
Pasture:					
Pasture Poor	**0.01**	**68**	**79**	**86**	**89**
Fair	**0.15**	**49**	**69**	**79**	**84**
Good	**0.22**	**39**	**61**	**74**	**80**

To determine how much reduction of total phosphorus could be gained from an improvement in the land treatment, the best possible scenario was assumed to occur for each of the 154 critical cells using the same method previously described. Tables 2 and 3 show the CN adjustments made for improved farming practices for each of the 154 critical cells. These adjustments in the CN resulted in a 12.3% reduction in the total phosphorus loadings from the watershed to Lake Herman (Table 6).

3. Antecedent moisture conditions – There are three antecedent soil moisture conditions labeled I, II, and III. Condition II is considered to be average conditions and was not changed during the Lake Herman Watershed AGNPS v3.65 analysis.

Cropping-Factor or cover management factor (C-factor) – The C-factor is the cropping and management factor expressed as a ratio of soil loss under a specific cropping and management system to the soil loss under a clean-till, continuous fallow system. This variable incorporates the effects of tillage management (dates and types), crops, seasonal erosivity index distribution, cropping history (rotation), and crop yield level (organic matter production potential). Table 3 shows an excerpt from a table used by the Natural Resources Conservation Service (NRCS) in identifying the c-factors for a typical corn/soybean rotation found within the Lake Herman Watershed.

For the 154 critical phosphorus cells identified in the Lake Herman Watershed, the c-factors based on current farming practices were adjusted to an overall 0.15. In most instances the critical cells were under some type of tillage practice which is indicated by the cropping factor statistics shown in Table 7 Increasing the residue cover and changing the tillage practice (no-till) is a standard BMP. The effect of this BMP was modeled in each cell by changing the C-factor to 0.15. This BMP resulted in a 12.79% reduction in phosphorus loadings (Table 6).

Table 3. Cropping & Management Factors for Cropland (C-Factors for South Dakota)									
	Percent Ground Cover After Planting								
Crop Sequence	**Clean Tillage**		**Conservation Tillage**						
	0	**10%**	**20%**	**30%**	**40%**	**50%**	**60%**	**70%**	**80%+**
Corn or Sorghum after Soybeans 3 or more years after grass/legume.									
No-Till				**.18**	**.15**				
Ridge Plant Contour			**.17**	**.14**					
Ridge Plant U & D			**.20**	**.17**					
Strip Till Contour			**.22**	**.18**					
Strip Till U & D			**.25**	**.2**					
Spring Chisel or Disk		**.35**	**.28**	**.23**					
Spring Chisel & Spring Disk	**.39**	**.37**	**.30**	**.27**					
Fall Chisel & Spring Disk	**.43**	**.38**	**.35**	**.30**					
Spring Plow – Clean Tillage	**.45**								
Fall Plow – Clean Tillage	**.48**								

SDDENR, 1996 (SDDENR AGNPS v3.65 Users Guide).

Conservation buffers are small strips of vegetation designed to slow water runoff, provide shelter and stabilize riparian areas. When these buffer strips are properly designed and installed within agricultural landscapes they can effectively reduce the sediment, nutrients, and pesticides loadings to receiving waterbodies. The Conservation Technology Information Center reports that on average conservation buffers can reduce phosphorus up to as much as 40% from farm fields (http://www.ctic.purdue.edu/Core4/Buffer/Bufferfact.html).

Using this as a basis for the AGNPS modeling the C-Factors from the 154 critical cells were dropped to 0.10 assuming that a buffer strip was installed along the outlet boundary for each of the 40-acre cells. The reduced C-Factors resulted in a average reduction of 17.7% in phosphorus loadings from each of the 154 cells. This is significantly less that what has been reported in the literature. Because this number was extremely conservative SDDENR felt that it was an acceptable number for the development of the Lake Herman TMDL. This further reduction in C-Factors (0.15 to 0.10) resulted in an additional 4.6% reduction in the total phosphorus loadings from the Lake Herman Watershed.

Fertilization Level - The fertilization level is an indication of the level of fertilization on the field. Where the fertilization level was two this was reduced to one. Soil testing can be used to ensure that the particular field will not be over fertilized. This BMP resulted in a 12.34% (Table 8).

Table 4. AGNPS Fertilization Inputs

Assume Fertilization (lb./acre)

Level	N	P	Input
No Fertilization	**0**	**0**	**0**
Low Fertilization	**50**	**20**	**1**
Average Fertilization	**100**	**40**	**2**
High Fertilization	**200**	**80**	**3**

Avg. manure = low fertilization

High manure = avg. fertilization

Water or marsh = 0

Urban or residential = 0 for normal practices

Animal Feeding Areas – A total of 13 feedlots were identified in the Lake Herman Watershed (Lake Herman AGNPS Final Report, 1994). To measure the impact on phosphorus reductions an AGNPS v3.65 analysis was conducted without the feedlots. Each of the 13 feedlots was analyzed separately to quantify its individual impact on the phosphorus loadings to Lake Herman. The two feedlots recommended for animal waste management systems in the original AGNPS final report for Lake Herman exhibited the most significant reduction on the phosphorus loadings when removed from the watershed. Their removal constituted a 2.88 percent reduction in phosphorus loadings to Lake Herman (Table 8). The remaining 11 feedlots had a negligible effect when removed from the watershed.

Table 5. Nutrient outputs for outlet cell 460 in Lake Herman watershed (Figure 1).

Phosphorus outputs w/o 2 critical feedlots

			Sediment P		Soluble P		
		Drainage area	Within cell	cell outlet	Within cell	cell outlet	Conc.
	cell #	Acres	lbs/acre	lbs/acre	lbs/acre	lbs/acre	ppm
1 month	460	11120.00	0.02	0.03	0.00	0.04	4.84
6 month	460	11120.00	0.07	0.12	0.00	0.18	2.43
1 year	460	11120.00	0.12	0.22	0.00	0.26	1.79

Phosphorus outputs with 2 critical feedlots

			Sediment P		Soluble P		
		Drainage area	Within cell	cell outlet	Within cell	cell outlet	Conc.
	cell #	Acres	lbs/acre	lbs/acre	lbs/acre	lbs/acre	ppm
1 month	460	11120.00	0.02	0.03	0.00	0.04	4.96
6 month	460	11120.00	0.07	0.12	0.00	0.19	2.49
1 year	460	11120.00	0.12	0.22	0.00	0.27	1.84

Table 6. Descriptive Statistics for the most sensitive variables of the critical phosphorus cells for the Lake Herman Watershed (AGNPS v3.65, 40-acre Cells).

Statistic	Cropping Factor	Runoff Curve #	Fertilization Factor	Feedlot Indicator
Minimum	0.006	69	0	0
Maximum	0.43	89	2	1
Average	0.29	79	2	0
Median	0.35	78	2	0

Table 7. Descriptive Statistics after adjustment of critical variables for the critical phosphorus cells for the Lake Herman Watershed (AGNPS v3.65, 40-acre Cells).

Statistic	Cropping Factor	Runoff Curve #	Fertilization Factor	Feedlot Indicator
Minimum	0.006	60	0	0
Maximum	0.15	86	1	1
Mean	0.15	77	1	0
Median	0.15	75	1	0

Table 8. All land use adjustments and resulting reductions for total phosphorus outputs from the Lake Herman Watershed using AGNPS v3.65

Cropping-Management Factor Adjustment						
Subwatershed Outlet Cell	Total Phosphorus Output Original	Resulting Output when C-Factor changed to 0.15	% change	Resulting Output when C-Factor changed to 0.10	% change (.15-.10) estimating effect of buffer strips	Cumulative Reduction Percentage
780	3.64	3.63	0.27	3.58	1.38	
710	2.46	2.44	0.81	2.44	0.00	
489	1.96	1.9	3.06	1.89	0.53	
460	2.43	2.22	8.64	2.16	2.70	
		Reduction Percentage	**12.79**		**4.61**	**17.40**
Runoff Curve Number Adjustment						
Outlet Cell	Original Output	Reduction	% change			
780	3.64	3.64	0.00	3.64	0.00	
710	2.46	2.41	2.03	2.41	2.03	
489	1.96	1.92	2.04	1.92	2.04	
460	2.43	2.23	8.23	2.23	8.23	
		Reduction Percentage	**12.30**			**29.70**
Fertilization level Adjustment						
Outlet Cell	Original Output	Reduction	% change			
780	3.64	3.63	0.27			
710	2.46	2.40	2.44			
489	1.96	1.86	5.10			
460	2.43	2.32	4.53			
		Reduction Percentage	**12.34**			**42.04**
Feedlot Adjustment (Remove two feedlots)						
Outlet Cell	Original Output	Reduction	% change			
780	3.64	3.64	0.00			
710	2.46	2.46	0.00			
489	1.96	1.96	0.00			
460	2.43	2.36	2.88		**Total Reduction**	**44.92**
		Reduction Percentage	**2.88**			

<u>CONCLUSION</u>

The reanalysis of the AGNPS data collected in 1994 indicated that a 44.92% reduction could be achieved through standard BMPs such as no-till (conservation tillage), decreased fertilization rates, the installation of buffer strips and two animal waste management systems. Extremely conservative values were used when adjusting the Runoff Curve Number, Cropping-Management Factor, Fertilization Rates to insure the success of reaching a water quality target of 73.93 for the mean Trophic Status Index (TSI) for Lake Herman. The current implementation project for the Lake Herman, Lake Madison, and Brant Lake Watersheds is targeting the areas identified in this addendum as well as the original final report for the Lake Herman Watershed and the Lake Madison/Brant Lake Watershed Assessment final report completed in 1998.

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APPENDIX

A. Typical AGNPS OUTPUT for Lake Herman
B. Critical Phosphorus Cells for Lake Herman

APPENDIX A: Typical AGNPS OUTPUT for Lake Herman

Watershed Summary

1yr event w/o 2 critical feedlots

Watershed studied:	Lake Herman Watershed
Area of the watershed	44000.00 acres
Area of each cell	40 acres
Storm precipitation	2.20 in
Storm EI value	26.80

Values at Watershed Outlet

Cell Number	580
Runoff Volume	0.69 in.
Peak runoff rate	2906.9 cfs
Total N in sediment	0.36 lbs/acre
Total soluble N in runoff	1.26 lbs/acre
Total soluble N concentration in runoff	8.1 ppm
Total P in sediment	0.18 lbs/acre
Total soluble P in runoff	0.25 lbs/acre
Total soluble P concentration in runoff	1.58 ppm
Total soluble COD in runoff	20.56 lbs/acre
soluble COD concentration in runoff	131.70 ppm

Watershed Summary

1yr event w/ 2 critical feedlots

Watershed studied:	Lake Herman Watershed
Area of the watershed	44000.00 acres
Area of each cell	40 acres
Storm precipitation	2.20 in
Storm EI value	26.80

Values at Watershed Outlet

Cell Number	580
Runoff Volume	0.69 in.
Peak runoff rate	2906.94 cfs
Total N in sediment	0.36 lbs/acre
Total soluble N in runoff	1.27 lbs/acre
Total soluble N concentration in runoff	8.17 ppm
Total P in sediment	0.18 lbs/acre
Total soluble P in runoff	0.25 lbs/acre
Total soluble P concentration in runoff	1.59 ppm
Total soluble COD in runoff	20.72 lbs/acre
soluble COD concentration in runoff	132.67 ppm

APPENDIX B: Critical Phosphorus Cells for the Lake Herman Watershed.

Lake Herman Watershed.
Critical Cell Determination for Total Phosphorus (N=154)
25 year Event, Type II EI value = 133.5, Rainfall = 4.6"

Cell Number	Sediment Phos. Cell Outlet lbs/acre	Soluble Phos. Cell Outlet lbs/acre	Total Phosphorus	Mean	StDev
181	10.98	2.25	13.23	3.13	2.14
318	11.61	0.91	12.52	Min	Max
681	11.91	0.52	12.43	0.02	13.23
849	11.62	0.52	12.14		
682	11.51	0.44	11.95		
139	11.41	0.36	11.77		
144	11.41	0.36	11.77		
153	11.41	0.36	11.77		
643	11.41	0.36	11.77		
715	11.41	0.36	11.77		
762	11.41	0.36	11.77		
806	11.41	0.36	11.77		
397	11.2	0.52	11.72		
240	11.32	0.24	11.56		
143	10.7	0.52	11.22		
424	9.98	0.44	10.42		
161	10.15	0.2	10.35		
978	9.64	0.31	9.95		
703	8.35	1.34	9.69		
599	9.27	0.31	9.58		
145	8.89	0.36	9.25		
714	8.89	0.36	9.25		
235	8.72	0.36	9.08		
342	7.66	1.22	8.88		
383	8.41	0.45	8.86		
158	7.47	1.3	8.77		
205	8.22	0.52	8.74		
428	8.22	0.52	8.74		
438	8.22	0.52	8.74		
612	8.22	0.52	8.74		
783	8.22	0.52	8.74		
874	8.22	0.52	8.74		
875	8.22	0.52	8.74		
169	8.16	0.52	8.68		
805	7.94	0.53	8.47		
91	7.9	0.52	8.42		
441	7.88	0.52	8.4		
185	7.93	0.36	8.29		
1062	8.03	0.24	8.27		
214	7.88	0.36	8.24		
353	7.54	0.52	8.06		
90	7.77	0.24	8.01		
688	7.76	0.21	7.97		
496	7.59	0.36	7.95		
275	7.63	0.31	7.94		
944	6.96	0.83	7.79		
945	6.96	0.83	7.79		
51	7.3	0.36	7.66		
615	7.3	0.36	7.66		

981	7.3	0.36	7.66
465	7.6	0.03	7.63
827	6.98	0.53	7.51
74	6.03	1.45	7.48
812	6.07	1.34	7.41
980	6.41	0.94	7.35
196	6.74	0.45	7.19
363	6.88	0.31	7.19
162	6.85	0.31	7.16
222	6.85	0.31	7.16
225	6.85	0.31	7.16
242	6.85	0.31	7.16
251	6.85	0.31	7.16
386	6.85	0.31	7.16
446	6.85	0.31	7.16
593	6.85	0.31	7.16
597	6.85	0.31	7.16
616	6.64	0.52	7.16
750	6.28	0.83	7.11
110	6.26	0.83	7.09
130	6.26	0.83	7.09
284	6.26	0.83	7.09
848	6.26	0.83	7.09
293	6.24	0.83	7.07
191	6.8	0.21	7.01
120	6.54	0.31	6.85
182	4.54	2.25	6.79
468	6.44	0.15	6.59
884	6.06	0.52	6.58
467	6.47	0.02	6.49
270	6.16	0.31	6.47
826	5.86	0.54	6.4
184	6.02	0.34	6.36
302	5.99	0.36	6.35
303	5.99	0.36	6.35
112	5.8	0.53	6.33
704	4.82	1.22	6.04
804	5.6	0.44	6.04
925	5.77	0.2	5.97
586	5.43	0.48	5.91
425	5.55	0.35	5.9
705	4.85	1.02	5.87
264	4.63	1.22	5.85
642	4.93	0.91	5.84
77	5.46	0.36	5.82
512	5.58	0.22	5.8
152	4.96	0.83	5.79
573	5.43	0.35	5.78
1097	5.3	0.48	5.78
1016	5.4	0.36	5.76
632	5.23	0.52	5.75
304	5.38	0.36	5.74
25	4.86	0.87	5.73
210	4.5	1.22	5.72
343	4.5	1.22	5.72
751	4.5	1.22	5.72
752	4.5	1.22	5.72
753	4.5	1.22	5.72

1084	4.5	1.22	5.72
469	5.66	0.02	5.68
876	5.44	0.24	5.68
24	4.53	1.13	5.66
912	5.14	0.52	5.66
1068	5.07	0.51	5.58
119	5.11	0.45	5.56
928	4.33	1.22	5.55
277	4.32	1.22	5.54
410	5.1	0.44	5.54
439	5.31	0.2	5.51
146	5.06	0.42	5.48
38	5.16	0.31	5.47
157	3.63	1.78	5.41
462	5.38	0.03	5.41
464	5.38	0.03	5.41
34	4.93	0.45	5.38
221	4.93	0.45	5.38
243	4.93	0.45	5.38
382	4.93	0.45	5.38
498	5.19	0.19	5.38
588	4.93	0.45	5.38
589	4.93	0.45	5.38
701	4.93	0.45	5.38
763	4.93	0.45	5.38
317	4.38	0.98	5.36
818	4.48	0.83	5.31
175	4.93	0.36	5.29
788	5.12	0.17	5.29
71	4.91	0.36	5.27
131	4.91	0.36	5.27
137	4.91	0.36	5.27
313	4.91	0.36	5.27
338	4.91	0.36	5.27
364	4.91	0.36	5.27
391	4.91	0.36	5.27
420	4.91	0.36	5.27
422	4.91	0.36	5.27
620	4.91	0.36	5.27
666	4.91	0.36	5.27
667	4.91	0.36	5.27
722	4.91	0.36	5.27
745	4.91	0.36	5.27
821	4.91	0.36	5.27
839	4.91	0.36	5.27
956	4.91	0.36	5.27
1088	4.91	0.36	5.27

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September 29, 2004

Ref: 8EPR-EP

Steven M. Pirner, Secretary
Department of Environment & Natural Resources
Joe Foss Building
523 East Capitol
Pierre, SD 57501-3181

Re: TMDL Approvals
Brakke Dam
Fish Lake
Hayes Lake
Lake Herman

Dear Mr. Pirner:

We have completed our review, and have received Endangered Species Act Section 7 concurrence from the U.S. Fish and Wildlife Service, on the total maximum daily loads (TMDLs) as submitted by your office for the waterbodies listed in the enclosure to this letter. In accordance with the Clean Water Act (33 U.S.C. 1251 *et. seq*.), we approve all aspects of the TMDLs as developed for the water quality limited waterbodies as described in Section 303(d)(1).

Based on our review, we feel the separate TMDL elements listed in the enclosed review table adequately address the pollutants of concern, taking into consideration seasonal variation and a margin of safety. Please find enclosed a detailed review of these TMDLs.

For years, the State has sponsored an extensive clean lakes program. Through the lakes assessment and monitoring efforts associated with this program, priority waterbodies have been identified for cleanup. It is reasonable that these same priority waters have been a focus of the Section 319 nonpoint source projects as well as one of the priorities under the State's Section 303(d) TMDL efforts.

In the course of developing TMDLs for impaired waters, EPA has recognized that not all impairments are linked to water chemistry alone. Rather, EPA recognizes that *"Section 303(d) requires the States to identify all impaired waters regardless of whether the impairment is due to toxic pollutants, other chemical, heat, habitat, or other problems."* (see 57 Fed. Reg. 33040 for July 24, 1992). Further, EPA states that "*...in some situations water quality standards –*

particulary designated uses and biocriteria – can only be attained if nonchemical factors such as hydrology, channel morphology, and habitat are also addressed. EPA recognizes that it is appropriate to use the TMDL process to establish control measures for quantifiable non-chemical parameters that are preventing the attainment of water quality standards." (see Guidance for Water Quality-based Decisions: The TMDL Process; USEPA; EPA 440/4-91-001, April 1991; pg. 4). We feel the State has developed TMDLs that are consistent with this guidance, taking a comprehensive view of the sources and causes of water quality impairment within each of the watersheds. For example, in several of the TMDLs, the State considered nonchemical factors such as trophic state index (TSI) and its relationship to the impaired uses. Further, we feel it is reasonable to use factors such as TSI as surrogates to express the final endpoint of the TMDL.

Thank you for your submittal. If you have any questions concerning this approval, feel free to contact Vernon Berry of my staff at 303-312-6234.

Sincerely,

/s/ by Max H. Dodson

Max H. Dodson
Assistant Regional Administrator
Office of Ecosystems Protection and Remediation

Enclosures

Enclosure 1

Approved TMDLs

Waterbody Name*	TMDL Parameter/ Pollutant	Water Quality Goal/Endpoint	TMDL	Section 303(d)1 or 303(d)3 TMDL	Supporting Documentation (not an exhaustive list of supporting documents)
Brakke Dam*	phosphorus	TSI mean < 64.51	501 kg/yr total phosphorous load to the lake (18.9% reduction in average annual total phosphorus load)	Section 303(d)(1)	# Phase I Watershed Assessment and TMDL Final Report, Brakke Dam, Lyman County, South Dakota (SD DENR, April 2004)
Fish Lake*	phosphorus	TSI mean ≤ 66.3	1,864 kg/yr total phosphorous load to the lake (25% reduction in average annual total phosphorus load)	Section 303(d)(1)	# Phase I Watershed Assessment Final Report and TMDL, Fish Lake, Deuel County, South Dakota (SD DENR, January 2004)
Hayes Lake*	phosphorus	TSI mean ≤ 64.8	25,264 kg/yr total phosphorous load to the lake (24% reduction of average annual watershed load, and 25% reduction of internal load)	Section 303(d)(1)	# Watershed Assessment and TMDL Final Report, Hayes Lake / Frozen Man Creek, Stanley County, South Dakota (SD DENR, March 2004)
Lake Herman*	phosphorus	TSI mean ≤ 73.93	3,417 kg/yr total phosphorous load to the lake (45% reduction in average annual total phosphorus load)	Section 303(d)(1)	# Total Maximum Daily Load for Total Phosphorous in Lake Herman, Lake County, South Dakota (SD DENR, September 2004)

* An asterisk indicates the waterbody has been included on the State's Section 303(d) list of waterbodies in need of TMDLs.