FL44 Wetland Assessment and Feasibility Study

March 2010
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INTRODUCTION

Project Scope
The feasibility study of the rehabilitation of the former fish rearing pond will confirm the loading from the subwatershed FL44 wetland as well as measure the effect of the former fish rearing pond on phosphorus concentrations. The project objectives include:

- Estimate the phosphorus and sediment load contribution to Forest Lake from the subwatershed FL44 wetland.
- Evaluate the potential to reduce phosphorus and sediment load to Forest Lake from the subwatershed FL44 wetland through alterations to the former fish rearing pond.

Background
Five of the District lakes are currently listed as impaired by the MPCA due to excessive nutrients, however, the water quality of Forest Lake is not impaired. Forest Lake has an 8,160 acre watershed that is broken down into 87 subwatersheds in the District’s Hydrologic/Hydraulic and water quality models (CLFLWD 2005, CLFLWD 2007). The water quality and load allocation modeling effort led to the development of a District-wide Capital Improvement Program (CIP) to address nutrient loading issues. One of the projects in the CIP is a cattle exclusion/wetland restoration in a subwatershed to Forest Lake (identified as subwatershed FL44 in the District’s models). Subwatershed FL44 outlets to Forest Lake through a former DNR fish rearing pond then under North Shore Trail before entering the lake. The modeled load from FL44 was estimated to be 539 pounds total phosphorus per year, the largest subwatershed load identified to Forest Lake. The modeling effort was unable to determine the loading coming from the old DNR fish rearing pond and therefore was unable to be used for assessing remedial activities for the site.

This assessment and feasibility study includes an analysis of water quality parameters, flow, water levels, and the vegetative and physical conditions of the open water portion of the FL44 wetland as well as the vegetated region immediately adjoining the open water portion. To investigate the question of what the phosphorus and sediment load is to Forest Lake, the phosphorus and sediment concentrations were evaluated as water moves out of the open water portion of the wetland and into Forest Lake.

To investigate whether or not the former fish rearing pond is acting as a source of phosphorus to the lake, the study investigates the concentration of phosphorus in the former fish rearing pond sediments. The analysis of phosphorus concentrations in sediment samples informs the evaluation of the release of phosphorus from the sediment into the water. The loads are then evaluated with respect to their impact on Forest Lake.

The analysis of the vegetation and physical condition of the wetland provides information on the quality of the wetland from a different vantage point. Wetland vegetation quality and wetland function are reflections of various characteristics of the wetland. Poor water quality or large fluctuations in water levels will influence the plant composition of a wetland and can severely limit native plant diversity. The functional characteristics of the wetland provide
additional information about the wetland’s structure that will be important for determining what types of projects are feasible.

This assessment and feasibility study supports the overall project proposed for FL44 which also includes methods to reduce one of the largest estimated loads to the FL44 wetland (156 lbs). This estimated load results from the livestock operation at the northeast end of the FL44 wetland. Therefore, the District is working on the development of a 30-foot buffer along the wetland edge with exclusion fencing to keep cattle out of the wetland and eliminate this livestock-related load.

In addition, as part of the study, the three lake basins of Forest Lake were monitored from mid-April through mid-October, 2009. The monitoring locations are shown on Figure 1. While the western basin of Forest Lake was enrolled in the Metropolitan Council’s Citizen-Assisted Monitoring Program (CAMP), the middle and eastern basins used volunteers to collect Secchi transparency and user perception information.

**Methods**
The project included four major components to assess the former fish rearing pond:
- Water Quality monitoring
- Internal Phosphorus Loading estimates
- Wetland Function and Value Assessment
- Site Survey

To measure the impact of the former fish rearing pond on phosphorus concentrations, the project set up a continuous flow monitoring station at the outlet of FL44 and conducted seven grab sample monitoring events throughout the year at the outlet and inlet to the pond (Figure 1). Because there is no clear inlet to the former fish rearing pond from the rest of the wetland complex, the inlet samples were taken at the center of the pond. The samples were collected by the Washington Conservation District and analyzed at the Metropolitan Council Environmental Services Laboratory for total phosphorus, total dissolved phosphorus, total Kjeldahl nitrogen, total and volatile suspended solids, nitrite and nitrate, and ammonia. Data was also collected in Forest Lake itself by volunteers through the Metropolitan Council Citizen Assisted Monitoring Program. The collected data was provided for entry in the STORET system and is included here as Appendix B.

To evaluate the release of phosphorus from the sediments in the former fish rearing pond, the project included the collection and analysis of sediment samples. A WaterMark Sediment Sampler was used to collect an undisturbed column of sediment from the deepest areas of the pond. At each sampling location, the sediment sampler was manually pushed into the sediment
and then retrieved by pulling the sampler out of the water. A check valve at the top of the sampler kept the sediment core from sliding out of the tube during retrieval. The water within the sampler was drained out and the top seven centimeters of sediment was poured into a composite bucket. This procedure was repeated at two additional sites and all three sediment samples were composited. The contents within the bucket were then mixed together and poured into glass sample jars, placed on ice, and sent to a lab for analysis. Laboratory analysis results are presented in Appendix B.

To evaluate the function of the former fish rearing pond in the context of the FL44 wetland complex, the project included an assessment of the former fish rearing pond. A MnRAM 3.2 functional assessment was performed on the FL44 wetland. The purpose of completing the MnRAM assessment is to determine the wetland quality and functions of FL44 in its existing condition by assessing over fifty wetland indicators. These wetland indicators are then used to determine how a wetland functions for Vegetative Diversity/Integrity; Characteristic Hydrology; Flood Attenuation; Downstream Water Quality; Wetland Water Quality; Shoreline Protection; Wildlife Habitat Structure; Fish Habitat; Amphibian Habitat; Aesthetics, Recreation, Education, and Cultural uses; Commercial Uses; and Groundwater Interaction. Detailed explanations of MnRAM 3.2 Wetland Indicators and their associated Functions are described in the documentation from the MN Board of Water and Soil Resources (Board of Water and Soil Resources, 2008).

To determine the physical layout and conditions of the former fish rearing pond, the project included a survey of the pond bathymetry and outlet structure. The bathymetry of the pond was surveyed with a canoe outfitted with a Trimble R8 survey grade GPS. At each bathymetry point, the depth was measured with a graduated tape with a weight attached. This measurement was added to the antenna height to calculate the elevation of the bottom of the pond. To measure elevations of the culvert inverts, a temporary benchmark was set in the centerline of County Road 2 and a level was used to measure the invert elevations. The GPS was calibrated to a Mn/DOT benchmark located in Forest Lake (Sta. 8213 C). Survey data points are presented in Appendix B.

To measure the water quality of Forest Lake, volunteers were used to collect Secchi transparency, user perception, and epilimnion nutrient and chlorophyll information on the Western Basin, and Secchi and user perception information on the Middle and Eastern Basin’s.

Lake sites (Western Basin) enrolled in CAMP are monitored at pre-determined locations on two week intervals from mid-April to mid-October. During each event, Secchi transparency, water temperature, user perception and climatological information is collected. In addition, surface water samples are collected for lab analyses which include total phosphorus (TP), total Kjeldahl nitrogen (TKN), and chlorophyll-a (CLA). The chemical analyses are performed at the Metropolitan Council Environmental Services (MCES) laboratory, following USEPA approved methods. A full description of each program’s methodology can be found at http://www.metrocouncil.org/environment/RiverLakes/Lakes/index.htm.

In addition, Secchi transparency and user perception information was collected on two week from mid-April to mid-October, 2009 on the Middle and Eastern Basins.

The resulting 2009 data for the three basins of Forest Lake data was provided for entry in the STORET system and is included within the Results section of this report.
Figure 1. Monitoring locations for FL44 Assessment and Feasibility Study
RESULTS AND DISCUSSION

Physical Condition of Wetland
A site visit was conducted by EOR staff in August 2009 to observe the general condition of the wetland and its watershed. There was no visual indication that water quality in the wetland would be poor. However, some areas of disturbance were observed around the wetland edges. These disturbances included compost and other materials placed within likely wetland areas and accessory structures such as sheds and garages also located within likely wetland.

A review of historical aerial photographs shows that the open water area of the FL44 wetland has been in an open water condition since at least 1938, suggesting that this portion of the wetland was not excavated or otherwise disturbed in order to conduct fish rearing operations (Figure 2).

Figure 2. Historical (1938) Aerial Photograph of FL44 Wetland and Former Fish Rearing Pond Location

The FL44 wetland now outlets through a culvert under North Shore Trail, through a culvert under a private shed, and then through a shallow swale to discharge into Forest Lake (see photographs in Appendix A). At the time of the site visit there was no outflow from the FL44 wetland.
Water Quality Analysis
Precipitation in 2009 was lower than normal, with 19.4 inches of precipitation during the monitoring period (April 22 through November 2, 2009). Annual precipitation was 24.8 inches, compared to 30 inches of precipitation that falls in a normal year. As a result, flow out of the wetland was extremely low (Figure 3), with a maximum observed rate of 0.24 cfs.

![Figure 3. Flow at the FL44 pond outlet, compared to precipitation](image)

Water quality data were plotted against flow to investigate the impact that the pond has on pollutant loading to Forest Lake. Overall, total suspended solids (TSS) concentrations were low; all samples except for one were less than 5 mg/L TSS (Figure 4) and transparency remains high (Table 1). The average total phosphorus (TP) concentration in the pond was 234 µg/L, ranging from 51 to 458 µg/L, and the average TP concentration in the outflow was 96 µg/L, ranging from 20 to 235 µg/L (Figure 5). Total dissolved phosphorus TDP concentrations in the pond and outflow averaged 51 and 55 µg/L, respectively (Figure 6).

Since it was not possible to take water quality samples at the inflow to the pond, the data can not be used to estimate the phosphorus removal that the pond provides. However, conclusions can be drawn from looking at the TP concentrations and the function that the wetland complex provides overall. With an average outflow concentration of 96 µg/L TP, it appears that the wetland complex is healthy and is not contributing to excessive phosphorus loading. TP runoff concentrations typical of agricultural and residential land uses have concentrations in excess of 300 µg/L.

During the monitoring period, the wetland contributed only 2.0 pounds of phosphorus to Forest Lake, compared to the modeled load from FL44 of 539 pounds of phosphorus per year for the benchmark year (2004 water year) (CLFLWD, 2007). The low observed load is partly due to the dry conditions observed in 2009. The annual rainfall in the water year of 2004, used as a
benchmark year in the CLFLWD water quality model, was 28.09 inches in the City of Forest Lake. The annual rainfall in the 2009 water year evaluated in this study was only 20.45 inches at the same location, about 7.6 inches or 27% lower than the benchmark water year.

Additionally, the wetland is likely providing water quality treatment, which may not have been fully accounted for in the modeled load. The model assumes that wetlands have a phosphorus loading rate of -0.02 pounds of total phosphorus per acre per year. This loading rate implies some level of water quality treatment within the wetland, but does not appear to reflect the full amount of phosphorus storage provided by the FL44 wetland.

![Figure 4. Total Suspended Solids Concentrations](image-url)
Figure 5. Total Phosphorus Concentrations

Figure 6. Total Dissolved Phosphorus Concentrations
### Table 1. Water quality data

<table>
<thead>
<tr>
<th>Date</th>
<th>Flow, daily average (cfs)</th>
<th>Within pond</th>
<th>Pond Outflow</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>TSS (mg/L)</td>
<td>VSS (mg/L)</td>
</tr>
<tr>
<td>1-May-09</td>
<td>0.04</td>
<td>3</td>
<td>2</td>
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<tr>
<td>14-May-09</td>
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<td>12-Jun-09</td>
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<td>24-Jun-09</td>
<td>0.00</td>
<td>2</td>
<td>2</td>
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<td>25-Aug-09</td>
<td>0.07</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>8-Oct-09</td>
<td>0.12</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>
Internal Loading Analysis

Internal loading in lakes and ponds refers to the phosphorus load that originates in the bottom sediments and is released back into the water column. The phosphorus in the sediment was originally deposited in the sediment through the settling of particulates (attached to sediment that entered the lake from watershed runoff, or as phosphorus incorporated into biomass) out of the water column. Internal loading was estimated due to the release of phosphorus from sediments as a result of anoxic conditions. Additional internal loading due to bottom-feeding fish and wind mixing in shallow areas was not added to the estimate.

The internal phosphorus loading to the pond was estimated based on the expected release rate (RR) of phosphorus from the sediment, the lake anoxic factor (AF), and the pond area. Pond sediment samples were taken and tested for concentration of total phosphorus (TP) and bicarbonate dithionite extractable phosphorus (BD-P), which analyzes iron-bound phosphorus. The sediment phosphorus release rate was calculated using the average of two different equations relating the sediment concentrations to release rate. Given the potential error and uncertainty in the estimates, multiple equations were used in order to increase confidence and arrive at a reasonable range of internal loading values. Both equations are statistical regression equations, developed using measured release rate and sediment concentration data from different sets of lakes (Nürnberg, 1988; Nürnberg, 1996). The approach assumes that if a regression equation adequately characterizes the relationship between release rate and sediment phosphorus concentration data in the study set of lakes, then it is reasonable to apply the same equation to other lakes for which the sediment phosphorus concentration is known.

Phosphorus sediment concentration can be considered the internal loading potential of the sediments, since internal loading is dependent on the phosphorus contained in the sediments in addition to other factors such as the oxygen concentration in the water and the length of time of anoxia throughout the year. The phosphorus concentrations in the sediments were first compared to concentrations in nearby lakes to compare the internal loading potential. Both iron-bound phosphorus and total phosphorus concentrations were lower in Pond-44 than in the other lakes sampled within the District for the Watershed and Lake Water Quality Modeling Investigation for the Development of a Watershed Capital Improvement Plan (CLFLWD 2007) study (Figure 7).

When the sediment phosphorus concentrations were used to model internal loading rates within the pond, the two internal loading estimates were 0.0 pounds TP per year and 5.1 pounds TP per year; the average of these two estimates is 2.6 pounds TP per year. Both of these models use the annual average TP concentration within the lake or pond as input; since data from only one year are available, these estimates should be considered preliminary. For reference, the measured TP load from FL44 to Forest Lake was 2.0 pounds TP per year, approximately the same as the estimated internal load. It appears that, during dry years, the internal load may constitute the majority of the load from FL44 to Forest Lake. However, the actual magnitude of the load is very low. During wetter years, the load from FL44 is likely much higher, and the internal load would therefore be a much lower proportion of the total load to the lake.
Wetland Function and Value Assessment

The following table summarizes the results of the MnRAM 3.2 functional assessment, and the text provides explanation for the final rating calculated for each Wetland Function based on MnRAM 3.2 guidance. The functional assessment determined that the FL44 wetland ranks high for most all wetland functions. The relatively high rankings for the FL44 wetland indicate that it is functioning as a diverse and self-sustaining system, and does not seem to be degraded much by past or present land uses.

<table>
<thead>
<tr>
<th>Function Name</th>
<th>Existing Final Rating</th>
<th>Condition Rating</th>
<th>Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vegetative Diversity/Integrity</td>
<td>1.00</td>
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<td>High</td>
</tr>
<tr>
<td>Hydrology - Characteristic</td>
<td>0.75</td>
<td></td>
<td>High</td>
</tr>
<tr>
<td>Flood Attenuation</td>
<td>0.58</td>
<td></td>
<td>Med</td>
</tr>
<tr>
<td>Water Quality--Downstream</td>
<td>0.73</td>
<td></td>
<td>High</td>
</tr>
<tr>
<td>Water Quality--Wetland</td>
<td>0.93</td>
<td></td>
<td>High</td>
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<tr>
<td>Shoreline Protection</td>
<td>N/A</td>
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<td>N/A</td>
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<tr>
<td>Characteristic Wildlife Habitat Structure</td>
<td>0.87</td>
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<td>High</td>
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<tr>
<td>Maintenance of Characteristic Fish Habitat</td>
<td>0.83</td>
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<td>High</td>
</tr>
<tr>
<td>Maintenance of Characteristic Amphibian Habitat</td>
<td>0.26</td>
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<td>Low</td>
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<td>Aesthetics/Recreation/Education/Cultural</td>
<td>0.63</td>
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<td>Med</td>
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<tr>
<td>Commercial use</td>
<td>N/A</td>
<td></td>
<td>N/A</td>
</tr>
<tr>
<td>Special Features listing</td>
<td>N/A</td>
<td></td>
<td>none</td>
</tr>
<tr>
<td>Groundwater Interaction</td>
<td>N/A</td>
<td></td>
<td>discharge</td>
</tr>
</tbody>
</table>
Vegetative Diversity/Integrity
The functional rating for Vegetative Diversity/Integrity is based primarily on the diversity of vegetation within the wetland in comparison to an undisturbed condition for that wetland type. The FL44 wetland ranks “High” because it contains a high diversity of native wetland plant species. As shown in Pictures 14 through 23 (Appendix A), the open water portion of FL44 contains a diversity of submerged and floating aquatic vegetation including coontail, sago pondweed, lesser duckweed, some yellow water lily, and some bladderwort. Pictures 14 through 23 (Appendix A) also show a high diversity of emergent vegetation around the edges of the open water portion, including cattail, three-way sedge, large St. Johnswort, marsh fern, arrowhead, and water hemlock.

Maintenance of Characteristic Hydrologic Regime
The functional rating of Hydrologic Regime reflects the seasonal pattern of the wetland water level, and the “High” rank reflects the constancy of the seasonal patterns from year to year which ensures a reasonable stability for the wetland.

Flood and Stormwater Storage/Attenuation
The functional ranking for Flood and Stormwater Storage/Attenuation is Medium for the FL44 wetland because the wetland area does not have large runoff volumes, nor continuously connected channels to other wetland areas.

Downstream Water Quality Protection
The functional ranking for Downstream Water Quality is “High” for the FL44 wetland because Forest Lake is a significant water resource that is less than 0.5 miles downstream and the FL44 wetland is high quality enough to protect this valuable downstream resource. FL44 is functioning at a level that does allow it to have a high nutrient removal rating due to dense and diverse vegetation composition, and can therefore effectively remove any sediment since some topsoil enters from time to time from outside runoff.

Maintenance of Wetland Water Quality
The functional ranking for Wetland Water Quality is “High.” The FL44 wetland is able to sustain its water quality characteristics because the upland land use allows a vegetated buffer area that helps to prevent sediment from entering the wetland.

Shoreline Protection
There was no functional ranking for Shoreline Protection because the FL44 wetland does not apply, as it is not directly adjacent to a lake or stream.

Maintenance of Characteristic Wildlife Habitat Structure
The functional ranking for Wildlife Habitat is High because the vegetative diversity is also high and the FL44 wetland provides many of the requirements that a diverse set of wildlife species would need to utilize the wetland. This high ranking for wildlife habitat was supported by a diversity of species actually observed during time of this MnRAM Assessment including:
- Cooper’s hawk
- American goldfinch
- song sparrow
- black capped chickadee
- green heron
- American goldfinch
- flycatcher
- green frog
- tiger swallowtail butterfly
- damselflies
- dragonflies
Maintenance of Characteristic Fish Habitat
The functional ranking for Fish Habitat is “High” because the characteristics of water quality contributions from upland factors (sediment delivery, nutrient loading, etc.) are not observed to be contributing to poor water quality within the wetland, and therefore are not degrading fish habitat. Additionally, the FL44 wetland is intermittently connected to Forest Lake and therefore has the potential to support native fish populations as a result of colonization during flood events.

Maintenance of Characteristic Amphibian Habitat for Breeding / Overwintering
The functional ranking for Amphibian Habitat is Low because there are no areas in the FL44 wetland with deep enough habitats (greater than one meter deep) to support amphibian overwintering. However there are areas in the FL44 wetland where several species of frogs were observed within the wetland basin at the time of this MnRAM Assessment.

Aesthetics/Recreation/Education/Cultural/Science
The functional ranking for Aesthetics, etc. is Medium because the FL44 wetland is publicly owned and is relatively near a population center so as to generate aesthetic/recreation/educational/cultural use.

Commercial Uses
There was no functional ranking for Commercial Uses because the FL44 wetland area does not apply, since it does not hold any commercially-valuable use. Products in this category would include crops such as cranberries, wet native grass seed, floral decorations, or wild rice.

Groundwater Interaction
The functional analysis for Groundwater Interaction for the FL44 wetland showed evidence of a discharge groundwater hydrology, meaning that it is likely that groundwater flows into the wetland. The presence of iron concentrations on the water surface (Appendix A- Photograph 17) and numerous plant species that are likely groundwater indicators support this determination. However, this does not offer a definitive result as to the actual movement of groundwater in the assessment area of the FL44 wetland.

Former Fish Rearing Pond and Outlet Survey
The pond bathymetry survey indicates that at the time of the site visit the depth of water in the former fish rearing pond portion of the FL44 wetland ranged from a little over 2.0 feet to 3.5 feet. With a lowest bottom elevation of 897.89 ft and an outlet elevation of 901.39 ft, the water depth must be over 3.5 feet in the deepest portion of the pond order to outflow to Forest Lake.
Figure 8. Bathymetric Survey of FL44 Former Fish Rearing Pond
Forest Lake Background Information
The entire 2,249-acre lake is located within the City of Forest Lake (Washington County). The acreage of each basin is as follows: west basin= 1,109 acres, middle basin= 360 acres, and the east basin= 780 acres. While the lake as a whole has a maximum and mean depths of 11.5 and 3.4 m (38 and 11 feet), the Western Basin itself has a mean and maximum depth of 3.0 m and 6.7 m (10 and 22 feet). The total volume of the whole lake is 24,986 ac-ft, and depending on hydrologic conditions has an 8-12 year residence time. Roughly 68 percent of the lake’s surface area is considered littoral, (the shallow [0-15 feet] area dominated by aquatic plants). Because of the lake’s multi-recreational uses it is considered a “Priority Lake” in the Metropolitan Area.

The three basins of Forest Lake were monitored in 2009 with the use of volunteer monitors, per the project work plan. While the monitoring of Basin 2 (DNR Lake ID # 82-0159-02) and Basin 3 (DNR Lake ID # 82-0159-03) consisted of simply Secchi transparency, and user perception readings from mid-April through mid October, the Western Basin (DNR lake ID # 82-0159-01) was enrolled in the Metropolitan Council’s Citizen-Assisted Monitoring Program (CAMP) with collected water samples. All resulting data were submitted for entry into the USEPA’s STORET water quality database.

2009 Lake Water Quality Monitoring Results

Forest Lake (Western Basin) [also know as Basin 1]
The Western Basin of Forest Lake was monitored 14 times from April 19 through October, 2009 and represents the 14th year the Basin was enrolled in CAMP (the previous being 1993, and 1996-2008). Each monitoring event resulted in the analysis of a water sample for total phosphorus (TP), chlorophyll-a (CLA), total Kjeldahl nitrogen (TKN), and Secchi transparency, as well as the volunteer’s perception of the lake’s physical condition and recreational suitability. Collected water samples were submitted to the Metropolitan Council Environmental Services laboratory for analysis.

The June-September summer means for the Western Basin of Forest Lake and resulting water quality grade (determined using the Metropolitan Council’s grading scheme for lakes in the Twin Cities Metro Area) are shown in Table 3.

<table>
<thead>
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<th>Parameter</th>
<th>Mean</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Grade</th>
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<td>TP (µg/l)</td>
<td>26.0</td>
<td>13.0</td>
<td>37.0</td>
<td>B</td>
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<tr>
<td>CLA (µg/l)</td>
<td>11.2</td>
<td>2.9</td>
<td>19.0</td>
<td>B+</td>
</tr>
<tr>
<td>Secchi (m)</td>
<td>1.7</td>
<td>1.0</td>
<td>3.0</td>
<td>C</td>
</tr>
<tr>
<td>TKN (mg/l)</td>
<td>0.80</td>
<td>0.57</td>
<td>0.92</td>
<td></td>
</tr>
</tbody>
</table>

Overall Grade: B

The Western Basin of Forest Lake’s 2009 Lake information page including: 2009 water quality data and means, TP and Secchi graphs, and historical report grade grades can be found on the following pages. Overall, the Western Basin of Forest Lake received an overall grade of B in 2009, similar to that of 2008. The Western Basin continues to have good TP and CLA means (as shown by their grade of B), while the Basin’s water clarity continues to lag behind that expected by the good TP and CLA concentrations. This likely indicates that something other than algal biomass is causing the diminished water clarity. Suspended particles from the re-suspension of sediments in the water column through frequent mixing events or recreation may be a likely cause. This would result in increased turbidity, a decrease in light penetration via reduced water clarity and thereby suppression of algal growth.
Summary Points

- Forest Lake was considered a mesotrophic lake in 2009, based on the Carlson Trophic State Index.
- Forest Lake is not listed as impaired for excessive nutrients.
- **Curly leaf pondweed and Flowering rush (invasive aquatic plants) are present in this lake.**
- Forest Lake has a healthy diverse aquatic plant population.
- The major land use is semi-urban and rural/agricultural.
- The lake does stratify throughout the summer months.
- The 2009 Secchi transparency summer means for the middle and eastern basins of Forest Lake were 2.5 and 2.4 meters, respectively.
<table>
<thead>
<tr>
<th>Date</th>
<th>Total Phosphorus (mg/L)</th>
<th>Chlorophyll-a (ug/L)</th>
<th>Total Kjeldahl Nitrogen (mg/L)</th>
<th>Secchi Disk Depth (m)</th>
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<td>4/19/09</td>
<td>0.023</td>
<td>3</td>
<td>0.63</td>
<td>2.7</td>
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<td>5/11/09</td>
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<td>2.9</td>
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<td>5/31/09</td>
<td>0.019</td>
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<td>6/12/09</td>
<td>0.013</td>
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<td>2.4</td>
</tr>
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<td>7/2/09</td>
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<td>9.1</td>
<td>0.71</td>
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</tr>
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</tr>
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<td>7/29/09</td>
<td>0.035</td>
<td>9.7</td>
<td>0.92</td>
<td>1.6</td>
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<tr>
<td>8/14/09</td>
<td>0.035</td>
<td>17</td>
<td>0.84</td>
<td>1.6</td>
</tr>
<tr>
<td>8/30/09</td>
<td>0.03</td>
<td>20</td>
<td>0.82</td>
<td>1.5</td>
</tr>
<tr>
<td>9/9/09</td>
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<td>9.8</td>
<td>0.79</td>
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</tr>
<tr>
<td>9/20/09</td>
<td>0.023</td>
<td>12</td>
<td>0.84</td>
<td>1.5</td>
</tr>
<tr>
<td>9/30/09</td>
<td>0.037</td>
<td>19</td>
<td>0.86</td>
<td>1</td>
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<tr>
<td>10/11/09</td>
<td>0.018</td>
<td>12</td>
<td>0.63</td>
<td>1.8</td>
</tr>
<tr>
<td>2009 Summer Average</td>
<td>0.026</td>
<td>11.190</td>
<td>0.797</td>
<td>1.690</td>
</tr>
</tbody>
</table>

**Water Quality threshold is 0.04 mg/L TP or higher**

**Shallow Lake water quality threshold is 0.06 mg/L or higher**

<table>
<thead>
<tr>
<th>2009 Elevation (ft)</th>
<th>High</th>
<th>High Date</th>
<th>Low</th>
<th>Low Date</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>901.68</td>
<td>4/23/2008</td>
<td>900.83</td>
<td>9/13/2008</td>
<td>901.3</td>
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</tr>
</tbody>
</table>

*MPCA description of Impaired Lake's Listing criteria:* "At a minimum, a decision that a given lake is impaired for the 303(d) list due to excessive nutrients will be supported by data for both causal and response factors. Data requirements for 303(d) listing consist of 12 or more TP measurements collected from June through September over the most recent 10-year period. Ideally this should represent 12 separate visits to the lake over the course of two summers; however it might also reflect four monthly samples over the course of three years (a typical sampling regimen for many lake monitoring programs). In addition to exceeding the TP guideline thresholds, lakes to be considered for 303(d) listing should have at least 12 Secchi measurements and 12 chlorophyll-a measurements. This amount of data will allow for at least one season (preferably more) of paired TP.

### Lake Water Quality Summary

<table>
<thead>
<tr>
<th>Trophic Status</th>
<th>Total Phosphorus (mg/l)</th>
<th>Chlorophyll-a (ug/l)</th>
<th>Secchi depth (ft)</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mesotrophic</td>
<td>B</td>
<td>C</td>
<td>C</td>
<td>B</td>
</tr>
<tr>
<td>B+</td>
<td>B</td>
<td>C</td>
<td>C</td>
<td>C+</td>
</tr>
<tr>
<td>B</td>
<td>C</td>
<td>B</td>
<td>C</td>
<td>B</td>
</tr>
<tr>
<td>B</td>
<td>C+</td>
<td>A-</td>
<td>B</td>
<td>B</td>
</tr>
<tr>
<td>Eutrophic</td>
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<td>C</td>
<td>C</td>
<td>B-</td>
</tr>
<tr>
<td>C</td>
<td>C</td>
<td>B</td>
<td>C</td>
<td>C+</td>
</tr>
<tr>
<td>C</td>
<td>C</td>
<td>C</td>
<td>C</td>
<td>B-</td>
</tr>
<tr>
<td>Mesotrophic</td>
<td>B</td>
<td>C+</td>
<td>C</td>
<td>B+</td>
</tr>
<tr>
<td>B</td>
<td>C+</td>
<td>C</td>
<td>C</td>
<td>B-</td>
</tr>
<tr>
<td>B</td>
<td>C+</td>
<td>C+</td>
<td>C</td>
<td>C</td>
</tr>
</tbody>
</table>

**Forest Lake (Middle and Eastern Basins) [also known as Basin 2 and 3]:**

Volunteers were used to collect Secchi transparency and user perception measurements on the Middle and Eastern Basins of Forest Lake in 2009 in order to determine water clarity throughout the summer. Secchi measurements were collected on 11 occasions on the Middle Basin between May 30 and September 23, 2009. Secchi measurements were collected on 10 occasions between April 22 and September 15, 2009 on the Eastern Basin.

The June-September summer means for the Middle and Eastern Basins of Forest Lake and resulting water quality grade (determined using the Metropolitan Council’s grading scheme for lakes in the Twin Cities Metro Area) are shown in Table 4. The entire 2009 database can be found in Table 5, and resulting graph of 2009 Secchi readings are shown on Figure 7.

The resulting summer means, shown in the table below, indicate similar water clarity for both Basins, relating to a grade of B.
Table 4. Forest Lake Middle and Eastern Basins 2009 summer means (June-September)

<table>
<thead>
<tr>
<th>Lake</th>
<th>Mean</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forest Lake-Middle Basin</td>
<td>2.5</td>
<td>2.1</td>
<td>3.5</td>
<td>B</td>
</tr>
<tr>
<td>Secchi (m)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Forest Lake-East Basin</td>
<td>2.4</td>
<td>1.6</td>
<td>3.0</td>
<td>B</td>
</tr>
<tr>
<td>Secchi (m)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 5. Forest Lake Basin Middle and Eastern Basins 2009 Secchi data

<table>
<thead>
<tr>
<th>Forest Lake Basin 2 Date</th>
<th>Secchi Reading (m)</th>
<th>Forest Lake Basin 2 Date</th>
<th>Secchi Reading (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5/30/09</td>
<td>3.5</td>
<td>4/22/09</td>
<td>3.3</td>
</tr>
<tr>
<td>6/12/09</td>
<td>3.0</td>
<td>5/15/09</td>
<td>2.8</td>
</tr>
<tr>
<td>6/17/09</td>
<td>3.0</td>
<td>5/29/09</td>
<td>2.8</td>
</tr>
<tr>
<td>7/1/09</td>
<td>2.7</td>
<td>6/9/09</td>
<td>2.8</td>
</tr>
<tr>
<td>7/9/09</td>
<td>2.7</td>
<td>6/28/09</td>
<td>3.0</td>
</tr>
<tr>
<td>7/13/09</td>
<td>2.5</td>
<td>7/2/09</td>
<td>3.0</td>
</tr>
<tr>
<td>7/17/09</td>
<td>2.5</td>
<td>7/19/09</td>
<td>2.6</td>
</tr>
<tr>
<td>7/27/09</td>
<td>2.3</td>
<td>8/5/09</td>
<td>1.7</td>
</tr>
<tr>
<td>8/10/09</td>
<td>2.1</td>
<td>8/17/09</td>
<td>1.6</td>
</tr>
<tr>
<td>8/16/09</td>
<td>2.1</td>
<td>9/15/09</td>
<td>1.7</td>
</tr>
<tr>
<td>8/23/09</td>
<td>2.1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 7. 2009 Secchi Readings for Middle and Eastern Basins of Forest Lake
Assessment of Need for Alterations to Pond and Wetland System

The initial concept for this project indicated that the options to be considered in the feasibility study may include alum treatment of the pond sediments, excavation to increase volume and retention time or to remove high-nutrient soils, and the installation of a rough fish barrier.

The internal load in the FL44 wetland was not identified as a significant source of phosphorus and the sediment phosphorus concentrations are fairly low. Therefore, alum treatment and excavation for removal of high-nutrient soils is not recommended. Since the wetland does not appear to be negatively impacted by the fish population and the wetland appears to connect hydraulically to Forest Lake only infrequently, a fish barrier is not recommended at this time. Additional ongoing monitoring of the wetland’s water quality and outflow is recommended in order to evaluate the actual average annual loading from this subwatershed to Forest Lake and to evaluate the impact of the livestock exclusion project.

Feasibility Evaluation

As discussed above, alum treatment, excavation, and fish barriers were determined to not be beneficial actions to reduce nutrient loads to Forest Lake. However, the wetland is of high quality and should be protected from disturbance and excessive nutrient inputs. Accessory buildings and compost piles were observed within likely wetland areas, suggesting that actions to increase local stewardship of the wetland may be beneficial to its protection. In addition, the site visits and a review of aerial photos indicate that there may be opportunities to increase the stormwater treatment provided for runoff into the wetland from roadways, ball fields and residential lots.

Preliminary Design Concepts and Actions

Landowner education encouraging appreciation and stewardship of the wetland and the installation of localized best management practices is recommended to supplement the load reduction efforts planned through the livestock exclusion project. The education efforts could focus on the benefits and functions of the FL44 wetland, its unique characteristics, be completed through targeted education sessions, neighborhood meetings, door to door discussions with landowners or other methods.

The installation of local best management practices to protect the quality of FL44 could include the targeted implementation of projects by CLFLWD, through the existing cost-share program where feasible, such as:

- biofiltration or other suitable feature to capture runoff from North Shore Trail and treat it prior to discharge to the FL44 wetland and Forest Lake
- best management projects in cooperation with road authorities where roads currently drain untreated to the wetland
- working with specific landowners to increase buffer areas where there are currently smaller buffers
- working with specific landowners who have structures or compost in the wetland to relocate those features
**Recommendations**

Based on the findings of this study it is recommended that the CLFLWD:

Conduct ongoing monitoring of the wetland’s water quality and outflow in order to:
- Evaluate the average annual loading from the FL44 subwatershed to Forest Lake in years with different hydrologic conditions
- Review and calibrate the District’s water quality model for FL44
- Evaluate the impact of the livestock exclusion project

Complete in the FL44 subwatershed by leveraging and targeting the CLFLWD cost-share program toward projects or by designing and installing projects that will:
- Increase the width and quality of wetland buffers
- Construct water quality treatment best management practices (BMPs) for roadways and developed areas that discharge to the wetland with no current treatment
- Provide education for landowners adjacent to the FL44 wetland on the benefits and stewardship of wetlands.
Objectives
The overall goal for this project is to protect the water quality of Forest Lake to ensure that phosphorus concentrations in the lake do not increase to the level of impairment as defined by state standards (40 µg/L). This study found that the FL44 wetland and subwatershed do not appear to be a major contributor of phosphorus to Forest Lake. However, the study determined that the wetland is of high quality and valuable for protection to ensure no increase in loading to Forest Lake. The implementation goals defined by this study are:

- Conduct ongoing monitoring of the wetland’s water quality and outflow
- Increase the width and quality of wetland buffers
- Construct water quality treatment best management practices (BMPs) for areas that discharge to the wetland with no current treatment
- Provide education for landowners adjacent to the FL44 wetland on the benefits and stewardship of wetlands

BMP Selection and Justification
The BMPs selected are intended to reduce the phosphorus load to the FL44 wetland, and consequently to Forest Lake.

Wetland Buffers
While most areas along the FL44 wetland have some buffer, the buffer varies in width and quality. Improvements to the quality and width of the wetland buffer will provide water quality and habitat improvements. Priority should be given to buffer establishment in areas where the buffer has been removed, covered to turfgrass, or is severely disturbed.

Installation of Best Management Practices (BMPs)
Few areas within the FL44 watershed appear to have stormwater treatment at this time. The installation of water quality and volume reduction BMPs will provide water quality benefits for the FL44 wetland and Forest Lake. Volume reduction BMPs will help to support the groundwater inputs to FL44 that contribute to its high wetland quality. Land use in the contributing watershed is primarily residential; so the areas requiring treatment are roadways and residential properties. Distributed, smaller-scale BMPs that reduce phosphorus load through storage, plant uptake, or outflow volume reduction are recommended.

Recommended BMPs for residential properties include raingardens, vegetated swales, and biofiltration/bioretention areas as well as practices such as rain barrels and the redirection of roof downspouts to vegetated areas. These practices are recommended for residential sites because they are aesthetically pleasing additions to a residential yard or are simple modifications to the management of roof runoff.

The BMPs recommended for roadways include porous pavement, vegetated swales, raingardens, biofiltration/bioretention areas, and filtration. These practices are recommended for roadway sites because they can be adapted to a linear arrangement within the road right-of-way.

Priority should be given to implementing BMPs on sites where runoff from impervious surfaces discharge without treatment to the FL44 wetland. Sites closer to the wetland should be given higher priority than those further away.
**Landowner Education**
The study noted that improved stewardship of the wetland and wetland buffers by neighboring landowners would assist in improving the quality of the resource. Education efforts should be targeted to landowners along the wetland and should emphasize:

- Qualities of the FL44 wetland
- Connection between the wetland’s quality and Forest Lake’s water quality
- Wildlife and unique plants of the FL44 wetland
- Stewardship practices

**Monitoring**
Ongoing evaluation of the phosphorus load from the FL44 wetland to Forest Lake will be crucial to the adaptive management of the subwatershed and the wetland. The hydrologic conditions in the year that current monitoring occurred were quite dry and may not be representative of future years. Data should be used to evaluate the average annual loading from the FL44 subwatershed to Forest Lake in years with different hydrologic conditions and to evaluate the need to revise planned implementation measures or to add new implementation measures. In addition, monitoring data should be used to review and calibrate the District’s water quality model for FL44 and evaluate the impact of the livestock exclusion project. Monitoring should include: water level in the FL44 wetland, grab samples analyzed for water quality parameters (phosphorous, sediment), and periodic outflow measurement to establish a rating curve.

**Implementation Cost**
The cost to implement this plan will include design and installation of the following types of BMPs installed on the properties of interested residents or to manage drainage from roadways and public sites. The total cost may be reduced if the projects are implemented primarily through cost-share programs, however, targeted fully-funded projects may also be necessary.

**Residential BMPs**
- Wetland buffers: $5,000 each to establish a new buffer
- Raingardens or small biofiltration/bioretention areas: $3,000 to $5,000 each
- Vegetated swales: $3,000 to $5,000 each
- Rain Barrels: $400 each
- Downspout redirection: $300 each project

**Roadway or Public Site BMPs**
- Porous pavement road sections: $5 - $10 per square foot
- Vegetated swales: $3,000 to $10,000 each
- Larger raingardens: $5,000 to $7,000 each
- Larger infiltration or biofiltration/bioretention or filtration facilities: $10,000 to $50,000
- Wetland buffers: $5,000 each to establish a new buffer

An education effort is also proposed at an estimated cost of $8,000 over two years to be targeted to landowners along the FL44 wetland.

**Conclusion**
The implementation plan includes BMPs for residential and roadway sites as well as an educational initiative.
REFERENCES


