Prepared by:
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For the Minnesota Pollution Control Agency

Golden Lake TMDL

August 2009

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Emmons & Olivier Resources, Inc.
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TMDL Summary Table

<table>
<tr><th>EPA/MPCA
Required Elements</th><th colspan="3">Summary</th><th>TMDL
Page #</th></tr>
<tr><td>Location</td><td colspan="3">Drainage Basin, Part of State, County, etc.</td><td></td></tr>
<tr><td>303(d) Listing Information</td><td colspan="3">Describe the waterbody as it is identified on the State/Tribe’s 303(d) list:
• Waterbody name, description and ID# for each river segment, lake or wetland
• Impaired Beneficial Use(s) - List use(s) with source citation(s)
• Impairment/TMDL Pollutant(s) of Concern (e.g., nutrients: phosphorus; biota: sediment)
• Priority ranking of the waterbody (i.e. schedule)
• Original listing year</td><td>1</td></tr>
<tr><td>Applicable Water Quality Standards/ Numeric Targets</td><td colspan="3">List all applicable WQS/Targets with source citations. If the TMDL is based on a target other than a numeric water quality criterion, a description of the process used to derive the target must be included in the submittal.</td><td>33</td></tr>
<tr><td>Loading Capacity (expressed as daily load)</td><td colspan="3">Identify the waterbody’s loading capacity for the applicable pollutant. Identify the critical condition.
For each pollutant: LC = X/day; and Critical Condition Summary</td><td>36</td></tr>
<tr><td rowspan="12">Wasteload Allocation</td><td colspan="3">Portion of the loading capacity allocated to existing and future point sources [40 CFR §130.2(h)].
Total WLA = lbs/day, for each pollutant</td><td rowspan="12">42</td></tr>
<tr><th>Source</th><th>Permit #</th><th>WLA</th></tr>
<tr><td>Blaine</td><td>MS400075</td><td rowspan="7">0.38</td></tr>
<tr><td>Circle Pines</td><td>MS400009</td></tr>
<tr><td>Lexington</td><td>MS400027</td></tr>
<tr><td>Lino Lakes</td><td>MS400100</td></tr>
<tr><td>RCWD</td><td>MS400193</td></tr>
<tr><td>Construction stormwater</td><td>General</td></tr>
<tr><td>Industrial stormwater</td><td>General</td></tr>
<tr><td>Anoka County</td><td>MS400066</td><td>0.010</td></tr>
<tr><td>Mn/DOT</td><td>MS400170</td><td>0.007</td></tr>
<tr><td>Aveda Corp.</td><td>MN0066524</td><td>0.016</td></tr>
<tr><td rowspan="3">Load Allocation</td><td colspan="3">Identify the portion of the loading capacity allocated to existing and future nonpoint sources and to natural background if possible [40 CFR §130.2(g)].
Total LA = lbs/day, for each pollutant</td><td rowspan="3">44</td></tr>
<tr><th>Source</th><th colspan="2">LA</th></tr>
<tr><td>Internal Load, Atmospheric Deposition and Non-MS4 runoff</td><td colspan="2">0.21</td></tr>
<tr><td>Margin of Safety</td><td colspan="3">Include a MOS to account for any lack of knowledge concerning the relationship between load and wasteload</td><td>41</td></tr>
</table>

	allocations and water quality [CWA §303(d)(1)(C), 40 CFR §130.7(c)(1)]. ***Identify <u>and explain</u> the implicit or explicit MOS for each pollutant***	
Seasonal Variation	Statute and regulations require that a TMDL be established with consideration of seasonal variation. The method chosen for including seasonal variation in the TMDL should be described [CWA §303(d)(1)(C), 40 CFR §130.7(c)(1)] ***Seasonal Variation Summary for each pollutant***	46
Reasonable Assurance	***Summarize Reasonable Assurance*** *Note: In a water impaired by both point and nonpoint sources, where a point source is given a less stringent WLA based on an assumption that NPS load reductions will occur, reasonable assurance that the NPS reductions will happen must be explained.* *In a water impaired solely by NPS, reasonable assurances that load reductions will be achieved are not required (by EPA) in order for a TMDL to be approved.*	53
Monitoring	***Monitoring Plan included?*** *Note: EPA does not approve effectiveness monitoring plans but providing a general plan is helpful to meet reasonable assurance requirements for nonpoint source reductions. A monitoring plan should describe the additional data to be collected to determine if the load reductions provided for in the TMDL are occurring and leading to attainment of water quality standards.*	47
Implementation	***1. Implementation Strategy included?*** The MPCA requires a general implementation strategy/framework in the TMDL. *Note: Projects are required to submit a separate, more detailed implementation plan to MPCA within one year of the TMDL's approval by EPA.* ***2. Cost estimate included?*** The Clean Water Legacy Act requires that a TMDL include an overall approximation ("…a range of estimates") of the cost to implement a TMDL [MN Statutes 2007, section 114D.25]. *Note: EPA is not required to and does not approve TMDL implementation plans.*	48
Public Participation	• Public Comment period (dates) • Comments received? • Summary of other key elements of public participation process *Note: EPA regulations require public review [40 CFR §130.7(c)(1)(ii), 40 CFR §25] consistent with State or Tribe's own continuing planning process and public participation requirements.*	54

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1. Background and Pollutant Sources

A. 303(D) LISTING

Table 1. TMDL Listing Information

DNR ID#:	02-0045
Pollutant or stressor:	Nutrient/eutrophication biological indicators
Impairment:	Aquatic recreation
Year first listed:	2002
Target start/completion:	2004/2008 (reflects the priority ranking)
CALM category:	5C – Impaired by one pollutant and no TMDL study plan is approved by EPA

B. BACKGROUND

The Golden Lake Watershed is located in the west-central portion of the Rice Creek Watershed District (RCWD) in southern Anoka County and is a sub-watershed of the Upper Mississippi Watershed. This area lies entirely within the North Central Hardwood Forest Ecoregion (NCHF). Golden Lake itself is located in the City of Circle Pines (Figure 1), and the watershed is located in Blaine, Circle Pines, Lexington, and Lino Lakes (Figure 2). The main tributary to Golden Lake is Anoka County Ditch 53-62 (ACD 53-62), which enters the lake from the north. Approximately 6,426 acres drain to the lake through the ditch, and approximately 139 acres drain to the lake directly. Golden Lake flows into Rice Creek just below the Rice Creek Chain of Lakes.

The MPCA's projected schedule for TMDL completions, as indicated on Minnesota's 303(d) impaired waters list, implicitly reflects Minnesota's priority ranking of this TMDL. The Golden Lake project was scheduled to begin in 2004 and be completed in 2008. Ranking criteria for scheduling TMDL projects include, but are not limited to: impairment impacts on public health and aquatic life; public value of the impaired water resource; likelihood of completing the TMDL in an expedient manner, including a strong base of existing data and restorability of the water body; technical capability and willingness locally to assist with the TMDL; and appropriate sequencing of TMDLs within a watershed or basin.

The RCWD considers Golden Lake a priority and has been monitoring the lake since 1997. Golden Lake has been the focus of much study over the years, which included a Clean Lakes study in the early 1980s and a state Clean Water Partnership study in the late 1980s. The current TMDL builds on this earlier work and outlines load reductions necessary to restore this system.

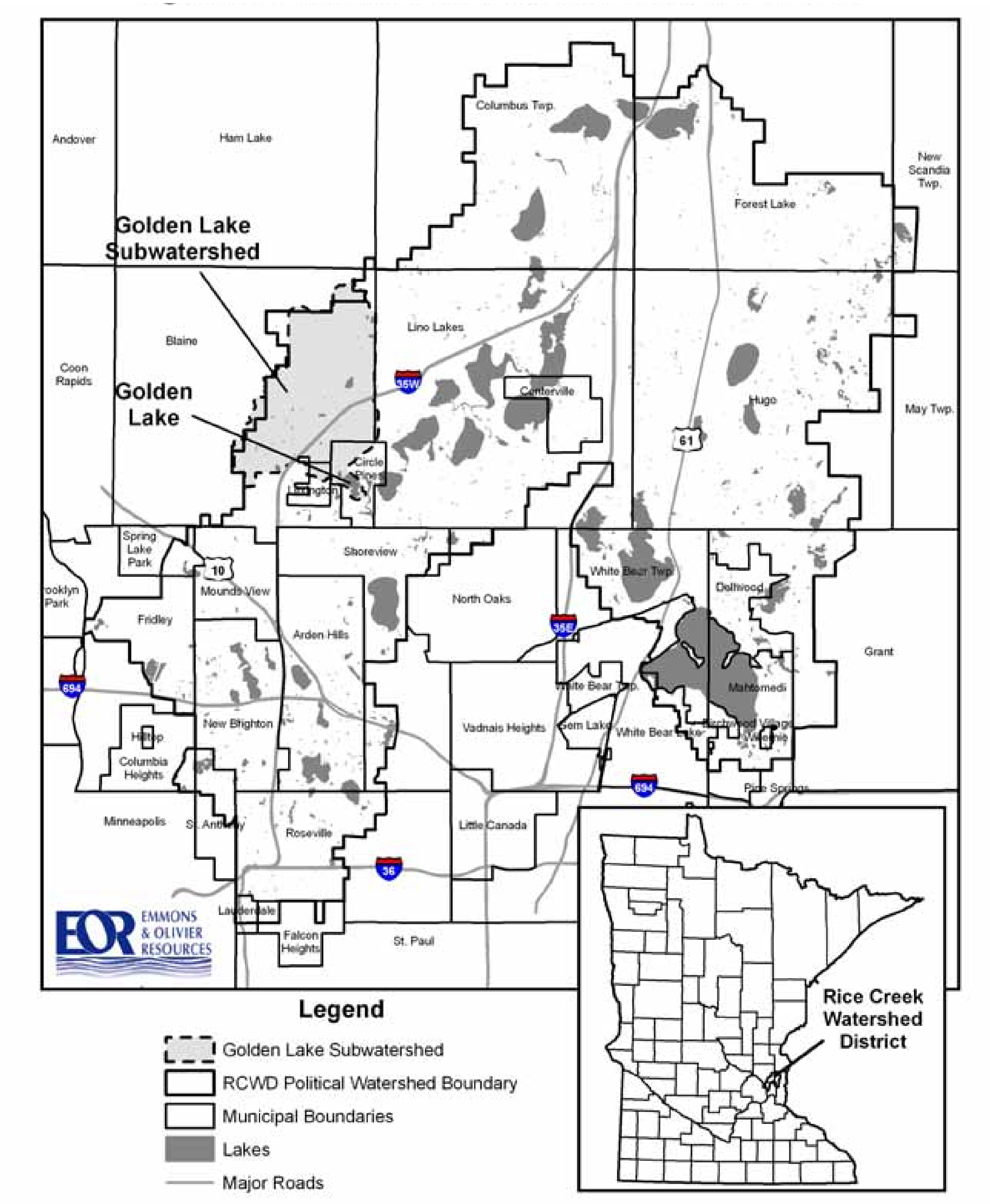


Figure 1. Location of the Golden Lake Watershed

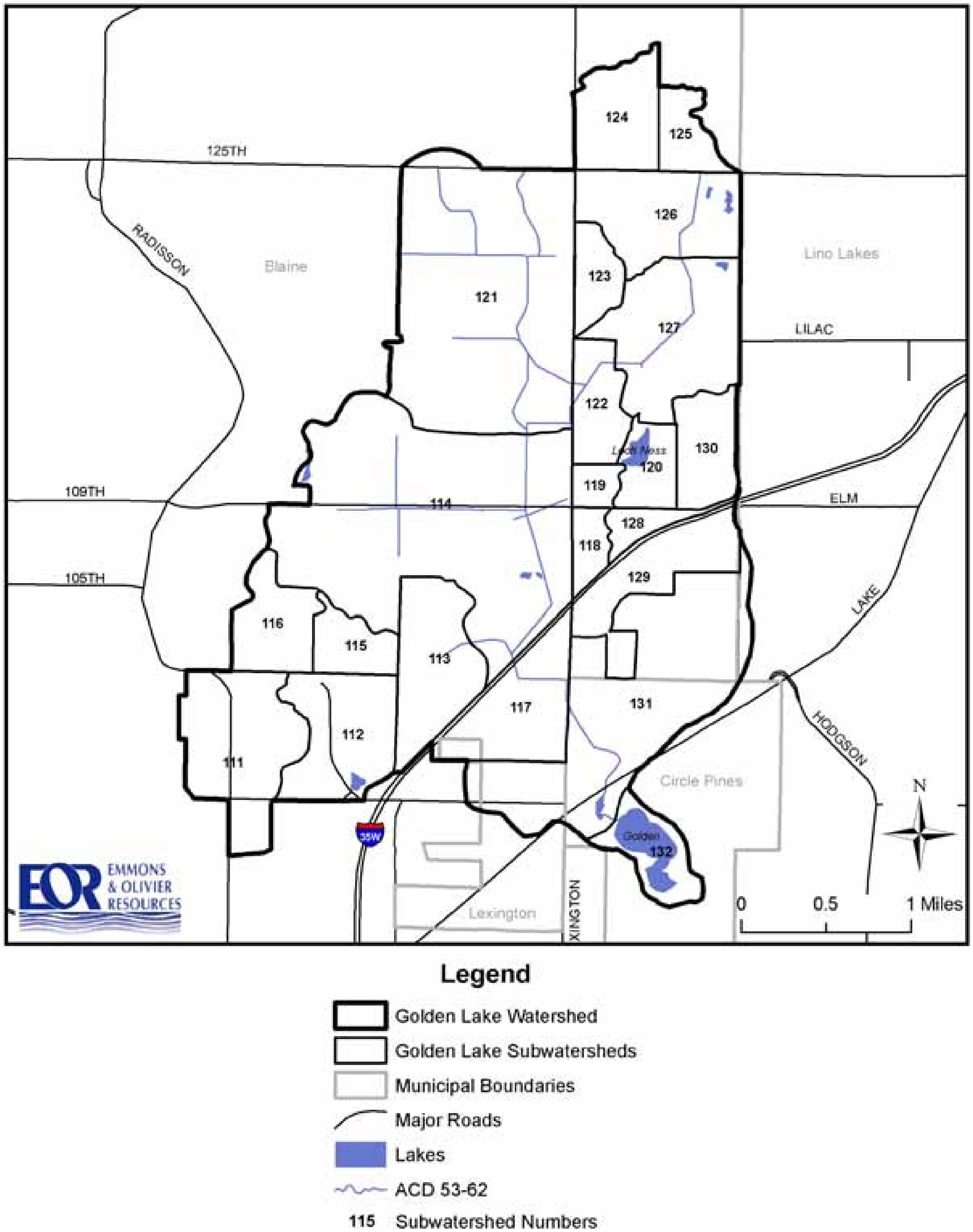


Figure 2. Golden Lake Watershed

Lake Description

Golden Lake is 57.2 acres in size and has a maximum depth of 24 feet and a mean depth of 8 feet (Figure 3). The littoral area of Golden Lake constitutes approximately 90% of the lake's total surface area (Table 2). The lakeshore area is well developed. The lake is used recreationally for fishing and non-motorized boating and there is a public access site located along the west side of the lake. Only trawling motors are allowed on the lake.

Table 2. Lake and Watershed Characteristics

Lake total surface area	57.2 ac
Lake littoral surface area	51.3 ac
Lake volume	458 ac-ft
Mean depth	8.0 ft
Maximum depth	24 ft
Drainage area	6566 ac

Due to Golden Lake's naturally high tannin concentrations, the lake has a brownish tint that limits light penetration. This was noted in the 1982 study, "Management alternatives report on the diagnostic – feasibility study for Golden Lake, Anoka County, MN." In a 1987 study (Circle Pines 1987), light was measured with a photometer and was used to calculate the light extinction coefficient in Golden Lake. It was concluded that photoinhibition of macrophytes from humics is occurring.

A groundwater assessment was conducted to determine whether or not Golden Lake is a discharge lake (Appendix A). In systems with substantial groundwater input, nutrients from the groundwater input need to be taken into account in the nutrient balance of the lake. In addition, the groundwater surface water interaction is an important component to consider when planning restoration activities. Lake elevations relative to groundwater elevations, the surrounding surficial geology, and surface water inflow and outflow were evaluated to determine Golden Lake's dependence on groundwater. This analysis suggests that Golden Lake recharges the local water table due to its elevation relative to the water table and the surficial geology of the region. Groundwater is unlikely a significant nutrient source to the lake.

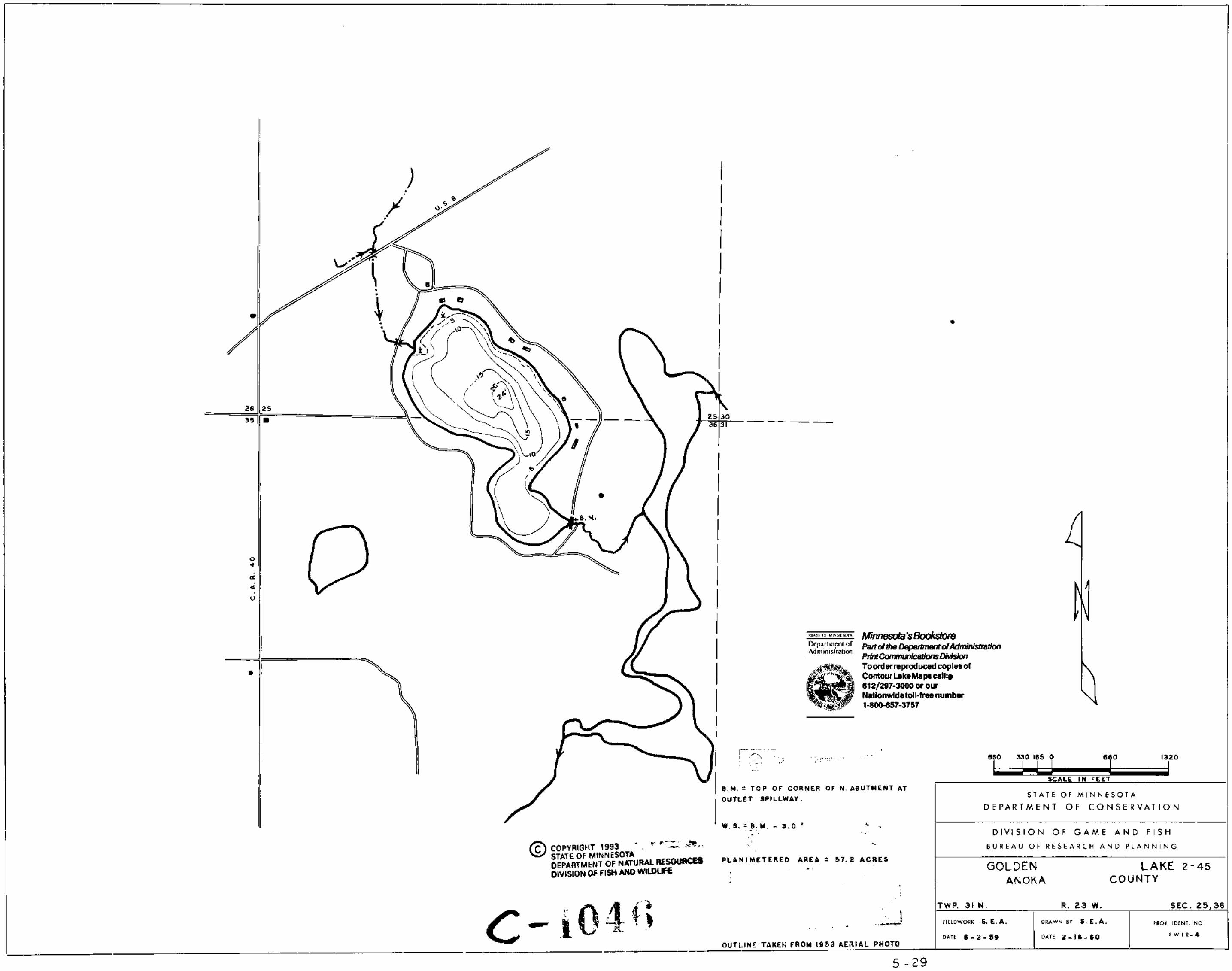


Figure 3. Golden Lake Bathymetric Map

Monitoring Data

In-lake monitoring data are available sporadically from 1991 through 2004. The last ten years of data were used to calculate the water quality data means (Table 3); the lake was monitored for seven seasons within this ten-year period.

Golden Lake ranges from eutrophic to hypereutrophic, with relatively higher TP and chlorophyll-*a* concentrations compared to transparency, as indicated by the TSI values (Table 3). This can be an indication that the phytoplankton are composed of relatively large algal species; these larger particles do not affect transparency, as measured with a Secchi disk, as much as smaller particles do. This is often the case where there is a healthy zooplankton community that has effectively grazed down all of the smaller algal particles, which are easier for them to eat than the larger particles. Results from 2005 zooplankton counts in Golden Lake indicate that there is a healthy population of large herbivores in the lake that would effectively graze smaller particles. These results differ from zooplankton counts taken in Golden Lake in 1982 that indicated that small herbivores unable to significantly contribute to the grazing of algae were the most dominant (Circle Pines 1982). This is thought to be the result of a shift in the fish community from 1982 to 2005 due to biomanipulation/fish stocking conducted by the Minnesota Department of Natural Resources.

TP concentrations have varied widely over the years (Figure 4), with higher concentrations in 2002 and 2004 than in the previous monitored years since 1994. Average annual TP concentration is significantly correlated with total annual precipitation (Figure 4; $R^2 = 0.74$, $p < 0.05$). The same general water quality pattern exists for chlorophyll-*a* (Figure 5) and Secchi depth (Figure 6). The water quality standards depicted in these figures are discussed in *Section 2: Standards and Goals*. The raw data are included in Appendix B.

Table 3. Surface Water Quality, 1994 - 2004

	Growing Season Mean (June – September)	Coefficient of Variation	Trophic Status Index
TP (µg/L)	89	0.11	69
Chlor-*a* (µg/L)	47	0.20	68
Secchi depth (m)	1.1	0.36	59

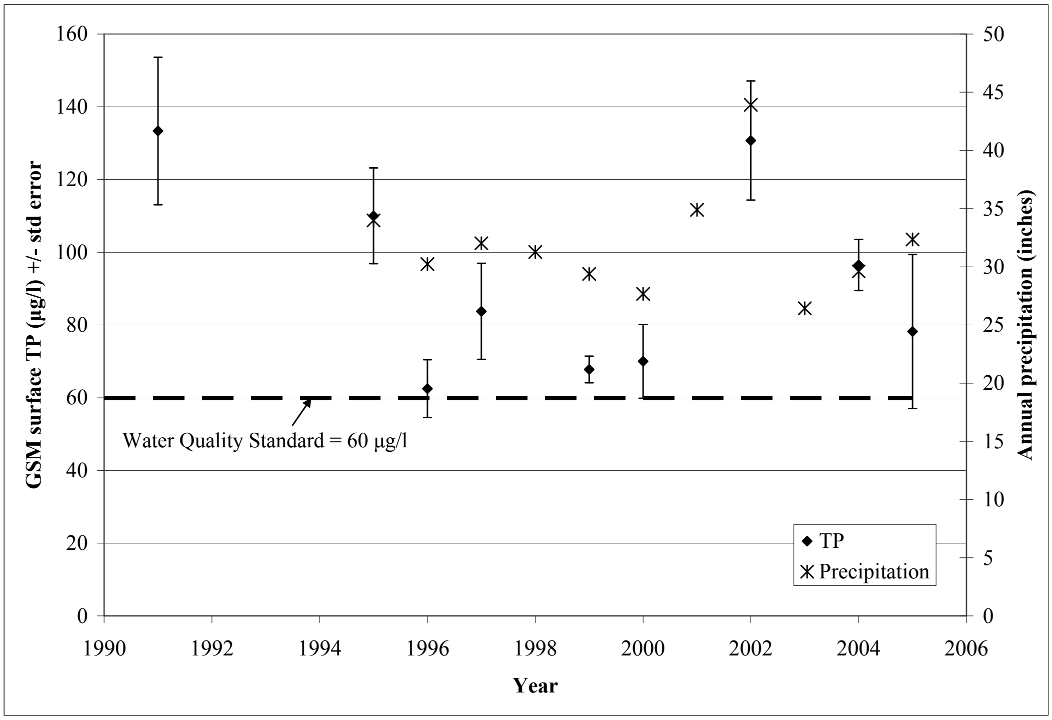


Figure 4. Total Phosphorus Monitoring Data

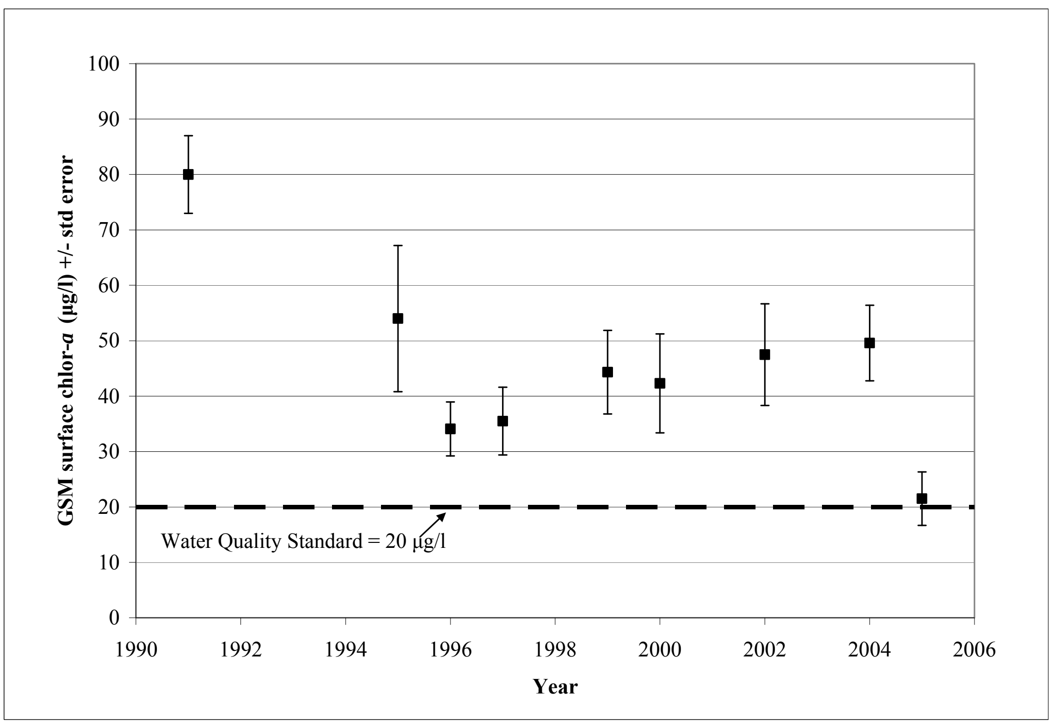


Figure 5. Mean Chlorophyll-*a* Monitoring Data

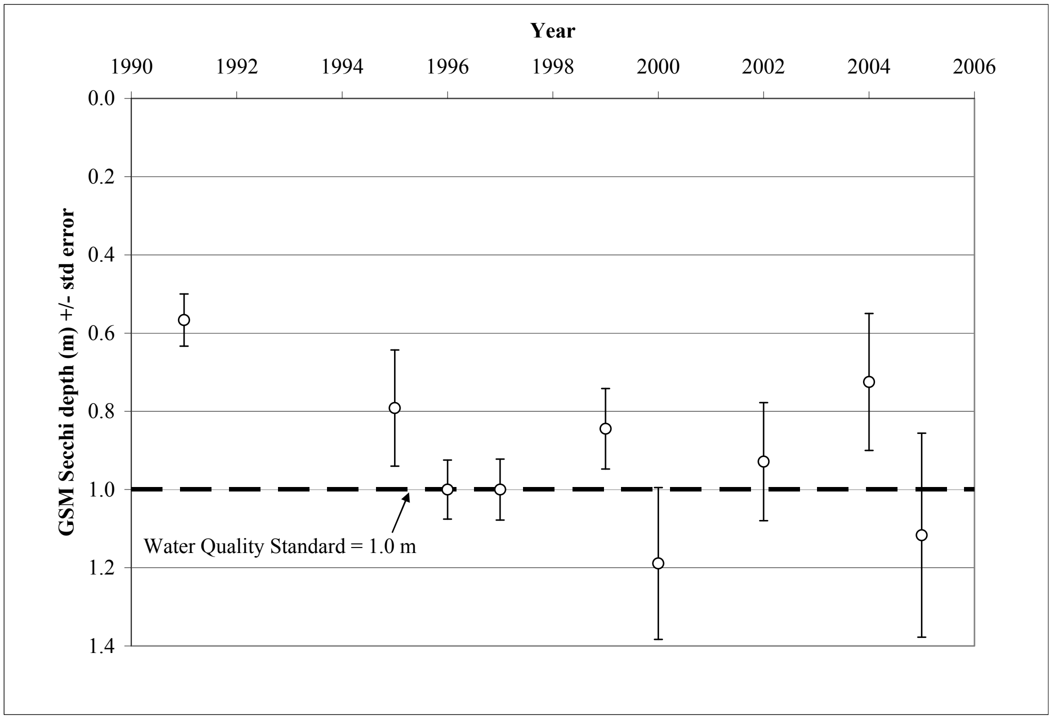


Figure 6. Secchi Depth Monitoring Data

Based on a 2003 DNR fish survey, black bullhead, black crappie, bluegill, channel catfish, sunfish, bass, pike, and walleye were found in Golden Lake. Bluegills were sampled in higher than typical numbers compared to lakes with similar physical and chemical characteristics. Both channel catfish and walleye were stocked in the lake over the last five years.

The most dominant macrophyte in the lake is curlyleaf pondweed (*Potamogeton crispus*). Colonies of curlyleaf pondweed grow in the littoral areas of the lake, at depths of five feet and under in spring and early summer, and are considered a nuisance to lake residents and users. After the June die-off of the curlyleaf pondweed there is no substantial growth of submerged aquatic vascular plants. The June die-off releases phosphorus into the water column, as evidenced by an increase of in-lake TP during June (Figure 7 and Figure 8).

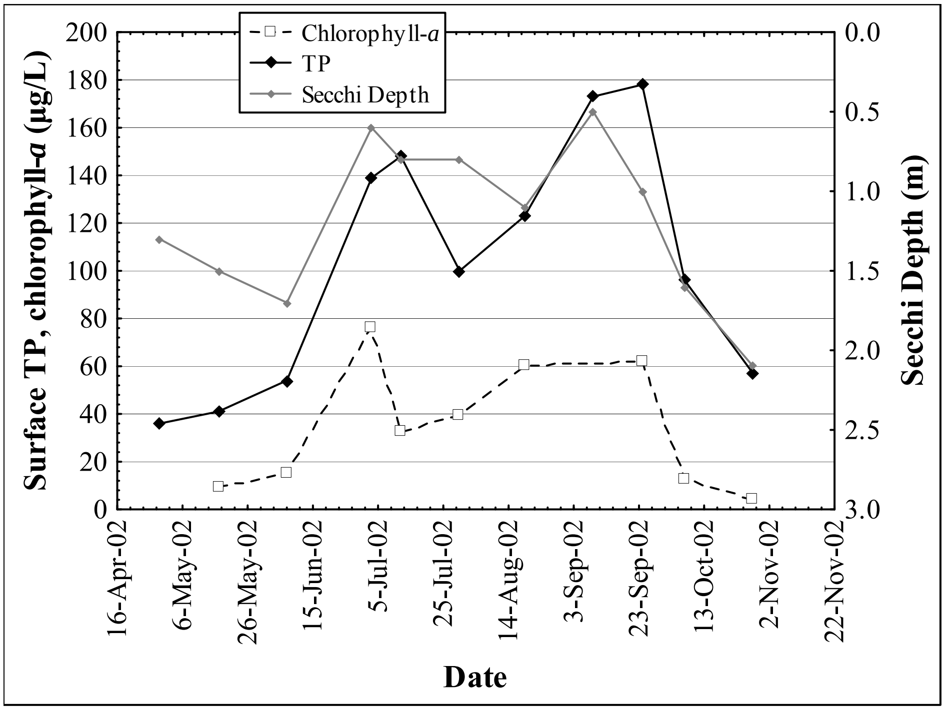


Figure 7. 2002 Water Quality Monitoring Data

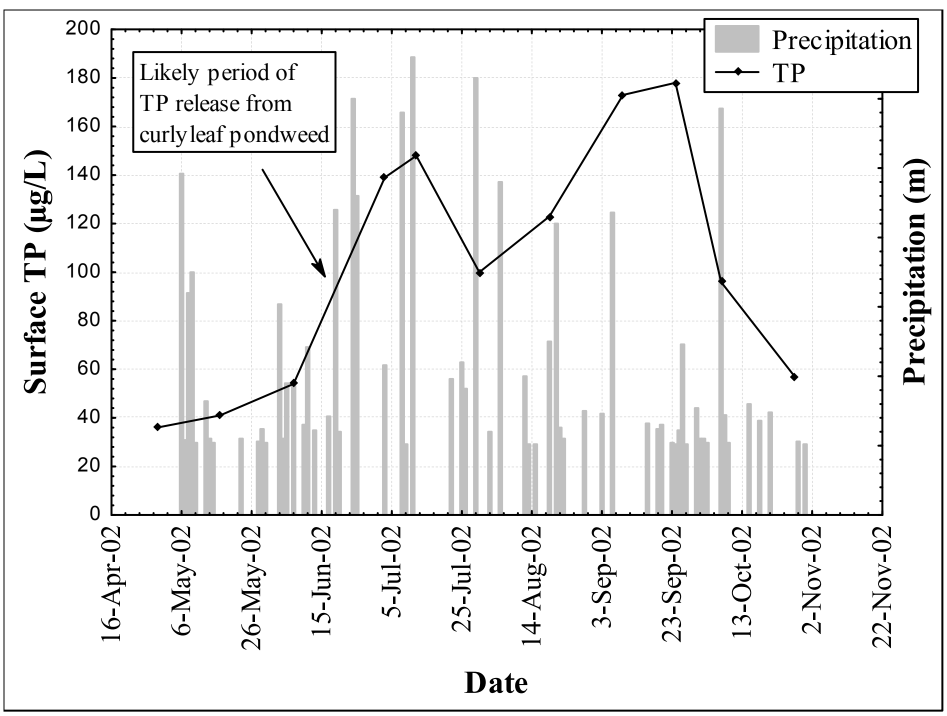


Figure 8. Curlyleaf Pondweed TP Release Timing

Depth profiles of dissolved oxygen and temperature are available for only parts of 1995 and 2004, and only in the deepest part of the lake. In 1995, this deep hole stratified during the summer months, with the hypolimnion becoming anoxic, and overturned sometime between September 18 and October 24 (Figure 9). In 2004, stratification also occurred during the summer months. Hypolimnetic TP data are available for 2004, in which concentrations increased dramatically towards the end of the summer (Figure 10).

The shallower areas likely intermittently stratify throughout the summer, as is common in most shallow lakes. During periods of stratification when the lower portion of the water column becomes anoxic, phosphorus is released from the sediment. The phosphorus is then distributed throughout the water column when the lake mixes. This process may happen multiple times over the course of the growing season, accounting for a substantial proportion of the total internal loading to the lake.

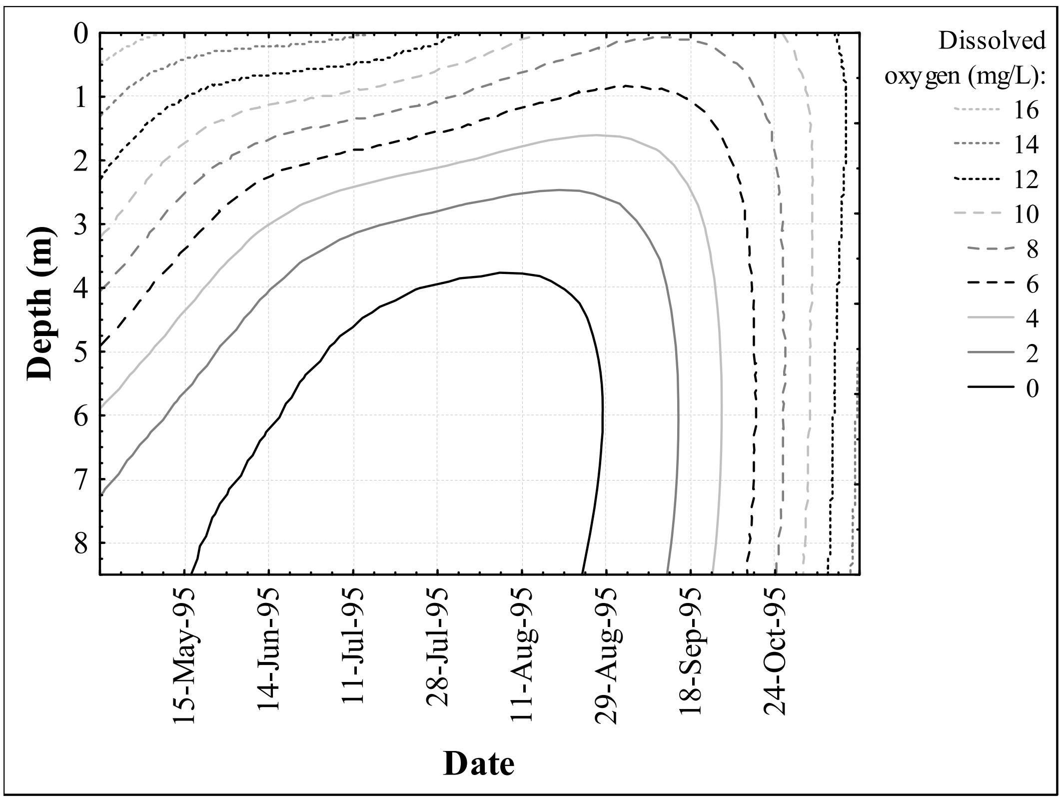


Figure 9. Dissolved Oxygen Depth Profiles

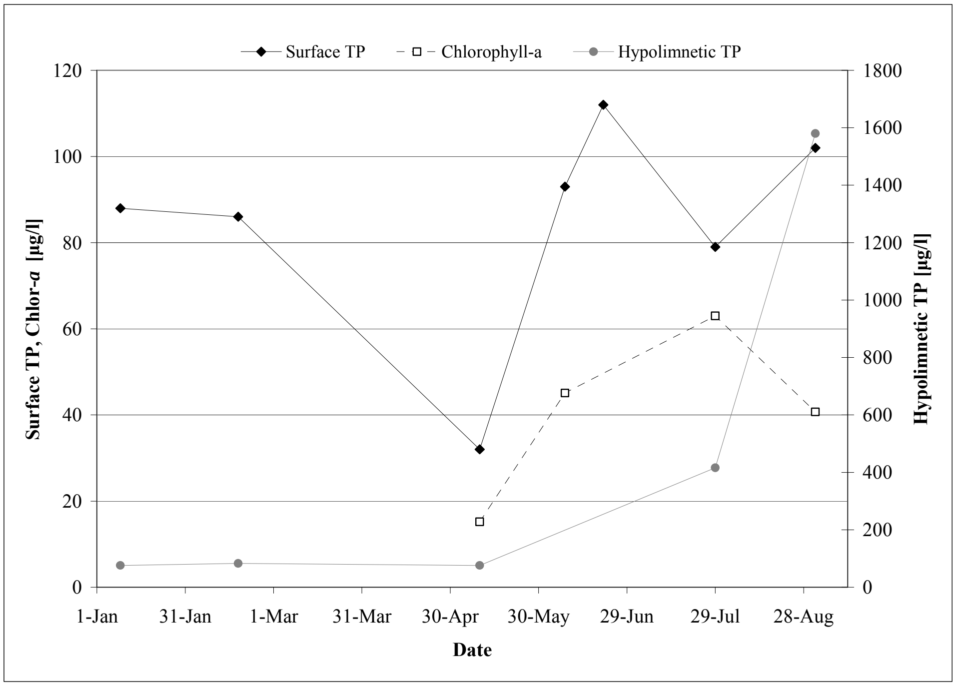


Figure 10. 2004 Surface TP and Chlorophyll-a, Hypolimnetic TP

Watershed Description

Golden Lake has a 6,565-acre watershed that currently includes a significant portion of rural and agricultural areas. ACD (Anoka County Ditch) 53-62, the main tributary to the lake, is a ditch system that was constructed in the early 1900s to provide drainage benefits to farmers in the area. Grade along the ditch is minimal, with many stretches, some exceeding one mile in length, being completely flat. The following is an excerpt from the original land survey notes written by Andrew J. Hewitt, Deputy Surveyor in 1847. Mr. Hewitt described the township including portions of the Golden Lake drainage area as follows:

> This township presents a surface almost level to the eye of the beholder. It is one dense marsh, interspersed at intervals with numerous islands; small lakes or ponds and tamarack swamps. The islands vary in size, from one to ten acres and most of them covered with thick brush and timber of various kinds. The water in the lakes or ponds is generally clear and cold and most of them have fish in them of various kinds. The margins of them are generally marshy and springy. This township is almost inaccessible either for man or beast excepting when frozen up. A small portion of the northern portion of this township is barrens, covered with short thin grasses and scattering near by Jack-oak trees. The soil on the bare site is light, loose sand 3rd rate.

Aerial photographs reviewed (1938, 1945, 1953, 1957, 1966, 1968, 1973, 1974, 1987) showed much of the area served by ACD 53-62 being used for hay production. Many sod fields existed in the watershed before Interstate 35W was constructed. Land use within the ACD 53-62 drainage area has been changing since the 1980s. With conversion from agricultural to urban uses, the ditch has become increasingly relied upon for storm water conveyance and less importantly for providing agricultural drainage.

Many changes have been made to ACD 53-62 since it was originally constructed. A latticework of private ditches has been dug by local landowners to improve drainage. In addition, landowners constructed many crossings along the ditch in order to readily access their fields. As the population continued to increase throughout the area, public road crossings were also built.

A pond treatment system exists to the northeast of Golden Lake on ACD 53-62. The basin, known as the Golden Lake Wetland Treatment Basin (referred to as WQ Pond in Table 9), was created in 1992 to treat water entering Golden Lake through the ditch. The pond was approximately 3.5 acres in size, and provided 7.0 acre-feet of dead storage for water quality treatment. The pond was expanded in 1997 to approximately 5.1 acres in size, with 7.5 acre-feet of dead storage and 3.5 acre-feet of live storage. At the time of its creation, the pond was excavated to a depth of approximately 9 feet.

Additional treatment is provided by a sedimentation basin within Golden Lake. This sedimentation basin was created in 1997 with the expansion of the Golden Lake Wetland Treatment Basin. This in-lake basin was constructed to provide additional treatment for water coming through ACD 53-62. It was originally excavated to a depth 8 feet below the water surface; 2,720 cubic yards of material were originally removed. The City of Circle Pines is responsible for the maintenance of the in-lake sedimentation basin. It was cleaned as recently as 2007.

More recently, large wetland restoration/creation projects have occurred in the upper portions of the ditch system.

Because of this rapid growth that is occurring within the Golden Lake Watershed, the RCWD developed a Resource Management Plan (RMP) for the entire ACD 53-62 drainage area (RCWD 2006), which constitutes the majority of the Golden Lake watershed. The comprehensive approach used in this large-scale RMP benefits all planning efforts by better clarifying development possibilities for landowners while identifying significant natural resources to be set aside for protection. (See *Resource Management Plan*, under this section, for RMP details.) The following are excerpts from the RMP that describe the physical characteristics of the watershed, past land use conditions, and drainage history.

Geologic History (Excerpt from 53-62 RMP Appendix A)

Anoka Sand Plain

With the recession of the last glaciations from Central Minnesota, several distinct landforms appeared. Each one is distinguished by the kind of glacial material left behind, such as silts, sands, gravel, coupled with the topographic pattern of lakes, rivers, and wetlands. The Anoka Sand Plain is one of the distinct landforms of Central Minnesota. The glacial sand coupled with the minimal change in elevation are the distinguishing features. These features are responsible for the highly interspersed pattern of terrestrial, aquatic, and wetland habitats found here.

Geology and Soils

The geology of the ACD 53-62 drainage area (which drains to Golden Lake) in the west-central portion of Rice Creek Watershed District consists of a 200 to 300 foot thick layer of glacial and post-glacial deposits overlying bedrock. The surface topography is slight, fluctuating only 14 feet in elevation within the 53-62 drainage area, and has a soil composition that allows for little natural drainage.

Surficial Geology

The ACD 53-62 Drainage Area is underlain by Des Moines Lobe glacial deposits of the Wisconsinan Glaciation. Part of the Grantsburg Sublobe of the Des Moines Lobe that flowed through the area bringing with it gray drift from Manitoba and the Red River Valley and the glacier retreated approximately 12,500 years ago. As the glacier wasted, Glacial Lake Fridley formed along the eastern edge of Anoka County and at the location where 53-62 Drainage Area is presently located.

The quaternary geology consists of a mix of glacial sands and post glacial organic deposits. The glacial sands are part of the New Brighton Formation and are composed of sediment deposited in Glacial Lake Fridley. This formation consists of fine to medium-grained sand that is loamy in places, with scattered lenses of silt to silty sand. The upper few feet of sand has commonly been reworked by wind action. Within the study area, the New Brighton Formation is partially overlain by organic peat accumulated in depressions formed within the glacial sand deposits. These organic peat deposits consist of partially decomposed plant matter deposited in marshes, with muck interspersed.

Bedrock Geology

The topmost bedrock layer beneath the study area is the St. Lawrence-Franconia Formation. This formation is one of the Paleozoic bedrock layers that was formed by the transgression and regression of a vast inland sea hundreds of millions of years ago. It is composed of dolomitic shale, siltstone, and dolostone that overlie fine to coarse-grained sandstone. The formation is sedimentary in origin as eroded materials from the north were transported to the flat inland sea and accumulated over time. The 53-62 drainage area lies at the northerly end of the Twin Cities Basin, and due to the shape of the basin, the younger Paleozoic rocks that are found under Minneapolis-St. Paul were eroded away before the glacial sediment was deposited at this site.

Soils

There are two soil associations within ACD 53-62 Drainage Area. Approximately 80 percent of the area is comprised of the Rifle-Isanti Association. The remaining 20 percent is part of the Zimmerman-Isanti-Lino Association.

The Rifle-Isanti Association is nearly level in topography, and has very poor drainage. It is comprised chiefly of organic material (muck, mucky peat), with some fine sand intermingled. Organic bogs with small sandy island features are common in this association. The natural water table is very high, usually between 0 and 2 feet from the surface. The Rifle-Isanti Association is poorly suited for urban, agricultural, and recreational uses.

The Zimmerman-Isanti-Lino Association is mainly found in the broad undulating glacial sand deposits. It is dominated by fine sands about 2 to 6 inches thick. The water table is high, usually between 2 to 6 feet from the surface. Much of this association is better suited for urban, agricultural, or recreational uses, unless the water table limits such uses.

The soils within the project area have been analyzed extensively. Soil borings, test pits, and hydrologic monitoring gauges have all been completed on the site to help determine peat/muck depths, historic ditch profiles and ground water elevations. All evidence indicates that peat/muck depths are extremely variable throughout the site.

Land Use

Approximately 70% of the watershed is vacant/agricultural and approximately 30% is developed (Figure 11). However, the area is quickly developing. Projected land use shows a dramatic change in the watershed (Metropolitan Council 2020 Land Use). In 2020, 85% of the watershed is predicted to be developed with only 15% of the land remaining undeveloped as either open/park space or rural residential (Figure 12).

Land Cover

The MLCCS land cover classifications were combined into five impervious surface area categories and six vegetative cover type categories, for both existing and future conditions (Figure 13). The 11% to 25% impervious cover and 51% to 75% impervious cover categories are predicted to increase the most in the future, with reductions coming from all terrestrial natural cover types – agricultural land, forests, woodlands, and grasslands (Table 4).

Table 4. Golden Lake Watershed Land Cover Summary

Land Cover Category	Percent Change (from existing to future conditions)
0% to 10% impervious cover	61%
11% to 25% impervious cover	214%
26% to 50% impervious cover	0%
51% to 75% impervious cover	992%
76% to 100% impervious cover	0%
Agricultural Land	-97%
Forests & Woodlands	-72%
Grasslands	-83%
Lakes & Open Water Wetlands	0%
Wetlands	0%

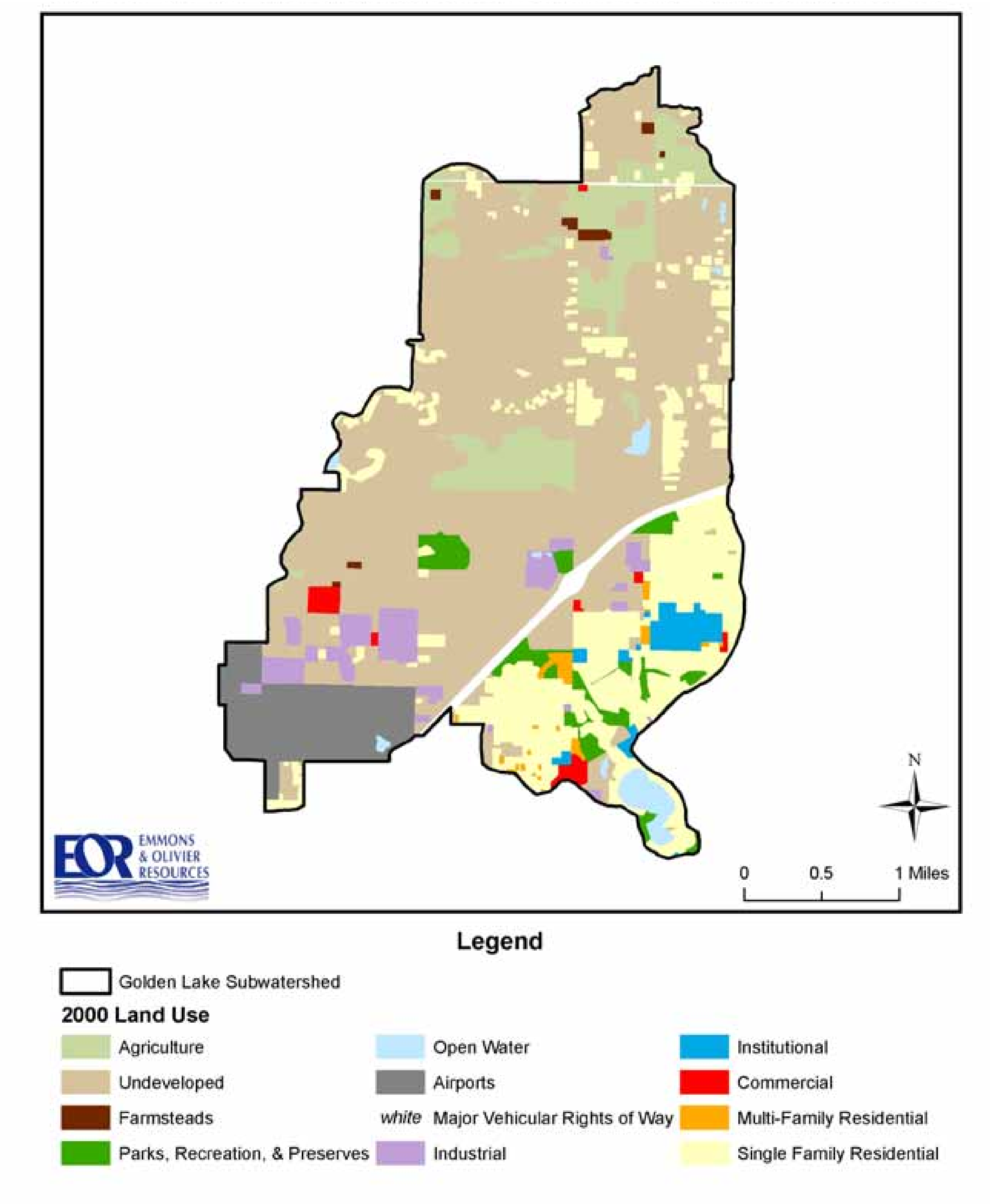


Figure 11. Existing Land Use in the Golden Lake Watershed

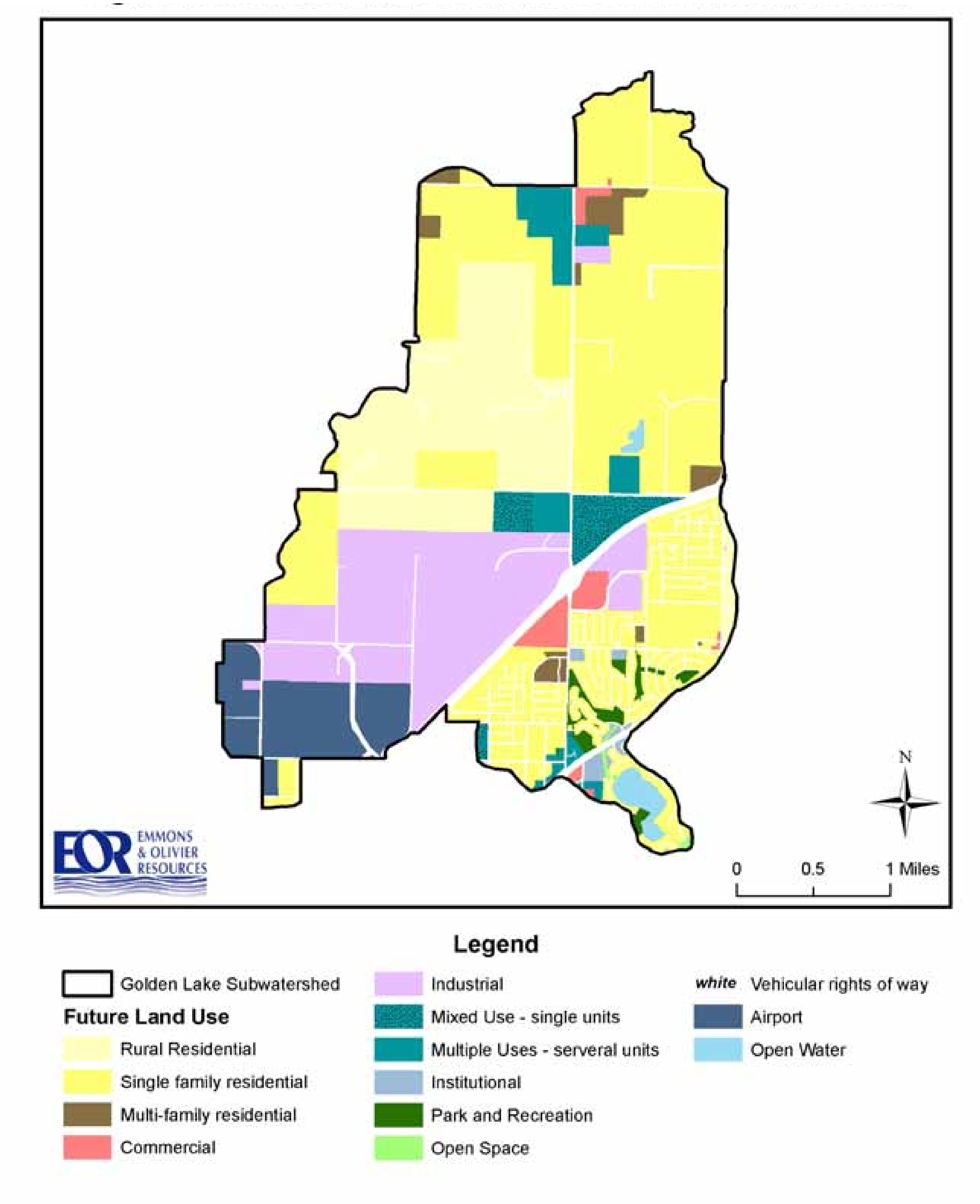


Figure 12. 2020 Land Use in the Golden Lake Watershed

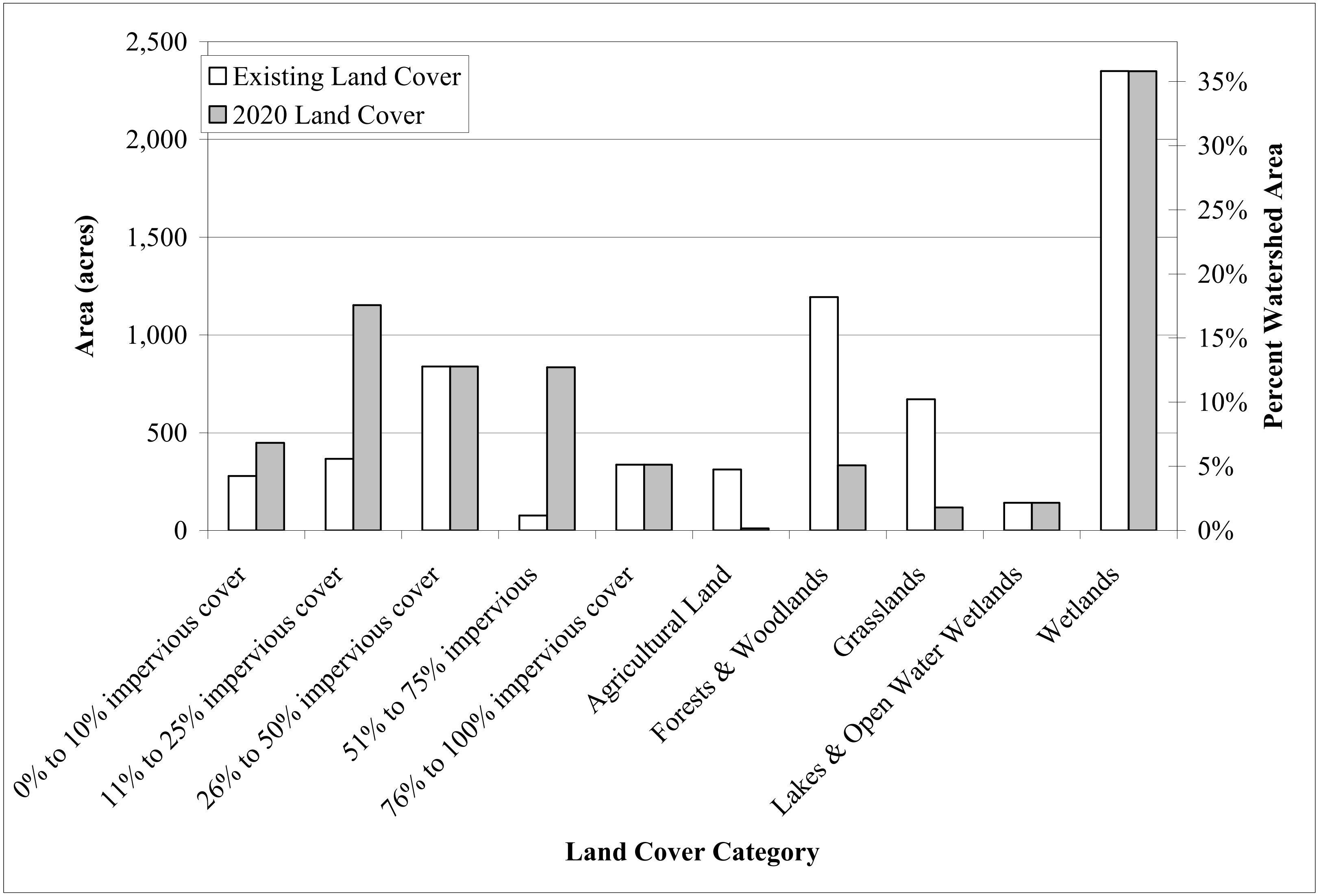


Figure 13. Land Cover Summary

Resource Management Plan and Watershed Rules

In 2004, the Rice Creek Watershed District adopted a Comprehensive Wetland Management Plan (Village Meadows CWMP) for a 1,132-acre portion of the Golden Lake watershed within the City of Blaine. This area is facing intense development pressure due to its close proximity to the urbanizing fringe of the Twin Cities Metropolitan Area and the major road corridor, I-35W. This area included the location for a future stadium for the Minnesota Vikings and other extensive commercial development plans.

The CWMP creates a balance between wetland enhancement and preservation and land development. The CWMP provides for full replacement of disturbed wetland, in addition to wetland functions and values, on an area rather than a parcel basis. The CWMP aggregates existing and replacement wetlands to create a larger, contiguous wetland complex providing ecological functions and values exceeding what would result from a parcel-based application of the Wetland Conservation Act (WCA). At the same time, it allows developable upland, referred to as the development envelope, to be aggregated in proximity to existing and planned development infrastructure in a manner that enhances the value of the property for development and facilitates municipal implementation of a comprehensive plan for development and open space protection.

Incorporated into the CWMP is a large effort to address regional water conveyance and water quality. By implementing the CWMP, ACD 53-62 will be converted from a ditch conveyance system into a wet meadow waterway that contains multiple flow-through wetlands. Portions of this redesigned waterway have already been constructed. The creation of the waterway and the wetland restorations do not substitute for water quality treatment required for runoff from the development envelope. Areas within the development envelope will need to use water resource best management practices (BMPs) to improve water quality and control runoff volume. Examples include infiltration areas, ponding, swales, shared parking, and other low-impact development techniques. These stormwater requirements are enforced under the District's Rule M, which was created solely to implement the CWMP. This rule regulates activities on both developable upland and protected wetlands within the CWMP area in order to fully enhance and protect the water resources of the CWMP area and Golden Lake without unduly limiting the benefits created for property owners and municipal development.

RCWD has also adopted a Resource Management Plan (RMP) over the entire City of Blaine located within the watershed. This expanded plan is referred to as the 53-62 RMP (resource management plan). It emphasizes the benefits afforded to all natural resources within the area and not just the wetlands. Watershed District Rule RMP-1, adopted to implement the RMP, was used in this Golden Lake TMDL to set watershed phosphorus loading goals (*Section 1.C: Pollutant of Concern – Point Sources – Methods*) and to form the basis of the implementation strategy (*Section 8: Implementation Strategy*). Appendix J of the RMP includes specific wetland restoration strategies throughout the drainage area (Appendix C of this TMDL report). Additionally, Rule RMP-1 emphasizes wetland protection and stormwater infiltration. For more information on the Resource Management Plan, contact the Rice Creek Watershed District or visit the District website.

C. POLLUTANT OF CONCERN

Total phosphorus is often the limiting factor controlling primary production in freshwater lakes. It is therefore the nutrient of focus for this TMDL, and is sometimes referred to as the causal factor. As phosphorus concentrations increase, primary production also increases, as measured by higher chlorophyll-*a* concentrations. Higher concentrations of chlorophyll-*a* lead to lower water transparency. Both chlorophyll-*a* and Secchi transparency are referred to as response factors, since they indicate the ecological response of a lake to excessive phosphorus input.

There is often a positive relationship between TP and chlorophyll-*a* in a lake, as is the case with Golden Lake (Figure 14). Similarly, a negative relationship is apparent between TP and Secchi depth (Figure 14).

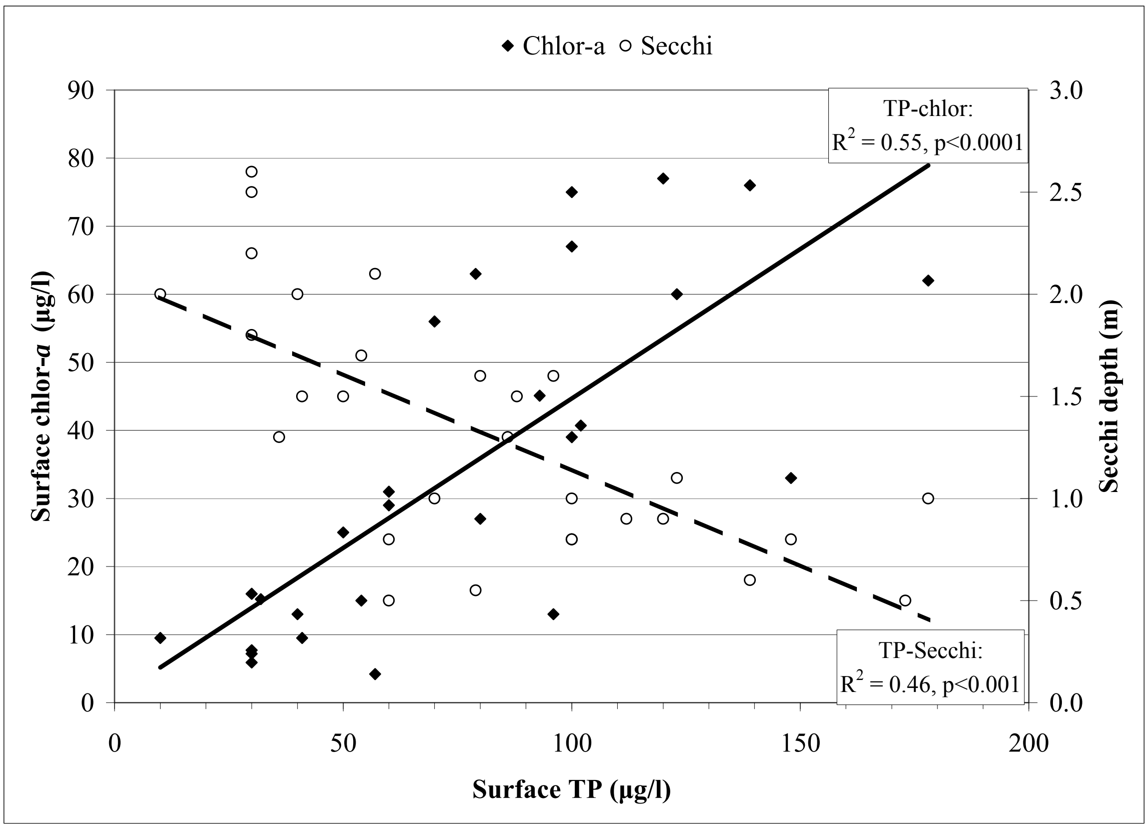


Figure 14. Relationship of Chlorophyll-a and Secchi Depth to TP in Golden Lake, 2000-2004
Statistics are for Pearson correlations

Point Sources

Point sources are those originating from a single, identifiable source in the watershed. Point sources are permitted through National Pollutant Discharge Elimination System (NPDES) permits.

Aveda Corporation Discharge

There is one traditional phosphorus point source with an NPDES permit within the Golden Lake watershed, Aveda Corporation. Aveda Corporation, NPDES permit # MN0066524, is located in the city of Blaine and is permitted to discharge non-contact cooling water (SD001) and reverse osmosis reject water (SD002) to a stormwater pond, drainage ditch, and thereto Golden Lake.

Stormwater Runoff

Stormwater runoff is generated in the watershed during precipitation events. Certain types of stormwater runoff are covered under National Pollutant Discharge Elimination System (NPDES) permits based on where the stormwater originates:

Municipal Separate Storm Sewer Systems

Municipal Separate Storm Sewer Systems (MS4s) are defined by the Minnesota Pollution Control Agency as conveyance systems owned or operated by an entity such as a state, city, town, county, district, or other public body having jurisdiction over disposal of storm water or other wastes. Phase I of the NPDES Storm Water Program identified Minneapolis and St. Paul as large MS4s, and each city has an individual NPDES permit. Under Phase II of the NPDES Storm Water Program, MS4s outside of urbanized areas, with populations greater than 10,000 (or greater than 5,000 if they are located within 0.5 mile of an outstanding value resource or impaired water) are classified as small designated MS4s. MS4s within urbanized areas and a population of at least 50,000 and a density of 1,000 people per square mile are classified as mandatory MS4s. Under the NPDES Stormwater Program, the MS4 entities are required to obtain a permit and design an MS4 Storm Water Pollution Prevention Program, which outlines a plan to reduce pollutant discharge, protect water quality, and satisfy water quality requirements in the Clean Water Act. A report is submitted each year by the municipality documenting the implementation of the Storm Water Pollution Prevention Program. The municipal stormwater permit holds municipalities responsible for stormwater discharging from the conveyance system within their city limits. The conveyance system includes ditches, roads, storm sewers, stormwater ponds, etc.

All of the MS4 entities within the boundaries of this project are Phase II communities, consisting of four municipalities, one county, the MN Department of Transportation, and the Rice Creek Watershed District (Table 5).

Construction Stormwater

Construction sites can contribute substantial amounts of sediment to storm water runoff. The NPDES Stormwater Program requires that all construction activity disturbing areas equal to or greater than one acre of land must obtain a permit and create a Stormwater Prevention Pollution Plan (SWPPP) that outlines how runoff pollution from the construction site will be minimized during and after construction. The construction permit is valid for the duration of the construction activities. Current construction permits are not listed here because their duration is relatively short.

Industrial Stormwater

The Industrial Permit applies to facilities with Standard Industrial Classification Codes in ten categories of industrial activity with significant materials and activities exposed to stormwater.

Significant materials include any material handled, used, processed, or generated that when exposed to stormwater may leak, leach, or decompose and be carried offsite. The NPDES Stormwater Program requires that the industrial facility obtain a permit and create a Stormwater Prevention Pollution Plan (SWPPP) for the site outlining the structural and/or non-structural best management practices used to manage stormwater and the site's Spill Prevention Control and Countermeasure Plan. An annual report is generated documenting the implementation of the SWPPP.

There are currently three facilities with industrial stormwater permits within the boundaries of this project. The current industrial stormwater permits are not listed because their permits status changes frequently as well as the number of facilities that exist in the watershed.

Table 5. National Pollutant Discharge Elimination System (NPDES) permits

Permit Type	Permit Name	Permit Number
MS4 stormwater	City of Blaine	MS400075
MS4 stormwater	City of Circle Pines	MS400009
MS4 stormwater	City of Lexington	MS400027
MS4 stormwater	City of Lino Lakes	MS400100
MS4 stormwater	Anoka County	MS400066
MS4 stormwater	Mn/DOT	MS400170
MS4 stormwater	Rice Creek Watershed District	MS400193
Construction stormwater	Various	Various
Industrial stormwater	Various	Various
Permitted Facility, Individual	Aveda Corporation	MN0066524

Stormwater Runoff Load Estimate

<u>Methods</u>

The EPA's Simple Method was used to calculate watershed pollutant loads. This method first calculates runoff volumes based on percent imperviousness (which is based on land use and land cover data), and then assigns an event mean concentration to the runoff volumes, also based on land use and land cover.

First, the runoff coefficient (Rvu) for each land cover type was derived using the following equation:

$$Rvu = 0.05 + (0.009 * \%Imp)$$

%Imp = Percent of impervious cover, derived from the MLCCS land cover classification

Volume of runoff (in acre-feet/year) was calculated using the following equation:

$$Volume = (P * P_j * Rvu * A) / 12$$

P = Precipitation (inches/year)
P_j = Proportion of storms producing runoff (default = 0.9), used in calibration
Rvu = Runoff coefficient for each land cover type
A = Area of land cover type (acres)

Monitoring data from 2004 were used for calibration. Precipitation was 29.6 inches, close to the 1995 - 2004 average precipitation (31.9 inches). Volumes were calibrated to 2004 monitoring data at the ACD 53-62 inflow to Golden Lake (station OWS11b, Table 6). The total annual volume was estimated with the 2004 monitoring data; the average flow rate during the monitoring period (April 9 through December 3) was assumed to be the average flow rate over the entire year (0.85 cfs). Due to recent patterns in snowmelt, in which there is not one major snowmelt event in the spring but rather snow melts in smaller events over the winter (Figure 15), the average monitored flow is an appropriate estimate of the average flow over the winter months.

Table 6. Monitored volume and TP loads at ACD 53-62 inflow to Golden Lake (station OWS11b)

Year	Period of Time	Volume (ac-ft)	Average Flow (cfs)	Depth of Runoff (inches)	TP Load (lbs/yr)	Data source
2004	Apr 9 – Dec 3	Monitored - 405	0.85	0.71	116	2004 RCWD data and analysis
2004	Jan – Dec	Estimated - 616	0.85	1.13	176	2004 RCWD data and analysis

2004 volumes were lower than estimates from previous studies; this is also thought to be due mostly to differences in snowmelt between these previous years and more recent data[1]. The low runoff volume in this watershed is also related to the flat topography; there is not a lot of change in elevation in the watershed and therefore a lower proportion of the rainfall ends up leaving the watershed as stormwater runoff, with greater amounts leaving through evapotranspiration and groundwater recharge (Appendix D).

[1] In 1979 and 1982, the volume of watershed runoff entering Golden Lake was substantially higher than in 2004. This resulted in higher phosphorus loads entering the lake (Circle Pines, 1979; Circle Pines, 1982). It was determined that approximately 68% of the entire inflow volume entered Golden Lake during March and April. It was also estimated that 95% of the total sediment carried into the lake and 80% of the total phosphorus came from spring snow melt (Circle Pines, 1979). In a 1980 spring runoff report, it was reported that snowmelt consisted of 120 acre-feet of water spread over an 8-day period in 1980 compared with 1310 acre-feet of run-off spread over a 40 day period in 1979 (Circle Pines, 1980). This comparison demonstrates the volatility of the Golden Lake inflow system. Looking at the historical climate data for the watershed from 1978 to present, there was less snow accumulation during the winter of 1980 and slightly warmer temperatures as compared to 1979 and 1982. Over the last 10 years (1995-2005), there has been less snow accumulation and warmer winter temperatures leading to less dramatic snowmelt episodes reducing the volume of runoff entering Golden Lake.

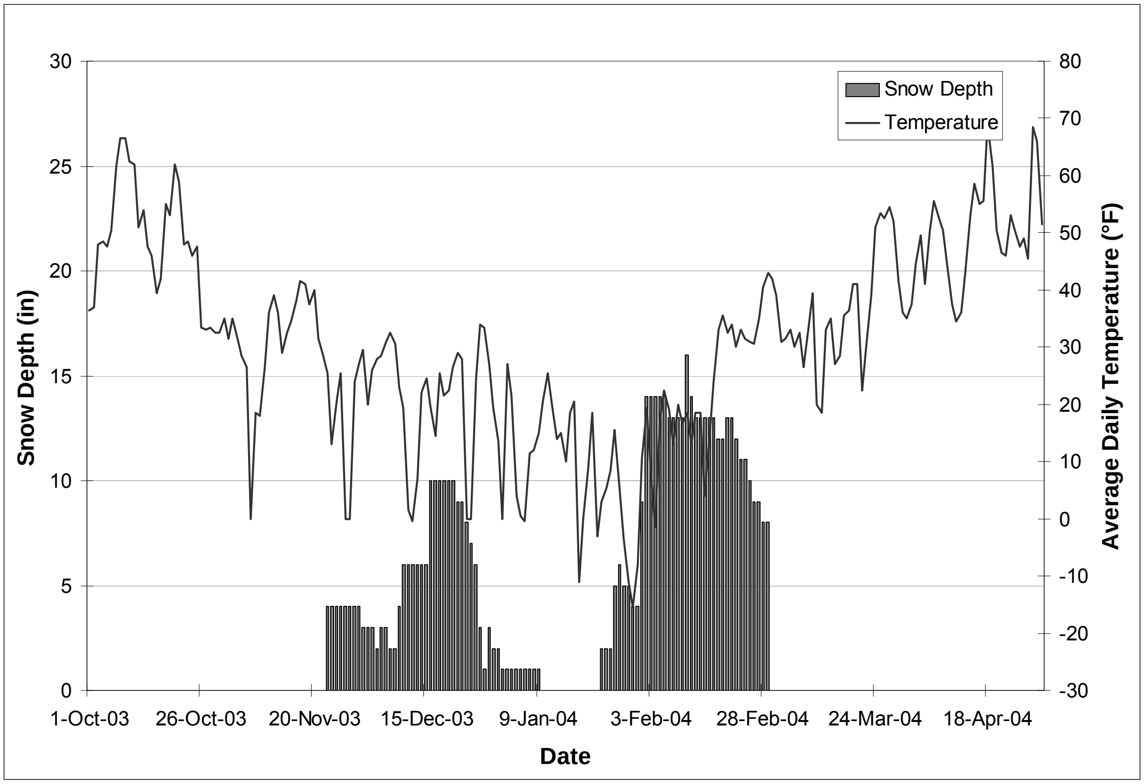


Figure 15. 2004 Snow Depth

Pollutant loads were then calculated using event mean concentrations and summed to determine the total pollutant load:

Pollutant Load = Volume * EMC

EMC = Event mean concentration for each land cover or land use type

Land use (Metropolitan Council 2000 and 2020 land use) and land cover (MLCCS) were both used to assign EMCs (Table 7). These EMCs were derived from a literature search of upper Midwest data and were then adjusted to calibrate them to ACD 53-62 monitoring data.

Table 7. TP Event Mean Concentrations (EMCs) Associated with Land Cover and Land Use

Land Cover	Phosphorus (µg/L)
Cropland	224
Forest/Shrub/Grassland	28
Open Water	87
Wetlands	7-28*
Land Use	**Phosphorus (µg/L)**
Airports	196
Commercial	196
Farmsteads	322
Industrial	196
Major roadways	196
Multi-Family Residential	224
Park and Recreation	28
Public Industrial	196
Public/Semi Public	196
Public/Semi Public Not Developed	196
Single Family Residential	322
Vacant/Agricultural	224

*Varied based on wetland type.

Percent removals were applied to the watershed runoff load estimates for wetlands, Loch Ness Lake, and the treatment basin at the bottom of ACD 53-62 (Table 9). The removal rates were estimated based on monitoring data and best professional judgment.

Three watershed-loading scenarios were modeled:

1) Existing conditions: Used 2000 land use plans with land cover (MLCCS) data.

2) Future conditions: Used 2020 land use plans with land cover (MLCCS) data. Land cover data in this scenario were used to estimate percent imperviousness and the location of wetlands; this scenario assumed that existing wetlands would not be developed and would remain as wetlands.

3) Future conditions with implementation of the Resource Management Plan (RMP, described in *Section 1.B: Background, Resource Management Plan*) Rule RMP-1 (Appendix E): This scenario addressed the question, How much phosphorus load reduction will result if the RMP were successfully implemented? The exercise used the boundaries of the RMP's wetland protection zones, 2020 land use plans, and soil type. In the wetland protection zones, loads were assumed to remain at existing conditions (scenario #1). Loads from the four subwatersheds to the southeast of I-35W (#117, 129, 131, and 132) were from the future conditions scenario (scenario #2), since the RMP will not cover that area. In the upland zones (of the subwatersheds to the north-west of I-35W), several assumptions were made:

- The proposed rule applies to all storm events that are 2.8 inches or less. In an average year this constitutes 100% of storms. As a more conservative estimate, it was assumed that 95% of the annual volume occurs in storm events less than 2.8 inches.

- Since the volume of infiltration required by the rule varies according to the feasibility of infiltration practices, soil type was used to estimate the distribution of infiltration practices. Surface area was categorized according to the average depth to the water table, as described by soil type in the Anoka County Soil Survey. The feasibility of infiltration practices will depend on the depth to the water table. The depth to water table categories were used to assign the volume of stormwater that was assumed to be either infiltrated or treated in each area (Table 8). The volumes in Table 8 refer to 95% of the total annual volume, as described in the above bullet.
    - For areas where the depth to the water table is 0 to 2 feet, it was assumed that infiltration practices are not feasible. All of the volume is assumed to be treated through BMPs; 80% of it will be treated using standard BMPs, and 20% of it will be treated using biofiltration practices. A 50% removal efficiency was assigned to standard BMPs and a 60% removal efficiency was assigned to biofiltration practices, since they are on average more efficient at removing phosphorus.
    - For areas where the depth to the water table is 2 to 4 feet, it was assumed that half of the volume would be infiltrated and/or treated according to the guidelines for the 0 - 2 feet category, and the other half would follow the guidelines of the >4 feet category.
    - For areas where the depth to the water table is greater than 4 feet, it was assumed that 80% of the volume will be infiltrated. A 90% removal efficiency (of the 80% infiltrated) was assumed, due to the fact that some of the infiltrated phosphorus can eventually reach the surface water through shallow groundwater movement. The other 20% of the volume will be treated using traditional BMPs (50% removal).

Table 8. Infiltration and Treatment Efficiency Guidelines, According to Depth to Water Table

Depth to water table (ft)	Soil types	Volume Infiltrated	Volume Treated
0 - 2	Isanti, Markey, Rifle, Seelyville Udorthent (urban fill)	No infiltration	• 80% of volume: traditional treatment (50% TP removal) • 20% of volume: biofiltration (60% TP removal)
2 - 4	Lino, Sodderville	• 50% of volume: guidelines specified in “0 - 2 ft” category (above) • 50% of volume: guidelines specified in “>4 ft” category (below)	
>4	Zimmerman	80% of volume is infiltrated (90% TP removal)	• 20% of volume: traditional treatment (50% TP removal)

Results

TP yields were greater at the lower portion of the watershed (Figure 16, Table 10). These subwatersheds (#117, 129, 131, and 132), located in north-west Circle Pines, north Lexington, and the southern portion of Blaine, are more developed and have more impervious surfaces than the northern portion of the watershed.

In the future conditions model, TP yields in the lower portion of the watershed remained the same, while yields in the other portions of the watershed generally increased (Figure 17, Table 10). This is due to the planned residential and industrial development in the watershed.

In the RMP model, the TP yields in the RMP portion of the watershed drop dramatically (Figure 18, Table 10) due to the phosphorus removal of the infiltration and water quality BMPs. The TP yields in the lower portion of the watershed are identical to the 2020 future conditions model.

The sum of the loads presented in Table 10 does not represent the load that actually reaches Golden Lake. The amounts in the table are the loads that originate in each subwatershed, and they do not take into account the treatment provided by the ponds and wetlands in the watershed (Table 9). The total modeled load reaching Golden Lake is 186 lbs.

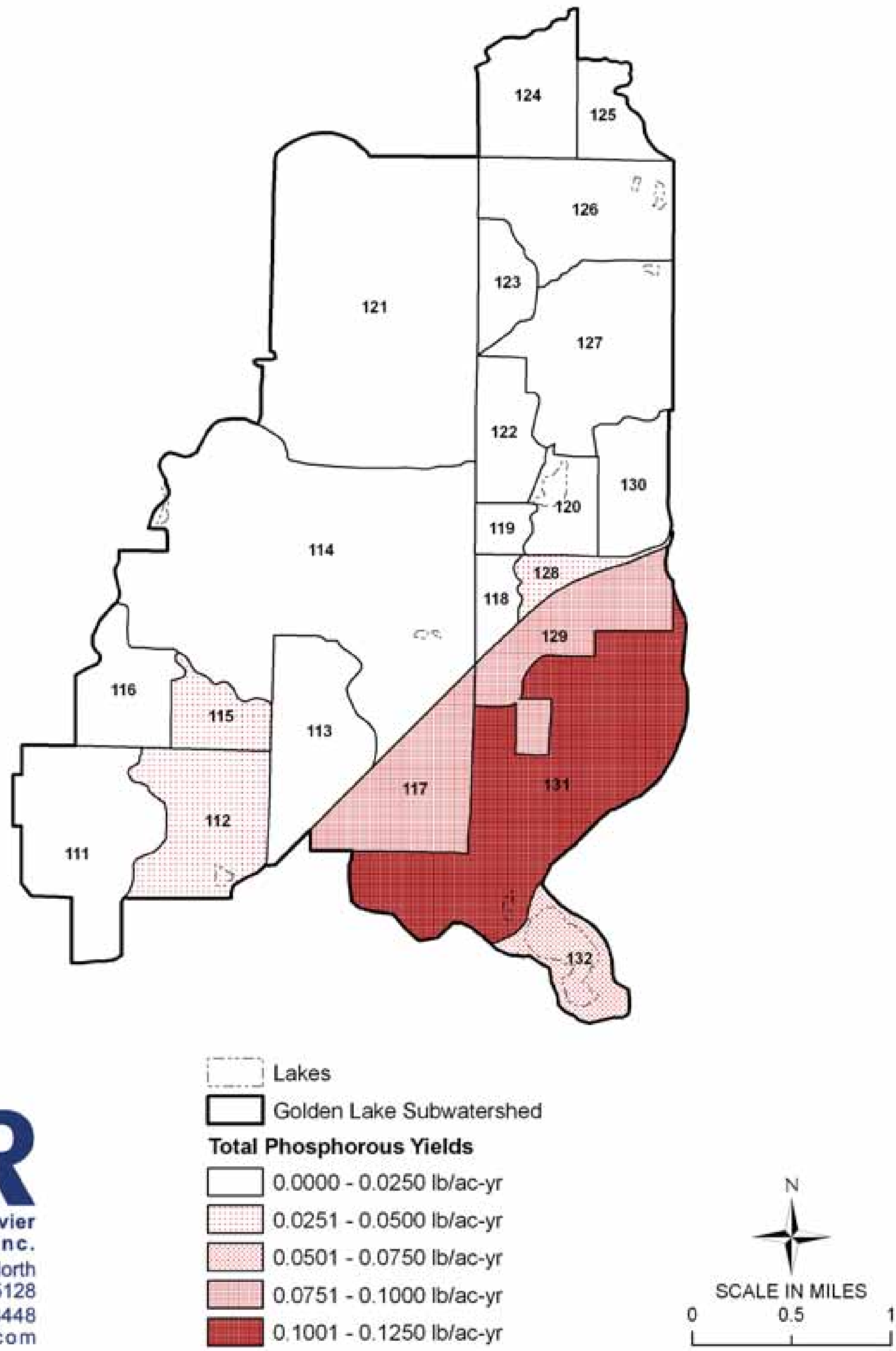
Table 9. Assumed TP Removals in Water Bodies within Golden Lake Watershed

Load and volume estimates from Simple Method modeling

Water Body	Subwatershed Location	Drainage Area (Subwatershed IDs)	TP Removal	Watershed Area (ac)	Runoff Volume (ac-ft)	TP in (lbs)	TP out (lbs)
Loch Ness	120	120,128,129	25%	407	59	28	21
Wetland	127	124-127	5%	1002	77	17	16
Wetland	121	121,123	5%	1154	93	19	18
Wetland	114	111,114,116	5%	1758	165	33	32
WQ pond	131	111-131	16%*	6425	628	221	186

*Estimated from 1995 monitoring data. Data available from 1995 only. Average TP concentration into the pond was 160 µg/L, average out of the pond was 135 µg/L, for a removal rate of 16% during 1995. In 1995 there were 34.0 inches precipitation, compared to the 2004 volume (the year used for water quality modeling calibration) of 29.6 inches.

The TP yields in this watershed are quite low, mostly due to the flat topography and quantity of wetlands in the watershed. Monitoring in ACD 53-62 will continue in the future to confirm these low yields.



EOR
Emmons & Olivier
Resources, Inc.
651 Hale Ave North
Oakdale, MN 55128
Tele: 651.770.8448
www.eorinc.com

Figure 16. Total Phosphorus Yields by Subwatershed, Existing Conditions

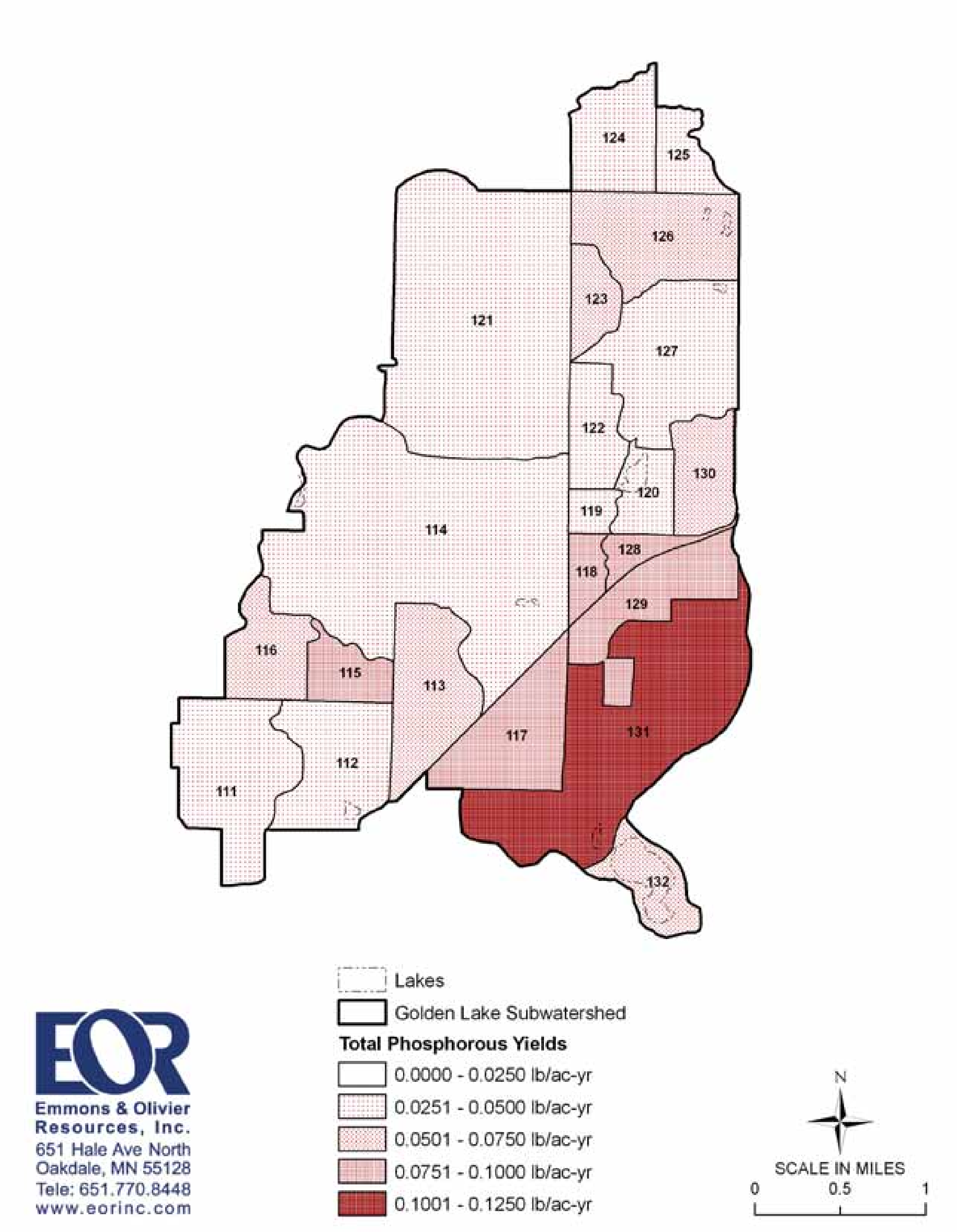


Figure 17. Total Phosphorus Yields by Subwatershed, 2020 Conditions

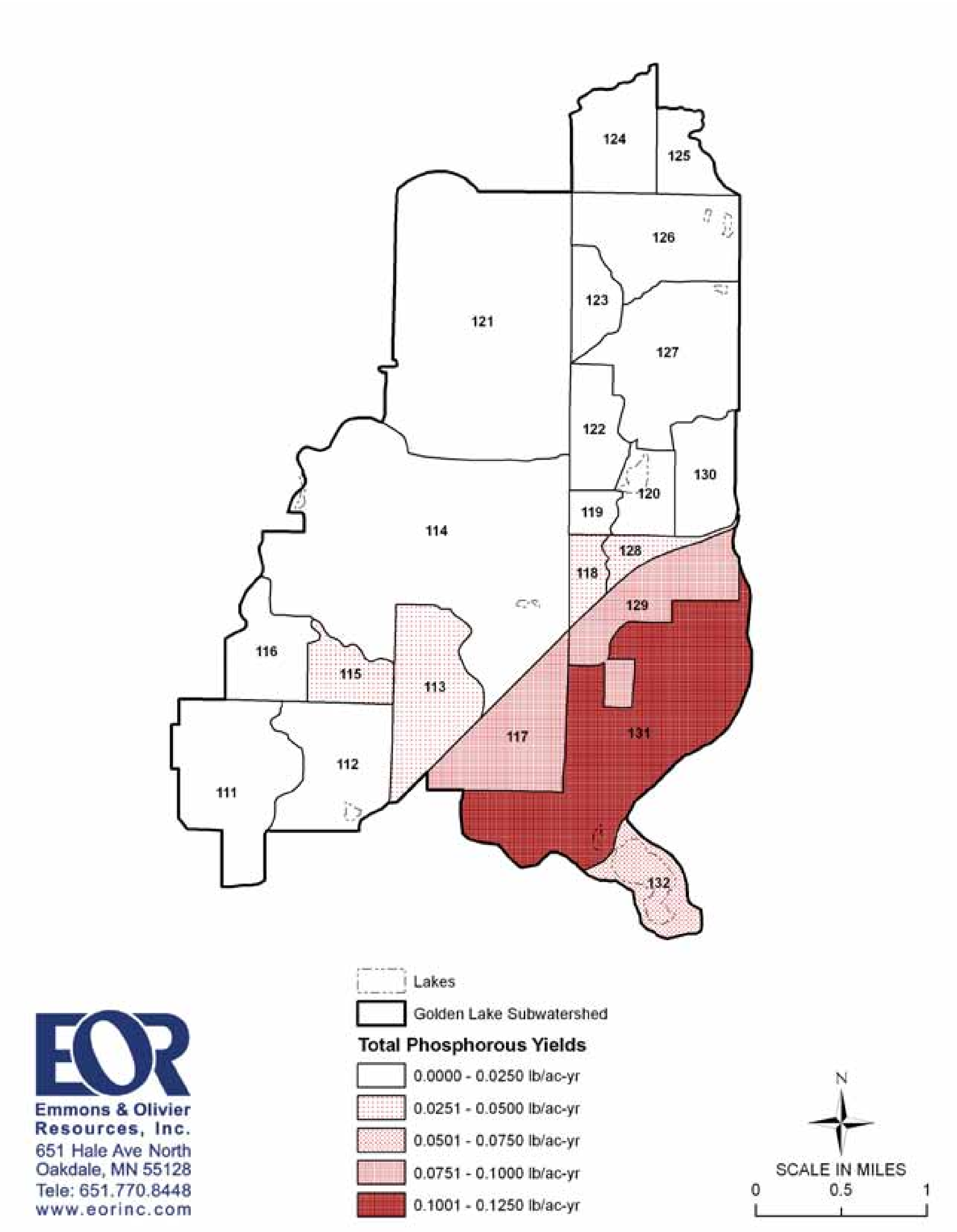


Figure 18. Total Phosphorus Yields by Subwatershed, Resource Management Plan Conditions

Table 10. Estimated Watershed Runoff Volumes and TP Loads

Subwatershed	Area (ac)	Volume (ac-ft/yr)			TP Load (lbs/yr)			TP Yield (lbs/ac-yr)		
		Existing	2020	RMP	Existing	2020	RMP	Existing	2020	RMP
111	363	41	44	39	8.4	10	4.4	0.023	0.028	0.012
112	281	32	39	30	8.7	13	5.1	0.031	0.045	0.018
113	272	19	40	37	4.0	16	7.7	0.015	0.060	0.028
114	1225	107	157	140	22	56	26	0.018	0.046	0.021
115	106	13	21	12	4.9	10	3.1	0.046	0.092	0.029
116	170	17	25	17	3.9	10	3.6	0.023	0.061	0.021
117	269	33	41	41	23	26	26	0.085	0.099	0.099
118	62	4	11	8	1.2	5.7	2.2	0.019	0.093	0.036
119	45	4	6	6	0.32	1.3	0.8	0.007	0.030	0.017
120	105	15	19	17	2.3	5.0	2.3	0.022	0.047	0.022
121	1059	88	111	100	15	37	18	0.014	0.035	0.017
122	139	10	12	11	2.9	5.8	2.5	0.021	0.042	0.018
123	95	5	10	6	1.8	5.7	1.8	0.019	0.060	0.018
124	199	12	16	12	2.5	7.6	2.8	0.012	0.038	0.014
125	97	5	8	6	1.3	4.7	1.9	0.014	0.049	0.019
126	307	25	41	34	5.6	17	7.0	0.018	0.054	0.023
127	398	35	41	36	6.2	13	5.4	0.016	0.032	0.014
128	57	6	11	8	2.2	5.3	2.0	0.037	0.092	0.034
129	244	38	45	45	22	24	24	0.089	0.099	0.099
130	153	11	15	11	3.5	7.8	2.8	0.023	0.051	0.018
131	776	108	114	114	79	83	83	0.102	0.107	0.107
132	139	31	32	32	8.8	8.6	8.6	0.063	0.062	0.062
Total	*6566*	*659*	*859*	*758*	*229*	*373*	*240*			

Septic Systems

In the undeveloped and agricultural areas of the watershed, faulty septic systems can be a substantial source of phosphorus. To estimate faulty septic systems within the Golden Lake watershed, parcel data for the watershed were evaluated for those areas outside of sewered connections. Parcels were evaluated to determine if they had homesteads on them. If an owner had more than one adjoining parcel, it was assumed that one homestead existed for all parcels. This was verified by looking at digital photographs of the watershed. For parcels that were purchased after 1996, it was assumed that the septic system was fully functional. 1996 is considered a cut off point because in 1996 the state of Minnesota initiated rule 7080, which provides a regulatory framework for individual sewage treatment systems. Prior to 1996, no state law existed. Rule 7080 provides the minimum standards and criteria for individual sewage treatment systems. Systems installed prior to 1996 may have been improperly designed and installed for the site and soil conditions in the Golden Lake watershed. Based on conversations with the City of Blaine, for those parcels that have not changed ownership since 1996, it was assumed that 5% of the septic systems are failing, totaling six failing systems. Using the WiLMS 3.0 model, estimates were made regarding phosphorus loading. Assumptions used in the model are below. Results indicate that 26 lbs, or 14%, of the watershed load may be from failing septic systems within the watershed.

- 6 failing septic systems
- 4 people per household
- No phosphorus retention in soils
- 1.1 lbs phosphorus per person per household per year

Non-Point Sources

The two non-point sources estimated were atmospheric deposition and internal loading.

Atmospheric deposition was estimated to be 15 lbs/yr, calculated from the BATHTUB default rate of 0.27 lbs/ac-yr (30 kg/km^2-yr).

Internal loading was estimated by subtraction: the estimated external load (calibrated to monitoring data) was subtracted from the total estimated load based on the BATHTUB model (*Section 3: Loading Capacity*). The monitored load at the bottom of ACD 53-62 covers the majority of the watershed; it was therefore assumed that there were no substantial external loads that were not accounted for. Based on this method, the estimated internal load was 260 lbs/yr, or 0.013 lbs/ac-day (averaged over the entire year).

Internal loading is due to the release of phosphorus from bottom sediments due to several causes:

- Anoxic conditions in the overlying waters: The deep hole in Golden Lake remains anoxic for a portion of the growing season (Figure 9), and hypolimnetic phosphorus concentrations can be high, as evidenced in 2004 at the end of the summer (Figure 10). The 1982 Golden Lake Diagnostic - Feasibility Study estimated internal loading due to anoxic release to be 154 lbs/yr (City of Circle Pines 1982). A hypolimnetic aeration system was installed in the lake in 1992 to minimize anoxic release from the sediments.

- Physical disturbance by bottom-feeding fish such as bullhead. Black bullheads were found in the lake in the 2003 fish survey.
- Physical disturbance due to wind mixing. This is common in shallow lakes such as Golden Lake, where wind energy can vertically mix the lake at numerous instances throughout the growing season.
- Phosphorus release from decaying curlyleaf pondweed (*Potamogeton crispus*)

These diverse sources of internal loading can vary from year to year. To estimate this variability, Bathtub models were developed for the years 1999 and 2004. Watershed volume and phosphorus loading data were based on monitoring data in ACD 53-62, and the Bathtub models were calibrated to observed in-lake conditions. The estimated internal load in 1999 was 92 lbs, as compared to the 2004 estimate of 260 lbs that represents existing conditions for this TMDL.

2. Applicable Water Quality Standards and Numeric Water Quality Targets

A. MINNESOTA WATER QUALITY STANDARDS

Water quality standards are established to protect the designated uses of the state's waters. Amendments to Minnesota's Rule 7050, approved by the MPCA Board in December 2007 and approved by the EPA in June 2008, include eutrophication standards for lakes (Table 11). Eutrophication standards were developed for lakes in general, and for shallow lakes in particular. Standards are less stringent for shallow lakes in certain ecoregions, due to higher rates of internal loading in shallow lakes and different ecological characteristics.

Golden Lake is a Class 2B water and meets the MPCA definition of a shallow lake. A lake is considered shallow by the agency if its maximum depth is less than 15 ft, or if the littoral zone (area where depth is less than 15 ft) covers at least 80% of the lake's surface area. The littoral area of Golden Lake (51.3 ac) is 90% of the lake's total surface area (57.2 ac), and the lake is therefore considered shallow.

To be listed as impaired, the monitoring data must show that the standards for both TP (the causal factor) and either chlorophyll-*a* or Secchi depth (the response factors) were violated. If a lake is impaired with respect to only one of these criteria, it may be placed on a review list; a weight of evidence approach is then used to determine if these lakes will be listed as impaired. For more details regarding the listing process, see the *Guidance Manual for Assessing the Quality of Minnesota Surface Waters for the Determination of Impairment* (MPCA 2007).

Table 11. MN Eutrophication Standards, North Central Hardwood Forests Ecoregion

Parameter	Eutrophication Standard, Shallow Lakes
TP (µg/L)	TP < 60
Chlorophyll-*a* (µg/L)	chl < 20
Secchi depth (m)	SD > 1.0

B. WATER QUALITY GOAL

To be de-listed, a TMDL-listed lake must achieve the nutrient standards. To evaluate the feasibility of reaching the nutrient goals, input from various sources was examined:

Monitoring data were first examined to describe water quality trends and current conditions. These data serve as a guide as to how much improvement in water quality can be expected, based on trends and annual variability.

Reference conditions were taken into account. MNLEAP (Minnesota Lake Eutrophication Analysis Procedure, MPCA) was used to predict what the TP concentration in Golden Lake would be if it were minimally impacted. The model does not take into account nutrient removal that occurs in lakes and wetlands in the watershed and therefore often overestimates a lake's watershed load. For lakes in the North Central Hardwood Forests ecoregion, MNLEAP assumes a depth of runoff in the watershed of 5.1 inches and a TP concentration in runoff of 148 µg/L. Both the depth of runoff and the runoff TP concentration default values are higher than what has been monitored in the Golden Lake watershed in recent years, which led to model predictions higher than current observed conditions (Table 12). To account for the lower than average runoff depth and TP concentrations in this watershed, the MNLEAP input parameters were adjusted, using current monitoring data for depth of runoff and runoff TP concentration. This reference condition assumes that current external loads are minimally impacted, and that any difference between the reference condition and the observed condition is due to internal loading.

The adjusted MNLEAP model predicted an in-lake TP concentration of 51 µg/L, a chlorophyll-*a* concentration of 21 µg/L, and a Secchi depth of 1.3 meters (Table 12).

Table 12. MNLEAP Input Data and Results

Parameter	MNLEAP Default	MNLEAP Adjusted
Runoff Depth (inches)	5.1	1.1
Runoff TP Concentration (µg/L)	148	104
Predicted TP (µg/L)	94	51
Predicted Chlorophyll-*a* (µg/L)	50	21
Predicted Secchi Depth (m)	0.8	1.3

Existing loads (external and internal) were examined to determine the feasibility of the water quality goal.

The concentration of runoff in the Golden Lake watershed in 2004 (the calibration year) was 104 µg/L. This is based on the modeled annual load of 187 lbs/yr and volume of 659 ac-ft/yr (Table 10). The estimated internal load is 260 lbs/yr, approximately 40% more than the external load.

To determine the average annual watershed load goal for Golden Lake, the TP goal for the watershed was set at an average of 100 µg/L across the watershed. Although this concentration is low for watershed runoff, the predicted average annual TP concentration in runoff from the RMP area is less than 100 µg/L (approximately 70 µg/L). This will allow for a runoff concentration slightly higher in the areas not governed by the RMP (approximately 228 µg/L).

The internal load goal of 44 lbs/yr represents an 82% reduction from the existing internal load. This internal load goal was determined by first adjusting the watershed load in the BATHTUB model (*Section 3: Loading Capacity*) to the load goal as described above, and then lowering the internal load rate in the existing conditions model until the predicted in-lake TP concentration reached 60 µg/L, the water quality goal and the MPCA's shallow lake criteria.

Goal setting: Using the Golden Lake BATHTUB model (*Section 3: Loading Capacity*), if these external and internal load goals were achieved and the in-lake TP concentration reached 60 µg/L, the chlorophyll-*a* concentration and Secchi depth would be 35 µg/L and 1.0 meters, respectively (Table 13). These values are consistent with the shallow lake criteria for both TP and Secchi depth, but not for chlorophyll-*a*. If the lake were to achieve the TP goal of 60 µg/L, a possible outcome is a shift in the lake from a phytoplankton-dominated community to a macrophyte-dominated community, in which case the chlorophyll-*a* concentration would likely be lower than 35 µg/L. However, due to the colored nature of the lake water resulting from the humics entering the lake from 53-62, light limitation may influence the colonization of macrophytes (see *Section 1.B: Lake Description*).

Table 13. Average Annual Water Quality Goals

Parameter	Existing Conditions	Predicted Conditions at TP Goal of 60 µg/L	Goal
TP (µg/L)	89	60	60
Chlorophyll-*a* (µg/L)	48	35	20
Secchi depth (m)	0.8	1.0	1.0

3. Loading Capacity

This section describes the derivation of the TMDL for Golden Lake. After the TMDL was calculated, the margin of safety was determined (*Section 4: Margin of Safety*). The difference between the TMDL and the margin of safety (MOS) was then apportioned between the load allocations (LAs) and the wasteload allocations (WLAs) (*Section 5: Load Reductions and Allocations*).

A. METHODS

To estimate the assimilative capacity of the lake, an in-lake water quality model was developed using BATHTUB (Version 6.1), an empirical model of reservoir eutrophication developed by the U.S. Army Corps of Engineers.

BATHTUB default rates were used for atmospheric deposition. Precipitation and evaporation were assumed to be equal (Table 14). Data describing annual changes in storage were not available, and the model was insensitive to small changes in the evaporation constant.

Table 14. BATHTUB Input Parameters

Parameter	BATHTUB Input
Precipitation	0.75 m
Evaporation	0.75 m
Atmospheric deposition TP load rate	30 mg/m^2-yr
Averaging period	1 year

An average rate of internal loading is implicit in BATHTUB since the model is based on empirical data. There are no complete estimates of internal loading in Golden Lake. (Sediment phosphorus release rates in the deep hole were estimated in 1982, but that internal loading source is not the only one, see *Section 1.C: Non-Point Sources*.) Due to the lake's shallow depth and the high observed surface and hypolimnetic TP concentrations, internal loading is suspected to be higher than average. To estimate internal loading, the internal loading rate in the model was adjusted to calibrate the model output to the observed in-lake TP concentration. This represents the internal load that is *in addition* to the average expected amount of internal load. Because of this approach, the internal load estimate, and the internal load portion of the non-point source-loading goal, represents only the amount of internal load above the load implicitly assumed in the model.

The Canfield and Bachmann Lakes TP equation (option 8) was selected; this model is often the best predictor of in-lake TP concentrations in this region. After the TP model was calibrated with the internal loading rate, the model 2 chlorophyll equation was selected, as it best predicted the observed concentration. Lastly, monitoring data were used to calculate the observed relationship between chlorophyll-*a* and Secchi depth, and the Secchi depth model (model #1) was selected (Table 15).

Table 15. BATHTUB Model Input

Morphometry	
Lake surface area:	57.2 ac
Lake volume:	458 ac-ft
Mean depth:	8.0 ft
Drainage area:	6659 ac
Length:	0.85 km
BATHTUB Model Selection	
Phosphorus balance	8 – Canfield & Bachmann, Lakes
Chlorophyll-*a*	2 – P, light, T
Secchi depth	1 – vs. chl-*a* & turbidity
Phosphorus calibration	1 – decay rates

After the model was calibrated to all parameters (TP, chlorophyll-*a*, and Secchi transparency), the water quality goal was used as an endpoint, and the TP loads were adjusted until the model predicted that the in-lake water quality goal would be reached. The model output includes predictions of chlorophyll-*a* concentration and Secchi depth at the TP goal, in addition to predicted algal bloom frequencies, which are based on chlorophyll-*a* concentration.

The model was used to predict the 2020 in-lake water quality conditions if development proceeded according to 2020 land use plans, without the use of BMPs in the watershed. The atmospheric load and internal load were assumed to remain constant between now and 2020. The watershed load was estimated using the Simple Method (*Section 1C: Description of Waterbody, Pollutant of Concern – Point Sources*). The model was also used to predict the 2020 in-lake water quality conditions under the scenario of full RMP implementation. The watershed load for this scenario was estimated using the Simple Method and expected TP reductions based on the RMP.

B. Model Calibration and Validation

After the in-lake TP concentration was calibrated by increasing the internal loading rate, the chlorophyll-*a* concentration and the Secchi depth both calibrated with the default model selections, without any changes to calibration coefficients (Table 16).

Table 16. BATHTUB Calibration Results

Water Quality Parameter	2004 Observed (June-Sept averages)	BATHTUB Predicted
TP (µg/L)	97	96
Chl-*a* (µg/L)	50	50
SD (m)	0.73	0.70

Monitoring data from 1999 were used for model validation (raw data included in Appendix F). The TP load was estimated from ACD 53-62 monitoring data, and the internal loading rate from the existing conditions (2004) model was used. The in-lake TP prediction was 41% higher than the observed concentration, the chlorophyll-*a* prediction was 14% higher, and the Secchi depth prediction was 17% lower (Table 17). When the internal loading rate was adjusted downward (from 1.4 to 0.5 mg/m^2-yr) to calibrate the TP concentration, the chlorophyll-*a* and Secchi predictions were close (Table 17).

Table 17. BATHTUB Validation Results

Water Quality Parameter	1999 Observed (June-Sept averages)	BATHTUB Predicted	% off	BATHTUB Predicted with Adjusted Internal Loading Rate
TP (µg/L)	68	96	41%	69
Chl-*a* (µg/L)	44	50	14%	39
SD (m)	0.84	0.7	-17%	0.9

C. RESULTS

To reach the in-lake water quality goal of 60 µg/L TP, the total annual phosphorus load to the lake must not exceed 264 lbs (0.72 lbs/day). At this concentration, both the chlorophyll-*a* and the Secchi depth will also improve (Table 18). This load is the lake's assimilative capacity, or TMDL, and will be split up among load allocations (LA) and wasteload allocations (WLA) (Section 5), plus a margin of safety (MOS) (Section 4):

$$TMDL = LA + WLA + MOS$$

The watershed/point source (PS) and internal loads in Table 18 are tentative because the MOS is not yet taken into account.

Table 18. BATHTUB Model Input and Results

	Existing (2004)	2020	RMP	60 µg/L TP Model Scenario*
TP load to lake (lbs/yr):				
Watershed/PS:	183	299	196	205
Atmospheric:	15	15	15	15
Internal:	260	260	260	44
Total:	458	574	471	264
In-lake water quality:				
TP (µg/L)	97	101	92	60
Chlorophyll-a (µg/L)	50	50	48	35
Secchi depth (m)	0.73	0.7	0.8	1.0

*These loading goals do not take into account the margin of safety, calculated in Section 4.

In the 60 μg/L TP model scenario, the modeled chlorophyll-*a* concentration of 35 μg/L is relatively higher than the TP concentration, compared to the relationship under existing conditions (2004), as indicated by TSI values (Figure 19). The same relationship also exists in the 1999 model, calibrated to 1999 data, in which the chlorophyll TSI is also slightly greater than the TP TSI (Figure 19). In 1999, water quality was better than in other recent years, and more closely resembles the 60 μg/L TP goal scenario than do any of the other recent years. These differences in TSI relationships among years are slight enough that they fall within normal inter-annual variability.

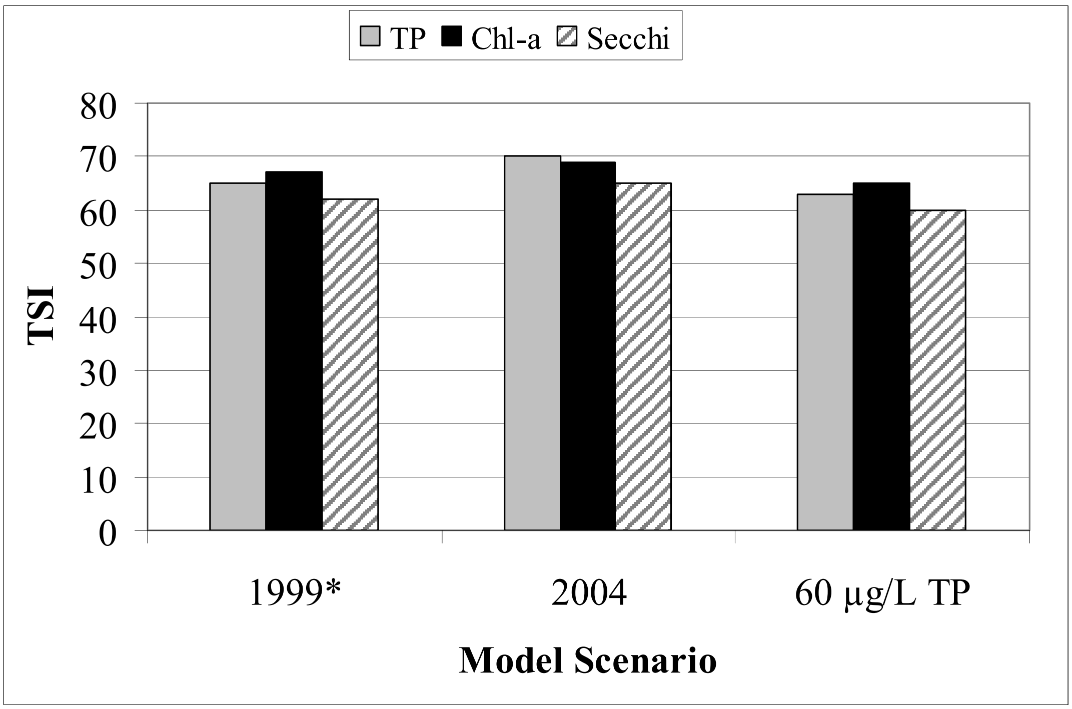


Figure 19. Trophic State Index (TSI) Values

* Modeled, using existing conditions (2004) model as the base, with the following variables changed: external TP load and inflow volume (from 1999 monitoring data), internal load (adjusted to calibrate in-lake TP concentration), 1999 precipitation.

At the 2004 TP concentration of 97 μg/L, nuisance algal blooms are experienced during 88% of the summer, with severe and very severe conditions seen 70% and 27% of the summer, respectively (Table 19). A decrease is expected if the goal of 60 μg/L is reached, with a drop to 72%, 47% and 12%, respectively, for nuisance, severe nuisance and very severe nuisance blooms.

Table 19. Algal nuisance bloom expected frequencies

Bloom severity	Chlorophyll-*a* concentration threshold for bloom severity	% of summer during which algal bloom will be evident			
		Existing conditions 97 µg/L TP 50 µg/L Chl-*a*	2020 conditions 101 µg/L TP 50 µg/L Chl-*a*	RMP 92 µg/L TP 48µg/L Chl-*a*	Goal 60 µg/L TP 35 µg/L Chl-*a*
Mild blooms	>10 µg/L	99%	99%	99%	96%
Nuisance blooms	>20 µg/L	88%	89%	87%	72%
Severe nuisance blooms	>30 µg/L	70%	71%	68%	47%
More severe	>60 µg/L	27%	29%	25%	12%

The state water quality standards for lakes are based on averages for the summer (growing season) since that is the critical period for lakes. The TMDL is written to ensure that the water quality standards are met over the course of the growing season. If the daily loads are met, then the average water quality conditions will be at or better than the standards.

4. Margin of Safety

The margin of safety (MOS) is included in the TMDL equation to account for both the inability to precisely describe current water quality conditions and the unknowns in the relationship between the load allocations and the in-lake water quality.

A. Methods

The MOS was calculated using the method described in Walker (2003). With this approach, the MOS is composed of a margin of variability (MOV) and a margin of uncertainty (MOU). The MOV is based on annual variability of lake TP concentrations, and is directly related to the compliance rate, or the frequency of meeting the water quality goal. The MOU is based on the uncertainty in predicting the TP concentration (current conditions as well as the effects of implementation activities on the TP concentration), and is directly related to the confidence level, or the probability of meeting the goal at the desired frequency. The compliance rate was set at 75%, and the confidence level was set at 60%. This means that the goal of an annual average of 60 µg/L TP will be met during 75% of years, and there is a 60% probability that the goal will be met with this desired frequency (of 75%). The compliance rate was set higher than the confidence level due to the lower annual variability of in-lake TP concentrations (CV = 0.11) compared to the uncertainty in predicting the TP concentration (model CV = 0.32). The compliance rate and the confidence level of the MOS do not affect the frequency that the actual TMDL loading limits will be met; the WLAs and LAs will need to be met 100% of the time.

After the MOS was determined, the remaining load was apportioned between the load allocations and the waste load allocations (Section 5) according to the same proportion as the distribution of the loads in the modeled goal scenario.

B. Results

For the goal of 60 µg/L TP, the MOS was calculated to be 38 lbs/yr (0.10 lbs/day, Table 20). The difference between the TMDL and the MOS was then split up among the wasteload allocations and the load allocation (Section 5).

Table 20. Margin of Safety

Parameter	Rate	lbs P/yr	lbs P/day
Compliance Rate (β)	0.75		
Margin of Variability (MOV)		18	0.050
Confidence level (α)	0.6		
Margin of Uncertainty (MOU)		20	0.055
TMDL		264	0.72
MOS		38	0.10
TMDL – MOS = LA + WLA		226	0.62

5. Load Reductions and Allocations

A. Load Reductions

The difference between the TMDL and the MOS represents the total load that can be allocated between the WLAs and the LA and equals 226 lbs/yr (Table 20). Since the atmospheric P load (15 lbs/yr) is considered fixed, the tentative P load goals shown in Table 18 for the watershed/PS (205 lbs/yr) and the internal load (44 lbs/yr) were reduced proportionately to 175 lbs/yr and 36 lbs/yr, respectively, to accommodate the MOS. The watershed/point source load of 175 lbs/yr includes a single industrial point source (Aveda Corporation) WLA of 6 lbs/yr, as described below. The remaining watershed load of 169 lbs/yr was divided on what amounts to an approximate areal basis (details below) between WLAs of 144.5 lbs/yr for municipal separate storm sewer systems (MS4s) and LAs of 24.5 lbs/yr for rural portions of the cities of Blaine and Lexington. The resulting breakdown of the TMDL among WLA, LA, and MOS is shown in Table 21 and Table 22. Based on this allocation, a 4% reduction in the WLA sources and a 75% reduction in the LA sources are necessary for the lake to achieve the water quality goal, relative to existing conditions. When calculated relative to 2020 conditions, a 41% reduction in the WLA sources and a 76% reduction in the LA sources are necessary.

Table 21. Annual TMDL Allocations

Load Category	Existing TP Load (lbs/yr)	2020 TP Load (lbs/yr)	TMDL Load (lbs/yr)	Load Reduction Relative to Current Conditions		Load Reduction Relative to 2020 Conditions	
				(lbs/yr)	% Reduction	**(lbs/yr)**	% Reduction
WLA / permitted	157	253	150.5	7	4%	103	41%
LA / non-permitted	301	321	75.5	225	75%	245	76%
MOS			38				
Total	***458***	***574***	***264***	***232***	***51%***	***348***	***61%***

Table 22. Daily TMDL Allocations

Load Category	Existing TP Load (lbs/day)	2020 TP Load (lbs/day)	TMDL Load (lbs/day)	Load Reduction Relative to Current Conditions		Load Reduction Relative to 2020 Conditions	
				(lbs/day)	% Reduction	**(lbs/day)**	% Reduction
WLA / permitted	0.43	0.69	0.41	0.02	4%	0.34	41%
LA / non-permitted	0.82	0.88	0.21	0.62	75%	0.61	76%
MOS			0.10				
Total	***1.25***	***1.57***	***0.72***	***0.64***	***51%***	***0.95***	***61%***

B. Wasteload Allocations

Stormwater runoff is generated in the watershed during precipitation events. Municipal stormwater from storm-sewered areas, construction stormwater, and industrial stormwater runoff are covered under NPDES permits and are provided wasteload allocations (WLAs). The stormwater sources were split into one categorical and two individual WLAs. The categorical WLA includes the storm-sewered portions of the Cities of Blaine, Circle Pines, Lexington, and Lino Lakes; the Rice Creek Watershed District (for ditch maintenance); and construction and industrial stormwater. The individual WLAs are for Anoka County and Minnesota Department of Transportation (Mn/DOT) highways.

The watershed phosphorus loadings were initially calculated on the basis of an average runoff TP concentration goal of 100 µg/L across the watershed. Although this concentration is low for watershed runoff, the watershed-wide runoff concentration in 2004 (the calibration year) was 104 µg/L, and the predicted average annual TP concentration in runoff from the RMP area is less than 100 µg/L (approximately 70 µg/L). This allows for a runoff higher concentration in the areas not governed by the RMP (approximately 228 µg/L).

The cities' runoff loads were then reduced in proportion to the Anoka County and MnDOT road right-of-way areas within their boundaries. The right-of-way areas were determined from information supplied by the county and the Minnesota Department of Transportation (MnDOT) and from aerial photos. The watershed runoff loads for the cities of Blaine and Lexington were split between WLAs for their storm-sewered portions, and LAs for their remaining areas. The remaining watershed loading was allocated to the two road authorities on an areal basis. The resulting unit areal P loads from the highway areas was very low, 0.026 lbs/acre-year, in keeping with the extremely low P export from the watershed as a whole.

One industrial point source in the watershed, Aveda Corporation, was given an individual WLA. The WLA allocation was calculated by considering the outfall maximum design flow, and the anticipated concentration. Individual outfall loads were added together and increased by 13% to account for facility variability (Table 23). In total, Aveda Corporation has a 2.7 kg/yr (6 lb/yr) WLA.

Table 23. Aveda Corporation Waste Load Allocation (NPDES # MN0066524)

Outfall	Description	Flow (mgd)	TP (mg/L)	TP (kg/yr)
SD001	Seasonal Discharge	0.003	1.2*	1.3^
SD002	Continuous Year-Round	0.008	0.096**	1.1
Combined waste load allocation				2.7^^
* Average concentration (2007-2008).				
** Concentration based on analytical test results.				
^ Total load divided by 4 to account for seasonal discharge				
^^ SD001 and SD002 annual mass plus 13% to account for variability				

Failing septic systems are given a zero WLA as they are out of compliance with Minnesota rule. A properly operating septic system in this watershed would not be expected to contribute to phosphorus loading of Golden Lake.

C. LOAD ALLOCATIONS

The load from atmospheric deposition is assumed to be constant, and the required load reductions are from the non-MS4-permitted watershed areas and the internal loading (Table **24** and Table 25).

Table 24. Annual LA Goals

Load Category	Existing Load (lbs/yr)	Goal Load (lbs/yr)	% Reduction
Blaine non-MS4	23	22	4%
Lexington non-MS4	2.7	2.5	8%
Internal Load	260	36	86%
Atmospheric Deposition	15	15	0%
Total LA	**300.7**	**75.5**	**75%**

Table 25. Daily LA Goals

Load Category	Existing Load (lbs/day)	Goal Load (lbs/day)	% Reduction
Blaine non-MS4	0.063	0.060	4%
Lexington non-MS4	0.007	0.007	8%
Internal Load	0.712	0.099	86%
Atmospheric Deposition	0.041	0.041	0%
Total LA	**0.823**	**0.207**	**75%**

D. RESERVE CAPACITY

Reserve capacity, an allocation for future growth, was not explicitly calculated for this TMDL. In effect, however, the LAs for non-MS4 portions of the watershed represent reserve capacity for the cities and the road authorities. Future extensions of storm sewer systems new highway development will require transfers of LA to WLA according to the areas involved.

E. TMDL ALLOCATION SUMMARY

Table 26 presents a summary of the WLAs, the LA, the MOS, and the TMDL for Golden Lake.

Table 26. TMDL Allocation Summary

Source	Permit #	Allocation (lbs/yr)	Allocation (lbs/day)
WLA		**150.5**	**0.41**
Blaine	MS400075	138	0.38
Circle Pines	MS400009		
Lexington	MS400027		
Lino Lakes	MS400100		
RCWD	MS400193		
Industrial stormwater	General		
Construction stormwater	General		
Anoka County (Highways)	MS400066	3.8	0.010
Mn/DOT	MS400170	2.5	0.007
Aveda	MN0066524	6.0	0.016
LA		**75.5**	**0.21**
Blaine non-MS4		22	0.060
Lexington non-MS4		2.5	0.007
Internal Load		36	0.099
Atmospheric Deposition		15	0.041
MOS		**38**	**0.10**
TMDL		***264***	***0.72***

6. Seasonal Variation and Critical Conditions

In-lake water quality models used for this TMDL predict growing season or annual averages of water quality parameters based on growing season or annual loads, and the MPCA's nutrient standards are based on growing season averages. Symptoms of nutrient enrichment normally are the most severe during the summer months; the nutrient standards set by the MPCA were set with this seasonal variability in mind.

Critical conditions in this lake occur in the summer, when TP concentrations peak and clarity is at its worst. The water quality standards are based on growing season averages. The load reductions are designed so that the lake will meet the water quality standards over the course of the growing season (June through September).

7. Monitoring Plan

The RCWD has been monitoring Golden Lake fairly consistently since 1999. Efforts should be made to monitor the lake annually for the next 5 years. Adaptive management may require additional monitoring when different BMPs are implemented. Details of the RCWD monitoring protocol can be found in the RCWD's Water Quality Monitoring Reports.

Monitoring of ACD 53-62 should be completed for additional years in order to confirm the low TP yields calculated from the existing monitoring data. If further monitoring data suggest that loading rates are substantially higher than what was assumed in this report, the TMDL may have to be re-opened to redistribute the WLAs and LA.

Summer and winter dissolved oxygen profiles will be measured by the Rice Creek Watershed District to better characterize oxygen and sediment phosphorus release dynamics. The Rice Creek Watershed District will work with the Department of Natural Resources and the City of Circle Pines to develop an aerator operations plan that sustains winter oxygen levels for fish, while taking into consideration the effects of hypolimnetic circulation and sediment phosphorus release.

8. Implementation Strategy

A. Approach

The implementation strategy presented below contains recommendations that will either reduce the watershed phosphorus load into Golden Lake or will improve in-lake water clarity through shifting ecological interactions within the lake. Included is a list of best management practices that already exist in the watershed. Due to the magnitude of impact that Rule M and the RMP will have on reducing future TP loads in the upper watershed, the majority of the BMP recommendations are aimed at the Cities of Circle Pines, Lexington, Lino Lakes, and Blaine (south of 35W), which are already predominately developed.

The recommendations are meant to serve as a guide to achieve the load reductions; a combination of other actions is possible, as long as the water quality goals are achieved. A more specific implementation plan will be developed in cooperation with stakeholders in an effort separate from this TMDL.

A detailed cost-benefit analysis has not been completed for each recommendation, but it is acknowledged that cost will be a factor in the decision-making process and that the feasibility of these recommendations will need to be assessed. It is estimated that lake restoration will cost approximately $1.4 million. This rough estimate will be refined during the implementation planning phase.

B. Implementation Strategy

A number of best management practices already exist in the Golden Lake watershed:

- The cities of Circle Pines, Lexington, Lino Lakes, and Blaine perform street sweeping once each spring, summer, and fall.
- A water quality pond is located in Circle Pines just north of the Golden Lake inlet. This pond treats runoff from watersheds 111-131 (Figure 16).
- The City of Circle Pines is considering dredging targeted areas of Golden Lake to reduce internal loading.
- A hypolimnetic aerator was installed in Golden Lake in the late 1980s and was modified in 1992. The purpose of this aerator was to prevent winter fish kills and limit internal loading due to anoxic conditions in the hypolimnion.
- RCWD Rule M and Rule RMP-1
- Educational efforts:
    - The City of Blaine includes a stormwater article in each monthly newsletter, sent to all residents.
    - RCWD employs a full-time environmental education coordinator

Implementation Action Descriptions

The recommended implementation actions include both infrastructure projects and management practices, and target both watershed and in-lake phosphorus sources (Table 27).

Table 27. Recommended Implementation Actions

	Infrastructure	Management	Watershed	In-lake
Rule M and Rule RMP-1 implementation		x	x	
P-free fertilizer		x	x	
Street sweeping		x	x	
Support enforcement of existing regulations		x	x	
Small-scale infiltration and volume reduction practices	x		x	
Neighborhood rain gardens/infiltration areas	x		x	
Stormwater retrofits	x		x	
Shoreline buffers	x			x
Food web manipulation		x		x
Protect and enhance fringe wetland vegetation		x		x
Alum treatment	x			x
Lake level drawdown in winter		x		x
Scraping of littoral sediments during a lake drawdown	x			x
Weed harvesting	x			x
Sediment delta removal	x			x

1) Rule M and RMP-1 implementation
RCWD's Rule M and RMP-1, described in Section 1.B under *Resource Management Plan and Watershed Rules*, requires new development to use water resource BMPs to improve water quality and control runoff volume. Examples include infiltration areas, ponding, swales, shared parking, and other low-impact development techniques. In order for Rule M and RMP-1 to have its intended impact on the water quality of Golden Lake, these rules will have to be enforced.

Responsible parties: RCWD

2) P-free fertilizer
Minnesota Statute (Chapter 18C) has been updated to include the Phosphorus Lawn Fertilizer Law (SF 1555), which went into effect in 2004 and restricts the use of fertilizer containing phosphorus in non-cropped land. Since this is a recent law, its full effect has not yet been observed. It has the potential to decrease phosphorus concentrations in residential runoff by approximately 20%, according to an unpublished study done by the Three Rivers Park District.

Responsible parties: MN Legislature (already passed)

3) Street sweeping

Street sweeping already exists in the Golden Lake watershed; however, the number of times that the streets are swept each year (currently approximately three) should be increased. Ideally, street sweeping should occur every 15 to 30 days during summer, spring, and fall where feasible.

Responsible parties: City of Blaine, City of Circle Pines, City of Lexington, City of Lino Lakes, and RCWD

4) Support enforcement of existing regulations
Existing regulations are often sufficient to improve water quality in these watersheds, but a lack of enforcement capabilities of the regulations can result in them being less effective. Enforcement of existing regulations by entities with management authority should be supported.

Responsible parties: City of Blaine, City of Circle Pines, City of Lexington, and City of Lino Lakes

5) Small-scale infiltration and volume reduction practices
Incentives and/or matching grants should be developed for property owners (residential, commercial, and institutional) who are willing to create small-scale infiltration and volume reduction practices, such as rain gardens and rain barrels, to benefit runoff water quality. Through the creation of matching grants and demonstration projects, the volume of stormwater that infiltrates to the groundwater instead of reaching Golden Lake could be increased. Key components include:

- Create a residential infiltration demonstration project.
- Create a matching grant program to financially support creation of infiltration practices on private property.
- Adopt volume control standards for new developments that require no net increase in volume discharged from site.

Responsible parties: City of Blaine (south of 35W), City of Circle Pines, City of Lexington, City of Lino Lakes, and RCWD

6) Neighborhood rain gardens/infiltration areas
Even though the majority of the lower watershed is developed, there are still opportunities for stormwater infiltration. Either neighborhood-scale rain gardens or subsurface filtration and infiltration devices could be used.

A neighborhood-scale rain garden would resemble large rain gardens, with native vegetation in depressed areas that would assist in stormwater infiltration. The rain gardens would also provide aesthetic benefits to the neighborhood, would serve a traffic calming function, and would provide an educational benefit. Educational displays would inform the public of the function of the rain garden and would explain the connection between stormwater management and the water quality of the lake.

If above-ground bioretention areas are not a possibility, subsurface chambers could serve a similar purpose. A subsurface stormwater drainage system is installed below a paved surface. Stormwater is diverted through the system, which stores the water and allows it to infiltrate into the groundwater. A cost-benefit analysis comparing these two options should be completed to aid in the decision of which approach to take.

Responsible parties: City of Blaine (south of 35W), City of Circle Pines, City of Lexington, City of Lino Lakes, and RCWD

7) Stormwater retrofits
As redevelopment arises, low impact development approaches should be incorporated into the stormwater management design.

Responsible parties: City of Blaine (south of 35W), City of Circle Pines, City of Lexington, City of Lino Lakes, and RCWD

8) Shoreline buffers
Vegetative buffers of native vegetation around the perimeter of Golden Lake would help remove pollutants in runoff from the drainage area before they reach the lake. Native vegetation also discourages geese.

Responsible parties: City of Circle Pines, RCWD

9) Food web manipulation
Since food web manipulation does not directly influence load inputs to a lake, but rather aims to shift ecological interactions within a lake, it does not naturally fit into the TMDL framework. However, it has the potential to shift a lake from a turbid state with dense phytoplankton to a clearer phase with more rooted aquatic macrophytes. Food web interactions often have a substantial influence on chlorophyll concentrations and water clarity within a lake and this influence is more pronounced in shallow lakes. Increased densities of large cladocera (a type of zooplankton) that graze on phytoplankton can lead to lower chlorophyll concentrations. Manipulating food web interactions, through the addition or removal of certain fish species, can influence zooplankton densities and therefore also influence chlorophyll concentrations, a food-web phenomenon known as "top-down" control.

The RCWD is working with Kyle Zimmer from the University of St. Thomas to collect information on the current zooplankton communities within Golden Lake. This information will be used to guide recommendations on how the biological community could be manipulated.

Responsible parties: City of Circle Pines, RCWD

10) Protect and enhance fringe wetland vegetation
Fringe wetland vegetation is an integral part of a shallow lake's ecosystem and benefits water quality by filtering out incoming nutrients and stabilizing the shoreline and bottom sediments. This habitat should be protected and enhanced in order to keep its function intact and/or improve it.

Responsible parties: City of Circle Pines, RCWD

11) Alum treatment for Golden Lake
Aluminum sulfate (alum) is a chemical addition that binds with phosphorus to form a non-toxic precipitate (floc). Alum removes phosphorus from the lake system so that is not available for algal growth by forming a barrier between lake sediments and the water to restrict phosphorus release from the sediments. However, due to the fact that Golden Lake is a shallow lake, it is unclear how long the floc would remain effective before being covered by resuspended lake bottom sediments.

Responsible parties: City of Circle Pines, RCWD

12) Lake level drawdown in winter
This option consists of drawing the water levels in the lake down four to six feet in the winter, and allowing the sediments in the shallower areas to freeze, consolidate, and decompose under different conditions than those present in the lake when they are under water. Water levels would be allowed to rebound to previous levels in the spring following this treatment. This process has been shown to be effective in reducing the growth of rooted aquatic plants, enhancing the consolidation of lake bottom sediments, and expanding the oxidation of organic bottom sediments in these shallow areas.

Responsible parties: City of Circle Pines, RCWD

13) Scraping of littoral sediments during a lake drawdown
This activity would reduce the presence of aquatic seed beds, remove organic sediments, and slightly deepen the littoral areas of the lake.

Responsible parties: City of Circle Pines, RCWD

14) Weed harvesting
This option consists of using an aquatic weed harvesting program to manage the rooted aquatic macrophyte infestation problem present in Golden Lake. This treatment would be required in spring prior to curly leaf die-off and periodically throughout the summer months. This harvesting alternative has the potential to address rooted aquatic plant growth problems for residents using the lake to the extent allowed by the Minnesota Department of Natural Resources.

Responsible parties: City of Circle Pines, RCWD

15) Sediment delta removal
The City of Circle Pines recently received Metropolitan Council funding to dredge the sediment delta that has been accumulating over the years at the inlet of Golden Lake.

Responsible parties: City of Circle Pines

An Implementation Plan will be developed for this TDML within one year of EPA approval. Through this process additional reduction strategies, such as fixing the failing septic systems, will be explored and considered to meet the allocations developed in this TMDL.

9. Reasonable Assurances

Reasonable assurances must be provided to demonstrate the ability to reach and maintain water quality endpoints. In addition to having a thorough knowledge of various kinds of best management practices that can be implemented as well as realizing their overall effectiveness, there are several other factors that control reasonable assurances with the RCWD.

REGULATION

Water Rules establish standards and specifications for the common elements relating to watershed resource management, including water quantity, water quality, natural resource protection, erosion and sediment control, wetland protection, shoreland management, and floodplain management. Of particular benefit to the Golden Lake Nutrient TMDL reduction strategies is the stormwater management Rule M, which is required of new development in the CWMP area. The complete water management rules can be found on the Rice Creek Watershed District Website (http://www.ricecreek.org).

EDUCATION

Education is an important part of what the Rice Creek Watershed District does. It plays an essential role in protecting the natural resources of the Rice Creek Watershed and will be utilized to educate residents in the Golden Lake watershed about the TMDL and the necessary improvements that need to be made.

INCENTIVES

The RCWD has an incentive grant program that awards financial assistance of 1) innovative BMPs, 2) shoreland management and stream bank restoration, 3) lake restoration, and 4) native landscaping and lakeshore buffers. In addition, after the approval of the Golden Lake TMDL by the EPA, when the RCWD enters into the implementation phase, the RCWD anticipates applying for monies to further assist landowners and local municipalities in the application of BMPs identified in the Implementation Plan.

10. Public Participation

Public participation associated with this TMDL began in 2003 with the public meetings held by RCWD regarding the CWMP. In addition, a Public Advisory Committee (PAC) was formed that consisted of local stakeholders in the watershed. Members are included in Table 28. This committee was formed based upon the premise that local involvement is crucial in applying science to community water quality and water quantity problems successfully.

Two PAC meetings were held in total to build trust, engage community pride, develop a common understanding of water resource issues and their relationship to identified problems, provide an opportunity for local prioritization of issues, and enhance participant dedication to eventual implementation (Table 29). Members of the PAC were notified via email about meeting times and dates. Two landowner meetings were held in September 2005 in Blaine and in March 2006 at the Circle Pines City Hall.

A draft TMDL report was put on public notice in the State Register for a 30-day comment period from March 2 to April 1, 2009. Comments were received and the report was revised where appropriate.

Table 28. PAC members

Attendees	Area of Representation
Marcey Westrick	Emmons and Oliver Resources, Inc. – Aquatic Ecologist
Steve Hobbs	Rice Creek Watershed District - Administrator
Chuck Johnson	Rice Creek Watershed District - Biologist
Tim Larson	Minnesota Pollution Control Agency - Project Manager
Marty Asleson	City of Lino Lakes – Environmental Director
Jim Keinath	City of Circle Pines – City Administrator
James Hafner	City of Blaine – Stormwater Management
Wayne LeBlanc	Peltier Lake Association
Kyle Zimmer	University of St. Thomas

Table 29. Public meetings held for the Golden Lake TMDL

Meeting Number	Meeting Topic	Meeting Date
Meeting #1	General Introduction of the TMDL Process/Why is Golden Lake listed?	September 14, 2005
Meeting #2	TMDL Allocation	March 29, 2006

References

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Appendices

Appendix A: Golden Lake Groundwater Assessment

Appendix B: Golden Lake Water Quality Data

Appendix C: RMP Wetland Management Area Goals and Concept Plans (Appendix J of Resource Management Plan Alternative for the Repair of Anoka County Ditch 53-62; RCWD September 2006)

Appendix D: Golden Lake Watershed Hydrology

Appendix E: Certified Rule RMP-1

Appendix F: ACD 53-62 Data

Appendix A. Golden Lake Groundwater Assessment

Golden Lake Groundwater Assessment

Surface water resources, such as lakes, are influenced by regional groundwater flow, local groundwater flow, locally perched groundwater, precipitation, topography, and soils. Identifying a lake's dependence on groundwater is critical to managing the surface watershed and groundwatershed in order to protect these resources.

The groundwater function of a lake can be defined as the character of interaction between the lake and the surrounding groundwater. Lakes have varying degrees of groundwater interaction. Lakes can be classified as groundwater recharge (lake loses water), groundwater discharge (lake gains water), or flow-through (both recharge and discharge occur in different areas). Soil type, both underlying and on the margins of a lake, partially controls the magnitude of groundwater interaction.

The groundwater function of Golden Lake was determined based on the following criteria:

1. Comparison to nearby groundwater elevations
2. Surficial geology based on geomorphic region
3. Surface water inflow and outflow

COMPARISON TO GROUNDWATER ELEVATIONS

Lake elevation compared to surrounding groundwater elevation is a strong indicator of the groundwater function. Lakes gain or lose water to the surrounding aquifers depending on the elevation of the lake water level relative to the groundwater level in the aquifers.

Elevation comparisons to one or two nearby wells are inadequate to determine the groundwater function because water levels in wells can vary depending on location (up-gradient or down-gradient), distance from the lake, well depth, aquifer materials, etc. Instead, the lake elevation was compared to a number of features including:

- Elevation of other nearby surface water bodies
- Mapped groundwater elevation contours

Lakes with high elevations relative to these features often serve a recharge function. Golden Lake (elevation 888 ft.) is roughly 8 feet higher in average elevation than the nearest surface water body, Baldwin Lake. Baldwin Lake is located 0.43 miles to the east of Golden Lake. Golden Lake's average surface water elevation is greater than 257 of 277 nearby wells static water elevations, although the majority of nearby wells are located in Buried Quaternary Artesian Aquifers (QBAA). Regional groundwater flow in the vicinity of Golden Lake is from northeast to southwest towards the Mississippi River. The local surficial groundwater table flow is from the northwest to southeast towards the Chain of Lakes. The average elevation of Golden Lake relative to the regional and local groundwater table and the elevation of nearby lakes indicate that Golden Lake is a recharge lake with flow-through characteristics. This means that surface water is recharging the local groundwater table as it flows into Golden Lake and groundwater is moving laterally to the east through Golden Lake.

SURFICIAL GEOLOGY BASED ON GEOMORPHIC REGION

Surficial geology can be used as an indicator of the degree of surface water/groundwater interaction. Sandy soils allow for a higher connection to groundwater than clayey soils. Clayey soils behave as an aquitard, restricting the movement of water. Golden Lake is located in the New Brighton Sand Facies Unit, a geologic unit that readily transmits water. Generalized cross-sections based from drillers' well logs in the vicinity of Golden Lake were developed to look at the relationship between geology, the water table, and lake bathymetry for Golden Lake (Figures 1 and 2). Figure 3 depicts the orientation of the cross section lines relative to Golden Lake. These cross-sections illustrate that the lake intersects a laterally extensive sand unit and that both the regional and local groundwater tables most likely intersect the lake. Sandy materials, such as outwash like the New Brighton Sand Facies, can be classified as having a high connectivity to groundwater.

SURFACE WATER INFLOW AND OUTFLOW

Surface water inflow and outflow is a very good indicator of groundwater interaction in a lake. A water balance approach was used to determine the groundwater function of Golden Lake. A recharge lake is identified when there is a large influx of surface water into a lake, and very little or no outflow. Discharge lakes are defined as having more surface water outflow than inflow. Flow-through lakes are defined as having approximately equal inflows and outflows. Stream inflow and outflow was monitored in 1982 by Environmental Research Group Inc. and in 1995 by Montgomery Watson. Precipitation data for the years 1982 and 1995 were retrieved from nearby Climatology Station 211420, located in Centerville.

Figure 4 illustrates the 1982 stream flow site locations. The stream flow inflow site was located south of old U.S. Highway 8 and the outlet site was located near Golden Lake Lane East. Table 1 presents 1982 stream flow site data collected at the inlet and outlet sites. Stream discharge data collected in 1982 at the Golden Lake sites suggest that for non precipitation driven stream flow, Golden Lake behaves as a recharge lake with flow-through characteristics. In 1982, from May 27 to July 23, there was measurable stream inflow into Golden Lake with no outflow. During this time the lake level was approximately between 887.50 and 887.05 ft. Some of the inflow was lost to evapotranspiration; however, this long stretch of continuous data with measurable stream inflow and no outflow demonstrates that the lake is recharging the local water table and the local water table elevation during this timeframe was approximately 887 feet above sea level.

Figure 5 illustrates the 1995 stream flow site locations and the geology of the Golden Lake area. Stream flow sites 11 and 11b are both located upstream of the lake and site 0 is located at the outlet of the lake. Table 2 presents 1995 stream flow site data collected at the inlet and outlet sites. Six of the twelve days of stream gauging that was performed demonstrate that volume is lost between the lake's inlet (site 11b) and outlet (site 0). Days where the outlet volume exceeded the inlet volume correspond to rainfall events in all but one case (5/03/1995). The increase on 5/03/95 in outlet discharge, 0.23 cfs, was not due to precipitation and may have been caused by seasonal fluctuations in the water table or an anthropogenic means such as flushing of fire hydrants or well purging. Days where the outlet volume is less than the inlet volume also have corresponding precipitation events. For these events, Golden Lake is losing water to the groundwater table. These data illustrate a fluctuating and dynamic water table that changes elevation seasonally and as a function of precipitation. Discharge data collected in 1995 at Golden Lake suggest that Golden Lake behaves as a recharge lake with flow-through characteristics.

CONCLUSIONS

Golden Lake's elevation relative to the local water table and the elevation of area lakes, the ability of local surficial geology to readily transmit water, and localized hydraulic gradients in the region classify Golden Lake as both a recharge and flow-through lake. The elevation of the local water table fluctuates with varying degrees of precipitation. A series of monitoring wells should be placed around the perimeter of Golden Lake to accurately describe the elevation of groundwater, the local hydraulic gradient, and the direction of groundwater flow in the vicinity prior to changing surface water input, outlet elevation, or draining of the lake. Groundwater is unlikely contributing to the excessive nutrients in Golden Lake.

Figure 1:Golden Lake A-A' Cross Section

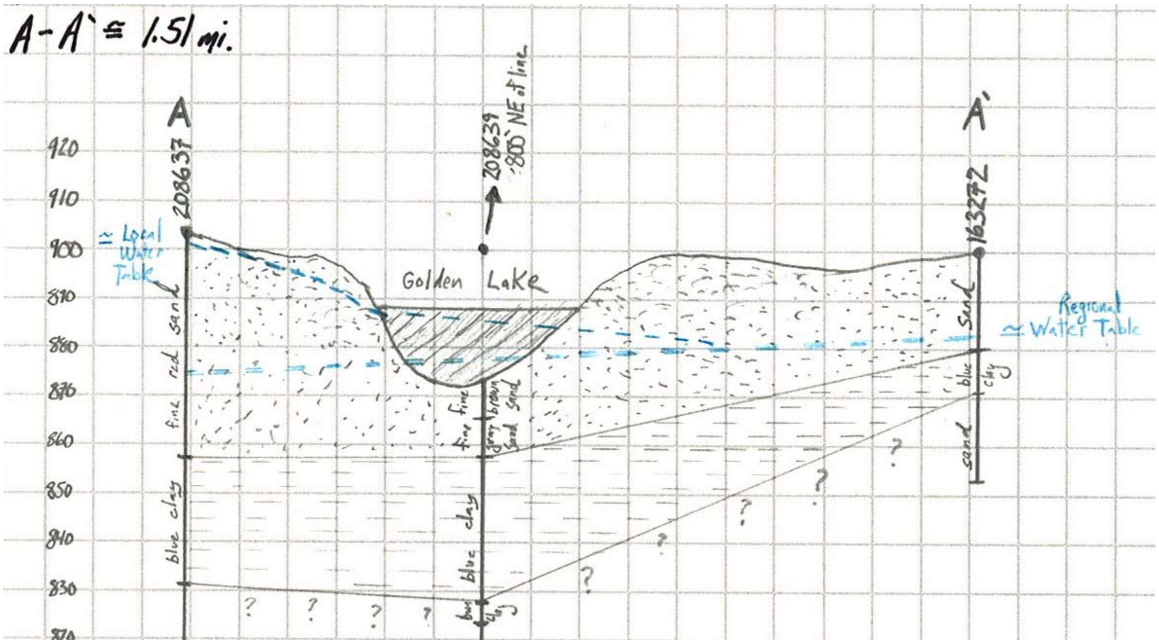


Figure 2: Golden Lake B-B' Cross Section

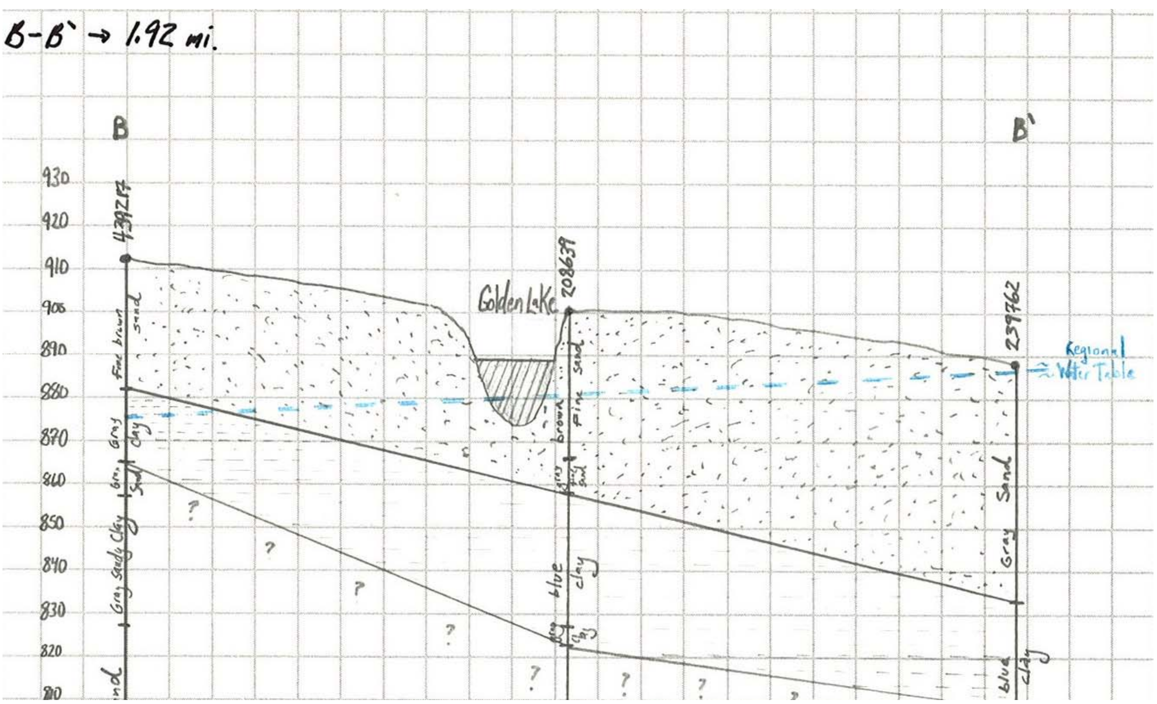
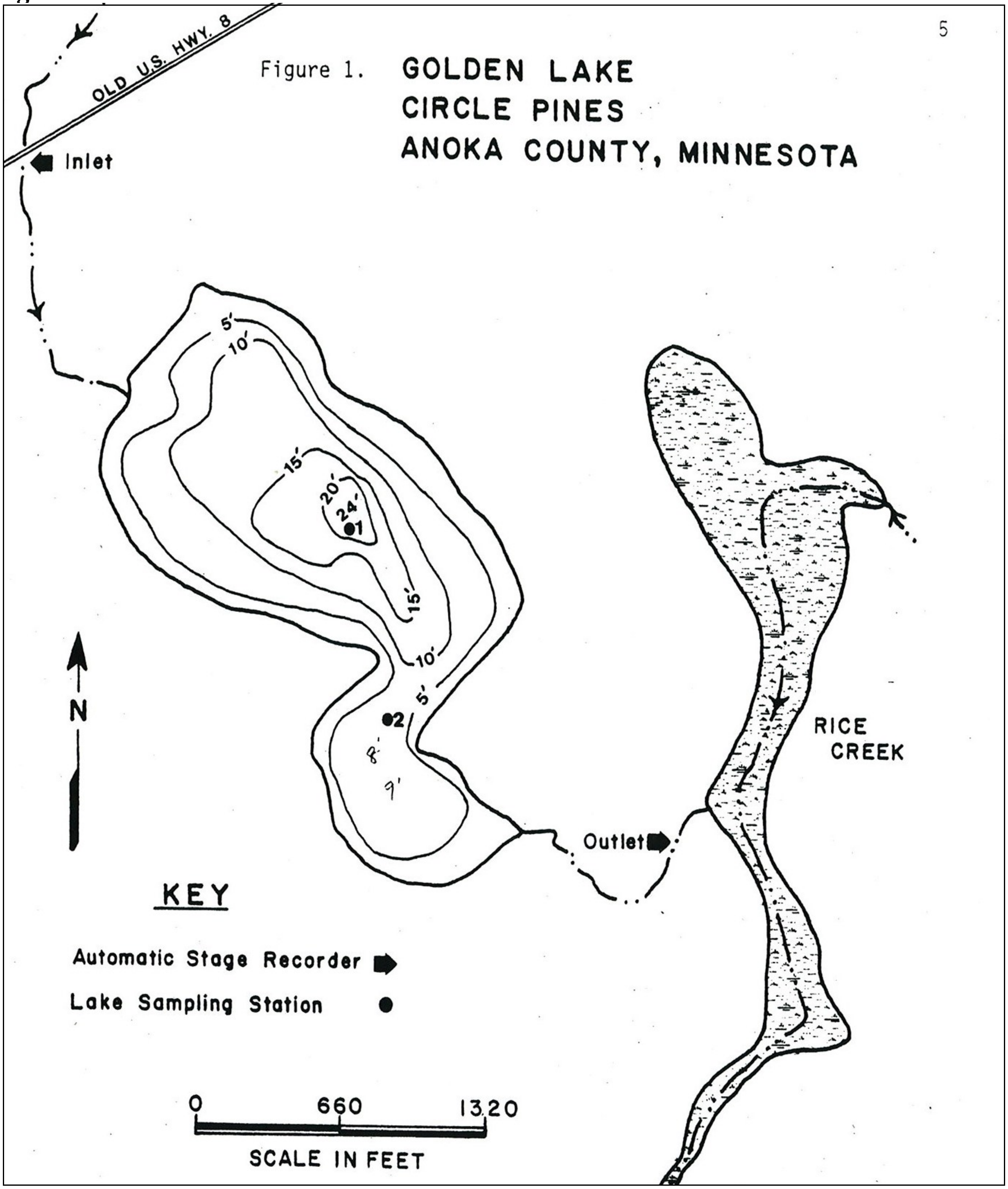


Figure 3: Golden Lake Cross Section Orientations

Figure 4: Golden Lake 1982 Flow Site Locations



Source: 1982 Management Alternatives Report on the Diagnostic-Feasibility Study for Golden Lake, Anoka County, MN

Figure 5: Golden Lake 1995 Flow Sites and Quaternary Geology

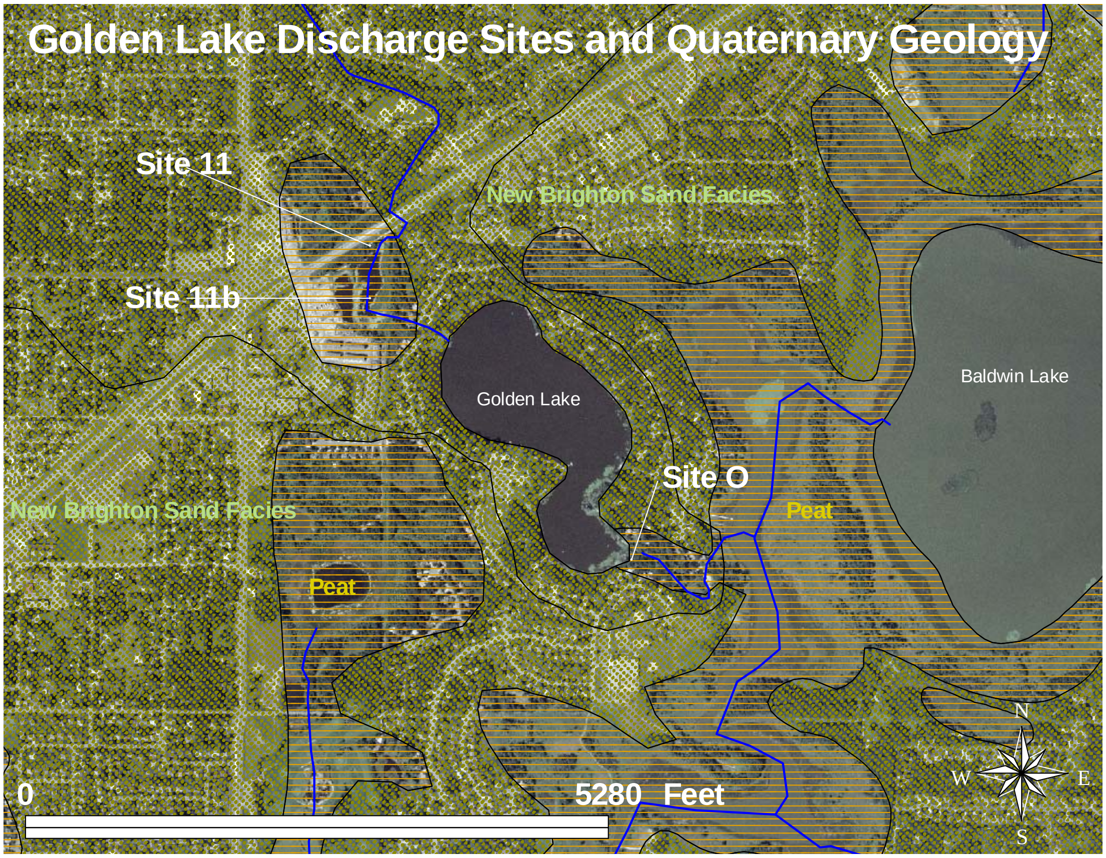


Table 1: Golden Lake Flow Values 1981-1982.

Golden Lake Inflow-Outflow Conditions 1982				
Source: 1982 Environmental Research Group Report				
Date	**Stream Inflow (cfs)**	**Stream Outflow (cfs)**	**Outflow/Inflow**	**Precipitation prior to 7 days before measurement?**
11/5/1981	0.13	0.61	>	No
11/30/1981	0.16	2.31	>	Yes, 0.09" three days
12/22/1981	0	0	=	No
1/20/1982	0	0	=	Yes, 0.03" two days
2/23/1982	0	0	=	No
3/3/1982	0	0	=	Yes, 0.04" seven days
3/5/1982	0	0	=	No
3/9/1982	0	0	=	No
3/11/1982	0.1	0	<	Yes. 0.1" two days
3/16/1982	0.68	0	<	Yes, 0.62" four days
3/23/1982	1.98	6.16	>	Yes, 0.62" two days
3/26/1982	0.78	1.35	>	Yes, 0.62" five days
3/31/1982	24.91	3.36	<	No
4/2/1982	24.3	8	<	Yes, 0.02" two days
4/6/1982	24.6	19.63	<	Yes, 0.22" two days
4/8/1982	17.09	22.53	>	Yes, 0.22" four days
4/13/1982	27.7	21.92	<	No
4/16/1982	20.46	20.74	>	Yes, 0.15" one day
4/20/1982	19.03	19.63	>	Yes, 0.41" one day
4/23/1982	16.54	12.19	<	Yes, 0.2" three days
4/27/1982	2.78	7.43	>	Yes, 0.2" seven days
4/30/1982	5.95	3.26	<	No
5/25/1982	0.73	0.27	<	Yes, 0.47" seven days

Source: 1982 Management Alternatives Report on the Diagnostic-Feasibility Study for Golden Lake, Anoka County, MN

Table 2: Golden Lake Flow Values 1995.

Golden Lake Inflow-Outflow Conditions 1995					
Source: 1995 Montgomery Watson Report					
Date	**11 Inflow (cfs)**	**11b Inflow (cfs)**	**0 Outflow (cfs)**	**Outflow/Inflow**	**Precipitation prior to 7 days before measurement?**
3/13/1995	4.89		14.6	>	Yes, 0.4" six days Snowmelt
4/12/1995	7.98	11.2	6.07	<	Yes, 0.22" one day
5/3/1995	3.73	4.08	4.31	>	Yes, 0.04" seven days
6/13/1995	7.31	11.6	10.5	<	Yes, 0.57" two days
7/7/1995	1.56	3.69	1.89	<	Yes, 0.69" two days
7/25/1995	0.72	0.42	0.42	=	Yes, 0.58" two days
8/8/1995	2.45	4.72	3.42	<	Yes, 1.73" one day
8/30/1995	4.36	7.87	6.34	<	Yes, 0.1" one day
9/19/1995	0.12		0.14	>	Yes, 0.38" three days
10/4/1995	2.2	2.67	3.44	>	Yes, 0.5" one day
10/26/1995	9.74	11.5	12.6	>	Yes, 1.8" two days
11/8/1995	8.25	12	10.5	<	Yes, 0.03" five days

Source: 1982 Management Alternatives Report on the Diagnostic-Feasibility Study for Golden Lake, Anoka County, MN

Appendix B. Golden Lake Water Quality Data

Golden Lake

Date (mm/dd/yy)	Depth (m)	Chl-a (µg/l)	TSS	TP (mg/l)	SRP (mg/l)	TKN (mg/L)	NOx (mg/L)	Secchi (m)	Temperature (C)	DO (mg/l)	pH	Conductivity (µS/cm)	Source
06/19/91	0	94		0.170				0.5		7.9			RCWD
07/10/91	0	73		0.130				0.5		9.0			RCWD
08/09/91	0	73		0.100				0.7		7.3			RCWD
05/15/95	0	23	1	0.050				1.4	17	12.0	8.3	350	RCWD
06/14/95	0	20	9	0.090				1.5	23	11.4	7.8	320	RCWD
07/11/95	0	83	5	0.100				0.7	27	16.0	9.1	295	RCWD
07/28/95	0	88	2	0.090				0.5	26	9.6	8.8	300	RCWD
08/11/95	0	78	9	0.080				0.6	26	9.0	8.8	295	RCWD
08/29/95	0	34	6	0.140				0.7	24	5.5	7.6	265	RCWD
09/18/95	0	21	2	0.160				0.8	19	5.7	7.6	260	RCWD
10/24/95	0	19	6	0.120				0.8	8	8.8	7.7	290	RCWD
04/30/96	0	25		0.080				1.1	10				CALMP
05/15/96	0	23		0.050				1.1	13				CALMP
05/28/96	0	20		0.060				1.1	15				CALMP
06/11/96	0	8		0.030				1.3	26				CALMP
06/25/96	0	30		0.050				1.3	22				CALMP
07/15/96	0	55		0.060				0.8	26				CALMP
07/26/96	0	40		0.040				0.8	23				CALMP
08/26/96	0	45		0.060				0.8	24				CALMP
09/09/96	0	32		0.090				1.1	22				CALMP
09/14/96	0	30		0.090				1.0	21				CALMP
09/18/96	0	33		0.080				0.9	19				CALMP
10/01/96	0	41		0.080				0.8	15				CALMP
10/16/96	0	21		0.090				0.8	14				CALMP
05/20/97	0	23		0.040				1.6	14				CALMP
05/24/97	0	18		0.030				1.7	15				CALMP
05/28/97	0	10		0.030				1.6	16				CALMP
06/13/97	0	73		0.080				0.8	27				CALMP
06/26/97	0	23		0.030				1.2	23				CALMP
06/30/97	0	36		0.040				1.1	26				CALMP
07/24/97	0	27		0.090				0.9	23				CALMP
08/05/97	0	47		0.150				0.6	23				CALMP
08/24/97	0	20		0.100				1.2	22				CALMP
09/08/97	0	28		0.080				1.0	22				CALMP
09/29/97	0	30		0.100				1.2	17				CALMP
04/16/99	0	20		0.040				1.5	8				CALMP
05/05/99	0	51		0.040				1.1	15				CALMP
05/20/99	0	25		0.040				1.0	19				CALMP
05/22/99	0	18		0.040				1.2	20				CALMP

Date (mm/dd/yy)	Depth (m)	Chl-a (µg/l)	TSS	TP (mg/l)	SRP (mg/l)	TKN (mg/L)	NOx (mg/L)	Secchi (m)	Temperature (C)	DO (mg/l)	pH	Conductivity (µS/cm)	Source
06/04/99	0	15		0.050				1.5	19				CALMP
06/18/99	0	33		0.070				1.0	20				CALMP
07/02/99	0	38		0.060				0.9	22				CALMP
07/20/99	0	40		0.070				0.7	24				CALMP
08/03/99	0	45		0.080				0.5	24				CALMP
08/17/99	0	93		0.080				0.5	22				CALMP
09/01/99	0	37		0.060				0.7	20				CALMP
09/17/99	0	66		0.080				0.8	15				CALMP
09/29/99	0	32		0.060				1.0	15				CALMP
04/10/00	0	16		0.030				1.8	9				
04/24/00	0	10		0.010				2.0	15				
05/08/00	0	6		0.030				2.5	22				
05/24/00	0	7		0.030				2.6	20				
06/12/00	0	8		0.030				2.2	23				
06/22/00	0	13		0.040				2.0	21				
07/06/00	0	25		0.050				1.5	26				
07/17/00	0	29		0.060				0.8	27				
07/31/00	0	31		0.060				0.5	28				
08/22/00	0	67		0.100				0.8	24				
09/07/00	0	75		0.100				1.0	28				
09/14/00	0	56		0.070				1.0	27				
09/25/00	0	77		0.120				0.9	23				
10/13/00	0	27		0.080				1.6	18				
04/29/02	0			0.036				1.3	9				CALMP
05/17/02	0	10		0.041				1.5	14				CALMP
06/07/02	0	15		0.054				1.7	20				CALMP
07/03/02	0	76		0.139				0.6	30				CALMP
07/12/02	0	33		0.148				0.8	29				CALMP
07/30/02	0	39		0.100				0.8	30				CALMP
08/19/02	0	60		0.123				1.1	24				CALMP
09/09/02	0			0.173				0.5	26				CALMP
09/24/02	0	62		0.178				1.0	17				CALMP
10/07/02	0	13		0.096				1.6	12				CALMP
10/28/02	0	4		0.057				2.1	5				CALMP
01/09/04	0			0.088				1.5	3	7.4		498	RCWD
02/18/04	0			0.086				1.3	1	5.8		515	RCWD
05/10/04	0	15		0.032	0.021				17	12.3	8.7		
06/08/04	0	45		0.093									
06/21/04	0			0.112				0.9	21	7.7	7.4		
07/29/04	0	63		0.079				0.6	24	8.0	8.3		

Date (mm/dd/yy)	Depth (m)	Chl-a (µg/l)	TSS	TP (mg/l)	SRP (mg/l)	TKN (mg/L)	NOx (mg/L)	Secchi (m)	Temperature (C)	DO (mg/l)	pH	Conductivity (µS/cm)	Source
09/01/04	0	41		0.102	0.014				22	12.3	8.3		
01/09/04	7.0			0.076					5	0.8		595	RCWD
02/18/04	6.0			0.083					4	4.5		509	RCWD
05/10/04	7.0	5		0.076	0.013				12	0.1	7.2		
07/29/04	6.0	4		0.416					16		7.5		
09/01/04	7.0			1.580	0.764				14		7.2		
06/02/05	0.5	3		0.017	0.009	0.75	0.07	2.3	21	9.2		476	
06/02/05	8.0			0.596	0.245	2.45	0.01		8			686	
06/16/05	0.5								25	6.4		468	
06/16/05	5.0			0.064		2.00	0.01		14	1.3		504	
07/07/05	7.0			0.294	0.179	2.70	0.01	1.4	12			566	
07/18/05									12	0.2		578	
07/18/05								0.7	27	8.1		454	
07/27/05	5.0	30		0.713	0.095				16	0.0		528	
07/27/05	0.5	24		0.073	0.009		0.03	0.8	26	8.4		448	
08/11/05	7.0	20		1.140		4.68	0.01		13			580	
08/11/05	0.5	27		0.073		1.92	0.01	0.7	26	6.8		425	
08/22/05	7.0	28		0.787	0.092	5.93	0.01		13	0.1		587	
08/22/05	0.5	24		0.078	0.009	1.80	0.01		23	6.4		435	
09/21/05	0.5	30		0.150	0.019	2.40	0.01	1.0	22	7.6		403	
09/21/05	7.0			2.230	0.033	5.96	0.01		13	0.1		614	
04/21/06		16		0.13		1.90							EDA download
04/21/06	0							1.4	14				EDA download
05/03/06		12		0.118		0.98							EDA download
05/03/06	0							1.8	16				EDA download
05/25/06		23		0.088		1.00							EDA download
05/25/06	0							1.6	21				EDA download
06/07/06		10		0.038		2.20							EDA download
06/07/06	0							2.1	27				EDA download
06/17/06	0							1.1					EDA download
07/01/06	0							0.6					EDA download
07/05/06		36		0.052		3.00							EDA download
07/05/06	0							1.5	26				EDA download
07/09/06	0							0.6					EDA download
07/24/06	0							0.8					EDA download
07/25/06		33		0.061		2.60							EDA download
07/25/06	0							1.0	28				EDA download
07/29/06	0							0.8					EDA download
08/14/06		61		0.063		2.30							EDA download
08/14/06	0							0.7	24				EDA download

Date (mm/dd/yy)	Depth (m)	Chl-a (µg/l)	TSS	TP (mg/l)	SRP (mg/l)	TKN (mg/L)	NOx (mg/L)	Secchi (m)	Temperature (C)	DO (mg/l)	pH	Conductivity (µS/cm)	Source
09/11/06		26		0.108		1.60							EDA download
09/11/06	0							1.1	18				EDA download
09/19/06		26		0.218		2.20							EDA download
09/19/06	0							1.2	17				EDA download
09/22/06	0							0.9					EDA download
10/06/06		25		0.056		1.30							EDA download
10/06/06	0							1.4	16				EDA download
10/27/06		20		0.263		1.40							EDA download
10/27/06	0							1.5	10				EDA download
05/12/07	0							1.1					EDA download
05/19/07	0							1.8					EDA download
05/30/07	0							1.1					EDA download
06/16/07	0							1.4					EDA download
07/01/07	0							0.6					EDA download
07/16/07	0							0.5					EDA download
07/29/07	0							0.3					EDA download
08/12/07	0							0.5					EDA download
08/25/07	0							0.5					EDA download
09/23/07	0							1.1					EDA download
10/05/07	0							1.2					EDA download
11/03/07	0							2.4					EDA download

Appendix C. RMP Wetland Management Area Goals and Concept Plans

(Appendix J of Resource Management Plan Alternative for the Repair of Anoka County Ditch 53-62; RCWD September 2006)

APPENDIX J: RMP WETLAND MANAGEMENT AREA GOALS AND CONCEPT PLANS

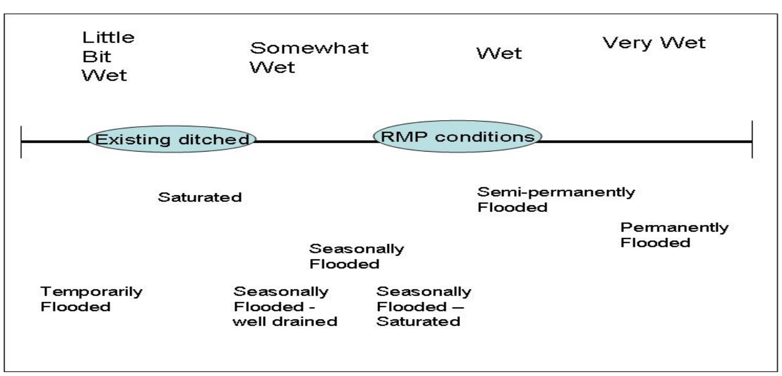
GOALS

Goals have been established for each management area for ditch repair and wetland hydrologic restoration. The implementation of management area goals will be phased in over a period of time. The phasing for each management area is prioritized in Table 21 based upon a logical sequence of development and restoration strategies for the entire RMP area. All activities will be subject to permit review. Permit conditions will be written to address risks of unanticipated drainage from RMP ditch repair.

It is worth revisiting Section III of this document for the criteria that define the feasible repair and RMP repair for the 53-62 ditch system. One intent of the RMP repair is to avoid draining wetlands requiring replacement under the drainage exemption in WCA. This includes all Type 3,4,5 and PWI wetlands. Thus, extent of ditch channel repair/redesigns is dependent on the kind of associated wetland.

The other, watershed management-based intent of all proposed channel excavations and outlet control structures is to restore the hydrologic storage capacity that is missing in some management areas. In general it is assumed that the unditched storage capacity is greater than the ditched capacity. The wetland hydrologic capacity can be related to a sliding scale of wetland wetness using the water regime modifiers described by the Cowardin classification system.

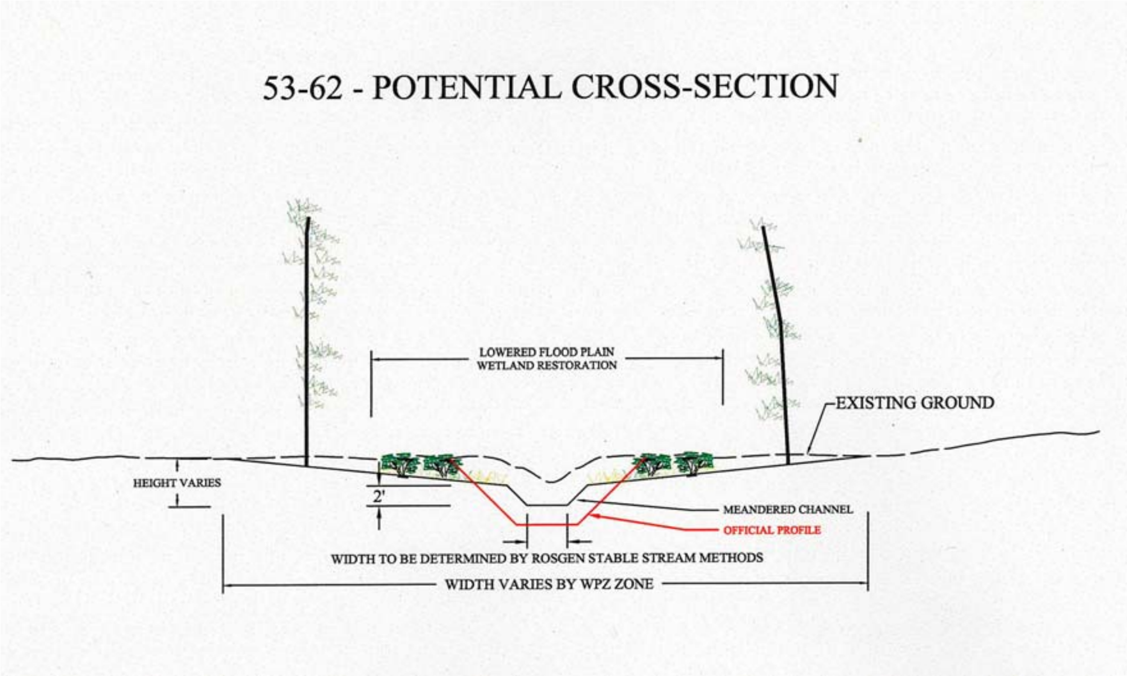
Scale of Wetland Wetness



This scale of wetland wetness is the working model for developing the concept plans and ultimately final design to compute actual hydrologic storage capacity. In general many of the existing wetlands have been impacted by drainage. One goal of the RMP is to restore those wetlands to a more natural hydrologic regime. There are several context-sensitive parameters to be incorporated into the restoration design and monitoring/adaptive management. These are:

- The watershed drainage area characteristics in an urbanizing landscape. There has to be a threshold below which the wetland system can ‘multi-function’ and not become a stormwater system. Crossing the threshold might trigger deterioration into a stormwater conveyance system; this is being addressed by means of the RMP Rule through infiltration practices in the watershed. Monitoring and adaptive management of redesigned channels/restored wetlands would be needed where watershed land use changes are occurring.
- The desired hydrologic regime of the wetland system. It is a given that the wetland system is predominantly driven by flow-through surface water and ground water, with seasonal fluctuation in both; within this prevailing hydrologic landscape, channel repair is intended to establish hydrologic diversity ranging from saturated to semi-permanently flooded. Monitoring and adaptive management would be used to assess the accuracy of the design parameters in reaching the goal and rectify significant variations. A range of acceptable range of hydrologic variability would be established and monitoring/management would be geared to maintaining within the range.
- Flood elevation limits based upon buildings in the surrounding drainage area; proposed wetland water level elevations will be restricted by flood elevations that will cause damage to buildings on adjacent uplands.
- Wetland complexity and diversity of hydrologic regimes in each management area. Multiple wetland types and regimes and microsite diversity will need to be surveyed for final design; monitoring/adaptive management will be used to evaluate increases or decreases in diversity and maintain hydrologic/biologic diversity.

Channel repair under the RMP is generally described as reconstruction to a ‘stable stream’ configuration. In some areas this will include shallow wetland excavation to create a widened plain for channel migration and wetter wetland hydrologic regime. The typical configuration for this stable stream is illustrated below. Channel repair under the full repair scenario would restore the ditch to its officially adopted profile. The full repair is based on historic ditch records, whereas the stable stream configuration is based on the flow conditions that occur, providing adequate conveyance and less maintenance due to appropriate sizing.



INDIVIDUAL MANAGEMENT AREA CONCEPT PLANS

Management area locations are shown in Figure 10, and the management area activities are summarized in Table 18. Following this, data on each management area are given. Also provided for each area are the results of hydrologic modeling showing ditch water elevations under the alternative scenarios. By using the H&H modeling, predictions have been made as to the potential hydrologic storage capacity that can be restored in each area.

In summary the basis of each concept plan was based on the following data:

- 2-foot contour and sometimes 1-foot spot elevations of wetland surfaces
- Ditch water elevations derived from models under existing and repair alternatives conditions (summarized in *H&H Results for each management area*)
- Extent of drainage predicted by lateral effect model (indicator of drainage which may have occurred historically) – shown in individual management area maps
- Wetland classification
- Wetland functions
- Scale of degradation of partially drained wetlands

For proposed excavation in wetlands as a result of channel reconstruction, the mitigation replacement is proposed as hydrologic restoration of partially drained wetland. Table 18 provides the wetland management area size and thus area to be investigated for estimating area of partially drained and degraded wetland. It is assumed that existing Type 2 wetlands with ditches are partially drained. The results of this investigation will be the basis for establishing the restoration credit. Guidance documents found in Appendix N for determining drainage extent and degradation will be followed.

Table 18: Implementation Priority and Channel Reconstruction/Hydrologic Restoration Strategy for Each Management Area

Area	Current Priority	Proposed Activities (includes excavation in wetland for ditch reconstruction)	Wetland Replacement Needed for Excavation in Wetlands During Channel Reconstruction	Wetland Management Area Size (acres)	Hydrologic Restoration Credit Area (to be determined in permitting)
MB.A (V.M.)	High	Creation of flow-through wetland to provide water quality improvement for entire drainage area.	yes	65	
MB.B (V.M.)	Medium	Limited excavation to create flow-through wetland connection	yes	44	
MB.C (V.M.)	High	Creation of flow-through wetland to provide water quality improvement for branches 1, 2 and 5.	yes	69	
B1.A	Medium	Creation of 2-stage channel	yes	105	
B1.B	High	Creation of flow-through wetland and control structure upstream of Hupp Street.	yes	170	
B1.C	Medium	Construction of 2-stage channel. Limited creation of flow through wetlands.	yes	102	
B1.D	Low	Limited channel modification to create flow through wetlands.		18	
B1.E	Low	No ditch modifications, wetland preservation.		98	
B1.F	Low	No ditch modifications, wetland preservation		68	
B1.G	Low	No ditch modifications, existing wetland mitigation site.		13	
B2.A	High	Creation of flow-through wetlands and control structure upstream of Austin Court.	yes	400	
B2.B	Medium	Construction of 2-stage channel	yes	89	
B5.A	High	Creation of flow-through	yes		

		wetland will provide water quality treatment for branches 1, 2 and 5. Construction of weir between B5.A and MB.C.		107	
B5.B	Low	No ditch modifications, wetland preservation		160	
B5.C	High	Wetland preservation. Control structure and possible culvert construction needed to route flows north under 109th Avenue.		49	
B5.D	High	Creation of flow-through wetland will provide water quality improvement for branch 5. Storm flows routed to B5.C then north under 109th Avenue.	yes	55	
B5.E	Medium	Creation of 2-stage channel	yes	36	
B5.F	Low	No ditch modifications, wetland preservation		166	
B6.A	Medium	Creation of 2-stage channel	yes	35	
B6.B	Low	No ditch modifications, wetland preservation		13	
B6.C	Low	No ditch modifications, wetland preservation		119	

Ditch Water Level Elevations Guide Restoration Design

In each of the following concept plans, the existing and future condition ditch water levels were used to determine the extent of unused hydrologic capacity of each wetland management area, in so far as the ditch contribution is concerned. These elevations are the result of hydrologic modeling. Existing means the water elevation in the ditch as exists today. The other three scenarios (Feasible Repair, No Action, RMP) represent future watershed development conditions and any proposed changes in the ditch. Hydrologic models prepared in the past include the 100-yr WSB (the entity preparing the model) and 100-yr snow. The 100-yr EOR was recently used with more refined model data. These 100-yr models represent bigger storms. The 1-yr 8-day average represents the smaller storms that would tend to occur more commonly throughout the rain season. When the ditch water elevation less than the range of adjacent wetland elevations then it is expected that after storms the water is confined to the ditch and does not spill onto the wetland surface. This means there may be unused hydrologic capacity for that wetland, in so far as the ditch channel is removing water and bank overflows are not contributing to the wetland. The RMP ditch elevations reflect the RMP hydrologic model using the watershed standards given in the RMP Rule for infiltration.

To refine the concept plans, new data will needed to be collected. This may include ditch bank elevations at additional locations along the channel, spot elevations of various wetland microsite locations and/or 0.5-foot wetland contours, and investigation of nonditch hydrologic contributions (adjacent upland runoff, groundwater).

Branch 1
B1.A- Branch 1, Zone A

Location: East of Lexington Avenue. West Section 13.

H&H Results Showing Ditch Water Elevation (in feet)

	Existing	Feasible Repair	No Action	RMP
	HWL	HWL	HWL	HWL
100-yr WSB*	897.0	-	897.0	-
100-yr Snow WSB*	897.2	-	-	-
100-yr EOR*	896.8	897.0	-	-
1-yr 8-day average*	895.7	893.7	-	-

*Does not include area south of 111th Avenue

Existing wetland elevations within this zone range from 898 to 896. An area within the WPZ to the south is presumably under no ditch influence. The wetland in the vicinity of the ditch is receiving occasional flood water (100-yr storms) but not water from common, 1-yr storms. Additional sources beyond ditch overflows are assumed to be contributing to and maintaining the wetter wetland types in this area. Permit-level field investigations will be needed to further assess wetland hydrology, types, and boundaries.

DNR-protected wetlands exist within this zone. Hydrologic manipulation from existing conditions or excavation is not proposed. The ditch section through this zone will be redesigned to a two-stage natural channel or stable stream. This zone will also include vegetative management and preservation.

B1.B- Branch 1, Zone B

Location: East of Hupp Street. South Section 12, North Section 13.

H&H Results Showing Ditch Water Elevation (in feet)

	Existing	Feasible Repair	No Action	RMP
	HWL	HWL	HWL	HWL
100-yr WSB	897.6	-	897.7	-
100-yr Snow WSB	898.2	-	-	-
100-yr EOR	897.3	897.2	-	-
1-yr 8-day average	893.7	895.7	-	895.7-897.7

Existing wetland elevations within this zone range from 898 to 897. Currently the wetland may receive some spring flooding and 100-yr floods from the ditch. Only the more common 1-yr storm model was run under the RMP conditions. In this case the wetland may receive ditch water overflows. The RMP 100-yr flood also would be expected to provide flood water to much of the wetland. Based upon the RMP modeling, the expected shallow marsh elevation is a range of 895.5-897.5. The existing wetland types and hydrologic regime are wetter than might be expected from receiving bank overflow water only. Additional hydrologic sources are likely contributing. Future investigations are warranted before proceeding with final design.

At this point an outlet structure is proposed upstream of Hupp Street to increase hydrologic storage of the entire zone, shifting the area to a wetter regime. More detailed information will be needed before implementation.

Excavation of low quality wetlands may be used to create a flow-through wetland system along the ditch alignment. The flow-through wetland will consist of heavily vegetated emergent species and limited open water. This zone will include vegetative management and preservation. Preservation of wooded fringe wetlands and adjacent uplands will be important in this zone.

B1.C- Branch 1, Zone C

Location: South of Main Street. North Section 12

H&H Results Showing Ditch Water Elevation (in feet)

	Existing	Feasible Repair	No Action	RMP
	HWL	HWL	HWL	HWL
100-yr WSB	897.6	-	897.7	-
100-yr Snow WSB	898.4	-	-	-
100-yr EOR	897.7	897.6	-	
1-yr 8-day average	894.0	897.0	-	897.0-897.7

Existing wetland elevations within this zone range from 898 to 897. Under existing conditions the ditch may provide some water to the wetland under 100-yr flooding. It appears that the ditch is providing partial drainage and there is unused hydrologic capacity. Under RMP conditions the common storms would be expected to flood this wetland. It is presumed that larger storms would definitely flood into this area. The shallow marsh type of hydrology (C modifier) would be expected at 897-897.5 feet based upon the RMP model. This would suggest that future wetland type would shift to a wetter regime.

Limited excavation of low quality wetlands will create a diversity of wetland habitat throughout this zone. The ditch will be redesigned to a stable stream configuration. The hydrology of the zone will be controlled by the structure upstream of Hupp Street to regulate hydrologic storage capacity and thus wetland hydrologic regime. These strategies will not impact the large mitigation site located in the northeast corner of the zone. This zone will include vegetative management and preservation. Preservation of wooded fringe wetlands and adjacent uplands will be important in this zone.

B1.D- Branch 1, Zone D

Location: North of Main Street. South Section 1

H&H Results Showing Ditch Water Elevation (in feet)

	Existing	Feasible Repair	No Action	RMP
	HWL	HWL	HWL	HWL
100-yr WSB	898.7	-	898.7	-
100-yr Snow WSB	899.4	-	-	-
100-yr EOR	898.6	898.2	-	
1-yr 8-day average	898.0	894.3	-	898

Existing wetland elevations within this small area are about 897. Thus, the wetland should be receiving flood water from both the common and larger storms, as well as spring flooding. Since the wetland hydrologic regime is on the drier side of the scale, the wetland may be quite dependent on this occasional overbank flooding. The RMP modeling suggests that a shallow marsh hydrology will form at elevation 897-897.5 feet.

Limited excavation and a slight modification to the existing ditch is currently proposed for this area. The culvert at Main Street does not need to be improved. This zone will include vegetative management and preservation.

B1.E- Branch 1, Zone E

Location: West of Lever Street. South Section 1

H&H Results Showing Ditch Water Elevation (in feet)

	Existing	Feasible Repair	No Action	RMP
	HWL	HWL	HWL	HWL
100-yr WSB	899.1	-	899.1	-
100-yr Snow WSB	899.6	-	-	-
100-yr EOR	898.6	898.2	-	-
1-yr 8-day average	898.0	894.3	-	898

Existing wetland elevations within this zone are between 899-898. The existing conditions models indicate this area receives spring snowmelt from ditch overflow, as well as overflows from more common storms. The RMP conditions would not change this. The existing wetland typing/hydrologic regime is consistent with the modeling. The RMP model indicates that shallow marsh hydrology (C modifier) is at 897-897.5 feet which is consistent with the mapping of a B modifier hydrologic regime. This wetland is apparently drier than might be expected without the ditch.

High quality wetlands exist within this zone and will be protected. Although there is potential storage, hydrologic manipulations to the wetlands are not proposed nor are ditch modifications. This zone will include vegetative management and preservation.

BRANCH 1, LATERAL 1

B1.F- Branch 1, Zone F

Location: North of 109th Avenue. Center Section 13

H&H Results Showing Ditch Water Elevation (in feet)

	Existing	Feasible Repair	No Action	RMP
	HWL	HWL	HWL	HWL
100-yr WSB*	898.3	-	898.4	-
100-yr Snow WSB*	898.5	-	-	-
100-yr EOR*	898.5	898.1	-	-
1-yr 8-day average*	897.5	895.5	-	897.5

*Not applicable to the area north of Lochness Lake Outlet

Existing wetland elevations within this relatively narrow zone are between 898-897. The model for smaller storms (1-yr) predicts that ditch overflow is expected under RMP conditions. The shallow marsh hydrologic regime under RMP conditions is expected at 897 feet. This is somewhat consistent with the wetter hydrologic regime of mapped wetlands. Additional sources may be contributing to hydrology. Under RMP conditions the hydrologic regime is expected to stay the same, with limited flooding under common storm events.

Many DNR-protected waters exist within this zone and will be protected. The temporary/less wet hydrologic regime of fringe wooded wetlands is anticipated to stay the same (at least from the perspective of hydrologic contributions from the ditch channel). Hydrologic manipulations to the wetlands are not proposed nor are ditch modifications. Loch Ness Lake is located within this zone. This zone will include vegetative management and preservation.

B1.G- Branch 1, Zone G

Location: South of 109th Avenue. North Section 24
Map not provided.

H&H Results Showing Ditch Water Elevation (in feet)

	Existing	Feasible Repair	No Action	RMP
	HWL	HWL	HWL	HWL
100-yr WSB	898.9	-	899.1	-
100-yr Snow WSB	898.9	-	-	-
100-yr EOR	899.5	899.2	-	-
1-yr 8-day average	898.7	896.2	-	-

This zone consists almost entirely of a mitigation site. No ditch or hydrologic modifications are proposed. Vegetation management will be included.

BRANCH 2 AND 3

B2.A- Branch 2, Zone A

Location: West of Lexington Avenue. South Section 11, North Section 14.

H&H Results Showing Ditch Water Elevation (in feet)

	Existing	Feasible Repair	No Action	RMP
	HWL	HWL	HWL	HWL
100-yr WSB	896.9	-	897.0	-
100-yr Snow WSB	897.1	-	-	-
100-yr EOR	896.8	896.7	-	-
1-yr 8-day average	895.1	893.4	-	896.5

Existing wetland elevations within this zone range from 897 to 896. This means that under existing conditions the ditch is not overflowing during common storms, is partially draining the wetland, and there is unused hydrologic capacity. Under the RMP scenario the ditch is expected to overflow to the wetland for the common storm events, and thus presumably larger events, with an expectation that wetland hydrology will become 'wetter'. The shallow marsh, C modifier hydrology is predicted to be at 895 feet under RMP conditions, a foot below the wetland surface. The existing wetland is mapped with a C modifier for hydrology. This suggests hydrologic sources other than the ditch are maintaining this wetland hydrology. More detailed information will be needed before implementation.

Preservation of wooded fringe wetlands and adjacent uplands will be important in this zone. Excavation of low quality wetlands will create a flow-through wetland system along the ditch alignment. The flow-through wetland will consist of heavily vegetated emergent species and limited open water. All intact ditch sections will be redesigned to a stable stream configuration. An outlet structure will be constructed upstream of Austin Court to regulate hydrology and storage in the entire zone. This zone will include vegetative management and preservation.

Branch 2, Peebles and Devine Lateral
B2.B- Branch 2, Zone B

Location: South of Main Street. North Section 11

H&H Results Showing Ditch Water Elevation (in feet)

	Existing	Feasible Repair	No Action	RMP
	HWL	HWL	HWL	HWL
100-yr WSB	896.9	-	897.0	-
100-yr Snow WSB	897.1	-	-	-
100-yr EOR	896.8	896.7	-	-
1-yr 8-day average	895.1	893.4	-	896.5

Existing wetland elevations within this zone range from 899 to 897. This wetland is not predicted to receive flood waters from the ditch under the existing conditions. Under RMP conditions ditch bank overflows are still not expected to contribute under smaller storms, and C modifier hydrology would be expected at an elevation of 895 feet. According the existing wetland mapping the hydrology of this wetland is in part already a C modifier (part of it is a B modifier). This suggests additional field data is needed for the models, or that additional sources contribute to the wetland. At this point the ditch is proposed to be redesigned to a stable stream configuration and provide additional hydrologic storage that may now be lacking in at least part of this wetland.

Limited excavation of low quality wetlands will create a diversity of wetland habitat throughout this zone. Preservation of wooded fringe wetlands and adjacent uplands will be important in this zone. This zone will include vegetative management and preservation.

BRANCH 5, LATERAL 1

B5.B- Branch 5, Zone B

Location: North of 109th Avenue. Southeast Section 15.

H&H Results Showing Ditch Water Elevation (in feet)

	Existing	Feasible Repair	No Action	RMP
	HWL	HWL	HWL	HWL
100-yr WSB	896.8	-	896.9	-
100-yr Snow WSB	896.9	-	-	-
100-yr EOR	-	-	-	-
1-yr 8-day average	-	-	-	-

Existing wetland elevations within this zone range from 897 to 895. Wetlands are general of a C modifier hydrology. No hydrologic manipulations, excavation or ditch modifications are proposed for this zone, and thus no future conditions modeling was performed. Flow from this zone will be routed to B5.A.

DNR protected and high quality wetlands exist within this zone. This zone will include vegetative management and preservation of wetlands and adjacent uplands.

B5.E- Branch 5, Zone E

Location: North of Radisson Road. South Section 22

H&H Results Showing Ditch Water Elevation (in feet) *

	Existing	Feasible Repair	No Action	RMP
	HWL	HWL	HWL	HWL
100-yr WSB	904.2	-	904.2	-
100-yr Snow WSB	904.1	-	-	-
100-yr EOR	901.0	901.1	-	-
1-yr 8-day average	900.4	896.3	-	-

* Water levels vary based on position along ditch.

Existing wetland elevations within this zone range from 903 to 901. It would appear that a source other than the ditch is contributing hydrology to maintain the C and F modifier wetland hydrology.

A DNR-protected wetland is within this zone and no hydrologic modifications are proposed. The ditch will be redesigned to a stable stream configuration. This zone will include vegetative management and preservation. Preservation of wooded fringe wetlands and adjacent uplands will be important in this zone.

BRANCH 5, LATERAL 2 PRIVATE

B5.F- Branch 5, Zone F

Location: South of Radisson Road. Northwest Section 27

H&H Results Showing Ditch Water Elevation (in feet)

	Existing	Feasible Repair	No Action	RMP
	HWL	HWL	HWL	HWL
100-yr WSB	904.3	-	904.3	-
100-yr Snow WSB	904.6	-	-	-
100-yr EOR	902.7	902.0	-	-
1-yr 8-day average	901.9	897.5	-	-

Existing wetland elevations within this diverse and complex area range from 905 to 902. Ditch bank overflow is expected under larger storm for existing conditions, but based upon the kinds of existing wetland hydrology, it is likely that other sources contribute. The ditch likely has no influence on a large part of this area. No modifications to the private ditch are proposed.

DNR protected wetlands are found throughout this zone as well as high quality plant communities. This zone will include vegetative management and preservation. Preservation of wooded fringe wetlands and adjacent uplands will be important in this zone.

BRANCH 6, LATERAL 1 PRIVATE

B6.B- Branch 6, Zone B

Location: West of Naples Street. Southeast Section 21

H&H Results Showing Ditch Water Elevation (in feet)

	Existing	Feasible Repair	No Action	RMP
	HWL	HWL	HWL	HWL
100-yr WSB	903.3	-	903.3	-
100-yr Snow WSB	903.7	-	-	-
100-yr EOR	-	-	-	-
1-yr 8-day average	-	-	-	-

Existing wetland elevations within this zone range from 902 to 901. Ditch overflow may be providing a fair amount of the hydrology to maintain the shallow marsh wetland conditions. No recent modeling was performed. No modifications to the private ditch are proposed.

B6.C- Branch 6, Zone C

Location: South of 101st Avenue. Northeast Section 27

H&H Results Showing Ditch Water Elevation (in feet)

	Existing	Feasible Repair	No Action	RMP
	HWL	HWL	HWL	HWL
100-yr WSB	904.9	-	905.0	-
100-yr Snow WSB	905.0	-	-	-
100-yr EOR	-	-	-	-
1-yr 8-day average	-	-	-	-

Existing wetland elevations within this zone range from 905 to 902. Most of this area is presumed to be under no ditch influence. No modifications to the private ditch are proposed.

DNR-protected wetlands are found throughout this zone as well as many high quality wetland plant communities. This zone will include vegetative management and preservation. Preservation of wooded fringe wetlands and adjacent uplands will be important in this zone.

Appendix D. Golden Lake Watershed Hydrology

Golden Lake Watershed Hydrology

A. Unique Watershed Hydrology

The hydrology of the current Golden Lake drainage area is very unique. From its highly pervious upland soils to its extensive partially drained wetlands and level topography, this drainage area has an incredible capacity to retain and evapotranspire higher volumes of precipitation compared to other drainage areas in the region. Additionally, a major portion of the current drainage area to Golden Lake was not historically connected prior to ditching. Each of the factors discussed below contributes to the low surface water runoff produced by this drainage area.

Topography

With the recession of the last glaciations from Central Minnesota, several distinct landforms appeared. Each one is distinguished by the kind of glacial material left behind, such as silts, sands, and gravel, coupled with the topographic pattern of lakes, rivers, and wetlands. The Anoka Sand Plain is one of the distinct landforms of Central Minnesota. The glacial sand coupled with minimal change in elevation are distinguishing features of the Anoka Sand Plain. These features are responsible for the highly interspersed pattern of terrestrial, aquatic, and wetland habitats found here.

The sand ridge located along the current alignment of Interstate 35W provides topographic separation between the level wetlands to the north and the Rice Creek Chain of Lakes (see Figures 1 and 2 in the body of the TMDL report). A gentle slope extends southward from I-35W to the chain of lakes. The direct drainage area to Golden Lake is level to gently sloping.

Soils

There are two soil associations within the current Golden Lake drainage area. Approximately 80 percent of the area is composed of the Rifle-Isanti Association. The remaining 20 percent is part of the Zimmerman-Isanti-Lino Association.

The Rifle-Isanti Association is nearly level in topography, and has very poor drainage. It is composed chiefly of organic material (muck, mucky peat), with some fine sand intermingled. Organic bogs with small sandy island features are common in this association. The natural water table is very high, usually between 0 and 2 feet from the surface. The Rifle-Isanti Association is poorly suited for urban and agricultural uses. These conditions are conducive to high rates of evapotranspiration.

The Zimmerman-Isanti-Lino Association is mainly found in the broad undulating glacial sand deposits. It is dominated by fine sands about 2 to 6 inches thick. The water table is high, usually between 2 to 6 feet from the surface. Much of this association is better suited for urban, agricultural, or recreational uses, unless the water table limits such uses. These conditions are conducive to high rates of stormwater infiltration.

Groundwater Connections

A groundwater assessment (Appendix A) was conducted as part of the TMDL study. Lake elevations relative to groundwater elevations, the surrounding surficial geology, and surface water inflow and outflow were evaluated to determine Golden Lake's dependence on groundwater. This analysis suggests that Golden Lake recharges the local water table due to its elevation relative to the water table and the surficial geology of the region. This result supports the 1982 hydrologic budget for Golden Lake, in which approximately 25% of the total inflow from Golden Lake leaves as groundwater input to the local water table (Circle Pines 1982).

Wetlands

Much of the current Golden Lake drainage area was wetland prior to drainage activities. The original marsh land survey is shown in Figure 1. The following description of the township is taken from original land survey notes written by Andrew J. Hewitt, Deputy Surveyor in 1847. Mr. Hewitt described the township as follows:

> This township presents a surface almost level to the eye of the beholder. It is one dense marsh, interspersed at intervals with numerous islands; small lakes or ponds and tamarack swamps. The islands vary in size, from one to ten acres and most of them covered with thick brush and timber of various kinds. The water in the lakes or ponds is generally clear and cold and most of them have fish in them of various kinds. The margins of them are generally marshy and springy. This township is almost inaccessible either for man or beast excepting when frozen up. A small portion of the northern portion of this township is barrens, covered with short thin grasses and scattering near by Jack-oak trees. The soil on the bare site is light, loose sand 3rd rate.

Because of the extensive drainage network, the characteristics of these wetlands has changed. For example, the extensive wetland system in sections 14 and 23 (location of current 109th Avenue) was described by Hewitt as a "Level floating Marsh." Currently this area for the most part can be described as a shrub/grassland with a scattering of small seasonal wetland basins. The soils consist of well-drained peats/mucks over sand. The drainage network has removed water from the surface of the presettlement wetlands and created additional water storage capacity within the soil column.

Wetland monitoring data confirm the seasonal fluctuations in the water table. During the spring, under wet conditions, water elevations in the ditch and adjacent wetlands are generally at or near the surface. As evapotranspiration begins during the growing season, the majority of the wetland areas have water table elevations many feet below the surface. This allows for storage of precipitation in the upper surface (rooted) portion of the soil column and subsequent evapotranspiration. Examples of the seasonal fluctuation in wetland water elevations can be seen in the multitude of shallow well data collected throughout the drainage area.

Evapotranspiration and groundwater recharge together represent a large portion of the hydrologic budget of the Golden Lake watershed. The simplified water budget schematic presented in

Figure 2 was developed using precipitation and monitoring data along with recent literature values related to evapotranspiration.

B. Land Use

The information provided above describes presettlement and recent land use. The most significant change made to the Golden Lake drainage area occurred when a previously isolated area was hydrologically connected by ditches. The incremental progression of ditch construction increased the geographic extent of Golden Lake's watershed.

The first ditches constructed in the current Golden Lake drainage area were built in 1890 and included County Ditch 9 and 10. County 9 was entirely within the current City of Blaine and was designed to route water north. Figure 1 illustrates County 9 and 10.

In 1894 County Ditch 22 and 24 were constructed. County 24, also known as the Elwell Ditch, routed flows from County 9 south to Golden Lake. This was the first attempt to drain the property north of 35W to Golden Lake. Figure 3 illustrates County 22 and 24.

In 1898 County Ditch 32 was built. This was a very extensive ditch system that routed a majority of the current Golden Lake drainage area into Lino Lakes and eventually to Marshan Lake. Figure 4 illustrates County 32.

County Ditch 53 was constructed in 1911. County 53 added many new branches to the existing 32 system and changed the flow direction for much of the drainage area back towards Golden Lake rather than through Lino Lakes. County Ditch 62 built in 1917 included minor modifications to County 53. From 1917 to the present, the ditch has been referred to as Anoka County Ditch 53-62 and outlets in Golden Lake. Figure 5 and Figure 6 illustrate the current configuration of Ditch 53-62 and its current watershed.

Aerial photographs reviewed showed much of the area currently draining to Golden Lake being used for hay production. More recently, the watershed is becoming more and more urbanized. First to develop were the obvious upland areas within the "sand islands" as they have been described. As land values increase and drainage becomes more effective, some of the areas formerly used for hay production are being developed.

C. Precipitation

The 2004 annual runoff volume estimate was lower than the estimates from previous studies (Circle Pines 1982); this is likely due to differences in climate patterns. Both years (1982 and 2004) had total precipitation depths and winter (December through April) precipitation depths close to the long term average (Figure 7 through Figure 10). This analysis is based on precipitation data from the Minnesota Climatology Working Group (data retrieval of T31 R23 S 23). Although the total amounts of precipitation were approximately average, the patterns of snow accumulation and snowmelt runoff were drastically different. In 1982 approximately 10 inches of snow remained on the ground at the end of March, and this all melted within a relatively short period in the spring (Figure 11). In contrast, in 2004 the snow melted more gradually over the course of the winter months, and it had all melted by the end of February (Figure 12). The pattern of small snowmelt events throughout the winter leads to less overall volume of runoff over the course of the season, due to greater amounts of evaporation as the snow melts in smaller quantities. The pattern seen in 2004 is more representative of climate patterns in recent years, with several snowmelt periods distributed throughout the winter.

Average streamflow data from recent years suggest that the 2004 runoff values were not substantially lower than other years (Table 1). Although the average streamflow in 2004 was lower than the other monitored years, all of the annual averages measured since 1999 are much lower than the average flow in 1982 and the flow in 1997, which was a year of high precipitation. These data validate the low runoff values observed in 2004.

Table 1. ACD 53-62 Average Daily Streamflow, April 11-Sept 3

Year	Average Daily Streamflow (cfs)
1982	4.2
1997	6.0
1999	1.4
2001	2.5
2002	1.9
2004	1.0

Phosphorus export rates in 1982 were approximately 0.2 lbs/ac-yr, which are low to normal rates considering the land use in the Golden Lake watershed. These rates occurred during a year of relatively high runoff volumes. The low export rate of 0.03 lbs/ac-yr observed in 2004 is therefore consistent, in that 2004 was a year of relatively average runoff rates.

D. Phosphorus Loading

The average TP concentration in ACD 53-62 has decreased since 1982 (Figure 13). Two different sites have been monitored off and on: 1) S003-026 (RCWD ID OWS11A), which is upstream of the water quality pond that treats incoming flows into Golden Lake, and 2) S003-056 (RCWD ID OWS11B), which is downstream of the water quality pond. The upstream site was monitored in 1982 and the downstream site was monitored in 2004, so the data are not directly comparable. However, the upstream site was monitored again in 2007, and those data show that the TP concentration has decreased substantially since 1982. TP concentrations at the downstream site were similar in 2004 and 2007.

This decrease in phosphorus concentration over time in the Golden Lake inlet explains a portion of the difference between the 1982 estimated watershed load to the lake and the 2004 estimate.

The average annual total phosphorus concentration in Golden Lake correlates strongly with annual precipitation (see Figure 4 in the TMDL report). Since the watershed load represents 40% of the total load to the lake, this correlation is understandable due to the substantial influence that the watershed load (driven by precipitation) has on the in-lake water quality. Additionally, since internal loading is expected to be fairly constant from year to year, external loading dominates the annual variability in loading, which in turn influences the annual variability in the in-lake water quality.

E. FIGURES

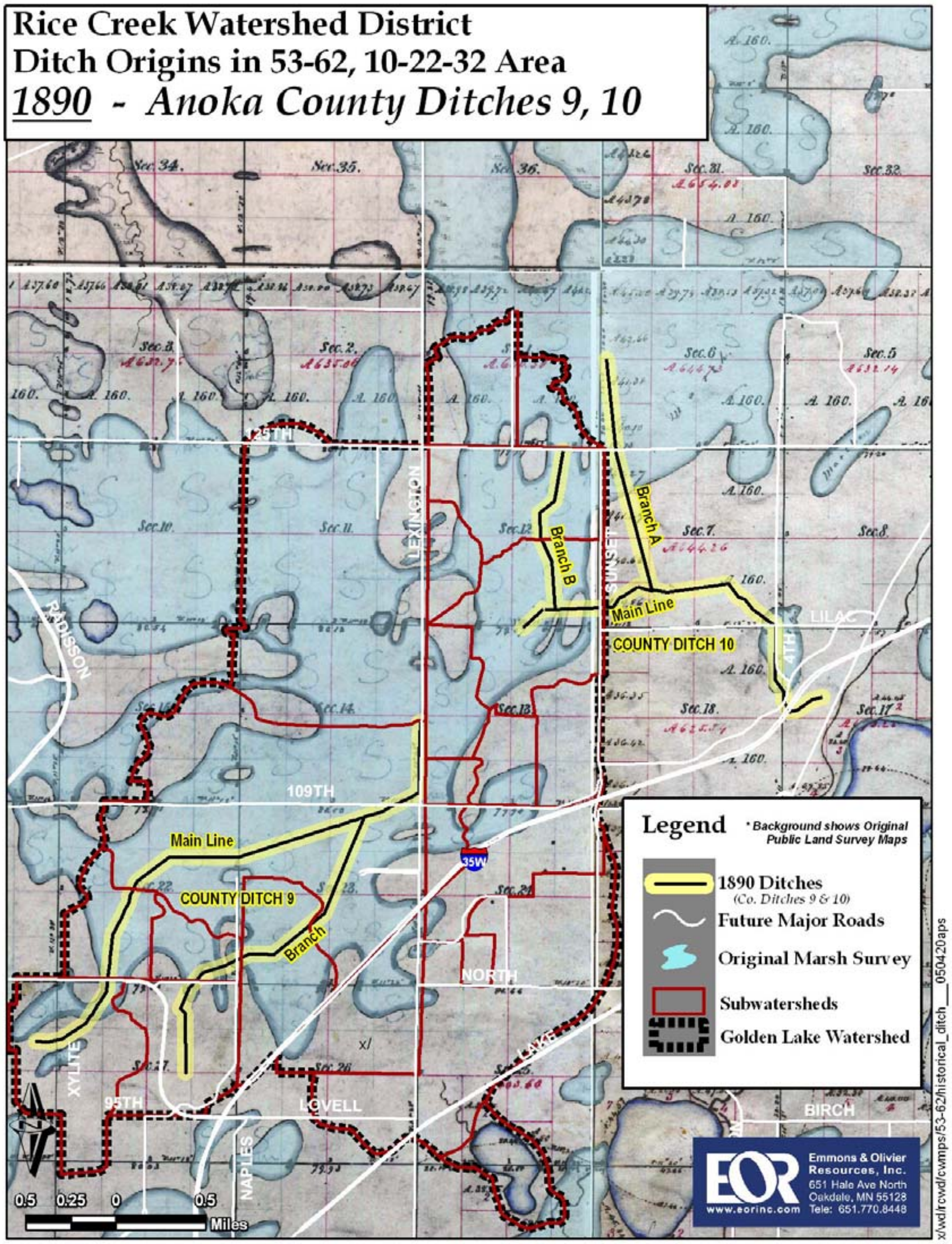


Figure 1. 1847 Original Survey and 1890 Ditch Construction

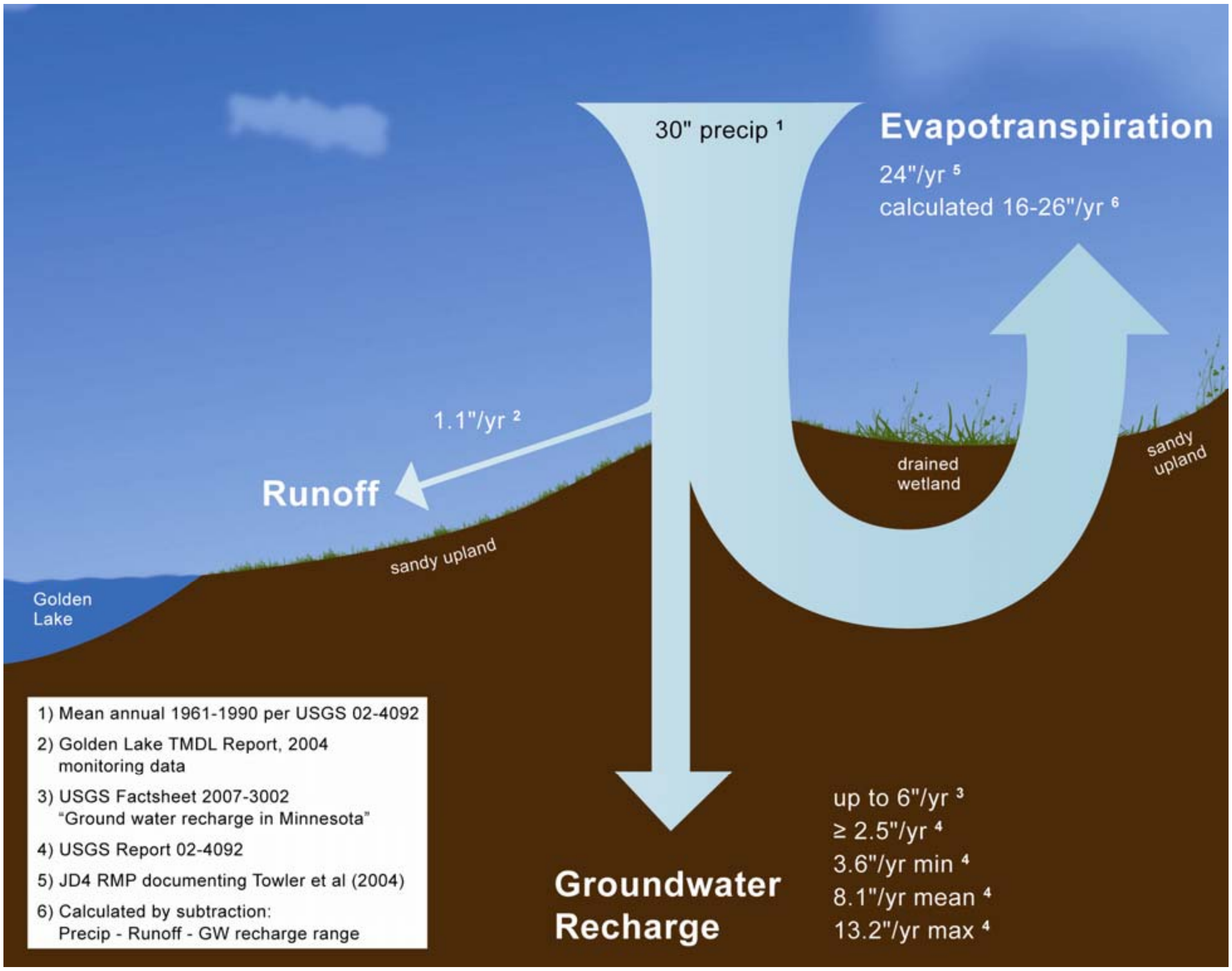


Figure 2. Golden Lake Watershed Water Budget

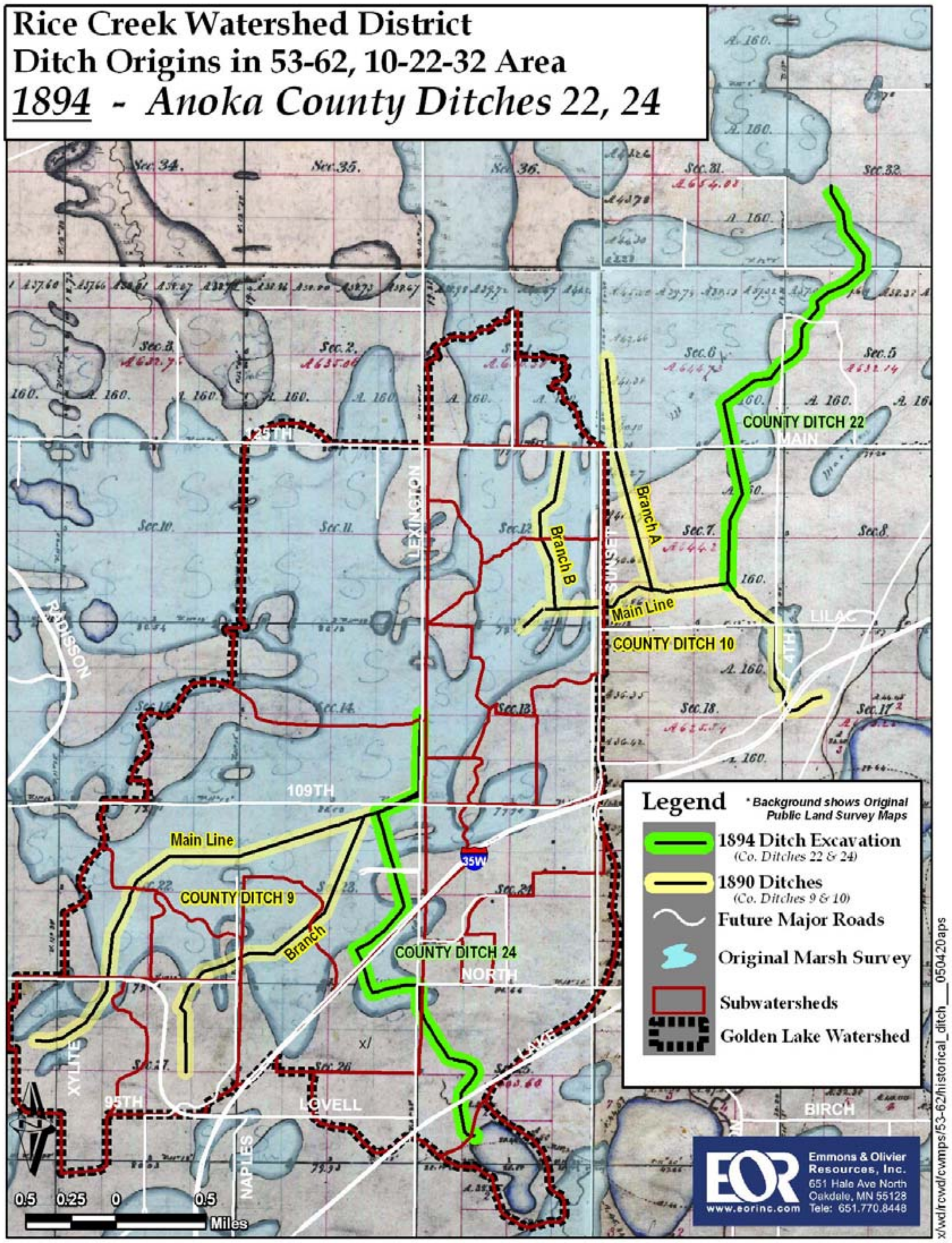


Figure 3. 1894 Ditch Construction

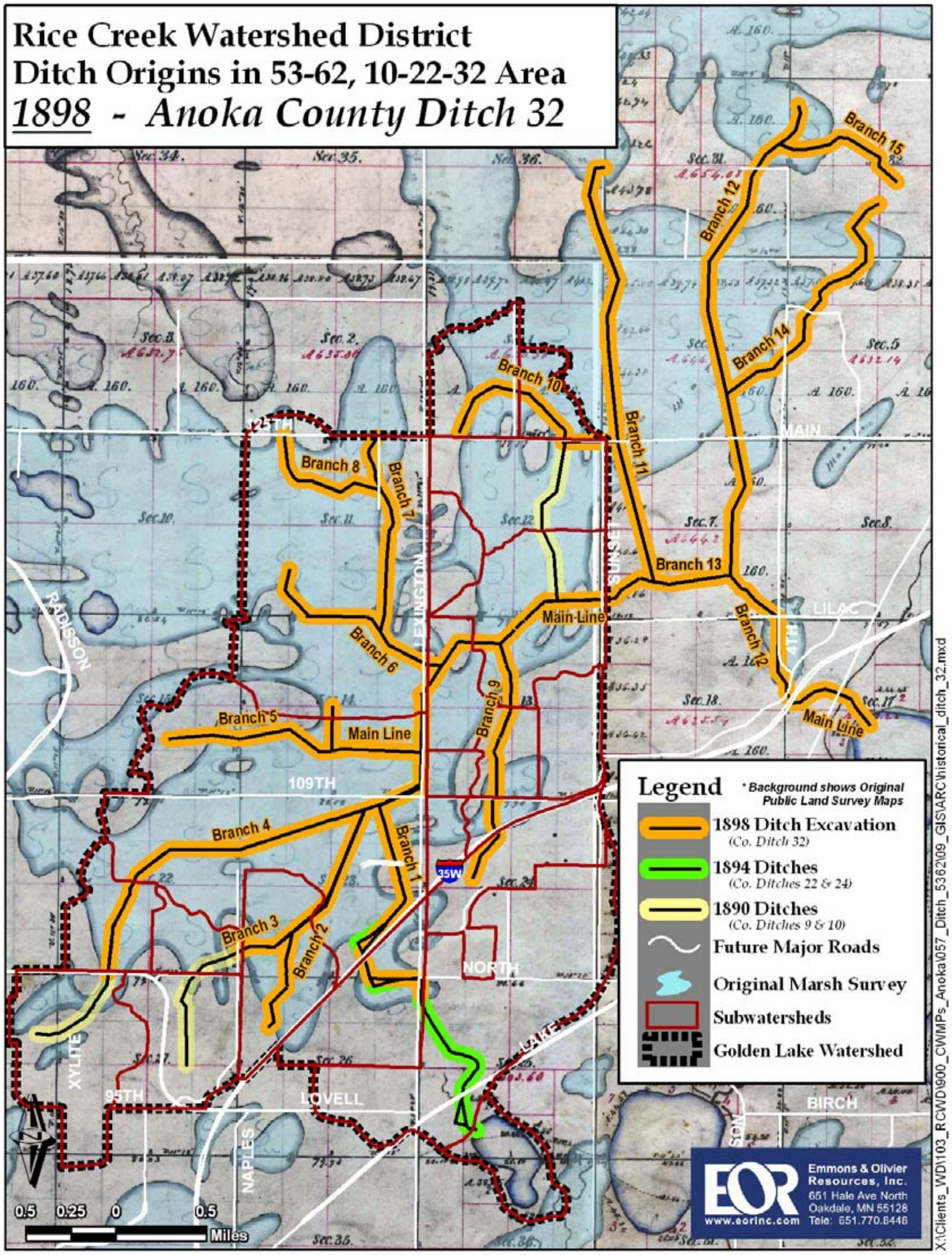


Figure 4. 1898 Ditch Construction

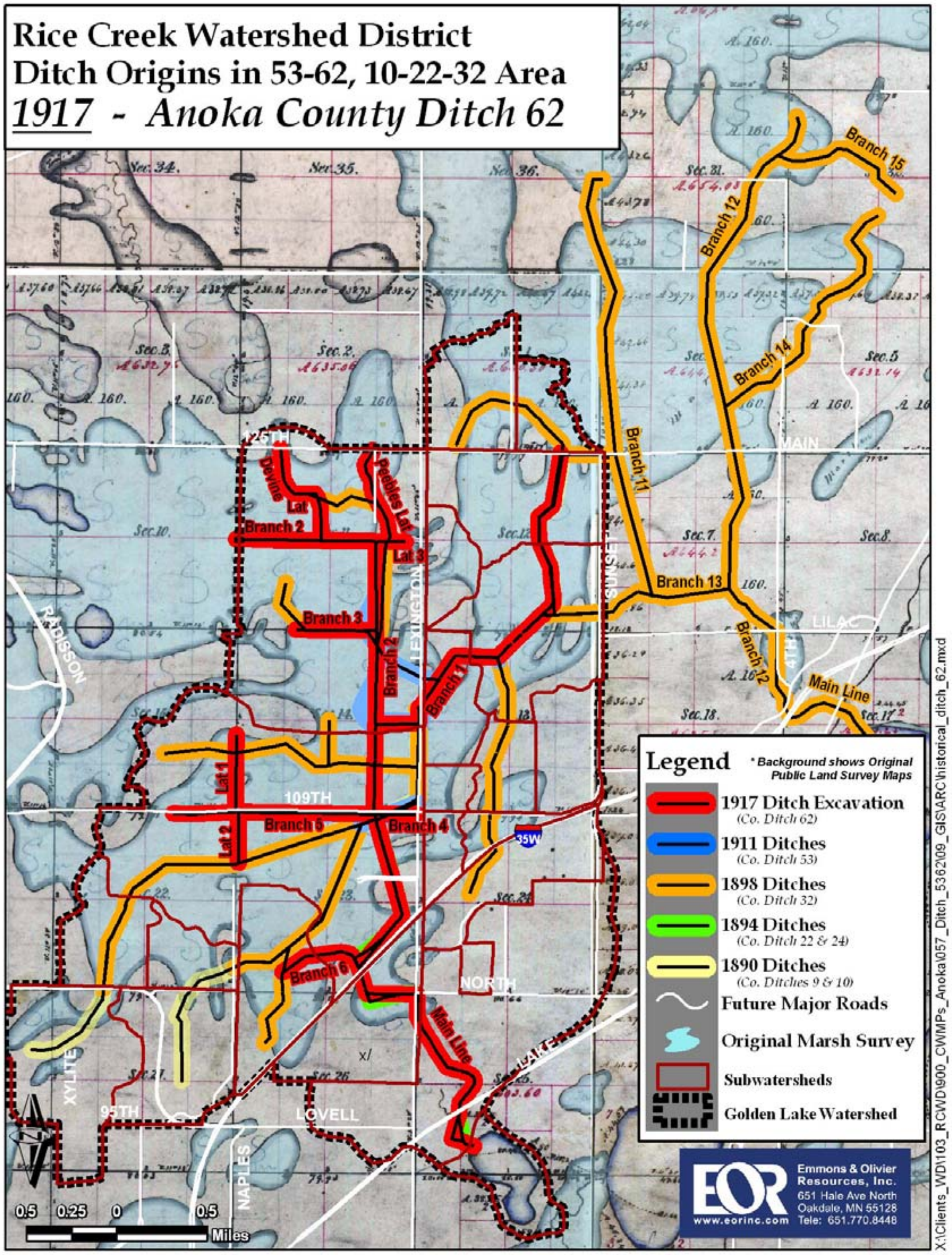


Figure 5. 1917 Ditch Construction

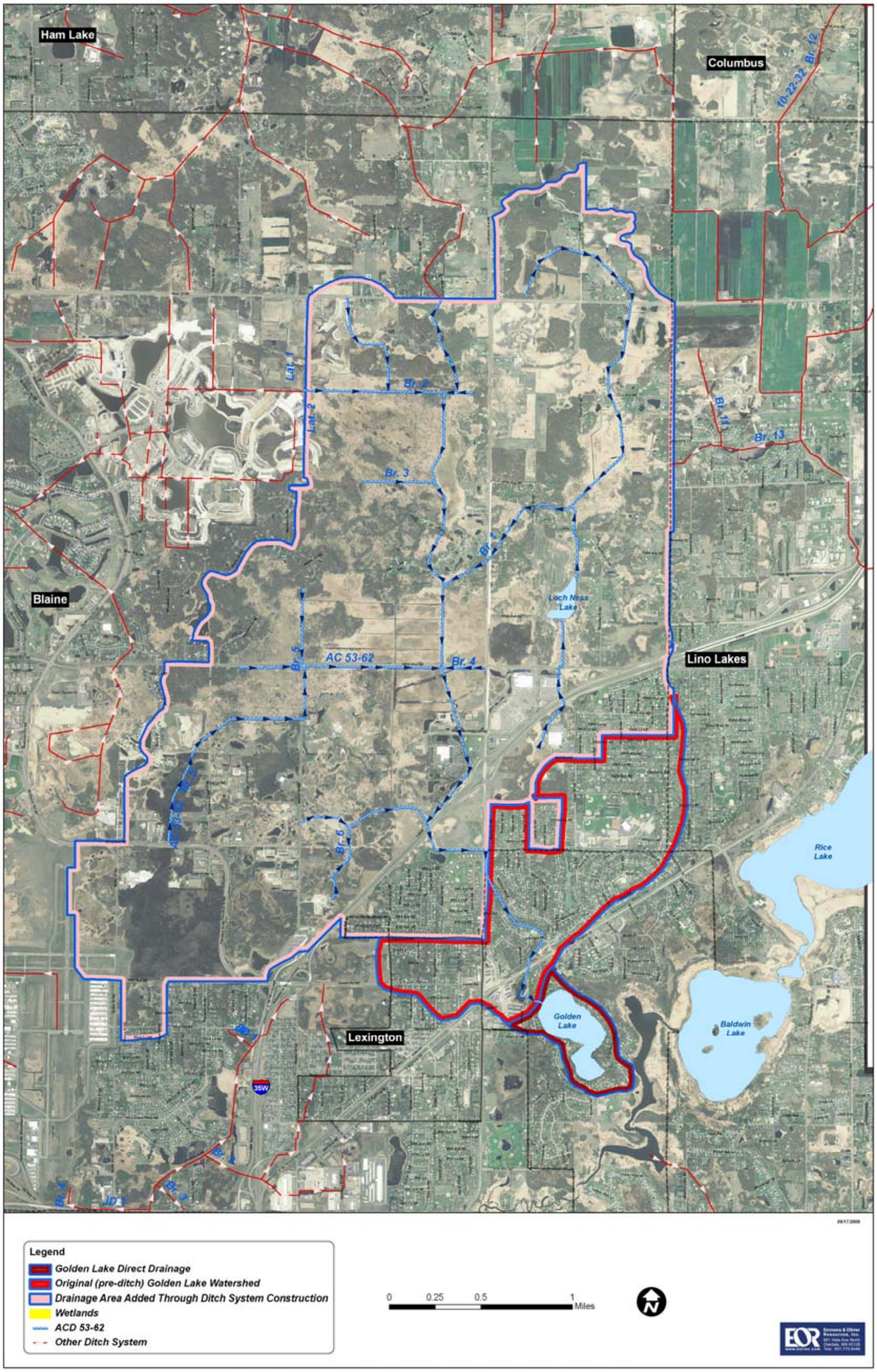


Figure 6. 2004 Aerial Imagery and Drainage Network

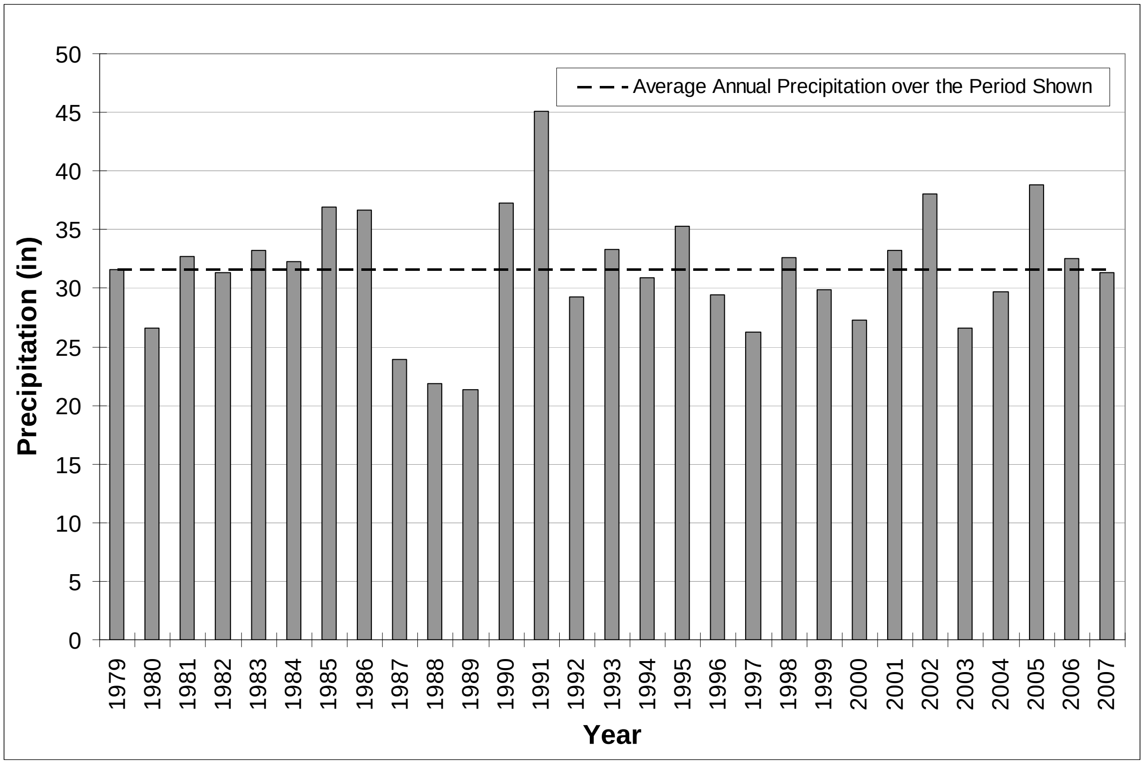


Figure 7. Annual Precipitation, 1979 - 2007

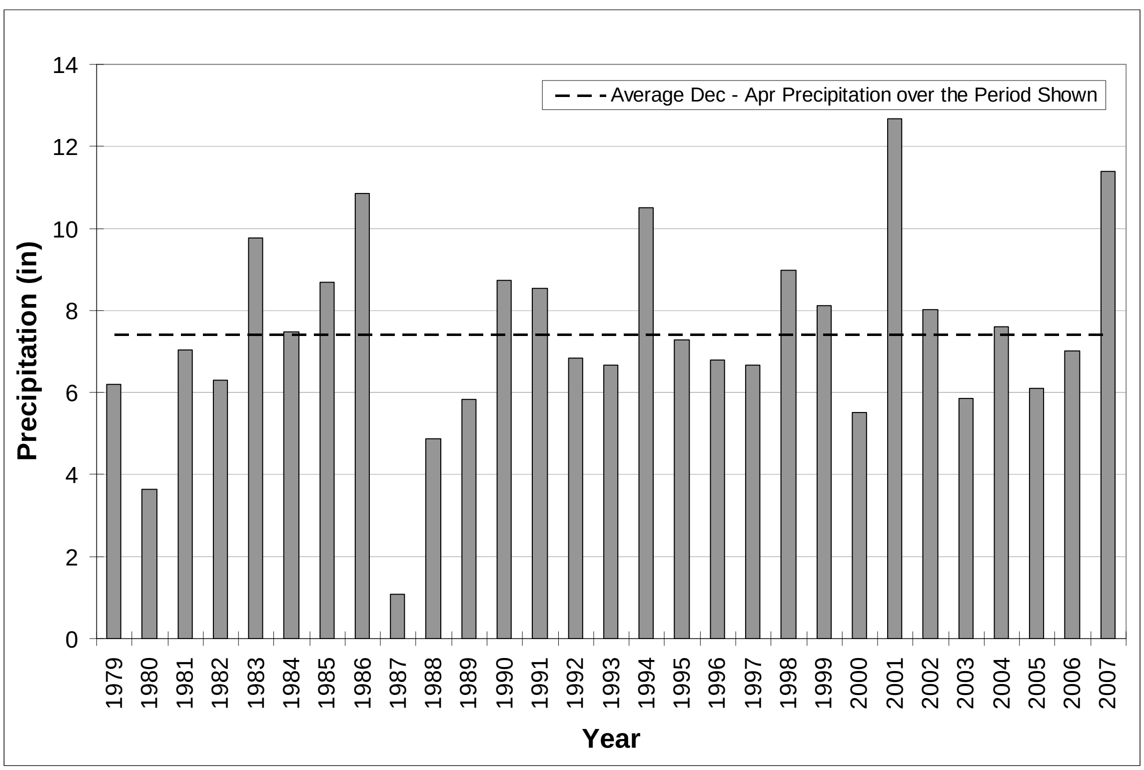


Figure 8. December through April Precipitation, 1979 - 2007

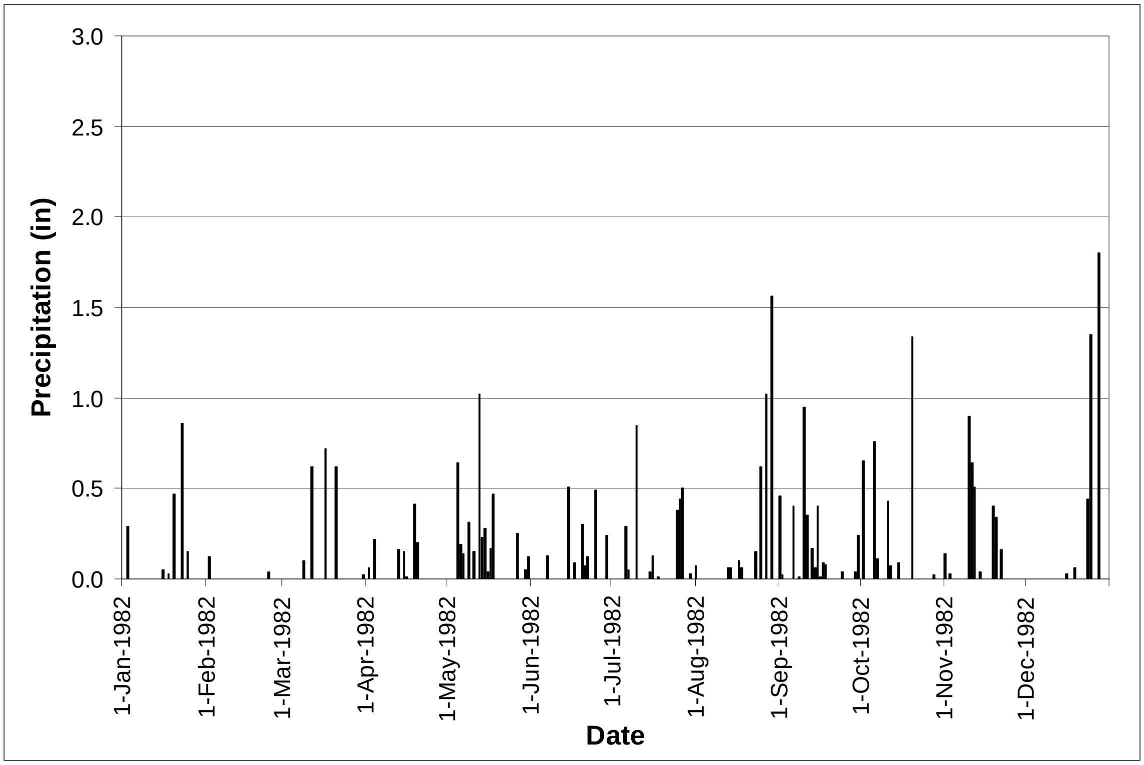


Figure 9. 1982 Precipitation Pattern

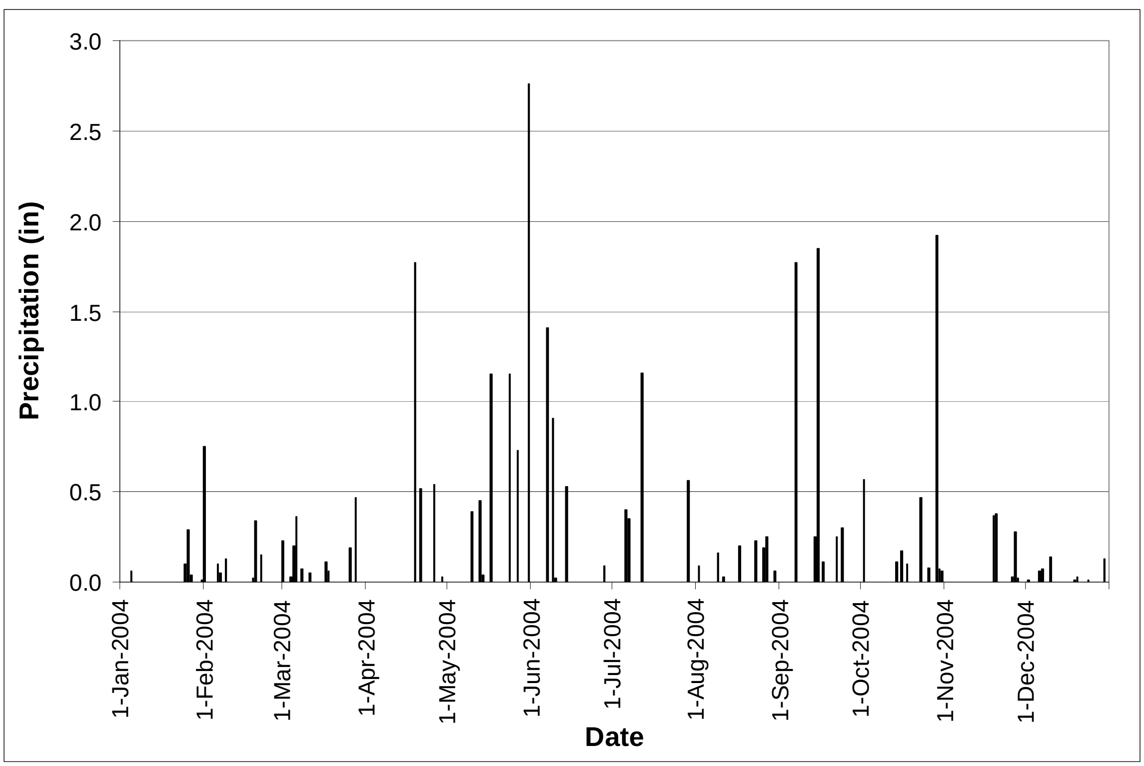


Figure 10. 2004 Precipitation Pattern

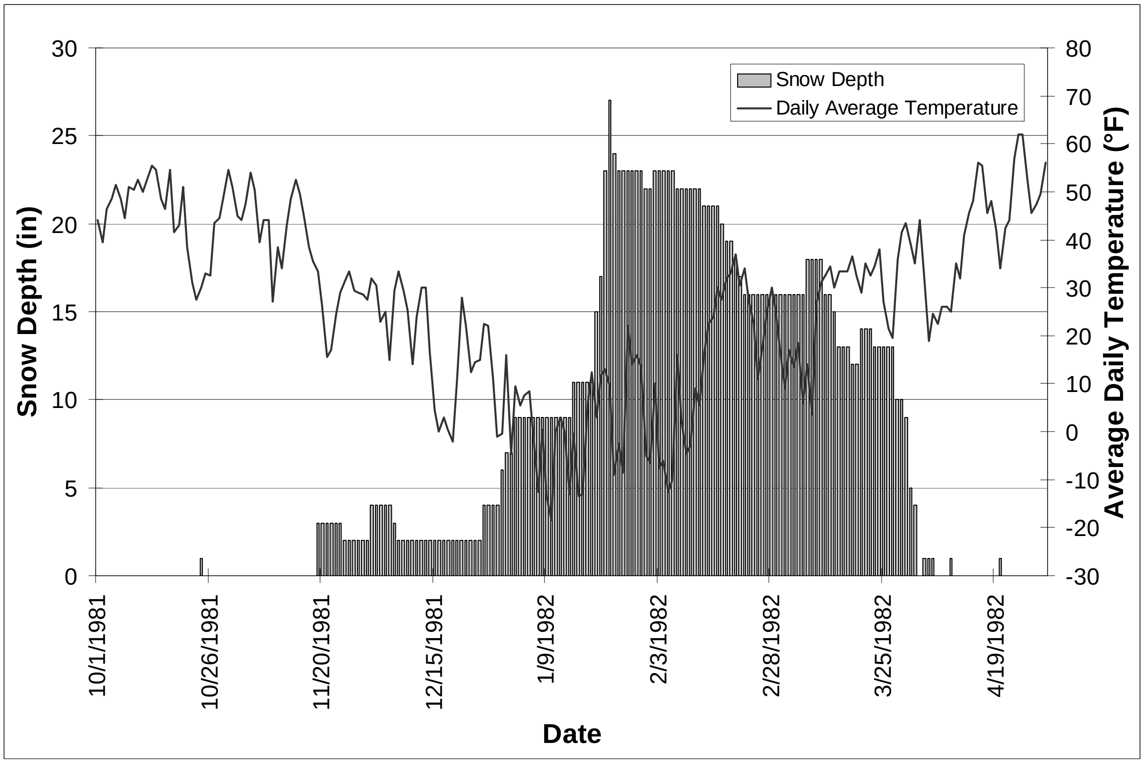


Figure 11. 1982 Snow Depth

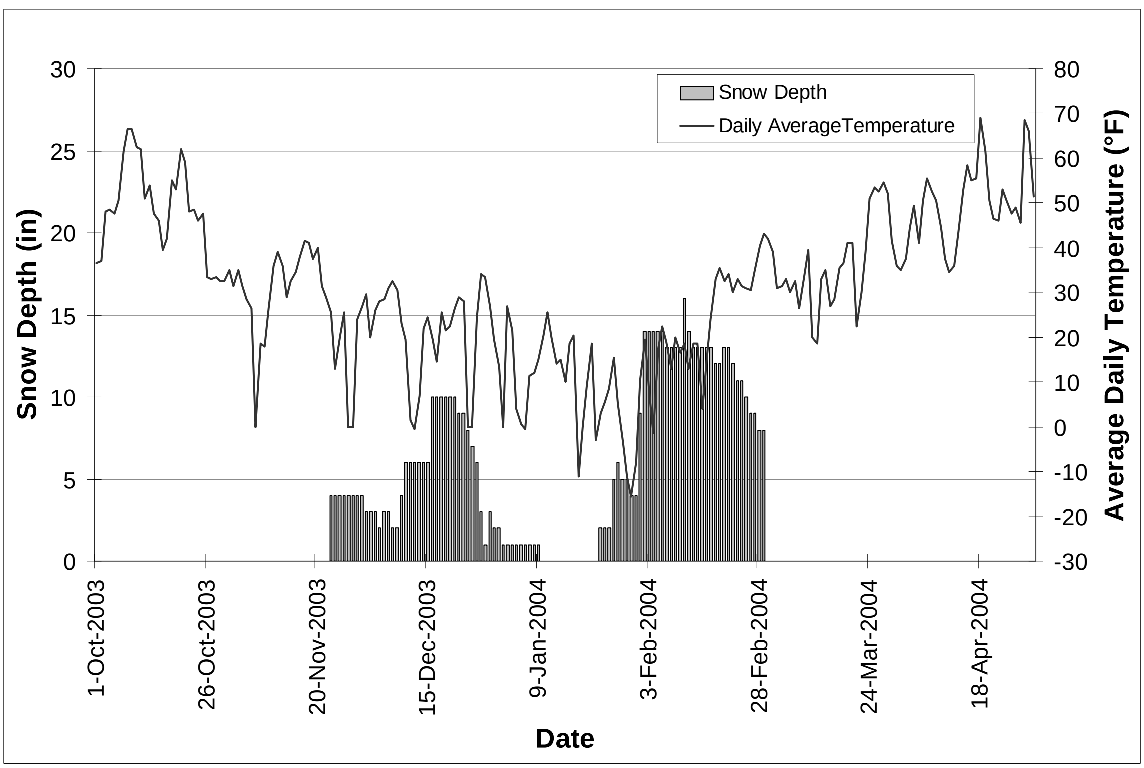


Figure 12. 2004 Snow Depth

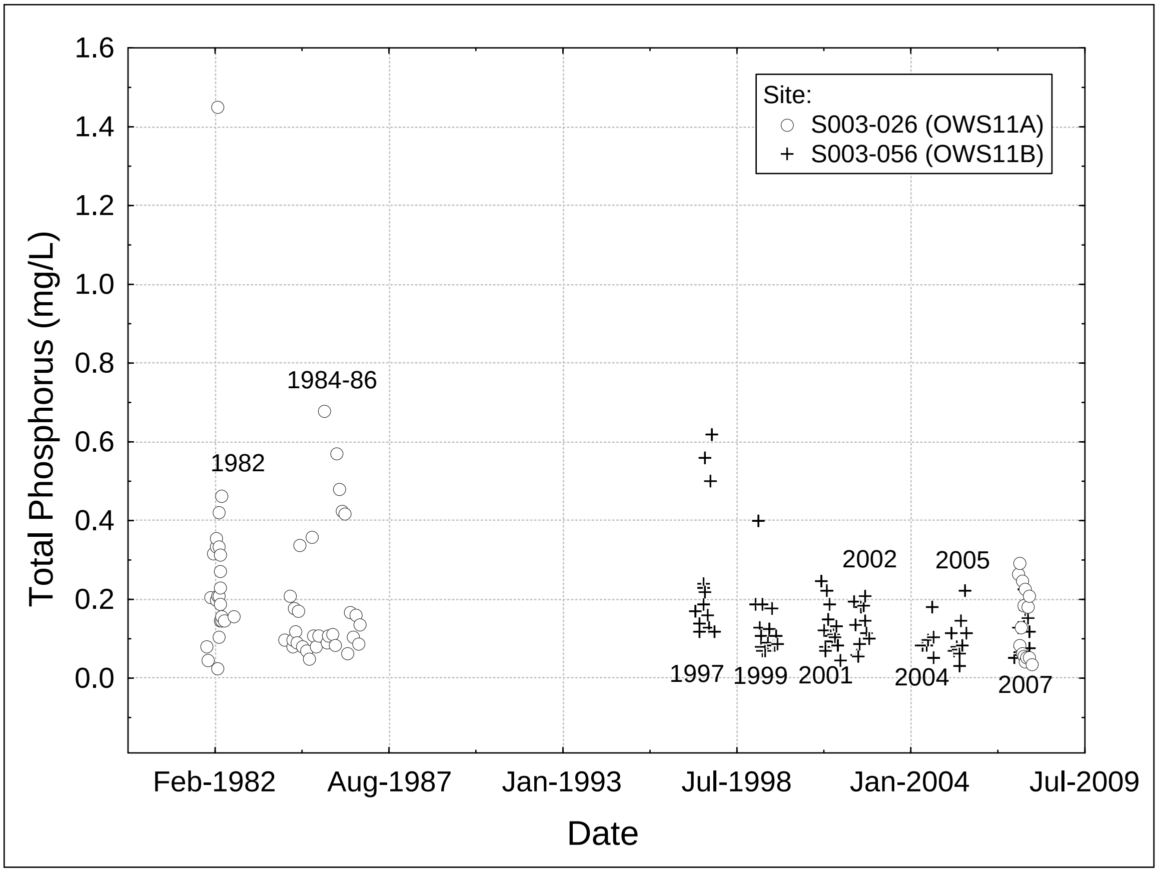


Figure 13. ACD 53-62 Phosphorus Concentrations

Appendix E. Certified Rule RMP-1

CERTIFICATION OF DECEMBER 13, 2006 RULE RMP-1

I, Donald J. Steinke, Secretary of the Rice Creek Watershed District Board of Managers, certify that the attached is a true and correct copy of December 13, 2006 Rule RMP-1 of the Rice Creek Watershed District having been properly adopted by the Board of Managers of the Rice Creek Watershed District.

Dated: Dec 13, 2006 ________________ Donald J Steinke

Donald J. Steinke, Secretary

ACKNOWLEDGEMENT

State of Minnesota
County of Ramsey

This instrument was acknowledged before me on 12-13-06, by Donald J. Steinke, as Secretary of the Rice Creek Watershed District Board of Managers, on behalf of the Rice Creek Watershed District Board of Managers.

THERESA M STASICA
NOTARY PUBLIC – MINNESOTA
MY COMMISSION EXPIRES 1-31-10

Theresa M. Stasica

Notary Public

Drafted by: Rice Creek Watershed District
4325 Pheasant Ridge Drive NE, Suite 611
Blaine, MN 55449-4539

RICE CREEK WATERSHED DISTRICT

BOARD OF MANAGERS

RULE RMP-1

Implementing Anoka County Ditch 53-62 Resource Management Plan

(Adopted December 13, 2006)

1. **PURPOSE.** The purpose of this Rule is to implement the Anoka County Ditch 53-62 Resource Management Plan (June 23, 2006) ("RMP") adopted by the Rice Creek Watershed District ("District") Board of Managers on August 23, 2006 and approved for submission to the Minnesota Board of Water and Soil Resources (BWSR). The RMP constitutes a Comprehensive Wetland Management Plan under Minnesota Statutes §103G.2243 and was approved by the Minnesota Board of Water and Soil Resources (BWSR) on September 27, 2006. It examines natural resources on a watershed basis to create a planning and regulatory framework that will protect and enhance those resources in the context of development pressures within the watershed and the continuing maintenance of capacity within the Anoka County Ditch 53-62 system in accordance with Minnesota Statutes Chapter 103E. This Rule regulates activity both in wetland and on upland within the RMP area. It comprehensively addresses wetland and other water resource protection concerns and therefore replaces permit review under individual District Rules C (Stormwater Management), D (Erosion Control) and F

(Wetland Alteration). The Rule applies only within the geographic area shown as "RMP Area" on Figure 1: RMP Rule Boundary and Wetland Preservation Zone.

2. DEFINITIONS

(a) Biofiltration- A stormwater quality and quantity BMP that utilizes vegetation and soil to filter and absorb pollutants including nutrients, hydrocarbons and metals and remove water volume through evapotranspiration.

(b) Filtration-A stormwater quality BMP that uses either natural media such as soil or vegetation or manufactured media to trap pollutants such as nutrients and particles in surface water.

(c) **Marginally Degraded Wetland**-State of degradation for existing wetland reflecting score of low/high or high/low for functional indicators *outlet condition/vegetative quality,* respectively, using MnRAM 3.0 or other state-approved wetland functional model.

(d) **Moderately Degraded Wetland**-State of degradation for existing wetland reflecting score of low/medium or medium/medium for functional indicators *outlet condition/vegetative quality,* respectively, using MnRAM 3.0 or other state-approved wetland functional model.

(e) **New Wetland Credit** (NWC) - A form of wetland replacement credit that can be used for any part of the wetland replacement obligation.

(f) **Non-Degraded Wetland**-State of degradation for existing wetland reflecting score of medium/high, high/medium or high/high for functional indicators *outlet condition/ vegetative quality,* respectively, using MnRAM 3.0 or other state-approved wetland functional model.

(g) **Plant Community Ranking**- Vegetative plant community ranking as defined in MnRAM 3.0 with a minimum definable size of one acre.

(h) **Plant Community Type**- One of the plant community types defined in MnRAM 3.0 with a minimum definable size of one acre.

(i) **Public Value Credit (PVC)** -A form of wetland replacement credit that can only be used for the part of wetland replacement required above a 1:1 ratio. The RMP differentiates PVC by Habitat Function and Hydrologic Function.

(j) **Severely Degraded Wetland**-State of degradation for existing wetland reflecting score of low/low or medium/low for functional indicators *outlet condition/vegetative quality,* respectively, using MnRAM 3.0 or other state-approved wetland functional model.

(k) **Technical Evaluation Panel**-The body described at Minnesota Rules 8420.0240, as amended.

(l) **Wetland Impact**-A loss in the quantity, quality, or biological diversity of a wetland caused by (a) draining, partially draining, filling, excavating, or diverting water from a wetland; or (b) type conversion of a wetland, by inundation or other means, without maintaining or improving wetland functions.

(m) **Wetland Preservation Zone** (WPZ)- High-priority wetland resources conceptually defined by the RMP and delineated at the time of individual project permitting as an area meeting one or more of the following criteria:

> (i) Wetland community that is physically contiguous with (not separated by upland from) the defined management units and general WPZ alignment shown in Figure 1.

(ii) Wetland plant community ranking high for vegetative integrity using MnRAM 3.0 or most recent state approved model, and area within 300 feet thereof.

(iii) Upland within fifty feet of WPZ qualifying wetland.

(n) Wetland Pulsing- A wetland restoration and stormwater management technique that focuses on reestablishing a natural hydrologic regime to drained and degraded wetlands.

3. APPLICABILITY.

(a) A Rule [ ] permit is required to:

(i) Fill or excavate in or drain, wholly or partially, a wetland within the RMP area;

(ii) Create more than 10,000 square feet of impervious surface within the RMP area; or

(iii) Use motorized equipment to alter land contours within the RMP area so as to increase or decrease the rate or volume of surface runoff into a wetland within the RMP area.

(b) For activity subject to this Rule, a separate permit under District Rule B (Procedural Requirements), C (Stormwater Management), D (Erosion Control) or F (Wetland Alteration) is not required. Other District Rules including Rule I (Drainage Systems) and the permit requirements of other units of government, including the U.S. Army Corps of Engineers, continue to apply.

(c) Sections 5 and 6 below are not applicable, and submittal requirements will be modified accordingly, in an instance where the District is not the local government unit under Minnesota Statutes §103G.005, subdivision 10e, responsible for implementing the Wetland Conservation Act.

4. APPLICATION REVIEW.

(a) In cases where wetland fill, excavation or draining, wholly or partly, is proposed, the applicant is encouraged to submit a preliminary concept plan for review with District staff and the Technical Evaluation Panel before submitting a formal application. The concept plan should examine two or more alternatives to the proposed action that will substantially achieve the applicant's project goals while avoiding wetland impact or minimizing impact if avoidance is not possible. The following approaches are among those that should be considered:

(i) Reducing the size, scope or density of the project action;

(ii) Changing the type of project action;

(iii) Applying low impact development site design principles;

(iv) Exploring development code flexibility, including conditional use permits, planned unit development, variances and code revisions; and

(v) Integrating into the wetland buffer zone compatible uses such as trails, sidewalks and stormwater Best Management Practices (BMPs) described in Section 9 of this Rule.

The applicant should provide documentation sufficient to assess project alternatives at a concept level and such other information as the District specifically requests.

(b) On receipt of a complete application, the District will review and act on the application in accordance with its procedural rules and in accordance with Wetland Conservation Act procedures.

(c) Replacement plan, exemption, no-loss and boundary decisions under this Rule will be subject to appeal in accordance with the terms and procedures of the Wetland Conservation Act. Other elements of a District permit decision will be subject to appeal in accordance with the terms and procedures of Minnesota Statutes Chapter 103D.

(d) On request, District staff will provide to an applicant a checklist showing status of application completeness and review.

5. **WETLAND REPLACEMENT.** Any activity subject to this Rule that includes wetland fill, excavation or complete or partial draining is subject to this Section.

(a) The RMP is incorporated into this Rule. The specific terms of this Rule will govern, but if a term of this Rule is susceptible to more than one interpretation, the interpretation that best carries out the intent and purposes of the RMP will be chosen.

(b) The provisions of the Wetland Conservation Act, Minnesota Statutes §§103G.221 through 103G.2372, and its implementing rules, Minnesota Rules 8420.0100 et seq., as amended, apply under this Rule except where this Rule provides otherwise. The exceptions contained in Minnesota Rules 8420.0122 are not applicable under this Rule, except as follows:

(i) The agricultural and wildlife habitat exemptions, Minnesota Rules 8420.0112, subparts 1 and 10, are applicable.

(ii) The drainage exemption, Minnesota Rules 8420.0112, subpart 2, is applicable on prior written approval of RCWD staff. Approval is based on the applicant's demonstration, through adequate hydrologic modeling, that the drainage activity will not change the hydrologic regime of an RMP-mapped high quality plant community type within the boundary of a Wetland Preservation Zone. Partial drainage of Type 3, 4, and 5 wetlands under this exemption will require 1:1 replacement.

(iii) The incidental wetland exemption, Minnesota Rules 8420.0112, subpart 5, is applicable if that applicant can show that the existing wetland was not wetland before the activity that caused its creation.

(c) Replacement plans will be evaluated and implemented in accordance with Minnesota Rules 8420.0230 and 8420.0500 through 8420.0630. Notwithstanding, the provisions of this Rule will apply in place of Minnesota Rules 8420.0540, 8420.0541, 8420.0543, 8420.0544, 8420.0546 and 8420.0549, as amended.

(d) A replacement plan must provide at least two replacement credits for each wetland impact acre.

(i) At least 50% of the replacement credits must be New Wetland Credit as identified in Table 2. The remainder may be Public Value Credit.

(ii) No more than 50% of the Public Value Credit may be in the form of infiltration Best Management Practices

(e) Acres of impact and replacement credits are determined by applying the following three steps:

(i) Multiplying actual acres affected by impacts and replacement by the ratios stated in Table 1; and

(ii) Multiplying the resulting product by two for impact within the Wetland Preservation Zone (WPZ).

(iii) Multiplying the replacement credits by the ratios stated in Table 2. All areas used to calculate wetland replacement credit that are not physically connected to the WPZ receive 50% credit.

(f) The applicant must demonstrate that the proposed action will result in no net loss of wetland function through a wetland assessment method approved by BWSR pursuant to the Wetland Conservation Act, Minnesota Statutes §103G.221 et seq.

(g) The location and type of wetland replacement will conform as closely as possible to the following standards:

(i) No wetland plant community of high or exceptional wildlife habitat function or vegetative integrity, as identified in the required wetland assessment, may be disturbed.

(ii) Replacement credit will not be given for excavation in an upland natural community with Natural Heritage Program rank A or B or equivalent quality.

(iii) Upland of equal or lower quality than Natural Heritage Program rank B/C may be converted to wetland for replacement credit.

(h) A road, utility or other structure, other than a structure related to a passive recreational or educational use, may be placed within a WPZ only on compelling need and pursuant to the District's variance procedures.

(i) Unless a different standard is stated in the approved replacement or banking plan, the performance standard for wetland restored or created to generate credit is the establishment, by the end of the WCA monitoring period, of a medium or high plant community ranking per the approved replacement plan and at least 50% of the total number of native species proposed in the planting or seeding plan.

6. WETLAND BANKING.

(a) Replacement requirements under Section 5 of this Rule may be satisfied in whole or part by application of replacement credits generated off-site within the RMP area, but not by credits generated outside of the RMP area.

(b) The deposit of replacement credits created within the RMP area for banking purposes and credit transactions for replacement will occur in accordance with Minnesota Rules 8420.0740 and 8420.0760. Credits generated within the RMP area may be used for replacement either within or outside of the RMP area.

(i) The District will calculate the amount of credit in accordance with the standard terms of WCA. This measure of credit will appear in the BWSR wetland banking account.

(ii) If a banking plan requests that credits generated qualify for replacement within the RMP area, the District will also calculate the amount of credit in accordance with Section 5 of this rule. The District will record this measure of credit internally. The District will adjust this internal account if the BWSR account later is debited for replacement outside of the RMP area. When credits are used for replacement within the RMP area, the District will convert credits used into standard WCA credits so that the BWSR account is accurately debited.

(iii) A banking plan may request that credits be calculated both ways so that credits are available for use both within and outside of the RMP area.

(iv) The amount of Public Value Credit accepted for deposit or internal District crediting will not exceed the amount of New Wetland Credit accepted in the transaction.

7. VEGETATED BUFFER.

(a) As a condition of permit issuance under this Rule, a property owner must record a declaration in a form approved by the District establishing a vegetated (wetland) buffer area adjacent to the delineated edge of wetland within the designated Wetland Preservation Zone or for other approved wetland buffer area. The declaration must state that on further subdivision of the property, each subdivided lot of record shall meet the monumentation requirement of paragraph 7(b). On public land or right-of-way, in place of a recorded declaration, the public owner may execute a written maintenance agreement with the District. The agreement will state that if the land containing the buffer is conveyed to a private party, the seller must record a declaration for buffer maintenance in a form approved by the District.

(b) Buffer is to be indicated by permanent, freestanding markers at the buffer upland edge, with a design and text approved by District staff in writing. A marker shall be placed at each lot line, with additional markers at an interval of no more than 200 feet. If a District permit is sought for a subdivision, the monumentation requirement will apply to each lot of record to be created. On public land or right-of-way, the monumentation requirement may be satisfied by the use of markers flush to the ground, breakaway markers of durable material, or a vegetation maintenance plan approved by District staff in writing.

(c) The buffer must average at least 50 feet in width, measure at least 25 feet at all points, and meet the average width at all points of concentrated inflow.

(d) The buffer will consist of vegetated land, primarily plant species native to this region, that is not cultivated, cropped, pastured, mowed, fertilized, used as a site for depositing snow removed from roads, driveways or parking lots, subject to the placement of mulch or yard waste, or otherwise disturbed, except for periodic cutting or burning that promotes the health of the buffer, actions to address disease or invasive species, or other actions to maintain or improve buffer quality, each as approved in writing by District staff. The application must include a vegetation management plan for District approval. For public road authorities, the terms of this subsection will be modified as necessary to accommodate safety and maintenance feasibility needs.

(e) Buffer may be disturbed to alter land contours or improve buffer function if the following criteria are met:

(i) An erosion control plan is submitted under which: alterations are designed and conducted to expose the smallest amount of disturbed ground for the shortest time possible; fill or excavated material is not placed to create an unstable slope; mulches or similar materials are used for temporary soil coverage; and permanent natural vegetation is established as soon as possible.

(ii) Wooded buffer and native riparian canopy trees are left intact;

(iii) When disturbance is completed, sheet flow characteristics within the buffer are improved; average slope is no steeper than preexisting average slope or 5:1 (horizontal:vertical), whichever is less steep, preexisting slopes steeper than 5:1containing dense native vegetation will not require regrading; the top 18 inches of the soil profile is not compacted, has a permeability at least equal to the permeability of the preexisting soil in an uncompacted state and has organic matter content of between five and 15 percent; and habitat diversity and riparian shading are maintained or improved.

(iv) A re-vegetation plan is submitted specifying removal of invasive species and establishment of native vegetation suited to the location.

(v) A recorded declaration or, for a public entity, maintenance agreement is submitted that states that for three years after the site is stabilized, the property owner will correct erosion, maintain and replace vegetation, and remove invasive species to establish permanent vegetation according to the re-vegetation plan.

(vi) Disturbance is not likely to result in erosion, slope failure or a failure to establish vegetation due to existing or proposed slope, soil type, root structure or proposed construction methods.

(f) No above- or below-ground structure or impervious surface may be placed within the buffer permanently or temporarily, except as follows:

(i) A structure may extend or be suspended above the buffer if the impact of any supports within the buffer is negligible, the design allows sufficient light to maintain the species shaded by the structure, and the structure does not otherwise interfere with the protection afforded by the buffer.

(ii) A public utility, or a structure associated with a public utility, may be located within a buffer on a demonstration that there is no reasonable alternative that avoids or reduces the proposed buffer intrusion. The utility or structure shall minimize the area of permanent vegetative disturbance.

(iii) Stormwater features may be located within buffer on site-specific approval.

(iv) Buffer may enclose a linear surface no more than 10 feet in width for non-motorized travel if wetland protection will not be measurably reduced. The surface will not count toward buffer width.

(g) Material may not be excavated from or placed in a buffer, except for temporary placement of fill or excavated material pursuant to dulypermitted work in the associated wetland, or pursuant to paragraph 7(e) of this Rule.

8. EROSION CONTROL. The requirements of District Rule D apply to activity subject to this Rule. The exceptions of Rule D, Section 5, do not apply.

9. STORMWATER MANAGEMENT. The following requirements apply to subdivision, grading or the creation of impervious surface subject to this Rule.

(a) The applicant must incorporate low impact development site design principles and Best Management Practices (refer to District BMP templates) to minimize impervious surface, maximize on-site surface runoff infiltration and reduce peak discharge rates, runoff volume and off-site pollutant transport.

(b) The requirements of District Rule C apply except as follows:

(i) Rule C, paragraphs 3(k), 6(a) and 6(b) do not apply.

(ii) Rule C, paragraph 6(g), applies but the applicant shall meet the peak flow control standards of paragraph 3(b).

(iii) Notwithstanding Rule C, paragraphs 6(e) and (f), a detention basin is not required provided that the applicant otherwise meets the standards of Section 9 of this Rule.

(c) Water quality and infiltration BMPs must be incorporated to the following standards:

(i) BMP volume to retain the two-year event by providing at least the volume equal to the runoff from a 2.8-inch, 24-hour storm over the tributary area under proposed conditions.

(ii) Infiltration BMPs are to be incorporated in areas with A & B hydrologic soil groups (see District BMP standard plates and design criteria). Stormwater from impervious surfaces other than rooftops must be pretreated before discharge to infiltration BMPs. Up to 20% of the volume required by paragraph 9(c)(i) of this rule may be provided by pretreatment features.

(iii) In the following areas, a minimum of 20% of the volume required by paragraph 9(c)(i) is to be provided by bio-filtration features (see District standard plates and design criteria):

(a) Areas of C or D hydrologic soil groups that cannot be routed by a gravity system to onsite A or B hydrologic soil groups;

(b) Areas with a high groundwater table;

(c) Areas where soil contamination is of concern.

Remaining volume may be provided by water quality BMPs consistent with NURP and District wet pond criteria.

(d) An increase in bounce or inundation period for any wetland following a 10-year, 24-hour precipitation event may not exceed existing conditions. This limitation does not apply to wetland restoration strategies for partially drained wetlands, such as wetland pulsing, approved by the District or wetland enhancement activities that are shown to enhance wetland function when evaluated by a District-approved functional assessment methodology.

(e) The proposed activity may not reduce hydraulic efficiency within ACD 53-62 at any point upgradient of the applicant's parcel boundary.

(f) The property owner must record a declaration , or a public owner execute a maintenance agreement, that prohibits the application of phosphorus-containing fertilizer or plowed snow storage in a location from which runoff will be conveyed without adequate pretreatment or sheet flow directly into a wetland within the RMP area.

(g) Soil amendment, excavation or filling pursuant to development within the RMP area may not impede groundwater flow so as to create a substantial risk of loss of function to any wetland.

10. SUBMITTALS.

(a) Except as provided below, an application for a permit review under this Rule will consist of application materials, fees and sureties as required by District Rules B (Procedural Requirements), C (Stormwater Management), D (Erosion Control) and F (Wetland Alteration).

(b) A proposal that does not involve subdivision, grading or development of upland within the RMP area need not submit application materials required by District Rule C (Stormwater Management).

(c) A proposal that does not involve fill, excavation or the partial or complete draining of a wetland within the RMP area need not submit application materials required by District Rule F (Wetland Alteration). "Draining" includes altering surface or subsurface flows in a way that materially reduces wetland hydrology.

(d) Unless exempted under paragraph 10(c) of this Rule, the application must include:

(i) A delineation report for each wetland on the property using methodology currently approved by District, state and federal authorities;

(ii) Plant community mapping and scoring standards for wetlands ranking "high" for vegetative integrity using MnRAM 3.0 or most recent state-approved wetland functional assessment model;

(iii) Wetland function and values assessments for existing and proposed conditions, using MnRAM or most recent state-approved wetland functional assessment model; and

(iv) All sequencing and replacement plan application components as listed in Minnesota Rules 8420.0520 and 8420.0530.

(e) On District request, the applicant will conduct an assessment of protected plant or animal species within the project area.

(f) The application will include an on-site location of all public and private ditches.

(g) The applicant will provide such other submittals as are reasonably requested by the District.

11. **EASEMENT.** As a condition of permit issuance, the property owner must convey to the District and record, in a form acceptable to the District, a perpetual, assignable easement granting the District the authority to monitor, modify and maintain hydrological and vegetative conditions within WPZ wetlands, upland enclosed by the WPZ and vegetated buffer, including the authority to install and maintain structures within those areas and reasonable

access to those areas to perform authorized activity. The WPZ shall be identified and delineated as part of the recorded easement.

12. PARTIAL ABANDONMENT. As a condition of permit issuance, the District may require a property owner to petition the District for partial abandonment of a public drainage system pursuant to Minnesota Statutes §103E.805, as amended. A partial abandonment under this Section may not diminish a benefited property owner's right to drainage without the owner's agreement.

13. SURETIES. Sureties required under Rule [ ] will be released as follows:

(a) Erosion control: at the close of one full spring season after site disturbance and stockpiles have achieved final stabilization.

(b) Stormwater management: when stormwater facilities have been installed, site disturbance and stockpiles have achieved final stabilization, and the landowner has submitted engineer or surveyor certification that the facilities conform to approved plans.

(c) Vegetated buffer: after monumentation has been completed, vegetation has been established, and one additional full growing season has passed.

(d) Wetland replacement: in accordance with Minnesota Rules 8420.0630.

Table 1. Wetland Impact Ratios

Existing Wetland Type	Acre-for-Acre Impact Ratio
Degraded shallow, deep marshes or open water	1.0
Non-Degraded shallow, deep marshes or open water	1.25
Degraded sedge meadow, wet meadow, or wet to mesic prairie	1.0
Non-Degraded sedge meadow, wet meadow, or wet to mesic prairie	1.5
Degraded shrub carr or alder thicket	1.0
Non-Degraded shrub carr or alder thicket	1.5
Degraded hardwood, coniferous swamp, floodplain forest, or bog	1.25
Non-Degraded hardwood, coniferous swamp, floodplain forest, or bog	2.0
Degraded seasonally flooded basin	1.0
Non-Degraded seasonally flooded basin	1.25

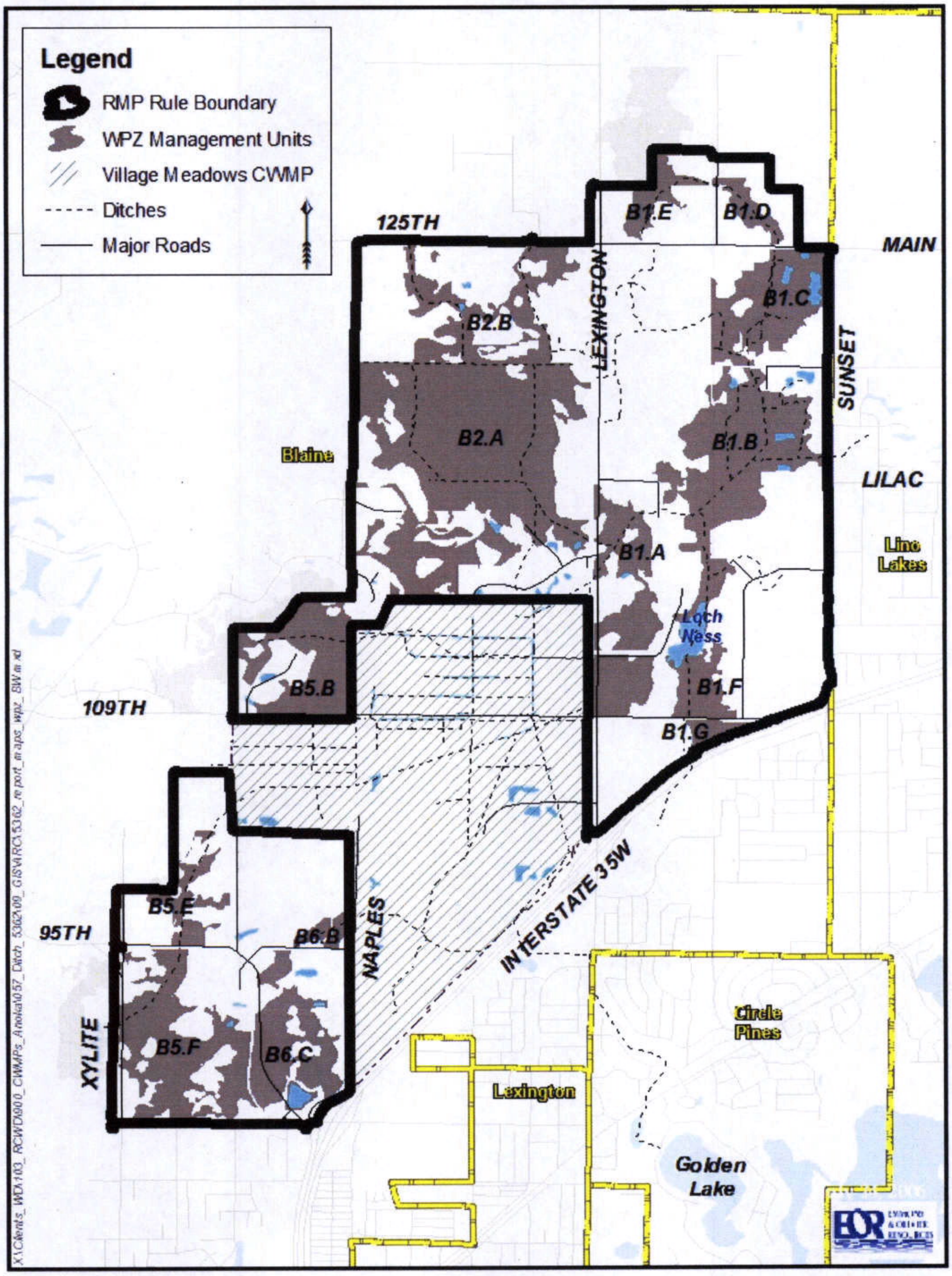
Note: Wetlands in the WPZ will have a 2x multiplier to the ratio shown.

Table 2. Wetland Mitigation Replacement Ratios

Replacement Method	Replacement Credit Ratio
1. Wetland Impact-Acre Replacement (NWC) (for area of wetland impact at a 1:1 ratio)	
Hydrologic and vegetative restoration of partially drained marginally degraded wetlands	Up to 0.25
Hydrologic and vegetative restoration of partially drained moderately degraded wetlands	Up to 0.5
Hydrologic and vegetative restoration of partially drained severely degraded wetlands	Up to 0.75
Wetland establishment (creation) in nonnative vegetated upland or effectively drained wetland	1
Farmed wetlands (WCA guidance) vegetation restoration	Up to 1
2. Wetland Function Replacement (PVC) (for impact above 1:1 acre replacement)	
a. Habitat Function Replacement	
Upland buffer contiguous with wetland	.25
Upland habitat area contiguous with WPZ wetland	Up to 0.5
Vegetation restoration of invasive or exotic dominated wetland in the WPZ	0.5
Preservation of high quality wetlands	0.5
Preservation of wetlands having "exceptional natural resource values" (WCA guidance; case by case approval under Section 404)	0.5
b. Hydrologic Function Replacement (maximum 50% of Functional Replacement;)	
Stormwater infiltration BMP: (1 ac-ft = 1 acre credit)	1

Note: Replacement not protected by the WPZ receives 50% credit. Minimum of 1:1 impact-acre replacement and minimum 2:1 function replacement. The amount of NWC for restoration of a partially drained, degraded wetland will be based on the District's determination of the portion of the basin qualifying as a degraded wetland.

Figure 1. 53-62 RMP Rule Boundary and Wetland Preservation Zone



Appendix F. ACD 53-62 Data

ACD 53-62 Flow

Date (mm/dd/yy)	Flow (cfs)
01/01/99	0.003
01/02/99	0.003
01/03/99	0.003
01/04/99	0.003
01/05/99	0.003
01/06/99	0.003
01/07/99	0.003
01/08/99	0.003
01/09/99	0.003
01/10/99	0.003
01/11/99	0.003
01/12/99	0.003
01/13/99	0.003
01/14/99	0.003
01/15/99	0.003
01/16/99	0.003
01/17/99	0.003
01/18/99	0.003
01/19/99	0.003
01/20/99	0.003
01/21/99	0.003
01/22/99	0.003
01/23/99	0.003
01/24/99	0.003
01/25/99	0.003
01/26/99	0.003
01/27/99	0.003
01/28/99	0.003
01/29/99	0.003
01/30/99	0.003
01/31/99	0.003
02/01/99	0.036
02/02/99	0.069
02/03/99	0.102
02/04/99	0.136
02/05/99	0.169
02/06/99	0.202
02/07/99	0.235
02/08/99	0.268
02/09/99	0.301
02/10/99	0.334
02/11/99	0.367
02/12/99	0.401
02/13/99	0.434
02/14/99	0.467
02/15/99	0.500
02/16/99	0.500
02/17/99	0.500
02/18/99	0.500
02/19/99	0.500
02/20/99	0.500
02/21/99	0.500
02/22/99	0.500
02/23/99	0.500
02/24/99	0.500
02/25/99	0.500
02/26/99	0.500
02/27/99	0.500
02/28/99	0.500
03/01/99	0.500
03/02/99	0.500
03/03/99	0.500

Date (mm/dd/yy)	Flow (cfs)
03/04/99	0.500
03/05/99	0.500
03/06/99	0.500
03/07/99	0.500
03/08/99	0.500
03/09/99	0.500
03/10/99	0.500
03/11/99	0.500
03/12/99	0.500
03/13/99	0.500
03/14/99	0.500
03/15/99	0.500
03/16/99	0.500
03/17/99	0.500
03/18/99	0.500
03/19/99	0.500
03/20/99	0.500
03/21/99	0.500
03/22/99	0.500
03/23/99	0.500
03/24/99	0.500
03/25/99	0.500
03/26/99	0.500
03/27/99	0.500
03/28/99	0.500
03/29/99	0.500
03/30/99	0.500
03/31/99	0.750
04/01/99	1.000
04/02/99	2.000
04/03/99	3.000
04/04/99	4.000
04/05/99	6.000
04/06/99	9.000
04/07/99	6.705
04/08/99	4.049
04/09/99	2.777
04/10/99	2.107
04/11/99	2.698
04/12/99	3.584
04/13/99	2.620
04/14/99	2.090
04/15/99	2.195
04/16/99	6.521
04/17/99	6.431
04/18/99	4.670
04/19/99	3.253
04/20/99	2.487
04/21/99	2.468
04/22/99	2.021
04/23/99	1.838
04/24/99	1.398
04/25/99	1.090
04/26/99	0.887
04/27/99	0.766
04/28/99	0.724
04/29/99	0.506
04/30/99	0.391
05/01/99	0.346
05/02/99	0.332
05/03/99	0.245
05/04/99	0.209

Date (mm/dd/yy)	Flow (cfs)
05/05/99	0.464
05/06/99	0.644
05/07/99	0.724
05/08/99	1.742
05/09/99	1.727
05/10/99	1.273
05/11/99	1.206
05/12/99	4.799
05/13/99	29.087
05/14/99	21.522
05/15/99	12.958
05/16/99	8.436
05/17/99	6.860
05/18/99	5.172
05/19/99	3.472
05/20/99	2.468
05/21/99	4.568
05/22/99	3.906
05/23/99	3.146
05/24/99	2.698
05/25/99	1.987
05/26/99	1.528
05/27/99	1.233
05/28/99	1.004
05/29/99	0.724
05/30/99	0.524
05/31/99	0.369
06/01/99	0.339
06/02/99	0.415
06/03/99	0.325
06/04/99	0.311
06/05/99	0.447
06/06/99	0.745
06/07/99	0.541
06/08/99	0.284
06/09/99	0.215
06/10/99	0.318
06/11/99	1.206
06/12/99	2.412
06/13/99	1.078
06/14/99	0.864
06/15/99	0.625
06/16/99	0.550
06/17/99	0.376
06/18/99	0.325
06/19/99	0.252
06/20/99	0.233
06/21/99	0.140
06/22/99	0.447
06/23/99	1.128
06/24/99	2.266
06/25/99	1.649
06/26/99	1.273
06/27/99	0.898
06/28/99	0.714
06/29/99	1.141
06/30/99	0.788
07/01/99	0.684
07/02/99	1.167
07/03/99	1.041
07/04/99	1.141
07/05/99	0.644

Date (mm/dd/yy)	Flow (cfs)
07/06/99	1.154
07/07/99	0.724
07/08/99	0.635
07/09/99	0.910
07/10/99	0.596
07/11/99	0.447
07/12/99	0.354
07/13/99	0.291
07/14/99	0.391
07/15/99	0.354
07/16/99	0.252
07/17/99	0.277
07/18/99	0.198
07/19/99	0.227
07/20/99	0.203
07/21/99	0.203
07/22/99	0.155
07/23/99	0.116
07/24/99	0.078
07/25/99	0.053
07/26/99	1.065
07/27/99	1.342
07/28/99	0.447
07/29/99	0.215
07/30/99	0.116
07/31/99	1.128
08/01/99	0.596
08/02/99	0.221
08/03/99	0.116
08/04/99	0.086
08/05/99	0.046
08/06/99	0.017
08/07/99	0.017
08/08/99	0.022
08/09/99	0.037
08/10/99	0.346
08/11/99	0.215
08/12/99	0.150
08/13/99	0.150
08/14/99	0.082
08/15/99	0.046
08/16/99	0.015
08/17/99	0.003
08/18/99	0.003
08/19/99	0.187
08/20/99	0.176
08/21/99	0.135
08/22/99	1.426
08/23/99	1.970
08/24/99	0.724
08/25/99	0.431
08/26/99	0.304
08/27/99	0.215
08/28/99	0.130
08/29/99	0.095
08/30/99	0.067
08/31/99	0.060
09/01/99	0.022
09/02/99	0.003
09/03/99	0.003
09/04/99	0.003
09/05/99	0.003

Date (mm/dd/yy)	Flow (cfs)
09/06/99	0.003
09/07/99	0.003
09/08/99	0.003
09/09/99	0.017
09/10/99	0.001
09/11/99	0.003
09/12/99	0.121
09/13/99	0.284
09/14/99	0.239
09/15/99	0.198
09/16/99	0.140
09/17/99	0.095
09/18/99	0.053
09/19/99	0.037
09/20/99	0.103
09/21/99	0.095
09/22/99	0.049
09/23/99	0.007
09/24/99	0.003
09/25/99	0.003
09/26/99	0.003
09/27/99	0.003
09/28/99	0.003
09/29/99	0.003
09/30/99	0.003
10/01/99	0.003
10/02/99	0.003
10/03/99	0.003
10/04/99	0.003
10/05/99	0.003
10/06/99	0.003
10/07/99	0.003
10/08/99	0.003
10/09/99	0.003
10/10/99	0.003
10/11/99	0.003
10/12/99	0.003
10/13/99	0.003
10/14/99	0.003
10/15/99	0.003
10/16/99	0.003
10/17/99	0.003
10/18/99	0.003
10/19/99	0.012
10/20/99	0.082
10/21/99	0.130
10/22/99	0.145
10/23/99	0.239
10/24/99	0.297
10/25/99	0.311
10/26/99	0.297
10/27/99	0.361
10/28/99	0.369
10/29/99	0.415
10/30/99	0.694
10/31/99	1.273
11/01/99	1.499
11/02/99	1.649
11/03/99	1.790
11/04/99	1.904
11/05/99	1.871

Date (mm/dd/yy)	Flow (cfs)
11/06/99	1.742
11/07/99	1.649
11/08/99	1.499
11/09/99	1.287
11/10/99	1.141
11/11/99	1.246
11/12/99	1.469
11/13/99	1.742
11/14/99	1.887
11/15/99	2.021
11/16/99	0.003
11/17/99	0.003
11/18/99	0.003
11/19/99	0.003
11/20/99	0.003
11/21/99	0.003
11/22/99	0.003
11/23/99	0.003
11/24/99	0.003
11/25/99	0.003
11/26/99	0.003
11/27/99	0.003
11/28/99	0.003
11/29/99	0.003
11/30/99	0.003
12/01/99	0.003
12/02/99	0.003
12/03/99	0.003
12/04/99	0.003
12/05/99	0.003
12/06/99	0.003
12/07/99	0.003
12/08/99	0.003
12/09/99	0.003
12/10/99	0.003
12/11/99	0.003
12/12/99	0.003
12/13/99	0.003
12/14/99	0.003
12/15/99	0.003
12/16/99	0.003
12/17/99	0.003
12/18/99	0.003
12/19/99	0.003
12/20/99	0.003
12/21/99	0.003
12/22/99	0.003
12/23/99	0.003
12/24/99	0.003
12/25/99	0.003
12/26/99	0.003
12/27/99	0.003
12/28/99	0.003
12/29/99	0.003
12/30/99	0.003
12/31/99	0.003

Date (mm/dd/yy)	Flow (cfs)
04/09/04	0.16
04/10/04	0.29
04/11/04	0.27
04/12/04	0.26
04/13/04	0.27
04/14/04	0.3
04/15/04	0.19
04/16/04	0.15
04/17/04	0.25
04/18/04	0.29
04/19/04	0.6
04/20/04	1.27
04/21/04	0.58
04/22/04	1.02
04/23/04	0.9
04/24/04	0.65
04/25/04	0.41
04/26/04	0.79
04/27/04	0.71
04/28/04	0.56
04/29/04	0.42
04/30/04	0.39
05/01/04	0.66
05/02/04	1.15
05/03/04	0.75
05/04/04	0.44
05/05/04	0.42
05/06/04	0.41
05/07/04	0.4
05/08/04	0.54
05/09/04	0.22
05/10/04	0.23
05/11/04	0.55
05/12/04	0.38
05/13/04	0.34
05/14/04	1.02
05/15/04	0.94
05/16/04	0.68
05/17/04	0.5
05/18/04	2.35
05/19/04	2.27
05/20/04	1.58
05/21/04	1.33
05/22/04	1.21
05/23/04	1.21
05/24/04	2.69
05/25/04	3.24
05/26/04	2.8
05/27/04	2.32
05/28/04	3.64
05/29/04	2.69
05/30/04	4.76
05/31/04	7.95
06/01/04	12.27
06/02/04	10.48
06/03/04	9.2
06/04/04	7.29
06/05/04	5.58
06/06/04	5.8
06/07/04	8.51
06/08/04	6.82
06/09/04	5.43

Date (mm/dd/yy)	Flow (cfs)
06/10/04	7.14
06/11/04	5.76
06/12/04	5.68
06/13/04	6.55
06/14/04	4.37
06/15/04	2.89
06/16/04	1.81
06/17/04	0.68
06/18/04	0.51
06/19/04	0.76
06/20/04	0.41
06/21/04	0.38
06/22/04	0.43
06/23/04	0.4
06/24/04	0.34
06/25/04	0.41
06/26/04	0.55
06/27/04	0.39
06/28/04	0.54
06/29/04	0.47
06/30/04	0.58
07/01/04	0.42
07/02/04	0.37
07/03/04	0.31
07/04/04	0.28
07/05/04	0.35
07/06/04	0.34
07/07/04	0.37
07/08/04	0.45
07/09/04	0.35
07/10/04	0.28
07/11/04	0.24
07/12/04	0.78
07/13/04	0.32
07/14/04	0.27
07/15/04	0.19
07/16/04	0.18
07/17/04	0.16
07/18/04	0.14
07/19/04	0.13
07/20/04	0.12
07/21/04	0.13
07/22/04	0.14
07/23/04	0.11
07/24/04	0.09
07/25/04	0.1
07/26/04	0.09
07/27/04	0.09
07/28/04	0.08
07/29/04	0.1
07/30/04	0.14
07/31/04	0.1
08/01/04	0.09
08/02/04	0.1
08/03/04	0.11
08/04/04	0.1
08/05/04	0.09
08/06/04	0.09
08/07/04	0.06
08/08/04	0.01
08/09/04	0.08
08/10/04	0.11

Date (mm/dd/yy)	Flow (cfs)
08/11/04	0.09
08/12/04	0.07
08/13/04	0.05
08/14/04	0.03
08/15/04	0.05
08/16/04	0.05
08/17/04	-0.01
08/18/04	-0.05
08/19/04	0.05
08/20/04	0.07
08/21/04	0.03
08/22/04	0.04
08/23/04	0.06
08/24/04	0.01
08/25/04	-0.1
08/26/04	0.02
08/27/04	0.04
08/28/04	0.07
08/29/04	0.04
08/30/04	0
08/31/04	0.05
09/01/04	0.04
09/02/04	0.04
09/03/04	0.03
09/04/04	0.02
09/05/04	0
09/06/04	0.21
09/07/04	0.22
09/08/04	0.1
09/09/04	0.05
09/10/04	0.02
09/11/04	0.04
09/12/04	0.05
09/13/04	0.04
09/14/04	0.09
09/15/04	0.06
09/16/04	0.63
09/17/04	0.24
09/18/04	0.13
09/19/04	0.09
09/20/04	0.01
09/21/04	0.05
09/22/04	0.18
09/23/04	0.14
09/24/04	0.13
09/25/04	0.24
09/26/04	0.22
09/27/04	0.21
09/28/04	0.2
09/29/04	0.32
09/30/04	0.44
10/01/04	0.43
10/02/04	0
10/03/04	0
10/04/04	0
10/05/04	0
10/06/04	0
10/07/04	0
10/08/04	0
10/09/04	0
10/10/04	0
10/11/04	0

Date (mm/dd/yy)	Flow (cfs)
10/12/04	0
10/13/04	0
10/14/04	0
10/15/04	0
10/16/04	0
10/17/04	0
10/18/04	0
10/19/04	0
10/20/04	0
10/21/04	0
10/22/04	0
10/23/04	0
10/24/04	0
10/25/04	0
10/26/04	0
10/27/04	0
10/28/04	0
10/29/04	0
10/30/04	0
10/31/04	0
11/01/04	0
11/02/04	0
11/03/04	0
11/04/04	0
11/05/04	0
11/06/04	0
11/07/04	0
11/08/04	0
11/09/04	0
11/10/04	0
11/11/04	0
11/12/04	0
11/13/04	0
11/14/04	0
11/15/04	0
11/16/04	0
11/17/04	0
11/18/04	0
11/19/04	0
11/20/04	0
11/21/04	0
11/22/04	0
11/23/04	0
11/24/04	0
11/25/04	0
11/26/04	0
11/27/04	0
11/28/04	0
11/29/04	0
11/30/04	0
12/01/04	0
12/02/04	0
12/03/04	0

ACD 53-62 1999-2004 TP Data:

Date (mm/dd/yy)	TP (mg/L)
02/10/99	0.19
03/15/99	0.4
04/07/99	0.13
04/16/99	0.11
04/29/99	0.08
05/10/99	0.19
05/13/99	0.07
06/07/99	0.07
06/14/99	0.08
07/07/99	0.093
07/27/99	0.123
08/02/99	0.125
08/16/99	0.177
08/30/99	0.18
09/14/99	0.085
09/30/99	0.083
10/11/99	0.108
11/03/99	0.088
03/21/01	0.249
04/09/01	0.124
04/24/01	0.082
05/08/01	0.07
05/21/01	0.225
05/29/01	0.152

Date (mm/dd/yy)	TP (mg/L)
06/21/01	0.188
07/02/01	0.11
07/18/01	0.094
08/02/01	0.114
08/20/01	0.104
09/07/01	0.133
09/24/01	0.086
10/16/01	0.045
04/23/02	0.059
05/08/02	0.056
05/30/02	0.088
06/19/02	0.181
07/11/02	0.184
07/29/02	0.211
08/06/02	0.148
08/19/02	0.116
09/10/02	0.103
05/04/04	0.085
05/26/04	0.084
07/07/04	0.084
07/15/04	0.098
09/02/04	0.183
09/17/04	0.105
10/01/04	0.052

FLUX Data Summaries:

1999 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	364	13	13	100.0	.783	3.307	-.076	.147
***	364	13	13	100.0	.783	3.307		

FLOW STATISTICS
FLOW DURATION = 364.0 DAYS = .997 YEARS
MEAN FLOW RATE = .783 HM3/YR
TOTAL FLOW VOLUME = .78 HM3
FLOW DATE RANGE = 19990101 TO 19991230
SAMPLE DATE RANGE = 19990407 TO 19990914

METHOD	MASS (KG)	FLUX (KG/YR)	FLUX VARIANCE	CONC (PPB)	CV
1 AV LOAD	295.2	296.3	.2095E+05	378.59	.489
2 Q WTD C	69.9	70.1	.5298E+03	89.58	.328
3 IJC	66.2	66.4	.7003E+03	84.86	.398
4 REG-1	77.9	78.2	.3428E+03	99.91	.237
5 REG-2	70.1	70.3	.1782E+03	89.85	.190
6 REG-3	81.6	81.9	.8892E+02	104.62	.115

2004 OWS11b CD53-62 monitoring 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	234	14	14	72.6	.563	2.412	.051	.491
2	6	10	10	27.4	8.297	12.364	-.394	.137
***	240	24	24	100.0	.756	6.559		

FLOW STATISTICS
FLOW DURATION = 240.0 DAYS = .657 YEARS
MEAN FLOW RATE = .756 HM3/YR
TOTAL FLOW VOLUME = .50 HM3
FLOW DATE RANGE = 20040409 TO 20041203
SAMPLE DATE RANGE = 20020423 TO 20041001

METHOD	MASS (KG)	FLUX (KG/YR)	FLUX VARIANCE	CONC (PPB)	CV
1 AV LOAD	183.5	279.2	.2512E+04	369.13	.179
2 Q WTD C	52.6	80.0	.6403E+02	105.77	.100
3 IJC	52.2	79.4	.6861E+02	105.03	.104
4 REG-1	52.4	79.8	.5097E+02	105.45	.090
5 REG-2	55.7	84.8	.9877E+02	112.05	.117
6 REG-3	55.7	84.8	.4552E+02	112.14	.080